ISSN 0970-0226

# THE JOURNAL OF RESEARCH ANGRAU

The J. Res. ANGRAU, Vol. LI No. (3), pp. 1-180, July - September, 2023

Indexed by CAB International (CABI), AGRIS (FAO) and ICI
www.jorangrau.org


ACHARYA N.G. RANGA AGRICULTURAL UNIVERSITY
Lam, Guntur - 522 034

# The Journal of Research ANGRAU

(Published quarterly in March, June, September and December)





**EDITOR - IN - CHIEF**

**Dr. G. Rama Rao**

Dean of P.G. Studies, ANGRAU, Guntur
Administrative Office, Lam, Guntur-522 034

**MANAGING EDITOR**

**Dr. A. Lalitha**

PAIO (FAC)
AI & CC, ANGRAU, Lam, Guntur - 522 034

**EDITOR** : **Dr. A. Lalitha,** AI & CC, ANGRAU, Lam, Guntur - 522 034

**SUBSCRIPTION TARIFF**

| | | | |
|---|---|---|---|
| Individual (Annual) | : Rs 400/- | Institute (Annual) | : Rs. 2000/- |
| Individual (Life) | : Rs. 2000/- | Printing Charges | : Rs. 125/- per page |

D.D drawn in favour of **COMPTROLLER, ANGRAU, GUNTUR** should be sent to the Managing Editor, Agricultural Information & Communication Centre, APGC Premises, ANGRAU, Lam, Guntur - 522 034, Andhra Pradesh

# CONTENTS

DoI: https://doi.org/10.58537/jorangrau.2023.51.3.01

J. Res. ANGRAU 51 (3) 01-09, 2023

# EXPRESSION OF CHITINASE AND β-1,3-GLUCANASES IN RICE CULTIVARS IN REACTION TO *Rhizoctonia solani*,THE CAUSAL AGENT OF RICE SHEATH BLIGHT

**SURESH MADUGULA*** and **PARIMAL K. SINHA**

Division of Plant Pathology, ICAR-Indian Agricultural Research Institute, New Delhi- 110 012

Date of Receipt : 17.4.2023 Date of Acceptance : 30.6.2023

## ABSTRACT

Fifteen high yielding rice cultivars were screened for their reaction to sheath blight under field as well as semi-controlled conditions inoculated with the pathogen *Rhizoctonia solani* Kuhn. Expression of two pathogenesis related proteins (PRPs), Chitinase and β-1,3-glucanases activities were estimated. Both chitinase and 1,3-glucanase PR proteins activity in terms of specific activity expressed after 72 h of pathogen inoculation was generally higher in tolerant cultivars (NLR 145, MTU 1061, NLR 3238, MTU 1153) including checks (TETEP and MTU 1001) as compared to control (MTU 7029) and other susceptible cultivars. The presence of a 33 kDachitinase and 32 kDa and β-1,3-glucanase proteins was revealed by western blot analysis, across all the rice cultivars following *Rhizoctonia solani* infection. No significant grain yield difference in relation to the expression of PRPs was observed across the test rice cultivars.

**Keywords**: β-1,3-glucanase, Chitinase, Disease resistance, Pathogenesis related Proteins (PRPs), *Rhizoctonia solani*, Rice, Sheath blight

## INTRODUCTION

The prevalence of rice sheath blight, incited by *Rhizoctonia solani,* has become a significant challenge in modern rice farming systems since the introduction of semi-dwarf, high-yielding rice varieties (Kalpana *et al.,* 2006), especially under costal ecosystem of Andhra Pradesh, where intensive system of rice cultivation is more common. Despite extensive efforts to identify rice cultivars and breeding lines with strong resistance against sheath blight, no cultivars with high levels of resistance have been found thus far (Hein, 1990). Additionally, genetic resistance to *R. solani* has not been observed in rice cultivars or wild relatives (Bonman *et al.,* 1992). In recent years, there has been considerable focus on unravelling the intricate defence mechanisms of plants when faced with pathogenic infections. One notable aspect is the rapid accumulation of host-encoded proteins, known as pathogenesis-related (PR) proteins, which possess antifungal properties. Among these proteins, hydrolytic enzymes like chitinases and β-1,3 glucanases have been extensively studied and characterized in various plant species, induced in response to fungal infections, as well as wounding and treatments involving ethylene or elicitors (Van loon *et al.,* 2006, Wubben *et al.,* 1996).

The class of proteins usually associated with infection by a pathogen or other biotic stresses are termed as Pathogenesis-related proteins (PR proteins). These proteins are induced coordinately, systemically and locally gets accumulated, and are have association with the induction of the systemic acquired response (SAR) (Jain and Khurana, 2018). Beta-1,3-glucanase and chitinase,

*Corresponding Author E-mail i.d: m.suresh@angrau.ac.in

the enzymes produced by plants that are capable of degradation of components of pathogen cell wall and are the key factors that contribute significantly to the plant's ability to withstand fungal diseases. Studies have provided evidence that the over-expression of PR proteins through genetic engineering can enhance plant resistance against fungal diseases (Velazhahan and Muthukrishnan, 2004).

While certain PR proteins are naturally expressed at low levels in plants, the majority of PR proteins are induced and upregulated in response to pathogen invasion. The induction of PR proteins is a consequence of activating plant defense pathways, which in turn helps restrict the entry or spread of pathogens. However, assigning a definitive role to PR proteins in plant resistance to pathogens is challenging due to the abundance of correlative data. For instance, there is often a stronger accumulation of PR proteins in resistant plants following inoculation compared to susceptible plants. Additionally, PR proteins are constitutively expressed in plants with high levels of natural disease resistance. Moreover, PR proteins are induced in plants exhibiting resistance or systemic acquired resistance (SAR), and PR proteins derived from transgenic resistant plants display elevated microbial activity, suggesting their direct involvement in disease resistance. It is important to note that only a few families of PR proteins in rice are well-known, and specifically, the PR-1, PR-2, PR-3, PR-4, PR-5, and PR-9 genes have been identified in response to *R. solani* infection (Van loon *et al.,* 2006).

In order to assess the role of PRPs activity in rice in determining disease reaction after infection by *R. solani*, 15 rice cultivars along with two checks were selected and evaluated for the level chitinase and β-1,3 glucanases accumulation. The relationship between chitinase and β-1,3 glucanases activity and relative resistance of selected rice cultivars to sheath blight infection was also determined in the study.

## MATERIALS AND METHODS

### Field experimentation

Resistance evaluation for all the test entries along with susceptible and tolerant check entries was carried out in the experimental farm of Regional Agricultural Research Station (RARS), Maruteru, West Godavari district of Andhra Pradesh, which is the hot spot for sheath blight disease during rabi season of 2020-2021. A total of 15 entries comprising 12 rice cultivars prominently cultivated throughout the coastal ecosystem, especially in Andhra Pradesh, along with two known tolerant entries (TETEP and MTU 1001) and one susceptible check (MTU 7029) were used in the present study (Table 1). Disease score was recorded as per the standard 0-9 scale (IRRI, 2002) and disease incidence was calculated using the formula (Wheeler, 1969) along with the grain yield.

### Preparation of plant material

One set of the test entries were grown under greenhouse, in 15 cm diameter plastic pots containing a clay: humus mixture (2: 1, v/v) @ two seedlings per pot. Two-week-old seedlings were used for inoculation with the pathogen. Inoculation was conducted with the maruteru isolate of *R. solani*, by placing slices of the margins of 5-day-old mycelial plugs (1–2 cm in diameter) grown on Potato Dextrose Agar (PDA), beneath the leaf sheath. The inoculated seedlings were covered immediately with plastic bags for the pathogen develop, and the pots were kept in incubators with temperature and humidity control. One gram of leaf sheath tissue, showing typical sheath blight symptoms, of all the test varieties along with checks were collected 72 h post inoculation.

### Determination of pathogenesis-related (PR) proteins

By using the method of Abeles *et al.,* (1970), the activities of the two PR proteins of interest, *viz*., β-1,3-glucanase and chitinase were determined in the Division of Plant Pathology, ICAR-IARI, New Delhi.

**Assay of β-1,3-glucanase**

Collected sheath blight infected leaf sheaths were homogenized in a pre-chilled mortar pestle using 4 ml of 0.05 M of potassium acetate buffer having pH 5. after filtering the homogenate through pre-moistened two-layered cheese cloth, the filtrate was centrifuged at 10,000 g in a cooling centrifuge for 10 min at 4 °C. The collected supernatant was used for enzyme estimation.The reaction mixture consisting of 50 µl sample, 450 µl of 0.05 M potassium acetate (pH 5) buffer and 2% laminarin substrate 500 µl, was incubated for at 40 °C for one hour. Post incubation, further assay was done for the released glucose using the method described by Nelson (1944) and Somogyi (1952). Using the standard curve of glucose, the β-1,3-glucanase activity was calculated.

**Chitinase assay**

In a pre-chilled mortar pestle the tissue was homogenized using 4 ml of 0.1 M sodium citrate buffer (pH 5). By passing through two layers of cheese cloth, pre-moistened in 0.1 M sodium citrate buffer (pH 5), the homogenate was filtered and the filtrate was centrifuged for 20 minutes at 10,000 *g* and the supernatant was collected and measured.Using colloidal chitin as substrate, chitinase activity was measured in terms of the release of N-acetyl-D-glucosamine (NAG) following the method of Reissig *et al.* (1955). Using the methods described by Berger and Reynolds (1958), colloidal chitin was prepared and chitinase activity was calculated using the standard curve of NAG.

**Western-blot analysis**

Protein concentrations were determined using the Bicinchoninic acid kit for protein determination (Merck). Crude extracts equivalent to 550 mg of protein were treated with 40 ml ice-cold Trichloro acetic acid (TCA) for 45 min. Precipitates were obtained by centrifuging TCA-treated extracts at 15000 g at 4 °C for 15 min. The precipitates were washed with acetone and centrifuged again at 15000 *g* for 15 min at 4 °C. The pellets were dissolved in sample buffer containing 1.*5%* Tris-hydroxymethyl aminomethane (Tris), pH 6.8, containing 0.002% bromophenol blue prior to loading them on to 10% SDS-PAGE for electrophoresis (Laemmli 1970). Immediately after electrophoresis, gels were blotted onto AmershamHybond P Western Blotting membrane sandwich PVDF. The membrane was subsequently exposed to a primary antibody at a concentration of 1:1000, specifically anti-rabbit class-I β-1,3 glucanase and anti-tobacco class I chitinase antibodies, which were prepared in TBST buffer. Following overnight incubation with the primary antibody, the membrane was washed twice with TBST for 10 minutes each time. Next, the membrane was exposed to a secondary antibody, alkaline phosphatase-conjugated goat-anti-rabbit (IgG-ALP), diluted at 1:8000 in TBST buffer, and allowed to incubate at room temperature for 2 h. Subsequently, the membrane was washed and incubated with a colour development reagent containing 5-bromo-4-chloro-3-indolyl phosphate and nitro blue tetrazolium (sigma), which initiated the alkaline phosphatase reaction. Immediately after color development, the membrane was rinsed with distilled water and left to air-dry. This experimental procedure was adapted from Gupta *et al.* (2013).

**RESULTS AND DISCUSSION**

The group of enzymes that hydrolyze chitin, the major component of many fungal cell walls is termed as chitinases. Individually or in conjunction with other enzymes, hydrolytic enzymes play crucial roles in the active defense response of plants, as highlighted by Mauch *et al.* (1988). Upon pathogen penetration, these enzymes act on fungal germlings, causing their weakening and ultimately preventing disease development in resistant plant varieties. However, in susceptible hosts, the pathogen may penetrate and colonize the tissue before PR proteins are induced to a sufficient level. PR proteins can operate through a distinct pathway that involves the release of chitin and glucan

fragments from fungal cell walls, resulting in the direct breakdown or damage of pathogens (refer to Figure 1). These oligosaccharide molecules, possessing elicitor activity, initiate a cascade of defense reactions within the host plant, as elucidated by Kombrink *et al*. (2001).

**Infection**

(Adopted from Dodds and Rathjen, 2010). In the context of plant defense against pathogens, β-1,3-glucanases have been proposed to play a direct role due to their ability to target the major component of fungal cell walls, β-1,3-glucan, as noted by Wessels and Sietsma (1981). Additionally, β-1,3-glucanases are known to release oligosaccharides from fungal walls, which act as signals to elicit host defense responses, as described by Ham *et al.* (1991). Ward *et al.* (1991) observed higher levels of β-1,3-glucanase activity in resistant musk-melon plants compared to susceptible ones following Fusarium infection. It can be concluded from the results (Fig. 2 and Table 1), both the PR proteins (chitinase and β-1,3-glucanase) activity in terms of specific activity expressed after 72 h of pathogen inoculation, in general was higher in tolerant cultivars (NLR 145, MTU 1061, NLR 3238, MTU 1153) including checks (TETEP and MTU 1001) in comparision to control variety (MTU 7029) and other susceptible cultivars. Broglie *et al.* (1991) demonstrated that increased chitinase activity in plants results in a reduction in pathogen-induced damage. Furthermore, it was observed that the synthesis of PR proteins is commonly triggered in response to attacks by various plant pathogens in most plants.

**Inoculated rice cultivars**

Upon pathogen attack, the induction of chitinase and other hydrolytic enzymes is observed as a coordinated defense mechanism, often displaying complexity and multifaceted responses. The induction of chitinases is typically considered as part of a nonspecific defense response that occurs in plants following pathogen attacks. PR proteins accumulate rapidly, both intracellularly and extracellularly, in response to various biotic and abiotic stimuli, including fungal pathogens, elicitors, and physical or chemical treatments, as

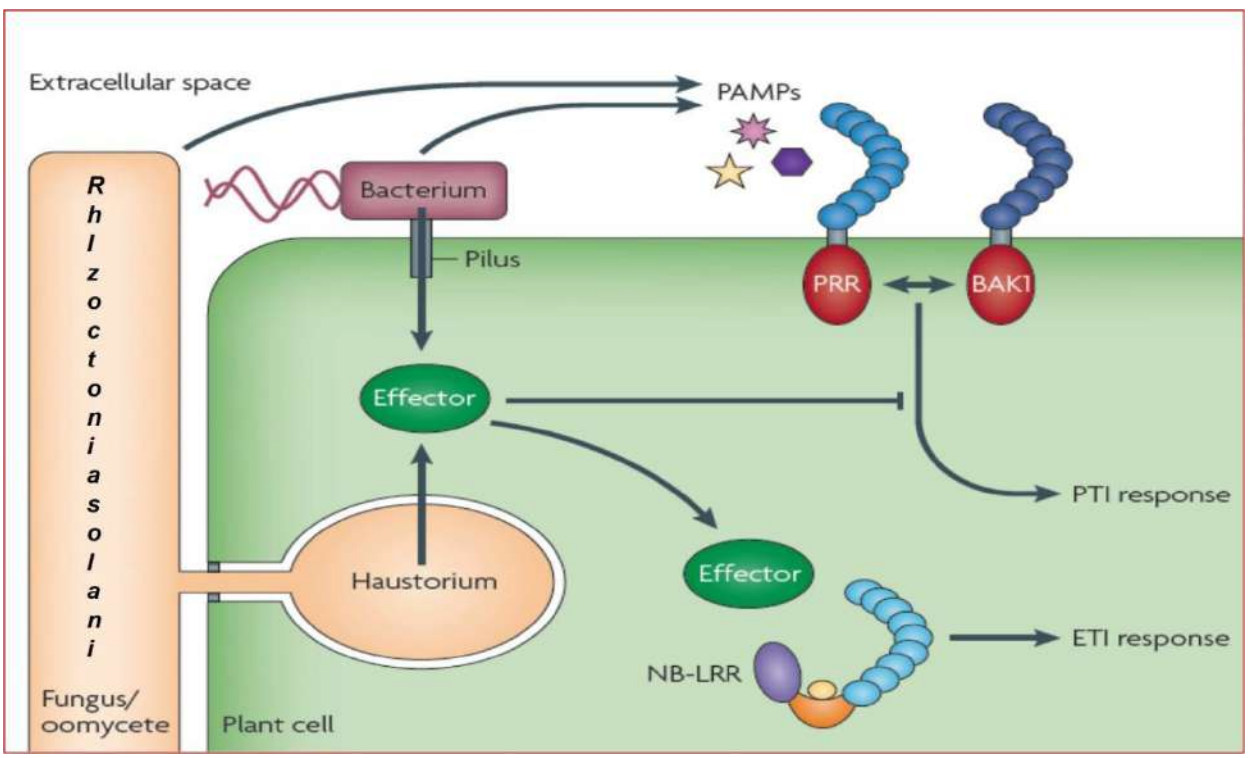



**Figure 1. Pathogenesis proteins expression of in response to sheath blight pathogen infection**

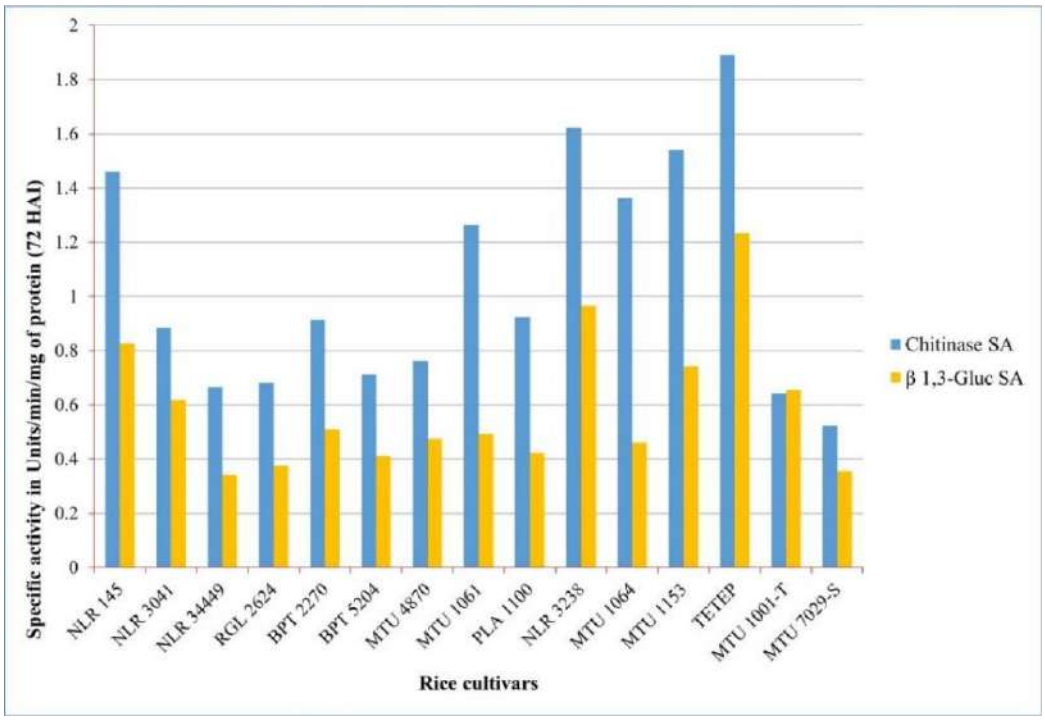



**Figure 2. Pathogenesis related proteins (PRP) expression in different sheath blight**

From the data on yield components (Table 1) it was observed thathighest grain yield recorded in MTU 1001, one of the tolerant checks (8.346 t $ha^{-1}$) and lowest yield was observed in TETEP (4.556 t $ha^{-1}$), the other tolerant check, but none of the varieties did not show significant difference in the final grain yields.

Western blot analysis revealed induction of a 33 kDachitinase (Fig. 3) and 32 kDa and β- 1,3-glucanase (Fig. 4) proteins, respectively across all the inoculated rice cultivars. Further, more it was observed that the expression levels of chitinase were higher in case of tolerant cultivar group (Fig. 3 a) and relatively lower expression is observed in susceptible cultivar group (Fig.3 b).

a) H-Healthy (MTU 1001-un inoculated)), S-Susceptible (MTU 7029- Inoculated); T-Tolerant(MTU 1001-Inoculated); Lines 1- 6 Inoculated test entries, 1-Tetep; 2-NLR 3238; 3-NLR 145; 4-MTU 1153; 5-NLR 3041; 6-BPT 2270; M- Marker.

b) H-Healthy (MTU 1001-un inoculated)), S-Susceptible (MTU 7029- Inoculated); T-Tolerant(MTU 1001-Inoculated); Lines 1to7-Inoculated test entries, 1-MTU 1061; 2-MTU 4870; 3- MTU 1064; 4 – PLA 1100; 5-BPT 5204; 6-RGL 2624; 7-NLR 34449.

Similar trend was observed with respect to β- 1,3-glucanase (Fig 4a and 4b). In their study, Gupta *et al.* (2013) found that PR proteins, specifically 1,3-glucanase and chitinase, were induced in *E. sativa* plants following inoculation with the fungal pathogen *A. brassicicola.* Notably, in the resistant variety, the expression of these proteins was observed at a higher intensity during the early stages of pathogenesis. In contrast, in the susceptible variety, the induction of these proteins occurred during the later stages of pathogenesis.Shreshta *et al.* (2008) reported the induction of class 1 and class 2 chitinases following *Rhizoctonia solani* infection in moderately resistant rice cultivars tested and the levels were detected 24 h and 36 h of inoculation in moderately resistant and susceptible cultivars, respectively as revealed by the western blot analysis.

**Table 1. Induction of Chitinase and β-1,3-glucanase in different rice cultivars in response to sheath blight disease infection**

| S.No. | Entry | Lesion length (cm) | SA of Chitinase | SA of β-1.3-Glucanase | Grain Yield (t ha$^{-1}$) | Disease score |
|---|---|---|---|---|---|---|
| 1 | NLR145 | 5.44 | 1.461 | 0.826 | 5.12 | 5 |
| 2 | NLR 3041 | 4.42 | 0.883 | 0.618 | 5.09 | 7 |
| 3 | NLR 34449 | 3.84 | 0.664 | 0.341 | 5.35 | 9 |
| 4 | RGL 2624 | 4.72 | 0.681 | 0.375 | 5.15 | 9 |
| 5 | BPT 2270 | 4.54 | 0.914 | 0.511 | 4.90 | 7 |
| 6 | BPT 5204 | 4.64 | 0.713 | 0.412 | 5.11 | 9 |
| 7 | MTU 4870 | 4.30 | 0.762 | 0.475 | 6.24 | 9 |
| 8 | MTU 1061 | 3.82 | 1.263 | 0.493 | 7.38 | 7 |
| 9 | PLA 1100 | 4.42 | 0.924 | 0.423 | 5.03 | 7 |
| 10 | NLR 3238 | 3.58 | 1.623 | 0.966 | 5.82 | 5 |
| 11 | MTU 1064 | 3.66 | 1.364 | 0.461 | 7.58 | 7 |
| 12 | MTU 1153 | 3.24 | 1.891 | 1.233 | 6.17 | 5 |
| 13 | TETEP (T) | 3.60 | 1.541 | 0.743 | 4.56 | 5 |
| 14 | MTU 1001 (T) | 3.65 | 0.643 | 0.655 | 8.35 | 7 |
| 15 | MTU 7029 (S) | 9.49 | 0.524 | 0.355 | 6.41 | 9 |

SA – Specific activity in units/minutes/mg of protein 72 hours after inoculation

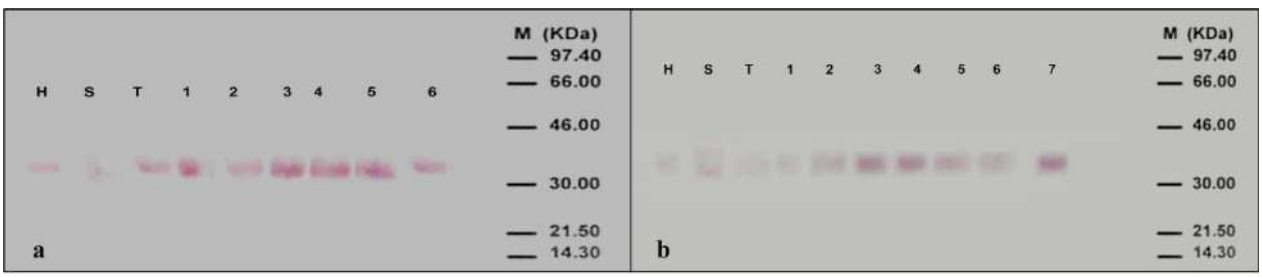



**Figure 3. Expression of Chitinase in rice cultivars - 33 kDa protein band (72 HAI) in Western blot**

a) H-Healthy (MTU 1001-un inoculated)), S-Susceptible (MTU 7029- Inoculated); T-Tolerant(MTU 1001-Inoculated); Lines 1-6 Inoculated test entries, 1-Tetep; 2-NLR 3238; 3-NLR 145; 4-MTU 1153; 5-NLR 3041; 6-BPT 2270; M- Marker

b) H-Healthy (MTU 1001-un inoculated)), S-Susceptible (MTU 7029- Inoculated); T-Tolerant (MTU 1001-Inoculated); Lines 1 to 7-Inoculated test entries, 1-MTU 1061; 2-MTU 4870; 3- MTU 1064; 4 – PLA 1100; 5-BPT 5204; 6-RGL 2624; 7-NLR 34449.

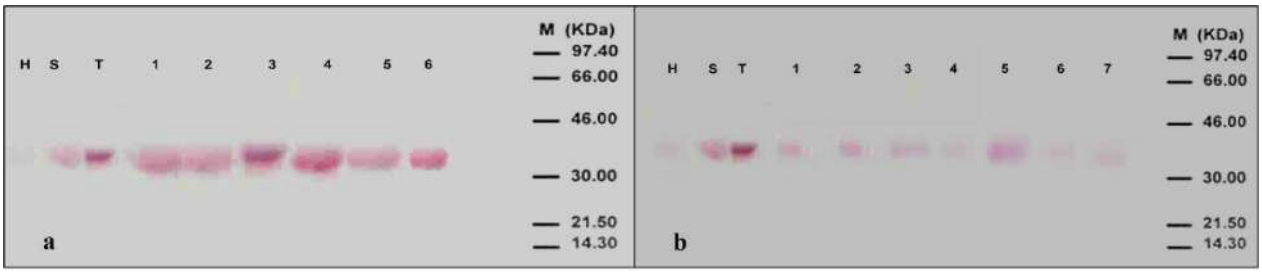



**Figure 4. Expression of 1,3-glucanase in rice cultivars 32 kDa protein band (72 HAI) –in Western blot**

This study suggested that the *Rhizoctonia solani* infection induced signaling process that begins upstream activation of PR proteins. Expression of pathogen inducible PR proteins has been well correlated with disease resistance (Vidhyasekaran, 1997). Datta *et al.* (2001) observed the enhanced disease resistance in plants by way of constitutive over expression of chitinase and β-1,3-glucanase. The results, therefore, concluded that PR proteins play important role in defense mechanism of *Rhizoctonia solani* against the sheath blight disease and the expression levels of these PRPs can be utilized for categorizing the varieties along with resistance components for efficient identification of resistant sources, for further utilization in breeding programmes.

## CONCLUSIONS

Both these PRPs (β-1,3-glucanase and chitinase) were induced in rice cultivars after inoculation of the pathogen *Rhizoctonia solani.* The results showed that in tolerant cultivars the protein expression was observed with higher intensity in comparision with the susceptible cultivars. Further, the accumulation these PRPS after 72 h after inoculation, quantified in terms of specific activity also varied according to their resistance reaction, *i.e.* higher levels in tolerant cultivars than in susceptible entries. Furthermore, no significant relation between grain yield and expression of PRPs was observed among the rice cultivars tested under the study. Thus, the expression of PRPs can be taken as a measure of the disease reaction and can be utilized for varietal categorization in combination with the modeled parameters developed in this study.

## Acknowlegements

The work was carried out by the first author as a part of ICAR-PDF programme grant at ICAR-IARI, New Delhi The field experimentation was carried out at RARS, Maruteru, Acharya N.G. Ranga Agricultural University, Andhra Pradesh. My sincere thanks to the Associate Director of Research, RARS, Maruteru, scientists and staff who helped me in the experiment.

## REFERENCES

Abeles, F.B., Bosshart, R.P., Forrence, L.E and Habig, W.E. 1970. Preparation and purification of glucanase and chitinase from bean leaves. Plant Physiology. 47: 129–134.

Anand, A., Lei, Z.T., Summer, L.W., Mysore, K.S., Arakane, Y., Backus, W.W and Muthukrishnan. S. 2004. Apoplastic extracts from a transgenic wheat line exhibiting lesion-mimic phenotype have multiple pathogenesis related proteins that are antifungal. Plant-Microbe Interactions.17:1306-1317.

Berger, L.R and Reynolds, D.M. 1958. The chitinase system of a strain of S*treptomyces griseus*. Biochem Biophys Acta. 29:522534.

Bonman, J. M., Khush, G. S and Nelson, R. J. 1992. Breeding rice for resistance to pests. Annual Review of Phytopathology. 30:507–526.

Broglie, K., Chet, I., Holliday, M., Cressman, R., Biddle, P., Knowlton, S., Maurais, C.J and Broglie, R. 1991. Transgenic plants with

enhanced resistance to the fungal pathogen *Rhizoctonia solani*. Science. 254:1194-1197.

Datta, K., Tu, J.M., Oliva, N., Ona, I., Velazhahan, R., Mew, T.W., Muthu krishnan, S and Datta, S.K. 2001. Enhanced resistance to sheath blight by constitutive expression of infection related rice chitinase in transgenic elite Indica rice cultivars. Plant Science. 160: 405–414.

Graham, M.Y., Weidner, J., Wheeler, K., Pelow, M.L and Graham, T.L. 2003. Induced expression of pathogenesis-related protein genes in soybean by wounding and the Phytophthorasojae cell wall glucan elicitor. Physiological and Molecular Plant Pathology. 63:141–149.

Gupta, P., Ravi, I and Sharma, V. 2013. Induction of β-1,3-glucanase and chitinase activity in the defense response of *Eruca sativa* plants against the fungal pathogen *Alternaria brassicicola*. Journal of Plant Interactions. 8(2): 155-161.DOI: 10.1080/17429145.2012.679705.

Ham, K.S., Kauffmann, S., Albersheim, P and Darvill, A.G. 1991.Host pathogen interactions. XXXIX. A soybean pathogenesis related protein with β-1,3-glucanase activity releases phytoalexin elicitoractive heat-stable fragments from fungal walls. Molecular Plant-Microbe Interactions. 4:545-552.

Hein, M. 1990. Reaction of germplasms to sheath blight of rice. Myanmar Journal of Agricultural Science. 2: 1–12.

IRRI, 2002. Standard evaluation system for rice. INGER. Genetic Resources Center, IRRI, Manila. pp. 20–21.

Jain, D and Khurana, J.P. 2018. Role of pathogenesis-related (PR) proteins in plant defense mechanism A. Singh, I. K. Singh (Eds.); Molecular Aspects of Plant-Pathogen Interaction.https://doi.org/10.1007/978-981-10-7371-7_12. pp. 265-281.

Kalpana, K., Maruthasalam, S., Rajesh, T., Poovannan, K., Kumar, K. K., Kokiladevi, E., Raja J.A.J., Sudhakar, D., Velazhahan, R., Samiyappan, R and Balasubramanian, P. 2006. Engineering sheath blight resistance in elite indica rice cultivars using genes encoding defense proteins. Plant Science. 170: 203–215.

Kombrink, E., Ancillo, G., Buchter, R., Dietrich, J., Hoegen, E., Ponath, Y., Schmelzer, E., Stromberg, A and Wegener, S. 2001. The role of chitinases in plant defense and plant development. 6th international workshop on PR proteins. May 20-24, 2001, Spa, Belgium. Book of Abstracts. pp.11-12.

Laemmli, U.K. 1970. Cleavage of structural proteins during the assembly of the head of bacteriophage T4. Nature. 227:680-685.

Mauch, F., Mauch-Mani, B and Boller, T. 1988. Antifungal hydrolases in pea tissue. II. Inhibition of fungal growth by combinations of chitinase and β--1,3-glucanase. Plant Physiology. 88: 936-942.

Nelson N. 1944. A photometric adaption of the Somogyi method for the determination of glucose. Journal of Biological Chemistry. 153: 375-380.

Reissig, J.L., Strominger, J.L and Leloir, L.F. 1955. A modified colorimetric method for the estimation of N-acetylamino sugars. Journal of Biological Chemistry. 217: 959-966.

Shrestha, C. L., Oña I., Muthukrishnan, S and Mew. T. W. 2008. Chitinase levels in rice cultivars correlate with resistance to the sheath blight pathogen *Rhizoctonia solani*. European Journal of Plant Pathology. 120:69–77. DOI: 10.1007/s10658-007-9199-4

Somogyi, M. 1952. Notes on sugar determination. Journal of Biological Chemistry. 195:19-23.

Van loon, L. C., Rep, M and Pieterse, C. M. J. 2006. Significance of inducible defense-related proteins in infected plants. Annual Review of Phytopathology. 44: 135–162.

Velazhahan, R and Muthukrishnan, S.2004. Transgenic tobacco plants constitutively overexpressing a rice thaumatinlike protein (PR-5) show enhanced resistance to *Alternaria alternata*. Biologia Plantarum. 47: 347-354.

Vidhyasekaran, P. 1997. Fungal pathogenesis in plants and crops. New York (NY): Marcel Dekker Inc. pp. 553.

Ward, E.R., Uknes, S.J., Williams, S.C., Dincher, S.S., Wiederhold, D.L., Alexander. D.C., Ahl-Goy, P., Me´traux, J.P and Ryals, J.A. 1991. Coordinate gene activity in response to agents that induce systemic acquired resistance. Plant Cell. 3:1085-1094.

Wessels, J.G.H and Sietsma, J.H. 1981. Fungal cell walls: A survey. In: Tanner, W., Louewus F.A., Editors. Encyclopedia of Plant Physiology. New York (NY): Springer-Verlag. New Series. pp. 352-394.

Wheeler, B.E.J. 1969. An Introduction to Plant Diseases. John Wiley and Sons Limited, New York. pp.1-374.

Wubben, J. P., Lawrence, C. B and De Wit, P. J. G. M. 1996. Differential induction of chitinase and 1,3-β-glucanase gene expression in tomato by *Cladosporium fulvum* and its race-specific elicitors. Physiological and Molecular Plant Pathology. 48:105–116.

Suresh M and Sinha P. K.2023. Expression of chitinase and β-1,3-glucanases in rice cultivars in reaction to *Rhizoctonia solani*, the causal agent of rice sheath blight. The Journal of Research ANGRAU. 51 (2) :1-9. DoI: https://doi.org/10.58537/jorangrau.2023.51.3.01

DoI: https://doi.org/10.58537/jorangrau.2023.51.3.02

J. Res. ANGRAU 51 (3) 10-19, 2023

# CHEMICAL COMPOSITION AND PEDOGENESIS OF SOILS OF AGRICULTURAL COLLEGE FARM, NAIRA, ANDHRA PRADESH

**P. GURUMURTHY*, T. SREELATHA and D. SRINIVAS**

Department of Soil Science and Agricultural Chemistry,
Agricultural College,Acharya N.G. Ranga Agricultural University, Naira- 532 185

Date of Receipt : 11.4.2023 Date of Acceptance : 20.6.2023

## ABSTRACT

The study on elemental composition and pedogenesis of soils of Agricultural College farm, Naira of Srikakulam district was carried-out during 2021. The soils were developed from granite-gneiss parent material. Total silica ($SiO_2$) content of soils ranged from 50.5 to 74.6 percentage. Silica content in general decreased with soil depth, while sesquioxides ($R_2O_3$), alumina ($Al_2O_3$), iron oxide ($Fe_2O_3$), CaO, $K_2O$, $Na_2O$, MnO were found increasing with depth. High silica/ sesquioxide ratio of soils indicated siliceous nature of soils. The aluminum oxide content of the profiles varied from 15.80% to 26.25%. Highest value was reported in *lowland* profile, whereas, the lowest value was recorded in *rainfed upland* profile. Iron oxide content varied from 5.04% to 8.50%. Iron oxide content showed slight variation within profiles. Among the other oxides, CaO > MgO > $K_2O$ > $Na_2O$ was of the order as the soils were developed under semi-arid climate, wherein, basic cations have accumulated in these soil profiles due to limited leaching. The molar concentration of silica ($SiO_2$) ranged from 0.841 to 1.24 moles, and molar concentration of sesquioxide ranged from 0.191 to 0.313 moles. The molar ratio of $SiO_2$ / $R_2O_3$ varied from 2.68 to 6.51 in different soil profiles. The $SiO_2$ / $Al_2O_3$ ratio varied from 3.33 to 8.02. These wider molar ratios indicated salacious nature of parent material and due to dominance of silica among chemical fractions. Midland (P3) and lowland (P4) soil profiles showed silt/clay ratio of less than 0.45 and upland profiles showed more than 0.45 indicating relatively advanced weathering in mid and lowland profiles while it was moderate weathering in upland profiles. The Weathering Index of Parker (WIP) values of the soils of study area ranged between 2.8 and 32.4. The lower WIP values (2.8 to 8.1) were associated with rainfed uplands and higher values of 14.7- 32.4 with irrigated low lands. The PIA values ranged from 67 to 97 tend to decrease with the depth in all profiles. The profiles examined have the CIA values varied from 66 to 95 indicating high to intense weathering. The CIA values decreased with depth in all the profiles. The surface horizons of P1 and P2 soil profiles were classified as moderately weathered. On the other hand, all subsurface horizons of these two profiles were highly weathered. However, in profiles P3 and P4 the CIA values ranged between 68 to 90 indicating that these soils were highly weathered. CIW values closely followed the trend of CIA values. The bases/$R_2O_3$ values of all profiles ranged from 0.061 to 0.608 and found increased with soil depth in all the profiles. Relatively higher values of bases/$R_2O_3$ were found in P4 (low lands) indicating base rich character. Middle land and lowland black soil profiles showed silt/clay ratio of less than 0.45 and upland profiles showed morethan 0.45 indicating relatively advanced weathering in mid and lowland profiles while moderate weathering in upland profiles.

**Keywords:** Elemental composition, Molar ratios, Pedogenesis, Weathering indices

*Corresponding Author E-mail i.d: p.gurumurthy@angrau.ac.in

## INTRODUCTION

Soils are the resultant action of chemical, biochemical and physical weathering processes (pedogenesis) took place on parent material over a period of time. It is useful to understand soil distribution patterns in current (soil geography) and past (paleopedology) of soils for proper management. The chemical composition of the soils reflects the land form, climate, parent material and intensity of weathering (Dengiz and Usul, 2017). Nearly ninety percent of the mineral matter of most of the soils consists of the combined oxides of silicon, aluminium and iron, while the oxides of calcium, magnesium, sodium and potassium together constitute 5% to 7% (ISSS, 2016).The elemental composition of soil also reveals the constituent minerals and nutrient supplying capacity of soils.

Chemical weathering indices are commonly used to quantitatively evaluate changes caused by chemical weathering in different materials. The indices are based on the principle that the ratio between concentrations of mobile (e.g. $SiO_2$, CaO, MgO and $Na_2O$) and immobile (e.g. $Al_2O3$, $Fe_2O_3$ and $TiO_2$) elements decrease over time as leaching progresses. However, the weathering of heterogeneous rocks confounds the understanding of the relationship between the weathering index and depth (Dengiz *et al.*, 2018). Different weathering indices like Chemical Index of Alternation (CIA), Chemical Index of Weathering (CIW), Weathering Index of Parker (WIP), Bases/$R_2O_3$ ratio, Plagioclase Index of Alteration (PIA) and Vogt's residual index (V) have been successfully applied to understand the pedogenesis of soils. The soils of Agricultural College Farm, Naira, Srikakulam district, Andhra Pradesh developed from granite-gneiss and calcareous murrum combined granite-gneiss. These soils were not studied earlier for their elemental composition, molar ratios and pedogenesis, hence, the study was taken up.

## MATERIALS AND METHODS

The study area, Agricultural College farm, Naira,Srikakulam district, Andhra Pradesh was located between $83^0$56.095 to $83^0$56.993 E and $18^0$23.045 to $18^0$26.988 N, covering 270 acres (109.3 ha) comprising red, black and associate soils on very gently sloppy terrain of rainfed uplands to irrigated low lands. Major soil types were red sandy loams on rainfed uplands, reddish yellow soils situated in rainfed uplands and medium black soils and deep black soils on irrigated low lands. The climate belongs to semi-arid monsoon type with alternate wet and dry seasons as evidenced by past one decade (meteorological data from 2012 to 2021). The mean annual temperature and rain fall were 26.48 $^oC$ and 982.7 mm, respectively.

A reconnaissance soil survey was conducted in the area of Tekkali mandal during April to June, 2022 using toposheets of 1: 50,000 scale as per the procedure outlined by AIS&LUS (1970). Auger bores, mini pits, road cuts of 7 profiles located on uplands and plains were studied. Soil correlation exercise lead to select 4 representative profiles *viz.,* rainfed uplands (P1), irrigated uplands (P2), irrigated midlands (P3) and irrigated lowlands (P4). These four soil profiles were exposed and horizon-wise soil samples were collected. A total of 19 horizon-wise disturbed soil samples were collected to investigate for this elemental composition. Soil samples were dried under shade and pulvarised with wooden hammer and passed through a 2 mm sieve and the fine earth fraction was analyzed for elemental composition by following standard procedure as described by Hesse (1971) and Jackson (1973). Molar concentrations and molar ratios were computed from the elemental composition and presented in the Tables 2 and 3. Weathering indices used (Table 1) to quantify chemical weathering intensity in the study included the Chemical Index of Alternation (CIA) (Nesbitt and Young, 1982), Chemical Index of Weathering (CIW) (Harnois, 1988), Weathering Index of Parker (WIP), (Parker, 1970), Bases/$R_2O_3$ Ratio (Birkeland, 1999), Plagioclase Index of Alteration (Fedo *et al*., 1995) and Vogt's residual index (Vogt, 1927). Molar ratios were used for calculation of weathering indices.

## RESULTS AND DISCUSSION

The total silica ($SiO_2$) content of profiles ranged from 50.5 to 74.6 percent (Table 2) hence these soils of study area are considered as siliceous in nature and silica content in general decreased with depth. Soils with relatively course texture ($P_1$and $P_2$) are dominated mostly by sand fraction hence showed more silica content. Sharma *et al.* (2020) also reported similar results in soils of Aravalli region of Rajasthan. Sesquioxide ($R_2O_3$) content ranged from 20.84 to 34.25 percent. Profile 4 (deep black soils on irrigated low land) had recorded highest value of 34.25 in lower horizon whereas the lowest value of 20.84 percent was noticed in Ap horizon of profile 1 (red sandy loam soils on rainfed upland). The variations in sesquioxide content might be due to the physiography, soil drainage and overall pedo-chemical environment (Prabhavathi *et al*., 2017).

The aluminum oxide content of the profiles varied from 15.80 to 26.25 percent. Highest value was reported in $P_4$ profile, whereas, the lowest value was recorded in $P_1$ profile. Increased trend of alumina with depth was observed in all the profiles which is an indication of more weathering in deeper layers. Aluminum oxide being the major fraction of the sesquioxides, Followed the pattern of sesquioxides distribution. Similar results were observed by (Himabindu *et al.*, 2019). Among the different profiles, iron oxide content varied from 5.04% to 8.50%. Iron oxide content showed slight variation within profiles and a little higher variation among profiles, which is attributed to variation in clay content and chemical composition of primary and secondary minerals. Similar observations were made earlier by Ramprakash and Seshagiri Rao (2012) in some selected soils of Krishna district of Andhra Pradesh. Among the other oxides, the order was CaO > MgO > $K_2O$ > $Na_2O$. Calcium oxide content ranged from 0.30 to 6.50 percent and noticed an increasing trend with soil depth. The CaO content was higher in profiles 4 and low in profile 1. Similar observations were made by Himabindu *et al.* (2018). MgO content ranged from 0.15 to 2.70 percent and found increased with increasing soil depth. The magnesium being more soluble than calcium, might have leached through

**Table 1. Different indices of chemical weathering**

| S.No. | Index | Formula | Source |
|---|---|---|---|
| 1 | Weathering index of Parker (WIP) | $WIP = \left(\frac{2Na_2O}{0.35} + \frac{MgO}{0.9} + \frac{2K_2O}{0.25} + \frac{CaO}{0.7}\right) \times 100$ | Parker (1970) |
| 2 | Vogt's Residual Index (V) | $V = \frac{Al_2O_3 + K_2O}{MgO + CaO + Na_2O}$ | Vogt (1927) |
| 3 | Chemical Index of Alteration (CIA) | $CIA = \frac{Al_2O_3}{Al_2O_3 + CaO + Na_2O + K_2O} \times 100$ | Nesbitt and Young (1982) |
| 4 | Chemical Index of weathering (CIW) | $CIW = \frac{Al_2O_3}{Al_2O_3 + CaO + Na_2O} \times 100$ | Harnois (1988) |
| 5 | Plagioclase Index of Alteration (PIA) | $PIA = \frac{Al_2O_3 - K_2O}{Al_2O3 + CaO + Na_2O - K_2O} \times 100$ | Fedo *et al.* (1995) |
| 6 | Bases/$R_2O_3$ Ratio | $(CaO+MgO+Na_2O+K_2O) / (Al_2O_3 + Fe_2O_3)$ | Birkeland (1999) |
| 7 | Silt/ Clay Ratio | %Silt / %Clay | Nwokocha *et al.* (2003) |

the profile to lower layers. Because of existing semiarid climate situation in the study area and due to limited leaching the basic cations might have accumulated in these soil profiles. Potassium oxide, sodium oxide, manganese oxide, copper oxide and zinc oxide of soils of study area ranged from 0.194 - 0.885%, 0.033 - 0.253%, 0.050-0.085%, 21- 53 ppm and 32- 84 ppm, respectively. Sodium oxide was found increasing with depth, whereas, potassium oxide, manganese oxide, copper oxide and zinc oxide did not follow any trend with profile depth. Similar observations were reported in some selected soils of Aravalli region of Rajasthan was also reported by Sharma *et al.* (2020).

The molar concentration (Table 3) of silica ($SiO_2$) ranged from 0.841to 1.242 moles, highest in rainfed upland profile and lowest in lowland profile. In general a decreasing trend of silica with depth was observed in all the profiles. Molar concentration of sesquioxide ranged from 0.191 to 0.313 moles. The highest value associated with lower horizon of profile 4 and lowest value in surface horizon of profile 1. An increased trend was observed in sesquioxide molar concentration with increasing soil depth. Of all the four profiles studied, the molar concentration of the alumina ranged from 0.155 to 0.257 moles with highest value in profile 4and lowest value in profile 1 Particular trend was not observed in respect of alumina molar concentration. The molar concentration for iron oxide ranged from 0.032 to 0.053 among various profiles and follow increased trend with soil depth. Highest value was recorded in P4 profile, while lowest in P1 profile.

The molar ratio (Table 3) of $SiO_2$ / $R_2O_3$ varied from 2.68 to 6.51 in different soil profiles. The $SiO_2$ / $Al_2O_3$ ratio varied from 3.33 to 8.02 in different soil profiles. The $SiO_2$ / $Fe_2O_3$ ratio values varied from 15.8 to 39.3. In general, wider $SiO_2$ / $R_2O_3$, $SiO_2$ / $Al_2O_3$ revealed that these soils are siliceous in nature due to dominance of silica among chemical fraction. The wider $SiO_2$ / $R_2O_3$ and $SiO_2$ / $Al_2O_3$ ratios could be ascribed to re-silication, a dominant process operating in these profiles. These results were in conformity with those of Sreedhar Reddy *et al.* (2016). A fairly high $SiO_2$ content and $SiO_2/Al_2O_3$ and $SiO_2$/ $R_2O_3$ molar ratio in surface horizons indicates more siliceous nature of surface horizons than subsurface horizons and there by advanced stage of pedogenic development (Sharma *et al*., 2020). Relatively less variation in molar ratios of the profiles could be due to variation in chemical composition of parent material. The results are in concurrence with those of Tulay et al., 2019. The molar ratios in general, decreased with increase in soil depth which might be due to decreased amount of sand and increased amount of clay with soil depth. The reports of Sreedhar Reddy *et al.* (2016) and Himabindu *et al.* (2019) supporting this study.

Silt/clay ratio ranged from 0.33 to 0.89. Middleland and lowland black soil profiles showed silt/clay ratio of less than 0.45 and upland profiles showed morethan 0.45 indicating relatively advanced weathering in mid and lowland profiles while moderate weathering in upland profiles (Sharma *et al.*, 2020).

**Weathering indices**

Weathering indices calculated from elemental oxide concentrations in molecular concentrations are used to evaluate the vertical changes in a weathering profile. In addition, weathering indices change systematically for soil profiles formed from homogeneous parent rocks with depth. In this study, six chemical weathering indices were used to evaluate four profiles under different topographic conditions. Major and micro element concentrations, molar ratios and molar concentrations of the profiles are presented in Tables 2 and 3.

Total element analyses showed that the $SiO_2$ content in all profiles decreased with depth (range of 50.5% to 74.6%) and that $Al_2O_3$ values varied from 15.8% to 26.25%. $SiO_2$ strongly resists weathering because it mainly contains in quartz minerals. In contrast, $Al_2O_3$ is mainly less resistant to weathering as it is contains in the clay minerals; a high content of $Al_2O_3$ indicates a high content of

clay minerals (Shan *et al.*, 2015). The highest amount of $Fe_2O_3$ (8.50 %) was in profile 4. In regions where the parent materials has calcareous murrum, elevated concentrations of CaO and MgO are seen in the soil (P4). The CaO content in these soils ($P_2$ and $P_5$) ranged from 0.3% to 6.5%.

Weathering indices of soil profiles of the study are presented (Table 4). The CIA index was proposed by Nesbitt and Young (1982) is based on the progressive removal of soluble cations (e.g. Ca, Na, and K) from minerals during chemical weathering and it reflects the proportion of primary and secondary minerals in the bulk sample. Generally, rocks from the upper crust and un-weathered igneous rocks have CIA values of near about 50, whereas the soils and sediments derived from intensely weathered rocks, and containing residual clay minerals such as kaolinite and/or gibbsite, have CIA values approaching 100 (Fedo *et al*., 1995; Ozaytekin *et al*., 2012).

The profiles examined in this study showed the CIA values varied from 66 to 95. The highest and lowest CIA values were in the Ap of P1 and Bss3 of P4, respectively. The CIA values decreased with depth in all profiles. In other words, the parent materials of all profiles had the lowest CIA values of all the layers. The soils of study area were moderate to highly weathered as per Nesbitt and Young (1982).

Harnois (1988) proposed the Chemical Index of Weathering (CIW) which modified CIA by excluding $K_2O$ from assessments. Because the CIW does not account for the aluminium associated with K-feldspar, it may generate very high values for K-feldspar- rich rocks, whether they are chemically weathered or not (Fedo *et al.*,1995). CIW values closely followed the trend of CIA values since the $K_2O$ content was very low in these soils (0.194 to 0.885%) In the study, the CIW values ranged between 68 and 97 and tended to decrease with depth in all profiles. The results indicated that the CIW and CIA indices display similar behavior for the different soil topography.

The bases/$R_2O_3$ values of all profiles ranged from 0.061 to 0.768 and found increased with soil depth in all the profiles. Relatively higher values of bases/$R_2O_3$ were found in P4 indicating base rich character.

Parker's Weathering Index (WIP) is used to evaluate the intensity of the weathering of silicate minerals, based upon the proportion of alkali and alkaline earth elements in the products of weathering. The WIP also takes into account some individual mobilities, namely sodium, potassium, magnesium and calcium, on the basis of their bond strengths with oxygen (Parker, 1970). According to the definition of WIP, smaller WIP values indicated stronger chemical weathering, which is opposite to the manner in which CIA values are generated. This index has been suggested to be most appropriate for application for weathering profiles on heterogeneous soils because the assessment only includes highly mobile alkali and alkaline elements (Price and Velbel, 2003). In the study, the WIP values of the soils ranged from 2.8 to 32.4. The lowest WIP values (2.8 to 10.8) were associated with profiles developed in uplands ($P_1$, $P_2$) while the soils of mid and lowlands (P3 and P4) recorded relatively high WIP values of 10.00 to 32.4. It means that the weathering process is more intense in low elevations soils ($P_4$); the soil derived from the parent material diverges progressively from that of the parent material under the influence of the pedogenic process with time; due to lower horizons of soil profiles are more weathered than upper horizons as evidenced by decreasing trends of CIA values and increasing trend of WIP values with soil depth.

Fedo *et al.* (1995), proposed the Plagioclase Index of Alteration (PIA) as an alternative to the CIW. Because plagioclase is abundant in silicate and dissolves relatively rapidly, the PIA may be used when plagioclase weathering needs to be monitored. In the present study, the PIA values ranged from 67 to 97 tended to decrease with the depth in all profiles indicating more weathering in lower horizons.

Among the weathering indices calculated using particle size distribution, chemical composition, molar ratios and molar concentration,

**Table 2. Chemical composition of the soils of Agricultural College Farm, Naira (oxide forms of Si, Al, Fe, Ca, Mg, K, Na, Mn, Cu and Zn)**

| S. No. | Profile No. & Horizon | Depth (m) | Chemical composition | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | $SiO_2$ | $R_2O_3$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO | $K_2O$ | $Na_2O$ | MnO | CuO | ZnO |
| | | | % | | | | | | | | | ppm | |
| **P1. Red sandy loams of Rainfed upland profile** | | | | | | | | | | | | | |
| 1 | Ap | 0.00-0.13 | 74.6 | 20.84 | 15.80 | 5.04 | 0.30 | 0.15 | 0.194 | 0.033 | 0.068 | 28 | 42 |
| 2 | $Bt_1$ | 0.13-0.32 | 72.1 | 22.10 | 16.25 | 5.85 | 0.50 | 0.25 | 0.235 | 0.050 | 0.065 | 25 | 37 |
| 3 | $Bt_2$ | 0.33-0.64 | 71.0 | 22.70 | 17.10 | 5.60 | 1.00 | 0.61 | 0.277 | 0.097 | 0.059 | 22 | 34 |
| 4 | C1 | 0.65- 0.86+ | 70.5 | 25.70 | 19.90 | 5.80 | 1.25 | 0.69 | 0.225 | 0.118 | 0.075 | 21 | 32 |
| **P2. Reddish yellow soils of irrigated middle land profile** | | | | | | | | | | | | | |
| 1 | Ap | 0.01-0.10 | 69.8 | 23.31 | 16.50 | 6.81 | 0.55 | 0.25 | 0.289 | 0.096 | 0.077 | 53 | 84 |
| 2 | $Bw_1$ | 0.11-0.38 | 68.3 | 24.96 | 17.60 | 7.36 | 1.00 | 0.25 | 0.270 | 0.138 | 0.067 | 50 | 82 |
| 3 | $Bw_2$ | 0.39-0.53 | 70.5 | 25.38 | 18.80 | 6.58 | 1.50 | 0.75 | 0.265 | 0.153 | 0.061 | 48 | 78 |
| 4 | $Bw_3$ | 0.54-0.75 | 65.1 | 27.96 | 20.60 | 7.36 | 1.50 | 0.60 | 0.295 | 0.126 | 0.055 | 44 | 75 |
| 5 | $Bw_4$ | 0.76-0.90+ | 65.1 | 28.75 | 21.20 | 7.55 | 1.85 | 0.85 | 0.269 | 0.159 | 0.066 | 42 | 73 |
| **P3. Medium black soils on irrigated middle lands** | | | | | | | | | | | | | |
| 1 | Ap | 0.01-0.18 | 63.5 | 27.48 | 21.50 | 5.98 | 0.80 | 0.52 | 0.510 | 0.238 | 0.062 | 41 | 61 |
| 2 | $Bw_1$ | 0.19-0.41 | 61.5 | 29.00 | 23.00 | 6.00 | 1.00 | 0.70 | 0.630 | 0.253 | 0.085 | 39 | 56 |
| 3 | $Bw_2$ | 0.42-0.68 | 57.3 | 29.05 | 22.80 | 6.25 | 1.35 | 1.00 | 0.820 | 0.226 | 0.073 | 36 | 52 |
| 4 | $Bw_3$ | 0.68- 0.81 | 55.0 | 30.10 | 24.10 | 6.00 | 2.10 | 1.50 | 0.970 | 0.226 | 0.063 | 34 | 48 |
| 5 | C1 | 0.82- 0.98 | 54.2 | 32.80 | 25.30 | 7.50 | 3.50 | 1.50 | 0.820 | 0.240 | 0.082 | 30 | 45 |
| **P4. Deep black soils on irrigated low lands** | | | | | | | | | | | | | |
| 1 | Ap | 0.00-0.14 | 60.5 | 29.45 | 22.60 | 6.85 | 2.50 | 1.15 | 0.492 | 0.106 | 0.050 | 51 | 81 |
| 2 | $Bss_1$ | 0.15-0.38 | 58.6 | 30.85 | 24.25 | 6.60 | 3.60 | 1.89 | 0.563 | 0.096 | 0.060 | 49 | 76 |
| 3 | $Bss_2$ | 0.39-0.72 | 55.2 | 32.00 | 25.20 | 6.80 | 5.70 | 2.50 | 0.635 | 0.122 | 0.054 | 47 | 69 |
| 4 | $Bss_3$ | 0.73-1.25 | 53.6 | 33.75 | 26.25 | 7.50 | 6.25 | 2.70 | 0.885 | 0.134 | 0.068 | 44 | 72 |
| 5 | $Bss_4$ | 1.26-1.48 | 50.5 | 34.25 | 25.75 | 8.50 | 6.50 | 2.50 | 0.885 | 0.149 | 0.072 | 41 | 65 |

**Table 3. Molar concentrations and molar ratios of elements and particle size distribution in soil profiles of Agricultural College Farm, Naira**

| S.No. | Profile No. & Horizon | Depth (m) | Molar concentrations (moles) | | | | | | | | Molar ratios | | | | | Particle size distribution | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | $SiO_2$ | $R_2O_3$ | $Al_2O_3$ | $Fe_2O_3$ | CaO | MgO | $K_2O$ | $Na_2O$ | $SiO_2/R_2O_3$ | $SiO_2/Al_2O_3$ | $SiO_2/Fe_2O_3$ | Bases/$R_2O_3$ | Bases/$Al_2O_3$ | Sand % | Silt % | Clay % | Silt / clay |
| **P1.Red sandy loams of Rainfed upland profile** | | | | | | | | | | | | | | | | | | | |
| 1 | Ap | 0.00-0.13 | 1.242 | 0.191 | 0.155 | 0.032 | 0.005 | 0.004 | 0.0021 | 0.0005 | 6.51 | 8.02 | 39.3 | 0.061 | 0.072 | 69.20 | 14.50 | 16.30 | 0.89 |
| 2 | $Bt_1$ | 0.13-0.32 | 1.200 | 0.202 | 0.159 | 0.037 | 0.009 | 0.006 | 0.0025 | 0.0008 | 5.94 | 7.53 | 32.8 | 0.091 | 0.111 | 65.00 | 14.50 | 20.50 | 0.71 |
| 3 | $Bt_2$ | 0.33-0.64 | 1.182 | 0.208 | 0.168 | 0.035 | 0.018 | 0.015 | 0.0029 | 0.0016 | 5.69 | 7.05 | 33.7 | 0.181 | 0.224 | 64.50 | 13.50 | 22.00 | 0.61 |
| 4 | C1 | 0.65- 0.86+ | 1.173 | 0.235 | 0.195 | 0.036 | 0.022 | 0.017 | 0.0024 | 0.0019 | 4.99 | 6.01 | 32.3 | 0.187 | 0.225 | 63.00 | 14.00 | 23.00 | 0.61 |
| **P2. Reddish yellow soils of irrigated middle land profile** | | | | | | | | | | | | | | | | | | | |
| 1 | Ap | 0.01-0.10 | 1.162 | 0.213 | 0.162 | 0.043 | 0.010 | 0.006 | 0.0031 | 0.0015 | 5.45 | 7.18 | 27.2 | 0.097 | 0.118 | 63.20 | 15.50 | 21.30 | 0.73 |
| 2 | $Bw_1$ | 0.11-0.38 | 1.137 | 0.228 | 0.173 | 0.046 | 0.018 | 0.006 | 0.0029 | 0.0022 | 4.98 | 6.59 | 24.7 | 0.128 | 0.169 | 59.80 | 17.10 | 23.10 | 0.74 |
| 3 | $Bw_2$ | 0.39-0.53 | 1.173 | 0.232 | 0.184 | 0.041 | 0.027 | 0.019 | 0.0028 | 0.0025 | 5.05 | 6.37 | 28.5 | 0.219 | 0.276 | 60.00 | 15.50 | 25.50 | 0.61 |
| 4 | $Bw_3$ | 0.54-0.75 | 1.084 | 0.256 | 0.202 | 0.046 | 0.027 | 0.015 | 0.0031 | 0.0020 | 4.24 | 5.37 | 23.5 | 0.184 | 0.232 | 59.50 | 14.00 | 25.50 | 0.55 |
| 5 | $Bw_4$ | 0.76-0.90+ | 1.084 | 0.263 | 0.208 | 0.047 | 0.033 | 0.021 | 0.0029 | 0.0026 | 4.12 | 5.21 | 22.9 | 0.227 | 0.287 | 59.50 | 14.00 | 26.50 | 0.53 |
| **P3. Medium black soils on irrigated middle lands** | | | | | | | | | | | | | | | | | | | |
| 1 | Ap | 0.01-0.18 | 1.057 | 0.251 | 0.211 | 0.037 | 0.014 | 0.013 | 0.0054 | 0.0038 | 4.21 | 5.01 | 28.2 | 0.145 | 0.173 | 55.10 | 13.10 | 31.80 | 0.41 |
| 2 | $Bw_1$ | 0.19-0.41 | 1.024 | 0.265 | 0.225 | 0.038 | 0.018 | 0.018 | 0.0067 | 0.0041 | 3.86 | 4.54 | 27.2 | 0.174 | 0.903 | 51.85 | 14.00 | 34.15 | 0.41 |
| 3 | $Bw_2$ | 0.42-0.68 | 0.954 | 0.266 | 0.224 | 0.039 | 0.024 | 0.025 | 0.0087 | 0.0036 | 3.59 | 4.27 | 24.4 | 0.231 | 0.275 | 52.40 | 13.20 | 33.40 | 0.40 |
| 4 | $Bw_3$ | 0.68- 0.81 | 0.915 | 0.275 | 0.236 | 0.038 | 0.038 | 0.038 | 0.0103 | 0.0036 | 3.33 | 3.87 | 24.4 | 0.323 | 0.376 | 51.30 | 14.10 | 34.60 | 0.41 |
| 5 | C1 | 0.82- 0.98 | 0.902 | 0.300 | 0.248 | 0.047 | 0.063 | 0.038 | 0.0087 | 0.0039 | 3.01 | 3.64 | 19.2 | 0.375 | 0.454 | 50.00 | 15.40 | 34.60 | 0.45 |
| **P4. Deep black soils on irrigated low lands** | | | | | | | | | | | | | | | | | | | |
| 1 | Ap | 0.00-0.14 | 1.007 | 0.269 | 0.222 | 0.043 | 0.045 | 0.029 | 0.0052 | 0.0017 | 3.74 | 4.54 | 23.5 | 0.298 | 0.363 | 50.00 | 14.90 | 35.10 | 0.42 |
| 2 | $Bss_1$ | 0.15-0.38 | 0.975 | 0.282 | 0.238 | 0.041 | 0.064 | 0.047 | 0.0060 | 0.0015 | 3.46 | 4.10 | 23.6 | 0.422 | 0.501 | 49.50 | 13.00 | 37.50 | 0.35 |
| 3 | $Bss_2$ | 0.39-0.72 | 0.919 | 0.293 | 0.247 | 0.043 | 0.102 | 0.063 | 0.0067 | 0.0020 | 3.14 | 3.72 | 21.6 | 0.591 | 0.700 | 48.40 | 13.00 | 38.60 | 0.34 |
| 4 | $Bss_3$ | 0.73-1.25 | 0.892 | 0.309 | 0.257 | 0.047 | 0.112 | 0.068 | 0.0094 | 0.0018 | 2.89 | 3.47 | 19.0 | 0.617 | 0.740 | 44.85 | 14.90 | 40.25 | 0.37 |
| 5 | $Bss_4$ | 1.26-1.48 | 0.841 | 0.313 | 0.252 | 0.053 | 0.116 | 0.063 | 0.0094 | 0.0024 | 2.68 | 3.33 | 15.8 | 0.608 | 0.754 | 45.70 | 13.50 | 40.80 | 0.33 |

**Table 4. Weathering indices of different soil profiles of Agricultural College Farm, Naira**

| S.No. | Profile No. & Horizon | Depth (m) | Weathering Indices | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | WIP | V | CIA | CIW | PIA | Bases/$R_2O_3$ | Silt/ Clay ratio |
| **P1.Red sandy loams of Rainfed upland profile** | | | | | | | | | |
| 1 | Ap | 0.00-0.22 | 2.80 | 17.23 | 95 | 97 | 97 | 0.061 | 0.89 |
| 2 | Bw1 | 0.22-0.34 | 4.00 | 10.66 | 93 | 95 | 95 | 0.091 | 0.71 |
| 3 | Bw2 | 0.34-0.55 | 7.50 | 4.92 | 88 | 90 | 89 | 0.181 | 0.61 |
| 4 | Bw3 | 0.55-0.88 | 8.10 | 4.76 | 88 | 89 | 89 | 0.187 | 0.61 |
| **P2. Reddish yellow soils of irrigated middle land profile** | | | | | | | | | |
| 1 | Ap | 0.00-0.16 | 4.60 | 10.26 | 93 | 94 | 94 | 0.097 | 0.73 |
| 2 | Bw1 | 0.16-0.28 | 6.80 | 6.66 | 88 | 90 | 89 | 0.128 | 0.74 |
| 3 | Bw2 | 0.28-0.47 | 9.60 | 3.90 | 85 | 88 | 86 | 0.219 | 0.61 |
| 4 | Bw3 | 0.47-0.75 | 9.20 | 4.68 | 86 | 89 | 87 | 0.184 | 0.55 |
| 5 | Ck | 0.76-0.90+ | 10.80 | 3.71 | 84 | 87 | 85 | 0.227 | 0.53 |
| **P3. Medium black soils on irrigated middle lands** | | | | | | | | | |
| 1 | Ap | 0.01-0.18 | 10.00 | 6.95 | 90 | 92 | 92 | 0.145 | 0.41 |
| 2 | $Bw_1$ | 0.19-0.41 | 12.20 | 6.18 | 89 | 91 | 91 | 0.768 | 0.41 |
| 3 | $Bw_2$ | 0.42-0.68 | 15.30 | 4.40 | 86 | 89 | 89 | 0.231 | 0.40 |
| 4 | $Bw_3$ | 0.68- 0.81 | 19.80 | 3.14 | 82 | 86 | 89 | 0.323 | 0.41 |
| 5 | C1 | 0.82- 0.98 | 22.20 | 2.47 | 77 | 80 | 78 | 0.375 | 0.45 |
| **P4. Deep black soils on irrigated low lands** | | | | | | | | | |
| 1 | Ap | 0.00-0.14 | 14.7 | 3.02 | 81 | 83 | 82 | 0.298 | 0.42 |
| 2 | $Bss_1$ | 0.15-0.38 | 20.1 | 2.16 | 77 | 80 | 78 | 0.422 | 0.35 |
| 3 | $Bss_2$ | 0.39-0.72 | 28.8 | 1.53 | 69 | 70 | 70 | 0.591 | 0.34 |
| 4 | $Bss_3$ | 0.73-1.25 | 32.0 | 1.47 | 68 | 69 | 69 | 0.602 | 0.37 |
| 5 | $Bss_4$ | 1.26-1.48 | 32.4 | 1.45 | 66 | 68 | 67 | 0.608 | 0.33 |

WIP: Weathering Index of Parker, V: Vogt's Residual Index, CIA: Chemical Index of Alteration, CIW: Chemical Index of Weathering, PIA: Plagioclase Index of Alteration

it was found WIP, silt/clay ratio and bases/$R_2O_3$ ratios are suitable for understanding pedogenisis of different soils of catena influence.

## CONCLUSIONS

The study provided information on total concentration of nutrient elements such as Si, Al, Fe, Ca, Mg, K, Mn, Cu and Zn. Molar concentration and molar ratios, on weathering indices and stage of weathering in soils. This study showed that catena phenomenon and climatic conditions played a strong role on the soil chemical composition. These results were supported by the application of the chemical weathering indices (pedogenesis), namely CIA, CIW, Base/$R_2O_3$ ($Al_2O_3$+ $Fe_2O_3$ sesquioxide or $R_2O_3$), PIA, silt/clay and bases/ $R_2O_3$. In this study, chemical weathering indices of soil profiles developed on parent material of granite gneiss in different topographical positions (uplands, midlands/lowlands) and land use (rainfed/irrigated). The elemental composition and particle size distribution of the profiles showed variation, and the weathering indices also had variation among profiles, indicating different weathering levels of moderate to intense weathering. Among the weathering indices, WIP, silt/clay ratio and bases/ $R_2O_3$ ratios are found useful for understanding pedogenisis of different soils under the influence of catena. Furthermore, the study was useful for crop planning and soil management options for sustainable land use.

## REFERENCES

AIS&LUS. 1970. Soil Survey Manual, All India Soil and Land Use Survey, IARI, New Delhi. pp.1-63.

Birkeland, P.W. 1999. Soils and Geomorphology, Third Edition. New York, Oxford University Press. pp 430-435.

Dengiz,O Saðlam, M., Özaytekin, H.H and Baskan, O. 2018. Weathering rates and some physico-chemical characteristics of soils developed on a calcic toposequences. Carpathian Journal of Earth and Environmental Sciences. 8(2): 13–24.

Dengiz,O and Usul, M. 2017. Multi-criteria approach in land evaluation studies. Eurasian Journal of Soil Science. 7(1): 20-29.

Fedo, C.M., Nesbitt, H.W and Young, G.M. 1995. Unraveling the effects of potassium metasomatism in sedimentary rocks and paleosols with implications for paleoweathering conditions and provenance. Geology. 23 (10): 921–924.

Harnois, L. 1988. The CIW index: A new chemical index of weathering. Sedimentary Geology. 55 (3-4) : 319-322.

Hesse, P. R. 1971. A Text Book of Soil Chemical Analysis. John Murry Ltd., London. pp.71-99.

Himabindu, K 2018. Taxonomic studies of soils of Thotapalli ayacut area of North coastal Andhra Pradesh. M.Sc thesis submitted to Acharya N.G. Ranga Agricultural University, Guntur.

Himabindu, K and Gurumurthy, P. 2019. Elemental composition and molar ratios of soils of Thotapalli ayacut area of north coastal Andhra Pradesh. The Journal of Research ANGRAU. 46(4): 17-24.

ISSS. 2016. Fundamentals of Soil Science. Indian Society of Soil Science. pp. 209-210.

Jackson, M. L. 1973. Soil Chemical Analysis. Oxford IBH Publishing Company, Bombay. pp. 58-75.

Nesbitt, Y.W., Young, G. M. 1982. Early proterozoic climates and plate motions inferred from major element chemistry of lutites. Nature. 299: 715-717.

Nwokocha, C.C., Akamigbo, F.R. and Chukwu, G.O. 2003. Characterization and evaluation of soils of Umuahia locala area of Abia Sate for agricultural production. In: Ojeniyi *et al*., (Edited), Land degradation, Agricultural Productivity and Rural Poverty: Environmental Implications. Proceedings of

the 28th Annual Conference of SSSN 4- 7th Nov, 2003, Umudike, Nigeria. pp. 308-315.

Ozaytekin, H.H., Mutlu, H.H and Dedeoglu, M. 2012. Soil formation on a calcic chronosequence of ancient Lake Konya in Central Anatolia, Turkey. Journal of African Earth Science. 76: 66-74.

Parker, A. 1970. An index of weathering for silicate rocks. Geological Magazine. 107(6): 501-504.

Prabhavathi, K., Dasog, G.S., Sahrawat, K.L., Patil, P.L and Wani, S.P. 2017. Characterization, and classification of soils from three agro-climatic zones of Belgavi district, Karnataka. Journal of the Indian Society of Soil Science. 65 (1): 1-9.

Price, J.R and Velbel, M.A. 2003. Chemical weathering indices applied to weathering profiles developed on heterogeneous felsic metamorphic parent rocks. Chemical Geology. 202(3-4): 397-416.

Ramprakash, T and Seshagirirao, M. 2012. Characterization and classification of some soils in a part of Krishna district, Andhra Pradesh. The Andhra Agricultural Journal. 49 (3&4): 228-236.

Shan, H.M., Liang, H.C., Peng, S.X., Longe, A.A and Zhou, A.G. 2015. Effects of water-saturation and water-loss processes on composition and structure variations of landslide, Three Gorges reservoir, China. In: Water- Rock Interaction. Birkle, P., Torres-Alvarado, I. S. (Eds.). CRC Press, New York, USA. pp. 921-924.

Sharma, R.P., Raja, P and Bhaskar, B.P. 2020 Pedogenesis and minerology of alluvial soils from suthern part of Rajashtan in Aravalli range, India. Journal Geological Society of India. 95: 59-66.

Sreedharreddy, K and Naidu, M.V.S. 2016. Characterization and classification of soils in semi-arid region of Chennur mandal in Kadapa district, Andhra Pradesh. Journal of the Indian Society of Soil Science. 64 (3): 207-217.

Tulay, T., Oran, D., Ilhami, B., Seref, K and Oguz, B. 2019. Chemical weathering indices applied to soils developed on old lake sediments in semi-arid region of Turkey. Eurasian Journal of Soil Science. 8 (1) 60-72.

Vogt, T. 1927. Sulitjelmafeltets geologiog petrografi Norges Geologiske Undersokelse (In Norwegian, with English Abstract) 121: 1-56.

Gurumurthy, P., Sreelatha, T and Srinivas, D. 2023. Chemical composition and pedogenesis of soils of agricultural college farm, Naira, Andhra Pradesh. The Journal of Research ANGRAU. 51(3):10-19. DoI: https://doi.org/10.58537/jorangrau.2023.51.3.02

DoI: https://doi.org/10.58537/jorangrau.2023.51.3.03

J. Res. ANGRAU 51 (3) 20-27, 2023

# IMPACT OF SPRAYING 19:19:19 AS A DROUGHT MITIGATION TECHNIQUE ON YIELD AND B:C RATIO OF RAINFED GROUNDNUT IN CHITTOOR DISTRICT

**SAHAJA DEVA*, R. PRASANNA LAKSHMI and M.K. JYOSTHNA**

Krishi Vigyan Kendra, Achayra N.G. Ranga Agricultural University, Kalikiri - 517 234

Date of Receipt : 01.5.2023 Date of Acceptance : 31.7.2023

## ABSTRACT

The on-farm trial was conducted in the farmer's fields of Chittoor district to assess the impact of spraying of 19:19:19 during water stress conditions of groundnut crop on yield and profitability during *kharif,* 2021 and *kharif,* 2022. Treatments assessed comprised of spraying of 0.5% 19:19:19 twice during the water stress conditions, spraying of 2% urea twice during water stress conditions and farmers practice (without spraying). Results of the study revealed that spraying of 0.5% 19:19:19 and 2% urea recorded 9.9% and 7.4% enhancement in the pod yield than the farmers practice (9.42 q $ha^{-1}$). It was also recorded that spraying of 19:19:19 improved the number of filled pods per plant, 100 pod weight and seed weight by 25.1 g, 93.6 g and 38.9 g and by spraying of 2% urea by 24.9 g, 91.5 g and 37.0 g. Economic analysis revealed that additional cost of spraying of 19:19:19 (Rs.300/-) and urea (Rs.625/-) resulted in additional income of Rs.5005 $ha^{-1}$ and Rs.3596 $ha^{-1}$, respectively with a B:C ratio of 1.09 and 1.08, whereas, in farmers practice B:C ratio was found to be 1.00.

**Keywords:**19:19:19, Drought, Rainfed Groundnut, Urea and Yield

## INTRODUCTION

Groundnut is the 13th most important food crop, 4th important source of vegetable oil and 3rd main source of vegetable protein in the world. (Shete *et al*., 2018). Groundnut is the major oilseed crops of India which accounts for 25% of total oilseed production in the country. Among the oilseed cultivated in India, groundnut occupies 22.98 percent area (5.30 million ha) and 14.52 percent (5.50 million tonnes) of total production and productivity of 1040 kg $ha^{-1}$ (http://www.indiastat.com). In Andhra Pradesh, groundnut is cultivated in an area of 7.48 lakh ha with production of 4.62 lakh tonnes production and productivity of 618 kg $ha^{-1}$ (http://www.indiastat.com). In Chittoor district, groundnut is one of the major oilseeds crop and ranks first in area and production in Andhra Pradesh. The crop was cultivated in 1.23 lakh ha during *kharif*, 2020-21 and 2,124 ha during *rabi*, 2020-21 in Chittoor. (O/o JDA, Chittoor). Groundnut is a self-fertilizing crop, neverthless, it is exhaustive crop when compared to other legumes because a very little portion of the plant residue is left in the soil after harvest. (Shete *et al*., 2018). It is cultivated in diverse agro-climatic environments characterized by soils of varying water holding capacity under rainfed as well as irrigated conditions (Priya *et al.*, 2016). It is planted in arid and semi-arid areas and is rich in protein and oil of good quality. Drought is one of the limiting factors to groundnut yield in

*Corresponding Author E-mail i.d: sahajadeva@angrau.ac.in

many countries and is resistant to water stress conditions but drought conditions adversely effect the pod yield and seed quality (Rajitha *et al*., 2018). In western mandals of Chittoor, farmers are growing varieties which are not tolerant to drought conditionsas a result, yields are reducing drastically and causes economic loss to farmers during moisture stress conditions. To mitigate the problem and to get good returns to farmers there is need to introduce technologies which can protect crop from water stress conditions and improve the yielding capacity of the crop. Hence, spraying of foliar fertilizers like 19:19:19 during water stress conditions was tested in the farmers fields.

## MATERIALS AND METHODS

An on-farm trial was conducted by Krishi Vigyan Kendra, Kalikiri during two consecutive *kharif* seasons of 2021 and 2022 to assess the performance of drought mitigation technologies such as spraying 0.5% 19:19:19 and 2% urea twice during dry spell in rainfed groundnut. Sites for the on-farm testing were selected when wilting symptoms were observed in the field. Groundnut variety Kadiri 6 (Table 1) was taken as test variety as this variety cannot tolerate moisture stress conditions.Trials were conducted in 2.0 ha area in five farmers fields during *kharif,* 2021 and 2022 in Chintalavaripalli village, Kalikiri mandal with two technologies and farmers practice. In Technology Option 1, spraying was done with 0.5% 19:19:19 twice during vegetative and pod development stage. In Technology Option 2 spraying was done with 2% urea and in Farmers practice no spraying was done. Soils of the study area are sandy loam in texture with low available nitrogen and phosphorus, high in potassium, deficit in zinc and iron. The OFTs were laid out in rainfed fields with groundnut as mono crop is more prevalent in the area. Seeds were sown at a depth of 5 cmwith seed drill during *kharif* in the month of Juneat 30 cm spacing. Pre emergence spraying of Pendimethalin @ 1.0 $lac^{-1}$ was done within 24 hours after sowing. One farmer field was split into three plotsand treatments were imposed. Each treatment was replicated in five farmers' fields during both the years. During *kharif*, 2021, prolonged dry spells were observed in the months of August and September. Whereas during 2022, during July, August and September prolonged dry spells were observed. In treatment plots, first spraying of 19:19:19 and urea was done during August when crop was in flower initiation stage as wilting was observed due to moisture stress conditionsdue to prolonged dry spells for 20 days. Second spraying was done during September at pod development stage as again there was moistures stress condition. Rainfall data is given in Table 2. Farmers have applied 20 q FYM $acre^{-1}$, urea @ 25 kg $ac^{-1}$, SSP @ 100 kg $ac^{-1}$ and MOP @ 35 kg $ac^{-1}$. The data recorded on various parameters such as dry pod, seed weight and yield were analysed.The average prices of input and output prevailed during each year were taken for calculating cost of cultivation, gross returns, net returns and benefit-cost ratio.

## RESULTS AND DISCUSSION

**Yield attributes:** The treatment which received sprays with 19:19:19, urea recorded 25.1 and 24.9 average no. of pods $plant^{-1}$ in the field as compared to farmers practice (24.1) (Table 3). Spraying of 19:19:19 recorded significantly higher mean 100 dry pod weight (93.6 g) followed by spraying with urea (91.5 g) over farmers practice (79.6 g). Similarly, significantly higher 100 dry seed weight was observed in the treatment where spraying was done with 19:19:19 (38.9 g)and wasfollowed by spraying with urea (37.0 g) alone and both the technologies were better than the farmers practice (24.8 g). Water stress condition reduced the mature number of pods slightly. These findings are similar to the findings of Bootang *et al*. (2014). Due to water stress pod and seed filling may be affected which in turn reduce pod and seed weight in farmers practice.

**Yield:** Data presented on yield revealed that spraying of 19:19:19 recorded substantially higher pod yield (105 kg $ha^{-1}$) over farmers practice during both the years. Perusal of the data (Table 3) revealed that in technology option 1 (10.50q $ha^{-1}$ and 10.20 q $ha^{-1}$ during 2021-22 and 2022-23, respectively), was found to be significantly superior

**Table 1. Salient features of groundnut variety Kadiri- 6**

| S.No. | Variety | Duration (No. of day) | Pod yield (q ha$^{-1}$) | | Shelling % | 100 seed weight (g) | Oil content (%) | Special features |
|---|---|---|---|---|---|---|---|---|
| | | | *kharif* | *rabi* | | | | |
| 1 | Kadiri-6 | 100-105 | 8-8.8 | 16-17 | 72 | 40-45 | 48 | Popular among farmers for its quality attributes |

**Table 2. Rainfall data during crop growth period**

| S.No. | Date | June 2021 | July 2021 | August 2021 | September 2021 | June 2022 | July 2022 | August 2022 | September 2022 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 01 | 13.4 | - | - | - | - | 6.4 | 42.0 | 14.4 |
| 2 | 02 | - | - | - | 53.0 | 2.0 | - | 83.2 | 1.2 |
| 3 | 03 | - | - | - | 22.0 | - | - | 62.8 | - |
| 4 | 04 | - | 27.4 | - | 19.4 | - | - | - | - |
| 5 | 05 | 29.4 | - | - | - | - | - | - | - |
| 6 | 06 | 25.6 | - | - | 14.6 | 1.2 | - | 17.4 | - |
| 7 | 07 | - | - | - | - | - | 7.4 | - | 22.0 |
| 8 | 08 | - | 37.4 | - | - | - | - | - | 32.2 |
| 9 | 09 | - | - | - | - | - | - | - | 3.2 |
| 10 | 10 | - | - | - | - | - | 5.2 | - | - |
| 11 | 11 | - | - | - | - | - | - | - | 1.2 |
| 12 | 12 | - | - | - | - | - | - | - | - |
| 13 | 13 | 4.4 | - | - | - | 35.0 | - | - | - |
| 14 | 14 | - | 42.0 | - | - | - | - | - | - |
| 15 | 15 | - | - | - | - | 35.2 | - | - | - |
| 16 | 16 | - | 10.4 | - | - | - | - | - | - |
| 17 | 17 | - | 15.4 | - | - | - | - | 10.4 | - |
| 18 | 18 | - | - | - | - | - | - | - | - |
| 19 | 19 | - | 8.4 | - | - | 5.0 | - | - | - |
| 20 | 20 | - | - | - | - | 39.0 | - | - | - |
| 21 | 21 | - | - | - | - | - | - | - | - |
| 22 | 22 | - | - | - | - | - | - | - | - |
| 23 | 23 | - | - | - | 17.4 | 4.0 | - | - | - |
| 24 | 24 | 3.4 | - | 10.4 | - | - | - | - | - |
| 25 | 25 | - | - | 13.4 | - | - | - | 1.4 | - |
| 26 | 26 | - | - | - | 67.6 | - | 1.0 | 42.2 | - |

*Table 1 Contd...*

***Table 1 Contd...***

| S.No. | Date | June 2021 | July 2021 | August 2021 | September 2021 | June 2022 | July 2022 | August 2022 | September 2022 |
|---|---|---|---|---|---|---|---|---|---|
| 27 | 27 | - | - | 42.0 | - | - | - | 7.4 | - |
| 28 | 28 | - | 4.6 | 33.0 | - | - | - | 6.2 | - |
| 29 | 29 | - | - | 13.4 | 4.6 | - | - | 6.4 | - |
| 30 | 30 | - | - | - | 75.6 | 4.6 | - | - | 1.4 |
| 31 | 31 | - | - | - | - | - | - | - | - |
| 32 | No. of rainy days | 05 | 07 | 05 | 08 | 06 | 03 | 09 | 04 |
| **33** | **Total (mm)** | **76.2** | **145.6** | **112.2** | **274.2** | **126.0** | **20.0** | **279.4** | **75.6** |

than technology option 2 (10.21 q $ha^{-1}$ and 10.01 q $ha^{-1}$ during 2021-22 and 2022-23, respectively) and farmers practice (9.45 q $ha^{-1}$ and 9.38 q $ha^{-1}$ during 2021-22 and 2022-23) during both the years as well as in pooled data. During *kharif,* 2021, an additional yield of 105.0 kg $ha^{-1}$ and 76.0 kg $ha^{-1}$ was recorded due to spraying with 19:19:19 and urea, respectively when plant showed sign of wilting under moisture stress and during *kharif,* 2022, an additional yield of 82.0 kg $ha^{-1}$ and 63.0 kg $ha^{-1}$ was recorded. On an average additional yield of 93.5 kg $ha^{-1}$ and 69.5 kg $ha^{-1}$ were recorded in fields treated with foliar spraying of 19:19:19 and urea, respectively.Spraying of 19:19:19 recorded 9.9% higher yield compared to farmers practice.There was significant difference between treatments and farmers practice at 5% level (Table 4). Yield is an end product which obviously depends on dry matter production, number of pods per plant, 100 pod and seed weight. The improvement in the dry matter production may be due to the instant assimilation of nutrients supplied through foliar application meeting the required nutrient demand of the crop during the critical crop growth periods (Vinod and Salakinkop, 2017). Similar observations were made by Dalei *et al.* (2014) in niger crop. The increased yield might be due to the role of nitrogen fertilizer in increasing photosynthetic rate, synthesis of metabolites and translocation of assimilates to the seed (Rajitha *et al*., 2018). Naveen *et al*. (2015) stated that in groundnut, higher dry pod yield was obtained with foliar application of fertilizers during water stress conditions.Similar findings were also reported by Thakur *et al*. (2017) in pulses and Sharma (2016) in wheat farmers fields.

**Economics:** Based on average prices of inputs and output commodities prevailed during each year of assessment, values of economic indicators like cost of cultivation, gross returns, net returns and B:C ratio were calculated (Table 5). Gross returns, net returns and B:C ratio were higher when compared to farmers practice (Table 5). Average gross returns of technology option 1 (spraying with 19:19:19) and technology option 2 (spraying with 2% urea) were Rs.56,925 and Rs.55,605 $ha^{-1}$. Whereas, in farmers practice, gross returns were Rs.51,782 $ha^{-1}$. Economic analysis revealed that spraying of 19:19:19 provided higher net returns over farmers practice during both the years of study. Treatment 1 fetched average net returns of Rs.4922 $ha^{-1}$ and spraying of 2% urea fetched net returns of Rs. 3750 $ha^{-1}$. In farmers practice, negative net returns of Rs.82.5 $ha^{-1}$ were obtained which means there was a loss to the farmers. Additional cost of 19:19:19 and urea spraying worked out to be Rs.300 and Rs. 62.5 $ha^{-1}$, respectively during both the years which in turn provided additional returns of Rs.5475 and Rs.3644 $ha^{-1}$, respectively during 2021-22 and Rs.4535 and Rs.3548 $ha^{-1}$, respectively during

**Table 3. Yield attributes and yield of drought mitigation technologies and farmers practice**

| S.No. | Particulars | Year | | Mean |
|---|---|---|---|---|
| | | 2021-22 | 2022-23 | |
| **1** | **Number of pods per plant** | | | |
| 2 | TO1 | 25.2 | 25.0 | 25.1 |
| 3 | TO2 | 24.9 | 24.8 | 24.9 |
| 4 | Farmers practice | 24.0 | 24.2 | 24.1 |
| **5** | **100 dry pod weight (g)** | | | |
| 6 | TO1 | 94.6 | 92.5 | 93.6 |
| 7 | TO2 | 92.7 | 90.3 | 91.5 |
| 8 | Farmers practice | 80.4 | 78.7 | 79.6 |
| **9** | **100 dry seed weight (g)** | | | |
| 10 | TO1 | 38.8 | 38.9 | 38.9 |
| 11 | TO2 | 37.3 | 36.7 | 37.0 |
| 12 | Farmers practice | 25.7 | 23.9 | 24.8 |
| **13** | **Yield (q $ha^{-1}$)** | | | |
| 14 | TO1 | 10.50 | 10.20 | 10.35 |
| 15 | TO2 | 10.21 | 10.01 | 10.11 |
| 16 | Farmers practice | 9.45 | 9.38 | 9.42 |
| **17** | **Additional yield due to spraying (kg $ha^{-1}$)** | | | |
| 18 | TO1 | 105.0 | 82.0 | 93.5 |
| 19 | TO2 | 76.0 | 63.0 | 69.5 |
| 20 | Farmers practice | - | - | - |
| **21** | **Increase in yield (%)** | | | |
| 22 | TO1 | 11.1 | 8.7 | 9.9 |
| 23 | TO2 | 8.04 | 6.7 | 7.4 |
| 24 | Farmers practice | - | - | - |

TO1: Spraying of 0.5% 19:19:19 twice during dry spells TO2: Spraying of 2% urea twice during dry spells
Farmers practice: No spraying

**Table 4. Summary of one way ANOVA in comparing yield in treatments and farmers practice**

| S.No. | Particulars | Treatments | N | Mean | Std. Deviation | F-value | p-value |
|---|---|---|---|---|---|---|---|
| 1 | | TO1 | 5 | 10.35 | 0.40 | 5.69* | 0.02 |
| 2 | Yield | TO2 | 5 | 10.11 | 0.56 | | |
| 3 | | Farmers practice | 5 | 9.42 | 0.21 | | |

***Significant at 5% level**

**Table 5. Economics of drought mitigation technologies and farmers practice**

| S. No. | Particulars | Year | | Mean |
|---|---|---|---|---|
| | | 2021-22 | 2022-23 | |
| **1** | **Cost of cultivation (Rs. ha$^{-1}$)** | | | |
| 2 | TO1 | 52800.00 | 51205.00 | 52002.5 |
| 3 | TO2 | 52562.50 | 51147.00 | 51854.8 |
| 4 | Farmers practice | 52500.00 | 51230.00 | 51865.0 |
| **5** | **Additional cost for spraying (Rs. ha$^{-1}$)** | | | |
| 6 | TO1 | 300.00 | 300.00 | 300.0 |
| 7 | TO2 | 62.50 | 62.50 | 62.5 |
| 8 | Farmers practice | - | - | - |
| **9** | **Gross returns (Rs. ha$^{-1}$)** | | | |
| 10 | TO1 | 57750.00 | 56100.00 | 56925.0 |
| 11 | TO2 | 56155.00 | 55055.00 | 55605.0 |
| 12 | Farmers practice | 51975.00 | 51590.00 | 51782.5 |
| **13** | **Net returns (Rs. ha$^{-1}$)** | | | |
| 14 | TO1 | 4950.00 | 4895.00 | 4922.5 |
| 15 | TO2 | 3592.50 | 3908.00 | 3750.3 |
| 16 | Farmers practice | -525.00 | 360.00 | -82.5 |
| **17** | **Additional net returns due to spraying (Rs. ha$^{-1}$)** | | | |
| 18 | TO1 | 5475.00 | 4535.00 | 5005.0 |
| 19 | TO2 | 3644.50 | 3548.00 | 3596.3 |
| 20 | Farmers practice | - | - | - |

**Table 5. Economics of drought mitigation technologies and farmers practice**

| S.No. | Particulars | Year | | Mean |
|---|---|---|---|---|
| | | 2021-22 | 2022-23 | |
| **21** | **B:C ratio** | | | |
| 22 | TO1 | 1.09 | 1.09 | 1.09 |
| 23 | TO2 | 1.07 | 1.08 | 1.08 |
| 24 | Farmers practice | 0.99 | 1.01 | 1.00 |

TO1: Spraying of 0.5% 19:19:19 twice during dry spells TO2: Spraying of 2% urea twice during dry spells Farmers practice(control): No spraying

2022-23. Spraying of 19:19:19 and urea obtained mean B:C ratio of 1.09 and 1.08, respectively which was at par with each other and significantly higher than farmers practice (1.0). Overall, B:C ratio was also found higher in technologies over farmers practice which clearly indicates that spraying of 19:19:19 might be economically feasible and profitable techniques on farmer's fields. Sharma (2016) also reported 19:19:19 to be economical at farmers fields in Rajasthan. Farmers' were also found highly convinced with the technological interventions due to higher economic returns with least additional investment and management practices. The variation in cost benefit ratio during different years might be due to variation in yield performance and input output cost in that particular year. Similar findings were recorded by Sharma and Singh (2020). Spraying of 19:19:19 in groundnut when there are prolonged dry spells is economically beneficial to farmers.

## CONCLUSIONS

One-way ANOVA was carried out to compare three treatments effects on yield of rainfed groundnut. It is noticed that there is significant difference among the three treatments at 5% level ($p<0.05$). Spraying of 19:19:19 showed higher yield (10.35 q $ha^{-1}$) followed by spraying of urea (10.11 q $ha^{-1}$). It is concluded that spraying of 0.5% 19:19:19 during moisture stress conditions found to be remunerative and economically viable option to farmers to protect crop during prolonged dry spells of 15-20 days with 19:19:19 twice within one week to 10 days interval.

## REFERENCES

Bootang, S., Girdthai, T., Jogloy, S., Akkasaeng, C., Vorasoot, N., Patanothai, A and Tantisuwichwong, N. 2014. Responses of released cultivars of peanut to terminal drought for traits released to drought tolerance. Asian Journal of Plant Sciences. 9(7): 423-431.

Dalei, B. B., Kheroar, S., Mohapatra, P. M., Panda, S and Deshmukh, M. R. 2014. Effect of foliar sprays on seed yield and economics of niger (*Guizotia abyssinica* L.). Journal of Agricultural Sciences. 6(6): 143-147.

GoI. 2023. Area, Production and Productivity of Groundnut in India. Retrieved from website (http://indiastat.com) on 17.06.23.

GoI. 2023. Area, Production and Productivity of Groundnut in Andhra Pradesh. Retrieved from website (http://indiastat.com) on 17.06.23.

Naveen kumar, B.T., Malligawad, L.H., Halikatti, S.I., Hiremath, S.M., Srineevasa, M.N and Bidari, B.I. 2015. Effect of different ratios and levels of nitrogen and phosphorus fertilizers, and top dressing of nitrogen fertilizers on growth and yield of groundnut. Karnataka Journal of Agricultural Sciences. 28(1): 8-11.

Priya,T., Subramanyam, D and Sumathi, V. 2016. Performance of groundnnut (*Arachis hypogaea* L.) cultivars under different plant populations during early Kharif. Indian Journal of Agricultural Research. pp. 50-51.

Rajitha, B., Latha, P., Sudhakar, P and Umamahesh, V. 2018. A comparative study on the effect of foliar application of nitrogen, phosphorus, potassium, iron and zinc on proline content, yield and cost-benefit ratio of groundnut plants grown under water stress conditions. International Journal of Pure and Applied Biosciences. 6(1):784-789.

Sharma, N.K. 2016. Effect of foliar fertilization of NPK on wheat grain yield at farmer's field. Indian Journal of Extension Education. 24: 193-196.

Sharma, K.M. and Singh, M. 2020. Assessment of water soluble NPK foliar nutrition in wheat (*Triticum aestivum* L.) through on-farm testing for improving yield and economic returns. International Journal of Science, Environment and Technology. 9 (3): 510 – 515.

Shete, S.S., Bulbule, A.V., Patil, D.S. and Pawar, R.B. 2018. Effect of foliar nutrition on growth and uptake of macro and micronutrients of *Kharif* Groundnut (*Arachis hypogea* L.). International Journal of Current Microbiology and Applied Sciences. 7(10):1193-1200.

Thakur, V., Teggelli, R.G and Meena M.K. 2017. Influence of foliar nutrition on growth and yield of pulses grown under north eastern dry zone of Karnataka, A Review. International Journal of Pure and Applied Biosciences. 5(5):787-795.

Vinod Kumar, H.M and Salakinkop, S.R. 2017. Growth analysis in groundnut (*Arachis hypogea* L.) as influenced by foliar nutrition. Legume Research. 40(6):1072-1077.

Deva,S., Prasanna Lakshmi, R and Jyosthna, M.K.2023. Impact of spraying 19:19:19 as a drought mitigation technique on yield and B.C ratio of rainfed groundnut in chittoor district. The Journal of Research ANGRAU. 51 (3):20-27.
DoI: https://doi.org/10.58537/jorangrau.2023.51.3.03

DoI: https://doi.org/10.58537/jorangrau.2023.51.3.04

J. Res. ANGRAU 51 (3) 28-35, 2023

# GENETIC VARIABILITY, CORRELATION AND DIVERSITY ANALYSIS OF 12 IMPORTANT JHUM RICE *(Oryza sativa.* L.) GENOTYPES OF NAGALAND

**WANGYAL LEPCHA, N. MOSES* and SAPU CHANGKIJA**

Department of Genetics and Plant Breeding, School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema -797 106

Date of Receipt : 03.5.2023 Date of Acceptance : 08.7.2023

## ABSTRACT

With 12 jhum rice genotypes, the experiment was conducted with a randomized block design and replicated thrice in the year 2022. For every character under the study, the variance estimates between genotypes varied significantly, pointing to a large variation in the samples.Effective tillers/plant followed by 1000-grain weight and grain yield per plant had the highest genotypic coefficient of variation (GCV). Maximum heritability and genetic advance were seen for the 1000-grain weight, the number of grains per panicle and effective tillers/plant. Therefore, using these attributes as selection criteria might result in the accumulation of more additive genes, which will improve their performance, Indicating the relative usefulness of this character for selection,The number of effective tillers per plant, leaf length, leaf width, plant height, panicle length, and 1000- grain weight were significantly correlated positively with grain yield per plant.The study recommended that in order to increase the seed yield, consideration should be given to the number of effective tillers per plant, leaf length, leaf width, plant height, and panicle length. The 12 genotypes of rice were divided into four distinct clusters. Cluster I had two genotypes, Cluster III had two, and Cluster IV had one genotype. Cluster II had six genotypes. Cluster I and cluster IV were found to have the highest inter-cluster divergence, whereas cluster II and cluster III had the lowest divergence. As a result, hybridization programs including genotypes from clusters IV and I can be used.

**Keywords-** Genetic advance, Genetic divergence, Genotypes, Heritability, Rice

## INTRODUCTION

Rice, the principal crop of the North-Eastern Hill Region, occupies 3.5 million ha of land, accounting for 10.48% of all rice-growing area and accounting for 6.46% of total rice output in the country, with an average productivity of 1570 kg ha-$^{1}$ (Chandrasekhasan *et al.,* 2008). NE region is considered as the richest pockets of rice germplasrn in the world, of total 35,000 collection of rice germplasm from India. 8000 came from this region. The hill state of Nagaland is situated between 93$^{0}$ and 95$^{0}$ East longitudes and between 25$^{0}$ and 20 $^{0}$ North latitudes. It varies in altitude from 191 m to 3840 m above mean sea level and has significant topographical variety.

In Nagaland, rice is regarded as the most staple food crop. it is grown throughout the entire state in upland conditions as direct seeded on hill slop as well as irrigated low land conditions and in the terraces. Rice is being cultivated from 250 m to 2500 m. The traditional rice cultivation system in Nagaland is shifting (Jhum) cultivation. The Jhum

*Corresponding Author E-mail i.d: mosesnew111@gmail.com; M.Sc thesis submitted to Nagaland University, Medziphema -797 106

ricecomprises of about 56.50% of area and 49.26% of rice production in the state.

With Nagaland's growing population, limited land resources, and insufficient rice production, food scarcity is anticipated to become a severe issue in the future. In Nagaland, there are numerous local types and land races with high genetic variability. Since the cultivated area cannot be increased, efforts have to be intensified to increase the productivity per unit area. To increase the production andproductivity in these ecosystems, an alternative is to improve the existing local varieties with regard to yield potential, biotic and abiotic stress, grain quality, nutrient responsiveness, adaptability etc through breeding programs.Suitable and effective breeding programme for incorporatinguseful gene into a single genotype is largely effected due to the existence of genetic diversity in a given species. Greater the variability in the initial material better would be chances of evolving desirable types.

In Nagaland state, an array of local genotypes are in cultivation since long. Systematic attempts have not been made on the collection of information on genotypes regarding quantitative characteristics. Because of the region's diverse physio-graphic features and fragile environment, Nagaland's rice productivity and rice output are below the national average. Neither the wider recommendation of agricultural technologies nor the use of a single technology or variety can solve this problem of low yield. However, the development of location specific high yielding rice varieties using the existing land races prevalent in the area can be one of the promising technique for increasing the productivity and production of rice cultivation.

In this regard, the investigation was taken up with the broad objectives of assessment of genetic diversity/variability of the rice genotypes, to determine its character inter-relationship for grain yield and relateda gronomic traits and to facilitate the selection of parents for hybridization programmes by estimating genetic diversity.

## MATERIALS AND METHODS

The study on 12 jhum rice *(Oryza sativa.* L.) genotypes of Nagaland was carried at the Department of Genetics and Plant Breeding's experimental farm, SASRD, Nagaland University in the year 2022. Seeds of all 12 local uplandrice cultivars of jhum fields (shifting cultivation) from

**Table 1. Details of the 12 rice genotypes (Collected from different locations of Mokokchung)**

| S. No. | Treatment | Local name | Place of collection |
|---|---|---|---|
| 1 | $T_1$ | Longkhum | Mokokchung |
| 2 | $T_2$ | Longkhong 8 | Mokokchung |
| 3 | $T_3$ | Longkhong 20 | Mokokchung |
| 4 | $T_4$ | Longra-tenak | Mokokchung |
| 5 | $T_5$ | Malang-chari | Mokokchung |
| 6 | $T_6$ | Malang-satsuk | Mokokchung |
| 7 | $T_7$ | Malang-tenak | Mokokchung |
| 8 | $T_8$ | Manan/Meserong | Mokokchung |
| 9 | $T_9$ | Kumangri | Mokokchung |
| 10 | $T_{10}$ | Koyu 4 | Mokokchung |
| 11 | $T_{11}$ | Koyu 20 | Mokokchung |
| 12 | $T_{12}$ | Semer | Mokokchung |

different villages and blocks of Mokokchung district of Nagaland were collected from farmers and used. The local names of cultivars were used as designated by the farmers (Table 1).

Randomised Block Design (RBD) was use and replicated thrice adopting spacing of 20 cm x 15 cm. Data on the days to 50% flowering, days to grain maturity, effective tillers per plant, leaf length, leaf width, plant height, panicle length, grains per panicle, 1000-grain weight, grain ratio and yield per plant were collected based on five competitive plants that were randomly chosen.

The approach described by Bourton and Devane (1952) was used to compute and determine the coefficients of phenotype, genotype, and environmental variation. Genetic advance and heritability in a broad sense ($hbs^2$) were calculated in accordance with Allard (1960). The Mahalanobis $D^2$ statistic (Rao 1952) was used to analyze genetic divergence, among the 12 genotypes of the experiment, and correlation coefficients were work out in accordance with the Bourton (1961) approach.

**RESULTS AND DISCUSSION**

The results of the (ANOVA) for all the genotypes indicated significant differences, indicating theexistence of yield variability and the qualities contributing to it, offering choice for the progenies trait selection**.**

GCV and PCV were found highest for effective tiller per plant (33.77) and (46.43), similar result was also reported by Sharma *et al.* (1996) and Osman *et al.* (2012).Additionally, high character values were reported for the PCV and GCV ingrain per panicle (27.85) and (33.10), 1000-grain weight (28.65) and (28.67) and yield per plant (31.12) and (57.07), similar result were also reported by Lalitha and Sreedhar (1999) and Seyoun*et al.* (2012) and high PCV and GCV withlow ECV estimate for 1000-grain weight and grain per panicle, similar result were also reported by Shiva Acharya *et al.* (2018)

Low GCV and moderate PCV were found for plant height. In 50% days to flowering and days to grain maturity, low PCV and GCV values were observed. 100-grain weight had the highest heritability value (99.90%). Mahto and Mohan (2003) also reported similar result. Days to maturity, leaf width, grain per panicle, and grain ratio had the highest heritability. Indicting that genetics and less environmental factors play a role in variability

Days to 50% flowering, number of effective tillers, leaf length, plant height, and panicle length all showed moderate heritability. Yield has the least heritability (22.11%). 1000-grain weight and grain per panicle, high genetics advance as a percentage mean and high heritability were observed this conclusion was also reported by Elayaraja *et al*. (2005) and Seyoum *et al*. (2012). High heritability and low genetics advance was recorded in days to grain maturity.

Understanding the phenotypic and genotypic interactions of yield and its component qualities, as well as the interactions between the component characters, would aid the breeder in developing a successful selection strategy.Indirect selection based on preferred component features will be very helpful because yield is controlled by complicated character and influenced by numerous traits, and direct selection of yield is typically not very effective.

In this study, yield per plant was positively correlated with the number of effective per plant, leaf length, leaf width, plant height, panicle length and 1000- grain weights, respectively. Osman *et al.* (2012), Venkata Lakshmi *et al.* (2014), and Shiva Acharya *et al*. (2018) revealed similar findings. At the phenotypic level, grain yield and effective tiller number have a positive correlation, indicating the relative utility of both traits for selection.

Days to grain maturity was positively correlated with days to 50% flowering and leaf width, effective tiller with leaf width, leaf length with

**Table 2. ANOVA for 11 character of rice**

| Source | df | Days /50% flowering | Days / grain maturity | No/ effective tiller | Leaf length | Leaf width | Plant height | Panicle length | Grain per panicle | 1000 grain weight | Grain ratio | Grain yield per plant |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Replication | 2 | 4.19 | 5.36 | 1.463 | 5.57 | 0.005 | 28.82 | 3.07 | 96.17 | 0.004 | 0.004 | 54.45 |
| Genotype | 11 | 46.76** | 74.76** | 9.54** | 104.04** | 0.19** | 429.54** | 11.20** | 7989.23** | 193.19** | 0.72** | 84.81** |
| Error | 22 | 11.74 | 11.82 | 2.18 | 28.33 | 0.01 | 78.53 | 2.59 | 968.20 | 0.06 | 0.003 | 37.33 |

Note; *=Significant at 5% level of significance, **=significant at 1% level of significance

**Table 3. Genetic parameter for 11 characters in rice**

| S.No. | Character | Mean | Range | VARIANCE | | | Coefficient of variation | | | $hbs^2$ | GA as % of mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $ó^2_g$ | $ó^2_p$ | $ó^2_e$ | GCV | PCV | ECV | | |
| 1 | Days /50% flowering | 108.47 | 101.33-116.67 | 11.67 | 23.41 | 11.74 | 3.15 | 4.46 | 3.16 | 49.80 | 4.58 |
| 2 | Days/ grain maturity | 141.44 | 130.33-149.00 | 21.22 | 33.04 | 11.82 | 3.26 | 4.06 | 2.34 | 64.20 | 5.78 |
| 3 | No/effective tiller | 4.64 | 2.55-8.75 | 2.45 | 4.63 | 2.18 | 33.77 | 46.43 | 31.80 | 52.91 | 50.55 |
| 4 | Leaf length | 70.31 | 60.47-81.00 | 25.23 | 53.57 | 28.33 | 7.14 | 10.41 | 7.57 | 47.10 | 10.09 |
| 5 | Leaf width | 1.81 | 1.41-2.04 | 0.04 | 0.06 | 0.02 | 11.08 | 13.24 | 7.81 | 70.00 | 18.58 |
| 6 | Plant height | 117.98 | 97.65-139.28 | 117.00 | 195.53 | 78.53 | 9.17 | 11.58 | 7.51 | 59.83 | 14.60 |
| 7 | Panicle length | 26.34 | 29.90-24.22 | 2.87 | 5.47 | 2.59 | 6.43 | 8.88 | 6.10 | 52.50 | 9.60 |
| 8 | Grain per panicle | 173.7 | 83.56-238.32 | 2340.34 | 3308.54 | 968.20 | 27.85 | 33.10 | 17.91 | 70.74 | 48.25 |
| 9 | 1000 grain weight | 28.00 | 11.47-39.44 | 64.37 | 64.44 | 0.06 | 28.65 | 28.67 | 0.87 | 99.90 | 58.99 |
| 10 | Grain ratio | 2.47 | 1.74-3.04 | 0.23 | 0.24 | 0.003 | 19.80 | 19.93 | 0.44 | 98.75 | 42.63 |
| 11 | Grain yield/plant | 12.78 | 6.72-26.84 | 15.83 | 53.16 | 37.33 | 31.12 | 57.07 | 49.19 | 29.74 | 34.99 |

**Table 4. Rice yield phynotypic correlation ($r_p$) with yield attributing characteristics**

| S.No. | Characters | Days to 50% flowering | Days to grain maturity | No. of effective tiller | Leaf length | Leaf width | Plant height | Panicle length | Grain per panicle | 1000-grain weight | Grain ratio | Grain yield per plant |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Days/50% flowering | 1 | 0.83** | -0.12 | -0.11 | 0.15 | -0.22 | -0.26 | 0.40 | -0.09 | -0.34 | -0.08 |
| 2 | Days/grain maturity | | 1 | 0.14 | -0.19 | 0.30 | -0.08 | -0.14 | 0.26 | -0.29 | -0.31 | -0.07 |
| 3 | No/effective tiller | | | 1 | 0.45 | 0.50* | 0.52* | 0.30 | -0.17 | -0.12 | 0.09 | 0.60* |
| 4 | Leaf length | | | | 1 | 0.08 | 0.85** | 0.25 | 0.16 | -0.04 | 0.10 | 0.44 |
| 5 | Leaf width | | | | | 1 | 0.002 | -0.25 | -0.10 | -0.07 | -0.37 | 0.19 |
| 6 | Plant height | | | | | | 1 | 0.25 | 0.003 | -0.24 | 0.20 | 0.31 |
| 7 | Panicle length | | | | | | | 1 | 0.36 | 0.01 | 0.09 | 0.53* |
| 8 | Grain per panicle | | | | | | | | 1 | -0.28 | -0.64* | 0.09 |
| 9 | 1000- grain weight | | | | | | | | | 1 | 0.58* | 0.27 |
| 10 | Grain ratio | | | | | | | | | | 1 | 0.19 |
| 11 | Grain yield | | | | | | | | | | | 1 |

*=significant at 5% level of significance* *=significant at 1% level of significance

**Table 5. Rice yield genotypic correlation ($r_g$) with yield attributing characteristics**

| S.No. | Characters | Days to 50% flowering | Days to grain maturity | No. of effective tiller | Leaf length | Leaf width | Plant height | Panicle length | Grain per panicle | 1000-grain weight | Grain ratio | Grain yield per plant |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Days /50%flowering | 1 | 0.72* | -0.20 | -0.14 | 0.46 | -0.23 | -0.49 | 0.50* | -0.13 | -0.52* | -0.07 |
| 2 | Days/grain maturity | | 1 | 0.30 | -0.09 | 0.54* | 0.01 | -0.23 | 0.25 | -0.37 | -0.42 | -0.07 |
| 3 | No./effective tiller | | | 1 | 0.22 | 0.57* | 0.44 | 0.23 | -0.45 | -0.16 | 0.15 | 0.74** |
| 4 | Leaf length | | | | 1 | -0.14 | 0.90** | 0.53* | 0.22 | -0.06 | 0.13 | 0.68** |
| 5 | Leaf width | | | | | 1 | -0.33 | -0.176 | -0.01 | -0.09 | -0.44 | 0.50* |
| 6 | Plant height | | | | | | 1 | 0.53* | 0.01 | -0.32 | 0.26 | 0.52* |
| 7 | Panicle length | | | | | | | 1 | 0.21 | 0.03 | 0.16 | 0.63* |
| 8 | Grain per panicle | | | | | | | | 1 | -0.32 | -0.76** | -0.21 |
| 9 | 1000 grain weight | | | | | | | | | 1 | 0.58* | 0.52* |
| 10 | Grain ratio | | | | | | | | | | 1 | 0.38 |
| 11 | Grain yield | | | | | | | | | | | 1 |

*=significant at 5% level of significance, **=significant at 1% level of significance

**Table 6. Clustering of 12 rice genotypes based on genetic divergence**

| S.No. | Cluster number | Number of genotype | Genotype |
|---|---|---|---|
| 1 | Cluster I | 3 | Longkhum, Koyu 4, Koyu 20 |
| 2 | Cluster II | 6 | Longkhong 8, Longkhong 20, Longra-tenak, Malang-chari, Malang-satsuk, Malang-tenak |
| 3 | Cluster III | 2 | Kumangri, Semer |
| 4 | Cluster IV | 1 | Manan/Meserong |

**Table 7. Average inter and intra cluster distance of 12 rice genotypes**

| S.No. | Cluster number | Cluster I | Cluster II | Cluster III | Cluster IV |
|---|---|---|---|---|---|
| 1 | Cluster I | 126.664 **(35.548)** | 5873.414 **(76.638)** | 5841.092 **(76.427)** | 25013.342 **(158.156)** |
| 2 | Cluster II | | 3195.547 **(56.529)** | 1648.403 **(40.601)** | 10049.399 **(100.247)** |
| 3 | Cluster III | | | 921.306 (30.353) | 7610.225 **(87.237)** |
| 4 | Cluster IV | | | | 0 **0** |

plant height and panicle length, 1000- grain weight with grain ratio at the genotypic level.

All the genotypes were combined to form four distinct clusters. Cluster II had six genotypes out of the 12 total, while Cluster IV had only two genotypes. (1 genotype).

The biggest intra-cluster divergence is found in Cluster II (56.529), followed by Cluster I (35.548). Cluster I and cluster IV were determined to have the greatest inter-cluster distance (158.156), demonstrating that these two clusters were in general varied. As a result, the genotypes of clusters I and IV may be employed in a hybridization strategy to increase the variability of the segregating generation.

Clusters II and III had the shortest inter-cluster distance (40.60), showing that these clusters' genotypes are relatively close. The distance of in-clusters was larger than intra-cluster clusters, indicating increased genetic variety across the genotypes. Aktar *et al*. (2012) also observed a similar findings. Yield per plant and 1000-grain weight are the biggest contributions to divergence across the various traits. This was in

**Table 9. Each character's contribution to divergence**

| S. No. | Character | % Contribution |
|---|---|---|
| 1 | Days to 50% flowering | 0 |
| 2 | Days to grain maturity | 3.03 |
| 3 | No. of effective tiller | 0 |
| 4 | Leaf length | 0 |
| 5 | Leaf width | 0 |
| 6 | Plant height | 0 |
| 7 | Panicle length | 0 |
| 8 | Grain per panicle | 0 |
| 9 | 1000 grain weight | 37.88 |
| 10 | Grain ratio | 3.03 |
| 11 | Grain yield per plant | 56.06 |

**Table 8. Cluster wise mean value of 11 character in rice**

| S.No. | Characters / Cluster | Days to 50% flowering | Days to grain maturity | No. of effective tiller | Leaf length | Leaf width | Plant height | Panicle length | Grain per panicle | 1000 grain weight | Grain yield ratio | Grain yield per plant |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | I | 108.889 | 139.333 | 2.74 | 69.591 | 1.633 | 111.802 | 27.223 | 202.487 | 36.669 | 2.626 | 13.169 |
| 2 | II | 109.278 | 142.5 | 5.929 | 70.926 | 1.946 | 119.832 | 26.044 | 168.594 | 26.981 | 2.376 | 15.207 |
| 3 | III | 107.833 | 142.833 | 3.755 | 66.732 | 1.897 | 111.067 | 24.665 | 132.277 | 26.318 | 2.545 | 7.223 |
| 4 | IV | 103.667 | 138.667 | 4.33 | 75.887 | 1.41 | 139.223 | 28.78 | 200.863 | 11.473 | 2.437 | 8.193 |

line with the conclusion reached by Chandra *et al.* (2007).

## CONCLUSIONS

Significant variations between genotypes for each trait were found using ANOVA. According to the estimates, effective tillers per plant had the highest GCV and PCV, followed by 1000-grain weight and grain yield per plant. The 1000-grain weight exhibited strong heritability and genetic advance, Effective tillers per plant, leaf length, leaf breadth, plant height, panicle length, and 1000 grain weight all show strong positive genotypic relationships with yield per plant as well as significant genetic variability. As a result, breeding programs can use these characteristics as selection criteria, and selection for these characteristics can accumulate additional genes to improve performance.

## REFERENCES

Aktar, J.,Qaular, Zia, U. I., Asharal, M.,Akrarn, M and Hameed, A. 2012. A multivariate analysis of rice genetic resources. Pakistan Journal of Botany. (4): 1335-1340.

Allard, R.W.1960. Principle of Plant Breeding.John Wiley and Sons Inc., New York, USA. pp. 485

Burton,G .Wand Devane, E.M.1953. Estimating heritability in tall Fescue (*Festuca arundiacea* L.) from replicated clonal material. Agronomy. (545): 478-481.

Burton, G.W. 1961. Quantitative genetics in grasses. Proceeding of 6th International Grassland Congress.1: 277-288.

Chandra , B.S., Reddy, T . D and Ansari, N. A. 2007. Genetic divergence in rice *(Oriza sativa* L.). Research Crops. 8(3): 600-603.

Chandrasekhan, B., Annadurai, K and Kavimani, R. 2008. Rice botany. In: Rice Science. Scientific Publishers (India), Jodhpur. pp-7-8.

Elayaraja, K., Prakash, M., Saravana, K., Kumar, B.S and Ganesan, J. 2005. Studies on variability, heritability and genetics advance quantitative character in rice *(Oryza sativa* L.). Crop Research. 29 (1): 134-137.

Lalitha, R and Sreedhar, D. 1999. Genetic variability for quantitative charcters in rice grown on sodic and non sodic soils.Indian Journal of Agricultural Sciences. 51: 676-680.

Mohto, R. N and Mohan, K.S. 2003. Regression study in rainfed upland rice *(Oryza sativa L.).* Journal of Reearch.15 (2): 261-263.

Mahalanobis, P. C. 1936. On the generalized distance in statistics. Proceedings of the National Institute of Science of India. 2:49-55.

Osman, *A.,* Mustafa, A .M.,Ali, F., Zheng, Y. L and Qiu, F.A. Z. 2012, Genetic variability for yield and related attributes of upland rice genotypes in semi arid zone (Sudan). African Journal of Agricultural Research. 7(33): 4613-4619.

Rao, C. R. 1952. Advance Statistical Methods in Biometrical Research. John Wiley and Sons. Inc. New York, USA. pp. 390.

Shiva, A., Abhisek, S., Narayan, A., Ankur, P and Suvarna, A. 2018. Genetic variability, heritability andcorrelation analysis in quantitative traits of irrigated rice (*Oryza Sativa).* Biosciences Biotechnology Research Asia.15(3): 729-735.

Seyoum, M.,Alarnerew, S. and Bantte, K. 2012. Genetic variability, heritability, correlation coefficient and path analysis for yield and yield related traits in upland rice *(Oryza sativa* L.*).* Journal of Plant Science. 7(1):13-22.

Sharma, M.K,.Richharia, K and Agarwal, R .K. 1996. Variability, heritability genetic advance and genetic divergence in upland rice. Rice Research Notes. 21(1): 25-26.

Venkata Lakshmi, M., Suneetha, Y., Yugandhar, G and Venkata Lakshmi. N. 2014. Correlation Studies in Rice *(Oryza sativa L.)*. International Journal of Genetic Engineering and Biotechnology. 5(2) (2014): 121-126.

Lepcha, W., Moses, N and Changkija, S. 2023. Genetic variability, correlation, and diversity analysis of twelve (12) important jhum rice (Oryza sativa. L.) genotypes of Nagaland. The Journal of Research ANGRAU. 51(3): 28-35.
DoI: https://doi.org/10.58537/jorangrau.2023.51.3.04

DoI: https://doi.org/10.58537/jorangrau.2023.51.3.05

J. Res. ANGRAU 51 (3) 36-44, 2023

# EFFICACY OF FUNGICIDES, BIOCONTROL AGENTS AND BOTANICALS AGAINST ALTERNARIA LEAF BLIGHT (*Alternaria sesami*) IN SESAME CROP

**P. LAKSHMI PRAVALLIKA, S.L. BHATTIPROLU*, K. RADHIKA and M. RAGHAVENDRA**

Department of Seed Science and Technology, Advanced Post Graduate Centre,
Acharya N.G. Ranga Agricultural University, Lam, Guntur - 522 034

Date of Receipt :05.5.2023 Date of Acceptance : 10.7.2023

## ABSTRACT

Seed borne fungus, *Alternaria sesami* associated with sesame is the most destructive pathogen. Laboratory experiment was carried out during Dec.,2017 to Nov., 2018. The fungicides *viz.,* hexaconazole @ 0.2% and combination product of carbendazim 12% + mancozeb 63% @ 0.2%, bio-control agents viz., *Trichoderma viride* @ 10 g/kg and *Pseudomonas fluorescens* @ 10 g/kg seed and botanicals *viz.,* garlic clove extract 10% and neem leaf extract 10% against Alternaria blight of sesame var. YLM-17 in pot culture showed that seed treatment with combination product of carbendazim 12% + mancozeb 63% @ 0.2% was effective in reducing the per cent disease index (PDI) of Alternaria blight by 63.20 per cent and improving plant height (44.11 cm), number of capsules per plant (12.53), seed yield per plant (2.23 g) and harvest index (14.17%) when compared to control (without seed treatment). Hexaconazole, *T. viride* and garlic clove extract recorded 53.12%, 47.48% and 35.90% decrease in PDI, respectively. Sesame seed collected from the pots treated with carbendazim 12% + mancozeb 63% @ 0.2% recorded highest seed germination (99.33%), seedling length (17.37 cm), seedling vigour index-I (1725) and seedling vigour index-II (3.97) followed by *T. viride* with 98.33%, 16.75 cm, 1647 and 3.54, respectively.

**Keywords:** Alternaria leaf blight, biocontrol agents, botanicals, fungicides, sesame

## INTRODUCTION

Sesame (*Sesamum indicum* L.) is an important oil seed crop being cultivated in the tropics as well as temperate zone of the world. India, China and Mexico are the major sesame exporters, while Japan is the single largest buyer of sesame seed. India is the largest producer of sesame catering to the world market. Seed borne pathogens cause considerable damage both at early and late stages of sesame crop. Different fungi *viz.,* A*lternaria, Curvularia, Fusarium, Helminthosporium, Penicillium, Mommoniella* and *Rhizopus* sp. were associated with sesame seed (ISTA, 1999, Nagaraja *et al.,* 2009, Bharathi *et al.,* 2013). Among these, *Alternaria* is the most destructive pathogen of sesame and causes leaf blight which is one of the major seed borne fungal disease in sesame. Seed borne microflora are carried over by infected seed and cause seed deterioration, reduced germination resulting in reduction of plant population in the field and ultimately yield to the extent of 28.9 percent (Prasad *et al.,* 1997).

Chemical methods involving seed treatment with fungicides have been employed to improve germination, vigour, crop establishment, crop

*Corresponding Author E-mail i.d: <b.sreelakshmi@angrau.ac.in; M.Sc. thesis submitted to Acharya N.G. Ranga Agricultural University, Guntur - 522 034

stands and yield. In some cases, farmers in developing countries cannot afford high cost of chemical fungicides. This has resulted in the employment of botanicals and bio-control agents for the control of seed borne pathogens for which integration of various cultural, biological and chemical methods might be the solution (Barnwal *et al.,* 2011). During the investigation, fungicides, biocontrol agents and botanical extracts were tested to manage the major seed borne pathogen of sesame, *Alternaria sesami* in pot culture.

## MATERIALS AND METHODS

The investigation was carried out in the laboratory of Plant Pathology, Regional Agricultural Research Station, Lam and Department of Seed Science and Technology, Advanced Post Graduate Centre, Guntur, Andhra Pradesh between Dec., 2017 and Nov.,2018. Seeds of sesame var. YLM-17 susceptible to Alternaria blight was subjected to six seed treatments, comprising two each of fungicides (hexaconazole @ 0.2% and combination product of carbendazim 12% + mancozeb 63% @ 0.2%), bio-control agents (*Trichoderma viride* @ 10 g/kg and *Pseudomonas fluorescens* @ 10 g/kg seed) and botanicals (garlic clove extract 10% and neem leaf extract 10%). Ten g seed was soaked in the 100 ml fungicidal solution (0.2%) for two hours and then shade dried. For bio-control seed treatment, seed were shaken with the formulations of *T.viride* and *P.fluorescens* for 20 min in mechanical shaker for uniform application and then stored in separate boxes for two hrs. For botanical seed treatment, seed was soaked in 100 ml of 10% plant extract for two hours and then dried in shade for two hours. Seed soaked in sterile distilled water served as control. Treated seed along with untreated seed (control) of sesame was tested initially for germination and seedling quality parameters as per the standard procedures before sowing the seed in the pots.

The pot culture experiment was conducted in Completely Randomized Design (CRD) and replicated thrice. Each replication consisted of three pots and each pot contained five plants. Earthen pots of size 30 cm x 25 cm were used for raising the seedlings of sesame. One part of sand, two parts of clay soil and one part of red soil were used as potting medium. The required quantity of fertilizers was mixed with soil before sowing the seed. Necessary plant protection measures were taken against sucking pests. Since the seed treatment gives protection during early growth stage (upto 30 days) of crop, to manage the disease during flowering and pod formation stages, foliar application of fungicide (combination product of carbendazim 12% + mancozeb 63% @ 2 g/l) selected based on *in vitro* studies was taken up at 30 DAS and 45 Days after sowing (DAS). Harvesting was done at physiological maturity stage. Five representative plants of each treatment were selected randomly and tagged for recording various observations *viz.,* percent disease index (PDI), plant height at maturity (cm), dry weight of plant (g), number of capsules per plant, seed yield per plant (g) and harvest index (%). Harvested seed obtained from different treatments from pot culture was analysed for seed germination, seedling length, dry weight of seedlings and seedling vigour index-I and II as per the standard procedures.

### Seed quality parameters

**Germination (%):** On the day of final count ($6^{th}$ day), all the normal seedlings were counted. Based on the number of normal seedlings, the germination percentage from each sample in each replication was computed as per the formula mentioned here under:

$$\text{Germination (\%)} = \frac{\text{Number of normal seedlings}}{\text{Total number of seed sown}} \times 100$$

**Seedling length (cm):** Ten normal seedlings were taken from the each replication at random on the $6^{th}$ day and the seedling length was measured from tip of the primary leaf to the tip of the primary root with the help of the scale and mean seedling length was expressed in centimeters.

**Seedling dry weight (g):** Ten normal seedlings chosen for measuring seedling length were also used to determine seedling dry weight.

The seedlings were kept in brown paper bags and dried in hot air oven at 75±1 °C for 48 h. After drying, they were cooled in a desiccator for 30 minutes and weighed on an electronic balance and mean dry weight was expressed in grams.

**Seedling Vigour Indices**

**a) Seedling Vigour Index I:** Seedling vigour index was computed using the following formula given by Abdul-Baki and Anderson (1973).

Seedling vigour index I = Germination (%) × Mean seedling length (cm)

**b) Seedling Vigour Index II:** Seedling vigour index II was computed as per the formula suggested by Reddy and Khan (2001) as given below:

Seedling vigour index II = Germination (%) × Seedling dry weight (g)

**Disease severity:** Disease was scored on five randomly selected plants at seedling stage and 15 days after each spray following 0-5 scale (Shrestha *et al.*, 2005), where 0 = no infection, 1 = up to 5% area covered by the disease, 2 = 6-10% area covered by the disease, 3 = 11-20% area covered by the disease, 4 = 21-30% area covered by the disease, 5 = 31-100% area covered by the disease. Percent Disease Index (PDI) was calculated by using the formula:

$$\text{Per cent Disease Index (PDI)} = \frac{\text{Sum of all the numerical ratings}}{\text{Total number of leaves scored} \times \text{Maximum disease grade}} \times 100$$

The data were subjected to statistical analysis after subjecting the data to appropriate transformation.

**RESULTS AND DISCUSSION**

**Effect of seed treatment on initial seed quality parameters of sesame**

Significant differences in germination (%), seedling length (cm) and seedling vigour index-I were observed among different seed treatments. Seedling vigour index-II was not significantly influenced by different seed treatments.

Sesame seed treated with combination product of carbendazim 12% + mancozeb 63% @ 0.2% recorded significantly higher seed germination (98.75%), seedling length (16.80 cm), seedling vigour index-I (1659) and seedling vigour index-II (2.94) (Table 1) when compared to control (untreated seeds) (90.00%, 10.41 cm, 938 and 2.21, respectively). The lowest seed germination (95.00%), seedling length (12.52 cm), seedling vigour index-I (1191) and seedling vigour index-II (2.42) were recorded with neem leaf extract 10% among the seed treatments.

The results are in conformity with findings of Bharathi *et al.* (2013) who reported that seed treatment with a mixture of fungicides and bio-control agents in sesame was found superior in controlling the seed borne mycoflora, increasing the seed germination and seedling vigour index.

Similar results on seed quality parameters with seed treatment using fungicides, bio-control agents and botanicals were observed in soybean by Koche *et al.* (2009), Sajeesh (2012); in safflower by Gayathri (2012). Seeds treated with bioagents showed beneficial effects on germination which resulted in increased root-shoot length and seedling vigor and also reduced the mycofloral species that impede the seed germination (Margaret *et al.,* 2013).

**Evaluation of efficacy of seed treatments in controlling Alternaria blight in sesame**

Data on percent disease index before spray, after first spray (30 DAS) and second spray (45 DAS) revealed that the seed treatment with combination product of carbendazim 12% + mancozeb 63% @ 0.2% was significantly superior(4.1, 10.8 and 12.4 PDI, respectively) to other treatments. This treatment reduced Alternaria blight PDI by 63.2%. The highest PDI of 15.2, 28.5 and 33.7, respectively, was recorded before spray and second spray in the control. Between the biocontrol agents, seed treatment with *T. viride* @

10 g/kg seed was found to be the best which showed disease reduction of 47.48%. Neem leaf extract 10% was the least effective against the disease which reduced the PDI only to the extent of 27.2% (Table 2).

Seed treatment with combination product of carbendazim 12% + mancozeb 63% @ 0.2% recorded higher plant height (44.11 cm), number of capsules per plant (12.53), seed yield per plant (2.23 g), dry weight of the plant (15.72 g) and harvest index (14.17%), when compared to control (27.73 cm, 5.77, 0.84 g, 11.48 g and 7.36%, respectively) (Fig.1). High seed yield per plant and harvest index noticed in seed treatment with combination product of carbendazim 12% + mancozeb 63% @ 0.2% indicated that more food reserves might have been partitioned towards reproductive structures in the post anthesis period. Among the seed treatments, seed treatment with neem leaf extract 10% recorded lower plant height (36.17 cm), number of capsules per plant (9.27), seed yield per plant (1.79 g) dry weight of the plant (14.48 g) and harvest index (12.35%).

The results of the study revealed that, the combination product of carbendazim 12% + mancozeb 63% @ 0.2% significantly reduced the incidence of *Alternaria* blight. Deshmukh and Karve (1983) suggested an indirect effect of carbendazim in activating the natural mechanism of resistance. Fungicidal treatment induced metabolic changes leading to development of toxic factors, resulted in the internal environment unfavorable for pathogens growth and activity, ultimately inducing the resistance and protection against infection (Singh *et al.*, 2002).

*Trichoderma viride* was found effective over control in the management of *Alternaria sesami* in the present investigation next to the combination product of carbendazim 12% + mancozeb 63% @ 0.2%. Most of the antagonists inhibited the growth of pathogen, by their fast and over growing nature as observed in vitro. Trichoderma species produces inhibitory substances or acetaldehyde compound against the test pathogens (Pawar *et al.*, 2013).

The results are in accordance with Mallaiah *et al.* (2016) who found that seed treatment with *T. viride* (0.4%) and soil application of *T. viride* @ 2.5 kg/ha followed by spray of carbendazim + mancozeb 0.2% recorded highest disease control and yield over control in sesame. Seed treatment with carbendazim + mancozeb at 3 g/kg seed + two sprays of same combination@ 0.2% at 30 and 45 DAS recorded highest disease control and highest seed yield in sunflower (Waghe *et al.,* 2015). Thakur and Zacharia (2018) found that seed treatment and foliar spray with mancozeb 63% + carbendazim 12% was most effective against early blight of mustard with minimum disease intensity and maximum yield over control. Similar results were obtained by Deokar *et al.* (2014) in sunflower and Singh *et al.* (2014) in linseed.

Garlic clove extract 10% was found effective over control among the botanicals tested for the management of A. sesami in the present investigation. Similar result of antifungal effect of botanicals / plant extracts against A. carthami and Alternaria spp. were reported earlier by several workers, Mesta *et al.* (2009), Ranware *et al.* (2010) and Taware *et al.* (2014).

**Effect of seed treatment on seed quality parameters of harvested seed of sesame**

The observations on various seed quality parameters of harvested seed revealed that significant differences were observed in the germination (%), seedling length (cm) and seedling vigour indices of harvested seed from different treatments in pot culture. The combination product of carbendazim 12% + mancozeb 63% @ 0.2% showed an increase in germination (%), seedling length (cm), dry weight and seedling vigour indices and was significantly superior to all other treatments. Sesame seed harvested from the plants raised from the seed treated with combination product of carbendazim 12% + mancozeb 63% @ 0.2% recorded highest seed germination (99.33%), seedling length (17.37 cm), seedling vigour index-I (1725) and seedling vigour index-II (3.97) (Table 3). Harvested seed from control (without seed

**Table 1. Efficacy of different seed treatments on initial seed quality parameters of sesame sample of YLM-17 (prior to pot culture)**

| S.No. | Treatments | Germination (%)* | Seedling length (cm)* | Seedling Vigour Index-I* | Seedling dry weight(g)* | Seedling Vigour Index-II* |
|---|---|---|---|---|---|---|
| $T_1$ | Seed treatment with hexaconazole @ 0.2% | 98.00 (81.97)$^{ab}$ | 15.59$^{b}$ | 1530$^{b}$ | 0.03 | 2.72 |
| $T_2$ | Seed treatment with combination product of carbendazim 12% + mancozeb 63% @ 0.2% | 98.75 (84.47)$^{a}$ | 16.80$^{a}$ | 1659$^{a}$ | 0.03 | 2.94 |
| $T_3$ | Seed treatment with *Trichoderma viride* (isolate-2) @ 10 g/kgseed | 98.25 (82.57)$^{ab}$ | 15.52$^{b}$ | 1526$^{b}$ | 0.03 | 2.88 |
| $T_4$ | Seed treatment with *Pseudomonas fluorescens* (isolate-1) @ 10 g/kg seed | 96.00 (78.48)$^{c}$ | 13.73$^{d}$ | 1318$^{d}$ | 0.03 | 2.61 |
| $T_5$ | Seed treatment with garlic clove extract 10% | 96.75 (79.67)$^{bc}$ | 14.56$^{c}$ | 1411$^{c}$ | 0.03 | 2.47 |
| $T_6$ | Seed treatment with neem leaf extract 10% | 95.00 (77.08)$^{c}$ | 12.52$^{e}$ | 1191$^{e}$ | 0.03 | 2.42 |
| $T_7$ | Control | 90.00 (71.55)$^{d}$ | 10.41$^{f}$ | 938$^{f}$ | 0.03 | 2.21 |
| | Mean | 79.40 | 14.16 | 1368 | 0.03 | 2.61 |
| | SEm+ | 1.00 | 0.15 | 16.62 | 0.001 | 0.25 |
| | CD @ 5% | 3.43 | 0.50 | 57.22 | NS | NS |
| | CV (%) | 2.51 | 2.05 | 2.43 | 6.38 | 6.63 |

***Mean of three replications; Values in the parenthesis indicate angular transformed values Values followed by same alphabet in the same column do not differ significantly at 5% level of significance; NS: Non-significant at 5% level of probability**

treatment) recorded lowest germination (91.42%), seedling length (11.44 cm), seedling vigour index-I (1046) and seedling vigour index-II (1.83). Among the seed treatments, lowest seed germination (96.58%), seedling length (15.30 cm), seedling vigour index-I (1478) and seedling vigour index-II (2.35) was recorded in seed treatment with neem leaf extract 10%.

Lower seed infection (7.04 % and 9.21 %) of *A. porri* and higher seed germination (88.48 % and 85.64 %) of seed samples harvested from Dithane M–45 and Rovral 50 WP treated plots as against untreated control (17.44% and 67.62%), respectively, was reported by Uddin *et al.* (2006). Application of Dithane M-45 and *T. harzianum* significantly reduced the seed-borne infection of *Alternaria* spp. as compared to control in mustard.

**Table 2. Evaluation of fungicides, bio-control agents and botanicals on Percent disease index of Alternaria blight in sesame sample of YLM-17 under pot culture**

| S.No. | Treatments* | Percent disease index* | | | *Percent decrease over control (After 2nd spray) |
|---|---|---|---|---|---|
| | | Before 1st spray | After 1st spray | After 2nd spray | |
| $T_1$ | Seed treatment with hexaconazole @ 0.2% | 4.8 (12.6)[b] | 12.4 (20.6)[b] | 15.8 (23.4)[b] | 53.12 |
| $T_2$ | Seed treatment with combination product of carbendazim 12% + mancozeb 63% @ 0.2% | 4.1 (11.7)[a] | 10.8 (19.2)[a] | 12.4 (20.6)[a] | 63.20 |
| $T_3$ | Seed treatment with *Trichoderma viride* @ 10 g/kg seed | 5.4 (13.4)[c] | 15.4 (23.1)[c] | 17.7 (24.8)[c] | 47.48 |
| $T_4$ | Seed treatment with *Pseudomonas fluorescens* @ 10 g/kg seed | 8.6 (17.1)[d] | 20.3 (26.7)[e] | 22.5 (28.3)[e] | 33.23 |
| $T_5$ | Seed treatment with garlic clove extract 10% | 5.5 (13.6)[c] | 19.6 (26.2)[d] | 21.6 (27.7)[d] | 35.90 |
| $T_6$ | Seed treatment with neem leaf extract 10% | 9.4 (17.9)[e] | 21.4 (27.5)[f] | 24.5 (29.7)[f] | 27.20 |
| $T_7$ | Control | 15.2 (23.0)[f] | 28.5 (32.2)[g] | 33.7 (35.5)[g] | |
| | Mean | 7.58 | 18.33 | 21.17 | |
| | SEm+ | 0.42 | 0.57 | 0.64 | |
| | CD @ 5% | 1.32 | 1.28 | 1.73 | |
| | CV (%) | 3.12 | 3.36 | 4.83 | |

*** Two foliar sprays with combination product of carbendazim 12% + mancozeb 63% @ 2g $l^{-1}$ was sprayed commonly in all the treatments at 30 DAS and 45 DAS.**

**** Mean of three replications; Values in the parenthesis indicate angular transformed values Values followed by same alphabet in the same column do not differ significantly at 5% level of significance**

Plant extracts, Bojho powder and Neem powder were found better than control to check the disease. Furthermore, highest germination (76.75%) was observed in *Trichoderma* treatment, whereas, lowest germination (65.0%) was recorded in control (Prashant Rijal *et al.*, 2020).

## CONCLUSIONS

Combination product of carbendazim 12% + mancozeb 63% @ 0.2% was effective in reducing the seed borne infection besides improving the plant growth, yield and seed quality parameters in sesame. Seed treatment with *T. viride* @ 10 g/kg

**Table 3. Effect of seed treatment on seed quality parameters of seed harvested from YLM-17 sesame under pot culture**

| S. No. | Treatments | Germination (%)* | Seedling length (cm)* | Seedling Index-I* Vigour | Seedling dry weight (g)* | Seedling Vigour Index-II* |
|---|---|---|---|---|---|---|
| $T_1$ | Seed treatment with hexaconazole @ 0.2% | 98.50 (82.93)$^b$ | 15.74$^c$ | 1551$^c$ | 0.03$^b$ | 2.97$^c$ |
| $T_2$ | Seed treatment with combination product of carbendazim 12% + mancozeb 63% @ 0.2% | 99.33 (85.35)$^a$ | 17.37$^a$ | 1725$^a$ | 0.04$^a$ | 3.97$^a$ |
| $T_3$ | Seed treatment with *Trichoderma viride* (isolate-2) @ 10 g kg$^{-1}$ seed | 98.33 (82.55)$^b$ | 16.75$^b$ | 1647$^b$ | 0.04$^a$ | 3.54$^b$ |
| $T_4$ | Seed treatment with *Pseudomonas fluorescens* (isolate-1) @ 10 g kg$^{-1}$ seed | 97.42 (80.72)$^c$ | 15.39$^{cd}$ | 1499$^d$ | 0.03$^b$ | 2.44$^d$ |
| $T_5$ | Seed treatment with garlic clove extract 10% | 97.17 (80.28)$^c$ | 15.55$^{cd}$ | 1511$^d$ | 0.04$^a$ | 3.40$^b$ |
| $T_6$ | Seed treatment with neem leaf extract 10% | 96.58 (79.33)$^d$ | 15.30$^d$ | 1478$^d$ | 0.02$^c$ | 2.35$^d$ |
| $T_7$ | Control | 91.42 (72.93)$^e$ | 11.44$^e$ | 1046$^e$ | 0.02$^c$ | 1.83$^e$ |
| | Mean | 80.59 | 15.36 | 1494 | 0.03 | 2.93 |
| | SEm+ | 0.27 | 0.13 | 12.53 | 0.001 | 0.06 |
| | CD @ 5% | 0.59 | 0.32 | 31.20 | 0.002 | 0.16 |
| | CV (%) | 0.68 | 1.43 | 1.45 | 3.86 | 3.83 |

***Mean of three replications; Values in the parenthesis indicate angular transformed values; Values followed by the same alphabet in the same column do not differ significantly at 5% level of significance**

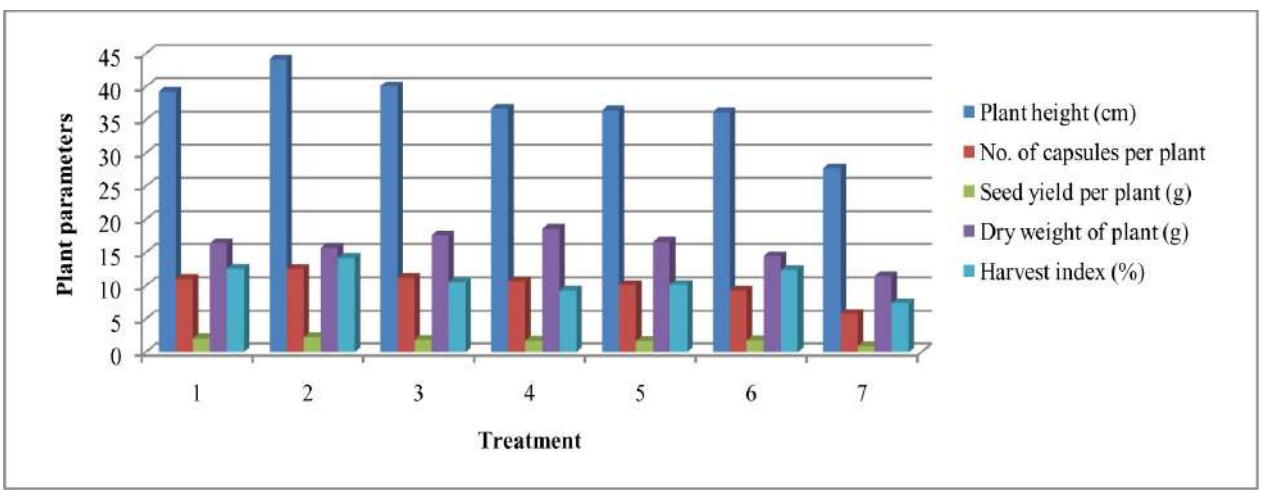



**Fig. 1. Evaluation of fungicides, bio-control agents and botanicals against seed borne Alternaria blight in sesame sample of YLM-17 under pot culture**

can be recommended as an ecofriendly sustainable disease management strategy for Alternaria blight in sesame crop.

**REFERENCES**

Abdul-Baki, A.A and Anderson, J.P. 1973.Vigour determination in soybean seed by multiple criteria. Crop Science. 13: 630-633.

Barnwal, M.K., Kumar, R and Kumar, B. 2011. Integrated management of Alternaria blight, Melampsora rust and fungal wilt of linseed (*Linum usitatissimum*) in field. Journal of Mycology and Plant Pathology. 41 (1): 53-56.

Bharathi, V., Sudhakar, R., Parimala, K and Reddy, A.V. 2013. Evaluation of bio-agents and bio-fertilizers for the management of seed and seedling diseases of *Sesamum indicum* (sesame). ESci Journal of Plant Pathology. 2 (3): 179-186.

Deokar, S.R., Thaware, D.S and Wagh, S.S. 2014. Integrated disease management of sunflower Alternaria blight (*Alternaria helianth*i). Trends in Bioscience. 7 (19): 3013-3020.

Deshmukh, A.K and Karve, A.D. 1983. Mode of action of carbendazim on Alternaria leaf blight of safflower. Indian Botanical Reporter. 2: 28-32.

Gayathri, D.A. 2012. Studies on seed mycoflora of safflower and its control. M.Sc. Thesis submitted to Acharya N.G. Ranga Agricultural University, Hyderabad, India.

International Seed Testing Association. 1999. International rules for seed health testing. Seed Science and Technology. 24: 1-335.

Koche, M.D., Kothikar, R.B., Anvikar, D.G and Udamale, S. 2009. Effect of seed dressing fungicides and bioagents on survival of seed-borne fungi and shelf life of soybean. Crop Research. 38 (1, 2 & 3): 215-218.

Mallaiah, B., Rajanikanth, E., Manjulatha, G and Anjaiah, T. 2016. Integrated management of sesame (*Sesamum indicum* L.) diseases. International Journal of Tropical Agriculture. 34 (6): 1591-1594.

Margaret, E., Neeraja, P.V and Rajeswari, B. 2013. Screening of seed borne mycoflora of C*icer arietinum* L. International Journal of Current Microbiology and Applied Science. 2 (8): 124-130.

Mesta, R.K., Benagi, V.I., Kulkarni, S and Shankergoud, I. 2009. In-vitro evaluation of fungicides and plant extracts against *Alternaria helianthi* causing blight of sunflower. Karnataka Journal of Agricultural Sciences. 22 (1): 111-114.

Nagaraja, O.S., Somashekar, A.G., Malammanavar, G and Krishnappa, M. 2009. Seed borne fungi of sesame (*Sesamum indicum* L.) seeds in Davanagere district and their effect on germination. Trade Science Inc. 3 (4): 157-163.

Pawar, S.V., Dey, U., Mundel,V.G., Sutar, D.S and Pal, D. 2013. Management of seed/soil borne diseases of safflower by chemical and biocontrol agents. African Journal of Microbiology Research. 7 (18): 1834-1837.

Prasad, P.R., Reddy, S.R., Reddy, S.M., Srivastava, H.P., Purohit, D.K and Reddy, S.R. 1997. Diseases of sesame in two districts (Warangal and Karimnagar) of Andhra Pradesh. Microbial Technology. 169-174.

Prashant Rijal, Subash Subedi, Chiran Adhikari, Sundarman Shrestha and Jiban Shrestha. 2020.Seed-borne infestation and management of *Alternaria* species in mustard seed at Chitwan district, Nepal. Journal of Agriculture and Natural Resources. 3(1): 190-197.

Ranaware, A., Singh, V and Nimbkar, N. 2010. In-vitro antifungal study of the efficacy of some plant extracts for inhibition of *Alternaria carthami* fungus. Indian Journal of Natural Products and Resources.1 (3):384-386.

Reddy, Y.T.N and Khan, M.M. 2001. Effect of osmopriming on germination, seedling growth and vigour of khirni (*Mimusops hexandra*) seed. Seed Research. 29 (1): 24-27.

Sajeesh, P.K. 2012. Studies on seed borne fungal diseases of soybean (*Glycine max* (L.) Merrill) in Northern Karnataka. M.Sc. Thesis submitted to University of Agricultural Sciences, Dharwad, Karnataka, India.

Shrestha, S.K., Munk, L and Mathur, S.B. 2005. Role of weather on Alternaria leaf blight disease and its effect on yield and yield components of mustard. Nepal Agriculture Research Journal. 6: 62-63.

Singh, R.B., Singh, H.K and Arpita, P. 2014. Yield loss assessment due to Alternaria blight and its management in linseed. Pakistan Journal of Biological Sciences. 17 (4): 511-516.

Singh, S.D., Rawal, P., Shekawat, N.S and Lodha, P.C. 2002. Management of mungbean (*Vigna radiata* (L.) Wikzek) seed mycoflora by seed dressing fungicides. Journal of Mycology and Plant Pathology. 23 (1): 149.

Taware, M.R., Gholve, V.M and Dey, U. 2014. Bio-efficacy of fungicides, bioagents and plant extracts/botanicals against *Alternaria carthami,* the causal agent of *Alternaria* blight of safflower. African Journal of Microbiology Research. 8 (13): 1400-1412.

Thakur, Y and Zacharia, S. 2018. Efficacy of Trichoderma spp. and garlic extract against Alternaria leaf blight of mustard (*Brassica juncea* L.). International Journal of Chemical Studies. 6 (1): 1164-1167.

Uddin, M. N. Islam, M. R. Akhtar N. and Faruq, A. N. 2006. Evaluation of fungicides against purple blotch complex of onion (*Alternaria porri* and *Stemphylium botryosum*) for seed production. Journal of Agricultural Education and Technology. 9 (1&2): 83-86

Waghe, K.P., Wagh, S.S., Kuldhar, D.P and Pawar, D.V. 2015. Evaluation of different fungicides, bioagents and botanicals against Alternaria blight caused by *Alternaria helianthi* (Hansf) of sunflower. African Journal of Agricultural Research. 10 (5): 351-358.

Lakshmi Pravallika, P., Bhattiprolu S.L., Radhika, K and Raghavendra M. 2023. Efficacy of fungicides, biocontrol agents and botanicals against *Alternaria* leaf blight (*Alternaria sesami*) in sesame. The Journal of Research ANGRAU. 51(3):36-44.
DoI: https://doi.org/10.58537/jorangrau.2023.51.3.05

DoI: https://doi.org/10.58537/jorangrau.2023.51.3.06

J. Res. ANGRAU 51 (3) 45-54, 2023

# EFFECT OF KORRA (*Setaria italica*) CROP RESIDUES INCORPORATION ALONG WITH MICROBIAL CONSORTIA ON HUMIC ACID, FULVIC ACID CONTENT IN SOIL AND PERFORMANCE OF CHICKPEA (*Cicer arietinum*)

**A.J. SUVARNA LATHA*, P. RATNA PRASAD, N.TRIMURTULU, and V. SRINIVASARAO**

Department of Soil Science and Agricultural Chemistry, Agricultural College
Acharya N.G.Ranga Aricultural University, Bapatla - 522 101

Date of Receipt : 22.5.2023 Date of Acceptance :01.8.2023

## ABSTRACT

The field experiment was conducted on the clay soils of Agricultural Research Station, Amaravathi, Guntur between *rabi* 2017-18 and 2018-19 to find out the influence of crop residues on soil biological activity, growth and yield of chickpea under rainfed agro-climatic condition of Krishna zone. The korra crop residue was incorporated in the soil 45 days before sowing of chickpea either alone or in combination with microbial consortia and starter dose of N and P fertilizers as decomposition accelerators. Humic acid and fulvic acid assayed at different crop growth stages of chickpea got significantly increased by the application of crop residue along with microbial consortia. The drymatter accumulation at different growth stages and grain yield of chickpea were significantly influenced by the treatments. Among the treatments, the highest drymatter accumulation and grain yield of chickpea were recorded with 100 percent RDF(20:50:0:40) and was at par with the treatment $T_{7,}$ which received crop residue @1.5 t $ha^{-1}$+ Microbial consortium@2 kg $t^{-1}$+ urea 3 kg $t^{-1}$ + SSP 15 kg $t^{-1}$ of residue incorporated to soil during both the years of the experimentation. There was a significant positive correlation between humic acid and fulvic acid content with drymatter production of chickpea.

**Key words:** Crop residue,Drymatter production,Humic acid,Fulvic acid, Microbial consortium and Yield

## INTRODUCTION

Humic and Fulvic acids are the building blocks of healthy soil. While both originate from humus, they play very significant roles. Working in tandem, humic and fulvic acids create great benefits to soil. They create healthy microbe-rich soil, increase plant health, and improve crop yields.In soil, humic and fulvic acids act as chelators and they combine with minerals and make them available as organic compounds that can be ingested by plants more easily. They also enable the soil to hold more water and can increase the water infiltration of the soil. Tang *et al*. (2017) and Ali *et al*. (2020) reported more content of humic acid and fulvic acid in crop residue treated plots. Deekshitha (2021) reported that significantly higher values of

*Corresponding Author E-mail i.d: aj.suvarnalatha@angrau.ac.in; Ph.D thesis submitted to ANGRAU, Guntur – 522 034

humic acid and fulvic acid in the treatments which received green leaf manure and vermicompost. In India, crop residues can be utilized as sources of nutrients by in-situ incorporation. Degradation of organic matter in soil is mainly biochemical in nature involving hydrolysis and oxidation brought about by various hydrolytic enzymes liberated by microorganisms. The chemical and physical characteristics of a crop residue will affect the rate of residue decomposition. Crop residues with high content of cellulose and lignin are less prone to decomposition process. Millet stems are inherently smaller and have grater surface area. Hence they decompose faster than the same weight of corn or sorghum or sunflower under the same conditions of soil temperature, water and tillage. The relative size of a crop residue also has an effect and breaking up of a crop residue into smaller particles exposes more residue surface area to microbial attack. The major requirement for crop residue decay is an active microbial population in contact with residue. Crop residues that have been chopped and tilled are more intimately mixed with soil microbial population. Addition of crop residues along with microbial consortium will increase the rate of decomposition and make the soil active to facilitate crop growth when compared to chemical application alone. Now a days, korra-chickpea cropping system is gaining importance and occupies a significant portion of the agricultural area in Vishakapatnam, Kadapa, Kurnool and Prakasam districts of Andhra Pradesh under rainfed situations. Korra, popularly known as fox tail millet, is one of the oldest cultivated millets. The crop grows well even in less rainfall and poor soil conditions and its cultivation has to be encouraged as it is going to become a part of human diet in the days coming. In India, Korra is cultivated in an area of 72.6 thousand hectares producing 50.2 thousand tonnes with productivity of 691 kg $ha^{-1}$ and in Andhra Pradesh. It occupies an area of 15000 hectares, with production of 18 thousand tonnes and productivity of 1118 kg $ha^{-1}$ (Directorate of Economics and Statistics, 2020). Chickpea occupies about 38 percent of the area under pulses and contributes about 50 percent of the total pulse production of India. In Andhra Pradesh there was an unprecedented growth in area, production and productivity in chickpea during the last decade with the cultivated area of 4.59 lakh hectares, with a production of 5.59 lakh tonnes and productivity of 1218 kg $ha^{-1}$. The grain contains about 20 percent protein and forms an essential part of human diet in many countries. As chickpea is a legume crop it can fix atmospheric nitrogen and additional fertilizers can be reduced. The reduced application of chemical fertilizers will reduce the cost of cultivation, maintain soil health and sustainable productivity. Bio-degradation of crop residues *viz*., korra residue employing urea, SSP and microbial consortium have been studied under field condition. The nutrient cycling is a complex process that takes place at different rates based on the type of residue. Keeping this in view, the study was conducted for two years (2017-19) using korra crop residue, microbial consortium and inorganic fertilizers to study the influence of decomposition products such as humic and fulvic acid on growth and yield in chickpea crop.

## MATERIALS AND METHODS

Field experiments were conducted for two consecutive years to study the effect of korra crop residue incorporation along with decomposing microbial consortia and fertilizers on succeeding chickpea*,*at two different locations at Agricultural Research Station, Amaravathi. During *rabi*, 2017-18 and 2018-19, the experiment was laid out with eight treatments in randomized block design and

replicated thrice using the residue obtained from korra grown in *kharif* season. Korra cultivar Suryanandi (SiA 3088) was raised in field numbers 4 and 6, respectively with a spacing of 20 cm x10 cm. Recommended dose of fertilizer (20-20-0 kg of N, $P_2O_5$ and $K_2O$, respectively) was applied uniformly by duly following the package of practices of ANGRAU. The biomass of korra obtained during *kharif* including stubbles were removed from field, chopped into 3 cm to 4 cm pieces and incorporated with rotovator to a depth of 15 cm of the soil in the field after quantification except in $T_1$ (control) and $T_8$ (RDF) treatments. Microbial Consortium consisting of decompo A and B was applied @2 kg $ton^{-1}$ of crop residue either alone or in combination with urea and single super phosphate as per the treatments. Chickpea was sown 45 days after the incorporation of korra residue.

**Treatments**

The treatments comprised of $T_1$: Absolute control ; $T_2$: Crop residue@1.5 t $ha^{-1}$; $T_3$: Crop residue@1.5 t $ha^{-1}$+ 3.0 kg Microbial consortia ;$T_4$: Crop residue@1.5 t $ha^{-1}$ +1.5 kg urea + 7.5 kg SSP ; $T_5$: Crop residue@1.5 t $ha^{-1}$ +3.0 kg urea + 15 kg SSP ; $T_6$: Crop residue@1.5 t $ha^{-1}$+3.0 kg Microbial consortia + 1.5kg urea+ 7.5 kg SSP ; $T_7$: Crop residue@1.5 t $ha^{-1}$+ 3.0 kg Microbial consortia + 3.0 kg urea + 15 kg SSP and$T_8$: RDF (20-50-0-40) of N,$P_2O_5$ and S $ha^{-1}$.

Microbial consortium consisted of decompo. A (fungal consortium of *Pleurotous ostreatous*, *Phanerochaete chrysosporium*, yeast and *Trichoderma*), decompo.B (bacterial consortium of *Bacillus sp*, *Lactobacillus* sp and *Pseudomonas sp*) developed at Agricultural Research Station, Amaravathi. The soil of experimental field used in both the seasons was clayey in texture, slightly alkaline in reaction, non saline, low in organic carbon and available N, medium in $P_2O_5$ and $K_2O$, sufficient in micronutrients. The soil samples collected at the time of sowing and at harvest of chick pea were assayed for humic and fulvic acid.The humic substances were extracted by taking fourty gram soil sample in a poly-ethylene centrifuge tube and treated with 200 mL 0.5 N NaOH solution. The mixture was shaken for 12 h on a mechanical shaker and centrifuged at 3000 rpm for 10 minutes. The dark coloured supernatant liquid formed was decanted and collected in a jar. The residual soil was treated with additional 200 mL 0.5 N NaOH, shaken for 12 h, centrifuged at 3000 rpm for 10 minutes and filtered. Later, 200 mL distilled water was added to the soil residue of principal extraction followed by shaking for 30 minutes, centrifugation at 3000 rpm for 30 minutes and decantation. The supernatant obtained was added to the previous extracts and pH was adjusted to 1.0 with concentrated HCl. The

**Table 1. Initial soil properties**

| S.No. | Soil property | 2017-18 | 2018-19 |
|---|---|---|---|
| 1 | pH | 8.1 | 8.1 |
| 2 | Electrical conductivity($dSm^{-1}$) | 0.23 | 0.24 |
| 3 | Organic carbon (%) | 0.21 | 0.22 |
| 4 | Humic acid(g $kg^{-1}$ ) | 0.40 | 0.52 |
| 5 | Fulvic acid(g $kg^{-1}$ ) | 4.28 | 4.29 |

Crop growth parameters such as plant height,root nodules,number of pods per plant as well as yield attributes *viz.,* dry matter production and grain yield of chickpea were recorded

extract was then allowed to stand overnight to get humic acid fraction. The supernatant liquid was siphoned off as fulvic acid and the suspension was centrifuged off at 3000 rpm for 10 minutes for the collection of humic acid precipitates which were then dried and weighed (Konnonova, 1966) and the initial values were presented (Table 1).

## RESULTS AND DISCUSSION

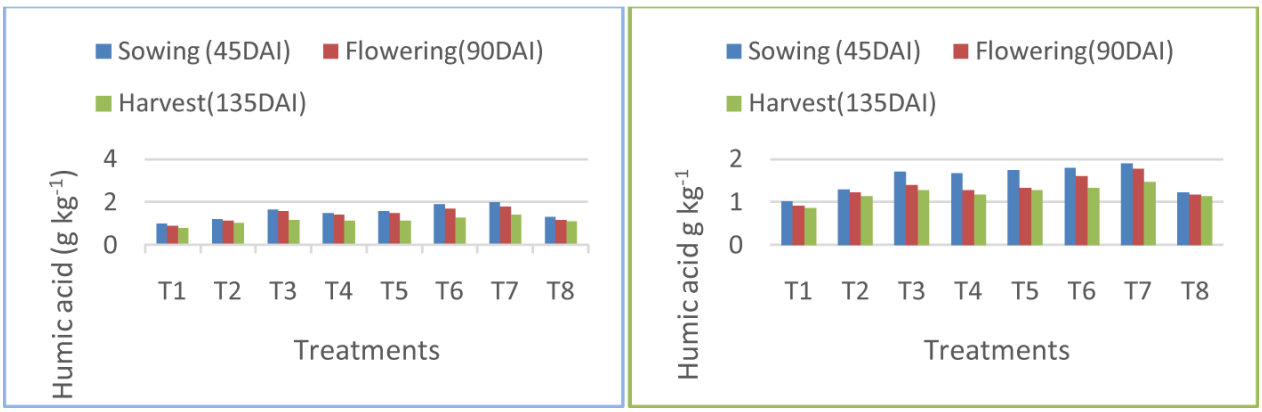
**Humic acid:**The data pertaining to humic acid (Table 2) illustrated in Figure 1 revealed there was a significant influence of treatments on humic acid content throughout the crop growth period during both the years of study. The humic acid content was decreased from sowing to harvest in all the treatments indicating that the microbial decomposition occurred efficiently. The higher humic acid content in theearlier period of decomposition might be due to inoculation of korra crop residue with microbial consortia consisting of bacteria and fungi. The decrease in humic acid content with maturity of crop might be due to degradation of humic acid by microorganisms. Similar significant effect on humic acid content by inoculation of wheat straw with microorganisms was earlier reported by Zhu *et al*. (2023) and Li *et al.* (2021).

Among the treatments, the highest humic acid content was observed in $T_7$ treatment which received crop residue @ 1.5 t $ha^{-1}$ along with 3.0 kg microbial consortia and 3.0 kg urea + 15 kg SSP at different stages of crop growth *viz*., sowing, flowering and at harvest (2.0 g $kg^{-1}$, 1.8 and 1.43 g $kg^{-1}$ soil, respectively in 2017-18 and 1.9, 1.77 and 1.47 g $kg^{-1}$ soil, respectively in 2018-19) and it was on a par with the treatment $T_{6,}$ which received crop residue@1.5 t $ha^{-1}$ along with 3.0 kg microbial consortia and 1.5 kg urea + 7.5 kg SSPat all the stages of crop growth. The highest percent improvement was observed in $T_7$ over initial, control ($T_1$) and RDF ($T_8$) were 150, 100 and 54, respectively during 2017-18, whereas,121%, 88% and 54%, respectively at harvest during 2018-19.

Furthermore, it was observed that the treatments which received crop residue along with microbial consortia had recorded higher contents of humic acid and the results clearly indicated that the microorganisms present in the microbial consortia played an important role in synthesis of humic acid during decomposition of korra residue. The results were in tune with the findings of Gouthami (2018) who reported higher contents of humic acid with addition of crop residue and green manure.The treatment $T_8$ which received recommended dose of fertilizers recorded higher humic acid content than the treatment $T_2$ which received only crop residue at flowering and at harvest. The positive effect of inorganic fertilizers on humic acid might be due to the addition of higher biomass in the form of root residue which might have produced more amount of humus fraction (Meshram *et al*., 2016). Similar results were reported by Patel *et al*. (2018) in soyabean-wheat crop sequence.The positive influence of humic acid on plant growth and productivity could be mainly due to activates of the humic acid through their involvement in cell respiration, photosynthesis, oxidative phosphorylation, protein synthesis and various enzymatic reactions.

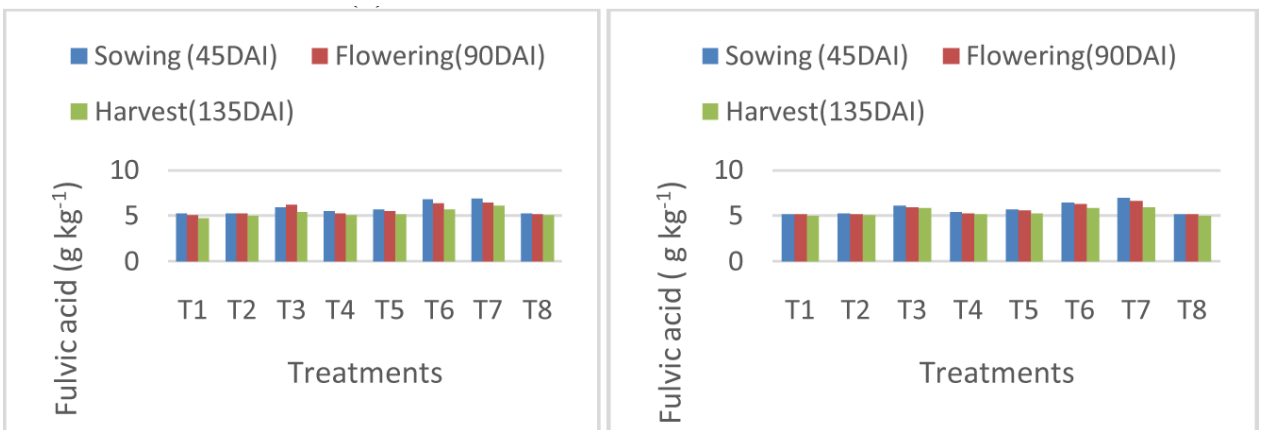
**Fulvic acid:**The data pertaining to fulvic acid was given (Table 2 & Figure 2) revealed significant influence of treatments on fulvic acid content throughout the crop growth period during both the years of study and the content was decreased from sowing to harvest in all the treatments.Among the treatments, the highest fulvic acid content at sowing(6.93 and 6.97 g $kg^{-1}$), at flowering (6.47 and 6.6 g $kg^{-1}$) and at harvest (6.13 and 5.96 g $kg^{-1}$) was observed in $T_7$ treatment which received crop

residue @ 1.5 t ha$^{-1}$ along with 3.0 kg microbial consortiaand 3.0 kg urea + 15 kg SSP in 2017-18 and 2018-19 respectively. The next best treatment with respect to fulvic acid content was $T_6$ (crop residue @1.5 t ha$^{-1}$ and 1.5 kg urea + 7.5 kg SSP along with 3.0 kg microbial consortia) followed by $T_3$ (crop residue@1.5 t ha$^{-1}$ along with microbial consortia) at all the stages of crop growth. Similarly, Li *et al.* (2022) reported a higher fulvic acid content in crop waste and in manure applied treatments than control.




(a) (b)

**Figure 1. Effect of incorporation of korra residue on humic acid content of soil in chickpea during 2017-18 (a) and 2018-19 (b)**




(a) (b)

**Figure 2. Effect of incorporation of korra residue on fulvic acid content of soil in chickpea during 2017-18(a) and 2018-19 (b)**

**Plant height:** The data on plant height measured at harvest of chickpea during both the years of study (Table 3) revealed that incorporation of korra residue along with microbial consortia and starter dose of inorganic N and P fertilization significantly influenced the growth of chickpea. Among the treatments, the plant height ranged from 19.47 cm to 26.0 cm and 19.53 cm to 25.67 cm with a mean of 21.73 cm and 21.66 cm, respectively during 2017-18

**Table2. Effect of incorporation of korra residue on humic and fulvic acid content in soil at different crop growth stages of chickpea**

| Treatment details | Humic acid (g $kg^{-1}$) | | | | | | Fulvic acid (g $kg^{-1}$) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2017-18 | | | 2018-19 | | | 2017-18 | | | 2018-19 | | |
| | Sowing (45DAI) | Flowering (90DAI) | Harvest (135DAI) | Sowing (45DAI) | Flowering (90DAI) | Harvest (135DAI) | Sowing (45DAI) | Flowering (90DAI) | Harvest (135DAI) | Sowing (45DAI) | Flowering (90DAI) | Harvest (135DAI) |
| $T_1$: Absolute control | 1.00 | 0.89 | 0.80 | 1.01 | 0.91 | 0.87 | 5.23 | 5.10 | 4.70 | 5.17 | 5.15 | 5.00 |
| $T_2$: Crop residue @ 1.5 t $ha^{-1}$ | 1.20 | 1.13 | 1.03 | 1.30 | 1.22 | 1.13 | 5.30 | 5.27 | 4.97 | 5.30 | 5.17 | 5.10 |
| $T_3$: $T_2$ + 3.0 kg Microbial consortium | 1.67 | 1.57 | 1.17 | 1.70 | 1.40 | 1.27 | 5.97 | 6.23 | 5.43 | 6.10 | 5.93 | 5.83 |
| $T_4$: $T_2$ + 1.5 kg Urea + 7.5 kg SSP | 1.50 | 1.40 | 1.14 | 1.68 | 1.27 | 1.17 | 5.50 | 5.30 | 5.07 | 5.47 | 5.30 | 5.16 |
| $T_5$: $T_2$ + 3.0 kg Urea + 15 kg SSP | 1.57 | 1.47 | 1.15 | 1.75 | 1.33 | 1.28 | 5.70 | 5.50 | 5.13 | 5.70 | 5.57 | 5.24 |
| $T_6$: $T_3$ + 1.5 kg Urea + 7.5 kg SSP | 1.90 | 1.70 | 1.27 | 1.79 | 1.60 | 1.32 | 6.80 | 6.37 | 5.73 | 6.47 | 6.27 | 5.89 |
| $T_7$: $T_3$ + 3.0 kg Urea +15 kg SSP | 2.00 | 1.80 | 1.43 | 1.90 | 1.77 | 1.47 | 6.93 | 6.47 | 6.13 | 6.97 | 6.60 | 5.96 |
| $T_8$: RDF (20-50-40) of N,$P_2O_5$& S kg $ha^{-1}$ | 1.30 | 1.17 | 1.10 | 1.23 | 1.18 | 1.14 | 5.23 | 5.17 | 5.10 | 5.20 | 5.20 | 5.03 |
| **SE (m)±** | 0.08 | 0.07 | 0.07 | 0.11 | 0.10 | 0.05 | 0.29 | 0.24 | 0.25 | 0.30 | 0.32 | 0.23 |
| **CD (0.05)** | 0.24 | 0.22 | 0.20 | 0.35 | 0.31 | 0.16 | 0.87 | 0.72 | 0.75 | 0.92 | 0.96 | 0.69 |
| **CV (%)** | 8.97 | 9.13 | 10.14 | 12.80 | 13.18 | 7.54 | 8.47 | 7.27 | 8.11 | 9.11 | 9.76 | 7.27 |

* DAI-Days after incorporation

and 2018-19. Among the treatments, maximum plant height was recorded in $T_8$ (26.0 cm and 25.67 cm) followed by $T_7$ (23.33 and 23.67 cm) during 2017-18 and 2018-19, respectively. The treatment $T_8$ was on par with $T_7$ and$T_6$ during both the years of study. The highest plant height in $T_8$ might be due to higher available N, P and S which increases chlorophyll content, photosynthesis, cell elongation and cell division led to increased plant height was reported earlier by Wong *et al.* (2015). Similarly, Dhar *et al*. (2014) observed increase in plant height when wheat straw was incorporated.

**Root nodules:** The data on root nodules counted at 30 days after sowing of chickpea during both the years of study (Table 3) indicated that numbers of root nodules per plant were significantly influenced by the treatments. Among the treatments, the highest numbers of root nodules per plant were recorded in $T_7$ (15 and 14) followed by $T_6$ (14 and 12) during 2017-18 and 2018-19, respectively. The highest number of root nodules in treatment $T_7$ might be due to the improved root colonization by the nitrogen fixing bacteria. The results are corroborated with Verma and Jadhav (2018).

**Number of pods:** The data on number of pods per plant counted at harvest of chickpea were significantly influenced by the treatments during both the years of study (Table 3). Among the treatments, the highest number of pods per plant were recorded in $T_8$ (26 and 24) followed by $T_7$ (22 and 21) during 2017-18 and 2018-19, respectively. This might be due to greater number of flowers per plant and availability of photosynthates, nutrients and metabolites that produce more number of pods in $T_8$.

**Drymatter:**The dry matter production was significantly influenced by the treatments during both the years of experimentation (Table 3). Among the treatments significantly the highest dry matter was recorded both at flowering (553 kg $ha^{-1}$and 568 kg $ha^{-1}$) and at harvest (1196 and 1182 kg $ha^{-1)}$ in treatment $T_8$ and it was at par with $T_7$ at flowering during 2017-18 and 2018-19, respectively. However, the treatment $T_7$ was on par with $T_6$ while the lowest dry matter was obtained in treatment $T_1$ (absolute control) at flowering (400 and 407 kg $ha^{-1}$) and at harvest (620 and 637 kg $ha^{-1}$) in the first and the second year, respectively. The dry matter production at the time of flowering is significantly correlated with humic and fulvic acid produced (0.937**).

**Grain yield:** The data (Table 3) revealed that grain yield was significantly influenced by the treatments during both the years of study. Among the treatments the grain yield ranged from 560 to 1097 kg $ha^{-1}$ and from 546 to 1058 kg $ha^{-1}$ with an average of 808 and 802 kg $ha^{-1}$ during 2017-18 and 2018-19, respectively. Significantly higher grain yield was recordedin treatment $T_8$ (RDF) (1097 and 1058 kg $ha^{-1}$) and lowest was recorded in absolute control *i.e.*$T_1$(560 and 546 kg $ha^{-1}$) during 2017-18 and 2018-19, respectively. The treatments $T_3$ to $T_7$ which received crop residue either in integration with microbial consortia or microbial consortia along with starter dose of N and P fertilization recorded higher yields. This might be due to mineralization process and release ofsecondary and micronutrients along with major nutrients and better synchrony of nutrient availability slowly throughout the growth period which resulted in better plant growth and higher yields. Starter dose of fertilization along with crop residue might have improved the soil health and consequently higher uptake of available nutrientsfromthe soil and increased the yield components, morphological and physiological characteristics which ultimately attributed to increased grain yield. The results corroborated the findings of Khamadi *et al.*(2017) and Pandiaraj *et al.* (2015) who reported abetter performance of crops inresidue retained plots, of mungbean with wheat residue incorporation and improvement in productivity of cereal cropping systems with incorporation of legume residues,

**Table3.Effect of incorporation of korra residue on performance of chickpea**

| Treatment details | 2017-18 | | | 2018-19 | | |
|---|---|---|---|---|---|---|
| | Plant height(cm) | No of root nodules per plant | No of Pods per plant | Plant height(cm) | No of root nodules per plant | No of Pods per plant |
| $T_1$: Absolute control | 19.47 | 6 | 12 | 19.53 | 5 | 11 |
| $T_2$: Crop residue @ 1.5 t $ha^{-1}$ | 19.53 | 13 | 14 | 19.87 | 12 | 13 |
| $T_3$: $T_2$ + 3.0 kg Microbial consortium | 22.00 | 14 | 18 | 22.27 | 13 | 16 |
| $T_4$: $T_2$ + 1.5 kg Urea + 7.5 kg SSP | 19.40 | 11 | 15 | 20.10 | 10 | 13 |
| $T_5$: $T_2$ + 3.0 kg Urea + 15 kg SSP | 20.40 | 12 | 16 | 20.70 | 11 | 14 |
| $T_6$: $T_3$ + 1.5 kg Urea + 7.5 kg SSP | 22.70 | 14 | 19 | 22.47 | 12 | 17 |
| $T_7$: $T_3$ + 3.0 kg Urea +15 kg SSP | 23.33 | 15 | 22 | 23.67 | 14 | 21 |
| $T_8$:RDF (20-50-40) of N,$P_2O_5$&S kg $ha^{-1}$ | 26.00 | 8 | 26 | 25.67 | 7 | 24 |
| **SE(m)±** | 1.11 | 0.36 | 0.90 | 1.10 | 0.54 | 0.92 |
| **CD@ 5%** | 3.38 | 1.11 | 2.74 | 3.33 | 1.64 | 2.80 |
| **CV(%)** | 8.88 | 10.31 | 9.00 | 8.78 | 14.92 | 10.15 |

*DAI-Days after incorporation

**Table 4.Effect of incorporation of korra crop residue on yield of succeedingchickpea**

| Treatment details | 2017-18 | | | 2018-19 | | |
|---|---|---|---|---|---|---|
| | Dry matter (kg $ha^{-1}$) | | Grain yield (kg $ha^{-1}$) | Dry matter (kg $ha^{-1}$) | | Grain yield (kg $ha^{-1}$) |
| | Flowering (45 DAI) | Harvest (135 DAI) | | Flowering (45 DAI) | Harvest (135 DAI) | |
| $T_1$: Absolute control | 400 | 620 | 560 | 407 | 637 | 546 |
| $T_2$: Crop residue @ 1.5 t $ha^{-1}$ | 410 | 740 | 680 | 423 | 760 | 663 |
| $T_3$: $T_2$ + 3.0 kg Microbial consortium | 464 | 957 | 860 | 469 | 934 | 877 |
| $T_4$: $T_2$ + 1.5 kg Urea + 7.5 kg SSP | 411 | 783 | 708 | 457 | 778 | 690 |
| $T_5$: $T_2$ + 3.0 kg Urea + 15 kg SSP | 412 | 807 | 720 | 480 | 800 | 701 |
| $T_6$: $T_3$ + 1.5 kg Urea + 7.5 kg SSP | 470 | 1017 | 883 | 490 | 973 | 887 |
| $T_7$: $T_3$ + 3.0 kg Urea +15 kg SSP | 495 | 1063 | 963 | 511 | 1093 | 967 |
| $T_8$: RDF (20-50-40) of N,$P_2O_5$&S kg $ha^{-1}$ | 553 | 1196 | 1097 | 568 | 1182 | 1058 |
| **SE(m)±** | 22 | 52 | 48 | 25 | 53 | 43 |
| **CD @ 5%** | 67 | 159 | 146 | 76 | 162 | 129 |
| **CV(%)** | 8 | 10 | 10 | 9 | 10 | 9 |

* DAI-Days after incorporation

respectively. Furthermore, it was attributed that the biological nitrogen fixation by chickpea might have increased due to better activity of rhizobia because of congenial conditions in the rhizospheric soil on incorporation of korra crop residue which led to improved crop growth and higher yield of chickpea.

## CONCLUSIONS

The crop growth, yield attributes and yield of chickpea at harvest were significantly influenced by the treatments during both the years of study. Among the treatments, significantly superior crop growth, number of pods per plant, drymatter at flowering and grain yield were recorded in the treatment $T_8$ (RDF) and it was on par with $T_7$ (crop residue @ 1.5 t $ha^{-1}$ along with 3.0 kg microbial consortium + 3 kg urea and 15 kg SSP) while lowest values were recorded in the treatment $T_1$ (absolute control). Significantly higher contents of humic and fulvic acids were recorded in $T_7$ treatment. Incorporation of korra crop residue 45 days before sowing along with microbial consortia consisting fungi and bacterial isolates in $T_7$ treatment have accelerated the process of decompositionand the resulted humic and fulvic acids have increased the growth and yield of chickpea.

## REFERENCES

Ali, J., Li, Y., Wang, X., Zhao, J., Xi, N., Zhang, Z and Xia, X. 2020. Climate-zone-dependent effect mechanism of humic acid and fulvic acid extracted from river sediments on aggregation behavior of graphene oxide. Science ofthe Total Environment; 721: 137682.

Deekshitha,D.K. D. 2021. Studies on soil health and carbon pools under integrated nitrogen management in rice-maize cropping system. Ph.D. Thesis submitted to ANGRAU, Lam, Guntur.

Dhar, D., Datta, A., Basak, N., Paul, N., Badole, S and Thomas, T.2014. Residual effect of crop residues on growth, yield attributes and soil properties of wheat under rice-wheat cropping system. Indian Journal of Agricultural Research. 48(5): 373-378.

Directorate of Economics and Statistics. 2020. Area, production and productivity of cotton in India. Retrieved from the website (https://eands.dacnet.nic.in) on 20.6.2023.

Gouthami, N. 2018. Carbon sequestration and soil health under long term soil fertility management in rice-rice cropping system. Ph.D. Thesis submitted to ANGRAU, Lam, Guntur.

Khamadi, Fatemeh, Mossa Mesgarbashi and Pyman Hassibi. 2017.The effect of wheat residue management and nitrogen levels on yield and yield component of mungbean (*Vigna radiata)*. Iranian Journal Pulses Research. 8(2): 96-108.

Kononova, M.M. 1966. Soil organic matter, its nature, origin and role in soil fertility (2nd Edition). Pergamon Press, Oxford.

Li, L., Guo, X. P., Zhao, T. N., Liu, L and Li, T. Y. 2021. Identifying the key environmental factors and bacterial communities in humification and their relationships during green waste composting. Applied Ecology and Environmental Research. 19: 45-62.

Li, Z., Chen, Q., Gao, F., Meng, Q., Li, M., Zhang, Yand Liu, Z. 2022. Controlled release urea combined with fulvic acid enhanced carbon/nitrogen metabolic processes and maize growth. Journal of the Science of Food and Agriculture. 102(9): 3644-3654.

Meshram, N. A., Ismail, Sand Patil, V. D. 2016. Long-term effect of organic manuring and inorganic fertilization on humus fractionation, microbial community and enzymes assay in Vertisol. Journal of Pure and Applied Microbiology. 10(1): 139-150.

Pandiaraj, T., Selvaraj, S and Ramu, N. 2015. Effects of crop residue management and nitrogenfertilizer on soil nitrogen and carbon content and productivity of wheat (*Triticum aestivum* L.) in two cropping systems. Journal of Agricultural Science and Technology.17: 249-260

Patel, G., Dwivedi, B. S., Dwivedi, A. K., Thakur, R and Singh, M. 2018. Long-term effect of nutrient management on soil biochemical properties in a vertisol under soybean-wheat cropping sequence. Journal of the Indian Society of Soil Science. 66(2): 215-221.

Tang, H., Xiao, X., Tang, W., Wang, K., Li, C and Cheng, K. 2017. Returning winter cover crop residue influences soil aggregation and humic substances under double-cropped rice fields. Revista Brasileira de Ciência do Solo. pp. 41.

Verma, J. P and Yadav, J. 2018. Implication of microbial consortium on biomass and yield of chickpea under sustainable agriculture. Environmental Engineering and Management Journal. 17(3): 34-39.

Wong, W. S., Tan, S. N., Ge, L., Chen, Xand Yong, J. W. H. 2015. The importance of phytohormones and microbes in biofertilizers. Bacterial Metabolites in Sustainable Agroecosystem. pp. 105-158.

Zhu, L., Zhao, Y., Yao, X., Zhou, M., Li, W., Liu, Zand Hu, B. 2023. Inoculation enhances directional humification by increasing microbial interaction intensity in food waste composting. Chemosphere. 322:138191.

Suvarna Latha, A.J., Ratna Prasad, P., Trimurtulu, N and Srinivasa Rao, V. 2023. Effect of korra (*Setaria italica*) crop residue in corporation along with microbial consortia on humic acid, fulvic acid content in soil and performance of chickpea (*Cicer arietinum*). The Journal of Research ANGRAU. 51(3): 45-54.
DoI: https://doi.org/10.58537/jorangrau.2023.51.3.06

DoI: https://doi.org/10.58537/jorangrau.2023.51.3.07

J. Res. ANGRAU 51 (3) 55-60, 2023

# STUDIES ON GENETIC VARIABILTY FOR YIELD AND FIBRE QUALITY TRAITS IN UPLAND COTTON (*Gossypium hirsutum* L.)

**M. DIVYA*, N. SABITHA and K. MOHAN VISHNUVARDHAN**

Department of Genetics and Plant Breeding, Agricultural College,

Acharya N.G. Ranga Agricultural University, Mahanandi - 518 502

Date of Receipt :13.5.2023 Date of Acceptance : 21.7.2023

## ABSTRACT

Thirty genotypes of cotton were studied to estimate genetic variability, heritability (broad sense) and genetic advance for 15 traits during *kharif,* 2022. Analysis of variance showed significant amount of variation among the genotypes for traits studied. PCV was greater than GCV for all the traits except days to 50% flowering. High PCV and GCV were recorded for number of monopodial branches, lint index, lint yield and ginning percentage. High heritability coupled with genetic advance as percent of mean was observed for number of monopodial branches, plant height, seed cotton yield, lint index, lint yield, ginning percentage and micronaire indicating preponderance of additive gene action and hence simple selection would be effective for the improvement of these traits.

**Key words**: Genetic advance, heritability, upland cotton, variability

## INTRODUCTION

Cotton remains the important fibre in the Indian textile industry, despite stiff competition from man-made synthetic fibres. Cotton is the most important natural fibre used in the textile industry worldwide, accounting for approximately 50% of all fibres. It is vital to the country's industrial and agricultural economies. Cotton production, processing and trade in cotton goods employ approximately 60 million people in India, giving it a place of pride in the Indian economy.

Cotton is a widely cultivated profitable fibre crop that has received a lot of attention in research (Haidar *et al*., 2012). Furthermore, raw cotton, yarn, textile, garments, cotton seed cake, oil and other byproducts are exported, earning valuable foreign exchange. It is cultivated on an average in 6.0 lakh hectares with a production of 20 lakh bales and a productivity of 580 kg $ha^{-1}$ in Andhra Pradesh. Cotton is a member of the *Malvaceae* family and the genus *Gossypium*. Only four gossypium species have been cultivated for fibre: *Gossypium arboreum, Gossypium herbaceum, Gossypium hirsutum* and *Gossypium barbadense*. India is the only country in the world that can grow all four species. Because of its wider adaptability, higher yield and good fibre quality, the species *Gossypium hirsutum* L. have been growing in larger proportion; it gradually replaced Asiatic diploid cottons and was grown under irrigated as well as rain fed conditions. Upland cotton *(Gossypium hirsutum* L.) is the world's leading fibre producing crop, grown in over 80 countries (Dutt *et al*., 2004). *G. hirsutum*

*Corresponding Author E-mail i.d: divyamanchikanti278@gmail.com; M.Sc. thesis submitted to Acharya N.G. Ranga Agricultural University, Guntur - 522 034

varieties and hybrids account for approximately 75% of area and 85% of cotton production. This has become the primary focus of research because its cultivars meet 90% of the world's bulk cotton demand. Genetic variability is the basis for genetic improvement in any crop. Availability of sufficient variability helps in the selection of desirable genotypes. Higher variability coupled with high heritability and genetic advance gives the most effective response to selection for any character. (Baloch *et al*., 2004). In the investigation, genetic variability for yield and fibre quality traits were assessed through genetic parameters so as to identify the traits for use in breeding programmes.

## MATERIALS AND METHODS

The investigation was carried out during *kharif,* 2022-23 at Regional Agricultural Research Station (RARS), Nandyal, Andhra Pradesh.The experimental material comprising 30 genotypes of cotton were raised in randomized block design and replicated thrice. Each genotype was planted in two rows of five meters length adopting a spacing of 60 cm x 30 cm. Need based plant protection measures were followed in raising a healthy crop.Observations on five randomly selected plants in each genotype were recorded for days to 50% flowering, days to maturity, number of monopodial branches, plant height, bolls per plant, boll weight, seed cotton yield, lint index, lint yield, ginning percentage and fibre quality traits *viz.,* fibre length, micronaire, fibre strength, uniformity index and fibre elongation.Genetic parameters *viz*., phenotypic coefficient of variance (PCV) and genotypic coefficient of variance (GCV), heritability in broad sense and genetic advance as per cent of mean were estimated. The genotypic means for each trait over three replications were subjected to the statistical analysis following INDOSTAT statistical package version 2022.

## RESULTS AND DISCUSSION

Greater variability ensures better chances of producing desired genotypes of a crop plant. The main goal of germplasm conservation is to gather and maintain the genetic diversity of native crop species so that it is accessible to both current and future generations. In the study, significant differences among genotypes for each of the investigated traits were recorded indicating the presence of genotype variability. Higher the heritability, simpler the selection process and greater the response to selection. The details of analysis of variance, genetic variability, heritability and genetic advance as percent of mean estimates were furnished in Tables 1 and Table 2.

Significant variation among the genotypes for the examined traits was recorded for yield and fibre quality traits. Recorded mean values for days to 50% flowering (58.78), days to maturity (103.88), number of monopodial branches (0.88), plant height (97.31), number of bolls per plant (18.60), boll weight (0.30), seed cotton yield (842.68), lint index (5.96), lint yield (276.30), ginning percentage (31.15), fibre length (26.67), micronaire (3.62), fibre strength (26.06), uniformity index (80.21) and fibre elongation (6.10). Range of variation for days to 50% flowering from (53.67 to 64.67), days to maturity (99.00 to 109.00), number of monopodial branches (0.33 to 1.34), plant height (78.83 to 113.90), number of bolls per plant (13.67 to 22.53), boll weight (0.24 to 0.34), seed cotton yield (540.10 to 1261.33), lint index (2.45 to 13.79), lint yield (183.49 to 375.47), ginning percentage (33.97 to 27.91), fibre length (24.50 to 29.03), micronaire (2.33 to 4.70), fibre strength (23.15 to 29.20), uniformity index (77.30 to 82.97) and fibre elongation (5.95 to 6.27).

**Table 1. Analysis of variance for yield and fibre quality traits in upland cotton**

| S. No. | Characters | Mean sum of squares | | |
|---|---|---|---|---|
| | | Replications (df:2) | Treatments (df:29) | Error (df:58) |
| 1 | Days to 50% flowering | 1.0111 | 31.89** | 1.5628 |
| 2 | Days to maturity | 7.6444 | 23.25** | 2.5525 |
| 3 | No. of monopodial branches | 0.0002 | 0.4098** | 0.0006 |
| 4 | Plant height (cm) | 55.016 | 376.63** | 21.084 |
| 5 | No. of bolls plant$^{-1}$ | 18.0107 | 18.4754** | 5.7716 |
| 6 | Boll weight (g) | 0.0018 | 0.0018** | 0.0006 |
| 7 | Seed cotton yield (kg ha$^{-1}$) | 4605.385 | 90999.98** | 11521.59 |
| 8 | Lint index (g) | 0.2448 | 20.7150** | 0.2306 |
| 9 | Lint yield (Kg ha$^{-1}$) | 0.2306 | 10329.74** | 785.32 |
| 10 | Ginning percentage (%) | 7.4621 | 3.7556** | 2.5968 |
| 11 | Fibre length (mm) | 0.3908 | 4.7409** | 0.9781 |
| 12 | Micronaire (µg inch$^{-1}$) | 0.0534 | 0.9464** | 0.0422 |
| 13 | Fibre strength (g tex$^{-1}$) | 4.7626 | 7.0073** | 2.1380 |
| 14 | Uniformity index (%) | 6.1314 | 6.7882** | 3.2133 |
| 15 | Fibre elongation (%) | 0.0197 | 0.0240** | 0.0097 |

**** : Significant at 1% level of probability**

High estimates of PCV and GCV were recorded for number of monopodial branches (42.09% and 41.99%), lint index (44.61% and 43.88%), lint yield (22.79% and 20.41%) and ginning percentage (25.16% and 23.88%) respectively. Moderate PCV and GCV were observed for plant height (12.14% and 11.19%), number of bolls per plant (13.64% and 11.70%), micronaire (16.21% and 15.18%) while low PCV and GCV were noted for days to 50% flowering (5.41% and 5.81%), days to maturity (2.96% and 2.53%), fibre length (5.60% and 4.20%), fibre strength (7.44% and 4.89%), uniformity index (2.62% and 1.36%) and fibre elongation (1.97% and 1.13%) respectively. Moderate PCV (10.63%) and low GCV (6.91%) was exhibited by boll weight where as high PCV (23.14%) and moderate GCV (19.32%) was observed by seed cotton yield. These results are in line with those of Aarthi *et al*. (2018) for days to 50% flowering; Khan *et al*. (2018) for days to maturity, Meena *et al*. (2022) for number of monopodial branches, plant height, boll weight, seed cotton yield, lint yield, fibre length and fibre strength; Siva Prasad *et al*. (2005) for number of bolls per plant, Kumar *et al*. (2019), Parre and Patil (2021) for lint index; Wadeyar and Kajjidoni (2021) for ginning percentage and Pandiyan *et al.* (2019) for micronaire, uniformity index and fibre elongation.

**Table 2. Mean, range, coefficient of variation, heritability (broad sense) and genetic advance as per cent of mean for yield and fibre quality traits in uplandcotton**

| S.No. | Character | Range | | | Coefficient ofvariation | | Herita-bility (broad sense)(%) | Genetica-dvance aspercen-tofmean |
|---|---|---|---|---|---|---|---|---|
| | | Mean | Minimum | Maximum | PCV(%) | GCV(%) | | |
| 1 | Days to 50% flowering | 58.78 | 53.67 | 64.67 | 5.41 | 5.81 | 86.60 | 10.37 |
| 2 | Days to maturity | 103.88 | 99.00 | 109.00 | 2.96 | 2.53 | 73.00 | 4.45 |
| 3 | No. of monopodial branches | 0.88 | 0.33 | 1.34 | 42.09 | 41.99 | 99.50 | 86.30 |
| 4 | Plant height (cm) | 97.31 | 78.83 | 113.90 | 12.14 | 11.19 | 84.90 | 21.24 |
| 5 | No. of bolls plant$^{-1}$ | 18.60 | 13.67 | 22.53 | 13.64 | 11.70 | 73.60 | 20.69 |
| 6 | Boll weight (g) | 0.30 | 0.24 | 0.34 | 10.63 | 6.91 | 42.30 | 9.27 |
| 7 | Seed cotton yield (kg ha$^{-1}$) | 842.68 | 540.10 | 1261.33 | 23.14 | 19.32 | 69.70 | 33.22 |
| 8 | Lint index (g) | 5.96 | 2.45 | 13.79 | 44.61 | 43.88 | 96.70 | 88.90 |
| 9 | Lint yield (kg ha$^{-1}$) | 276.30 | 183.49 | 375.47 | 22.79 | 20.41 | 80.20 | 37.66 |
| 10 | Ginning percentage (%) | 31.15 | 33.97 | 27.91 | 25.16 | 23.88 | 90.00 | 46.67 |
| 11 | Fibre length (mm) | 26.67 | 24.50 | 29.03 | 5.60 | 4.20 | 56.20 | 6.48 |
| 12 | Micronaire (µg inch$^{-1}$) | 3.62 | 2.33 | 4.70 | 16.21 | 15.18 | 87.70 | 29.30 |
| 13 | Fibre strength (g tex$^{-1}$) | 26.06 | 23.15 | 29.20 | 7.44 | 4.89 | 43.20 | 6.62 |
| 14 | Uniformity index (%) | 80.21 | 77.30 | 82.97 | 2.62 | 1.36 | 27.10 | 1.46 |
| 15 | Fibre elongation (%) | 6.10 | 5.95 | 6.27 | 1.97 | 1.13 | 32.90 | 1.34 |

Moderate values of heritability and low genetic advance were observed for boll weight (42.30% and 9.27%), fibre length (56.20% and 6.48%), fibre strength (43.20% and 6.62%), uniformity index (27.10% and 1.46%) and fibre elongation (32.90% and 1.34%). High heritability and low genetic advance was observed for days to maturity (73.00% and 20.69%). High heritability coupled with genetic advance as per cent of mean was observed for number of monopodial branches (99.50% and 86.30%), plant height (89.40% and 21.24%), seed cotton yield (69.70% and 33.22%), lint index (96.70% and 88.90%), lint yield (80.20% and 37.66%), ginning percentage (99.00% and 46.67%) and micronaire (87.70% and 29.30%) indicating preponderance of additive gene action. Hence, simple selection would be effective for the improvement of these traits. Mawlebei *et al*. (2022) for days to 50% flowering; Manonmani *et al*. (2019) for days to maturity; Meena *et al*. (2022) for number of monopodial branches; Mankar *et al*. (2021) for plant height; Iqbal *et al.* (2023) for number of bolls per plant; Gnanasekaran *et al*. (2020) for boll weight;Anjani *et al*. (2020) for seed cotton yield; Jyothi *et al*. (2021) for lint index; Kumar *et al*. (2019) for lint yield; Reddy *et al.* (2016) for ginning percentage; Reddy *et al*. (2019) for fibre length; Mahesh *et al*. (2020) for micronaire; Manonmani *et al*. (2019) for fibre strength; Pandiyan *et al*. (2019) for uniformity index and Erande *et al*. (2014) for fibre elongationin line with this study for heritability and genetic advance.

## CONCLUSIONS

High PCV, GCV coupled with high heritability and genetic advance was observed for number of monopodial branches, lint index, lint yield and ginning percentage. Greater estimates of GCV, PCV, heritability, and genetic advance as a percentage of mean suggested that these traits are mostly under the control of additive gene action and that genetic improvement may be achieved by direct selection for these traits.

## REFERENCES

Erande, C.S., Kalpande, H.V., Deosarkar, D.B., Chavan, S.K., Patil, V.S., Deshmukh, J.D., Chinchan, V.N., Anil, K., Utpal, D and Puttawar, M.R. 2014. Genetic variability, correlation and path analysis among different traits in *desi* cotton (*Gossypium arboreum* L.). African Journal of Agricultural Research. 9 (29): 2278-2286.

Gnanasekaran, M., Thiyagu, K and Gunasekaran, M. 2020. Studies on genetic variability correlation and path analysis in upland cotton. Electronic Journal of Plant Breeding.11 (3): 981-986.

Jyoti, J.G., Valu, M.G and Geeta, O.N. 2021. Correlation, path coefficient and $D^2$ analysis study of seed cotton yield and fibre quality traits in American cotton (*Gossypium hirsutum* L.). Journal of Pharmacognosy and Phytochemistry. 10 (3): 222-230.

Khan, M., Mohibullah, M., Shah, S.N.M., Amin, M and Asmat, S. 2018. Genetic variability and morphological characterization of the elite upland cotton germplasm (*Gossypium hirsutum* L.). Journal of Genetics, Genomics and Plant Breeding. 2(4):1-8.

Kumar, C.P.S., Prasad, V., Joshi, J.L., Rajan, R.E.B and Thirugnanakumar, S. 2019. Studies on genetic variability, heritability and genetic advance in cotton (*Gossypium hirsutum* L.). Plant Archives. 19 (1): 618-620.

Mahesh, R. H., Patil, B. R., Katageri, I. S., Kumar B. N. A and Janagoudar,B.S. 2020. Genetic variability and correlation analysis for agronomic and fibre quality traits in intraspecific cotton (*G. hirsutum* × *G. hirsutum*) recombinant inbred lines (RILs). International Journal of Current Microbiology and Applied Sciences. 9 (1): 493-503.

Mankar, A.D., Deosarkar, D.B and Chinchane, V.N. 2021.Studies of genetic parameters foryield, yield contributing and fiber quality characters in desi cotton (*Gossypium arboreum* L.).The Pharma Innovation Journal. 10 (8): 42-44.

Manonmani, K., Mahalingam, L., Malarvizhi, D., Sritharan, N and Premalatha, N. 2019. Genetic variability, correlation and path analysis for seed cotton yield improvement in upland cotton (*Gossypium hirsutum* L.). Journal of Pharmacognosy and Phytochemistry. 8 (4):1358-1361.

Mawblei, C., Premalatha, N., Rajeswari, S., and Manivannan, A. 2022. Genetic variability, correlation and path analysis of upland cotton (*Gossypium hirsutum* L.) germplasm for seed cotton yield. Electronic Journal of Plant Breeding. 13 (3): 820-825.

Meena, A.K., Patil, S.S and Verma, L.K. 2022.genetic variability and heritability study in double cross $f_3$ lines of cotton (*G. hirsutum* L.). Biological Forum – An International Journal. 14 (1): 656-660.

Pandiyan, J., Ramalingam, A., Pillai, M.A and Saravanan, S. 2019.genetic parameters of economic and fibre characters in upland cotton (*Gossypium hirsutum* L.). International Journal of Current Microbiology and Applied Sciences. 8 (6): 2084-2090.

Parre, S and Patil, R.S. 2021. Genetic variability studies in early segregation generation ($F_3$) of intra-hirsutum cotton hybrids of line x tester crosses under the rainfed situation. The Pharma Innovation Journal. 10 (3): 951-955.

Reddy, B., Nimbal, S., Sangwan, R.S., Kumar, P., Sagar and Jangid, K. 2019. Genetic parameters, correlation and path analysis of agro-morphological traits in elite genotypes of upland cotton (*Gossypium hirsutum* L.). International Journal of Chemical Studies. 7 (5): 1885-1889.

Reddy, K.B., Reddy, V.C., Ahmed, M.L., Naidu, T.C.M and Rao, V.S. 2016. Studies on genetic divergence in upland cotton (*Gossypium hirsutum* L.).*T*he Andhra Agriculture Journal. 63 (1): 97-103.

Siva Prasad, U., Chenga Reddy, V and Narisi Reddy, A. 2005. Studies on genetic variability in american cotton (*Gossypium hirsutum* L.). Karnataka Journal of Agricultural Sciences. 18 (4): 1095-1098.

Wadeyar, B.S and Kajjidoni, S.T. 2021. Effect of irradiation and recombination on genetic enhancement of boll weight, boll number, fibre length and fibre strength among the progenies in *desi* cotton – An Innovative approach to improve in *desi* cotton. East African Scholars Journal of Agriculture and Life Sciences. 4 (2): 31-37.

Divya, M., Sabitha, N and Mohan Vishnuvardhan, K. 2023. Studies on genetic variability for yield and fibre quality traits in upland cotton (*Gossypium hirsutum* L.).
The Journal of Research ANGRAU. 51(3): 55-60.
DoI: https://doi.org/10.58537/jorangrau.2023.51.3.07

DoI: https://doi.org/10.58537/jorangrau.2023.51.3.08

J. Res. ANGRAU 51 (3) 61-74, 2023

# PERFORMANCE EVALUATION OF HEXACOPTER UAV (ANGRAU- PUSHPAK) SPRAYING FOR MANAGEMENT OF CHILLI THRIPS (*Thrips parvispinus)*

**A. SAMBAIAH*, L. PRASANTHI, CH MADHURI,K. PURNA CHANDRA RAO, N. KAMAKSHI, N.VENKATA LAKSHMI and K. GURAVA REDDY**

Centre for Andhra Pradesh Sensors and Smart Applications Research in Agriculture (APSARA), Acharya N. G. Ranga Agricultural University, Guntur- 522 034

Date of Receipt :15.6.2023 Date of Acceptance : 31.7.2023

## ABSTRACT

The study aimed at evaluating efficacy of UAV spraying in managing invasive thrips, *Thrips parvispinus* on chilli. The experiment was conducted at operational research project (ORP) site at Lam village of Guntur district during *kharif* 2022-23 with restricted randomized block design. The recommended doses of pesticides issued by Central Insecticide Board and Registration Committee(CIB&RC), GoI, New Delhi were adapted. The treatments imposed were of 100%, 75% and 50% RDP with UAV and 100% RDP with human backpack sprayer and a control plot with only water spraying with drone for asserting the efficacy of drone spraying when sprayed at low volume spraying (25 L $ha^{-1}$).The first spray to control thrips was carried out 112 DAS (Days After Sowing) with a spinetoram 11.7% SC on with analysis of pre and post spraying (5 days after spraying) results showed that the bio-efficacy when sprayed with 100% RDP (T1), 75% RDP(T2), 50% RDP (T3) with drone and 100% RDP with human back pack sprayer (T4) and control(T5)reduced number of thrips per flower from 7.57 to 5.8, 7.55 to 6.40, 7.55 to 10.22, 8.05 to 8.22, 8.05 to 12.95, respectively with a percent reduction over control of 50.75, 46.19, 23.65 and 36.57, respectively. The second spray was carried out at 119 DAS with Flubendiamide 19.92% +Thiacloprid 19.92% SC. The pre and post spraying (5 days after spraying) data analysis revealed that the reduction of thrips per flower over control in T1, T2, T3, T4 and T5 to 7.37, 8.32, 12.12, 10.25 and 16.03 and the percent reduction over control in T1, T2, T3 and T4 are 52.22%, 44.88%, 24.29% and 36.78%, respectively. The third spray with Fipronil 80% WG was carried out at 126 DAS and the pre and post spraying data analysis revealed that the number of thrips per flower are 5.27, 6.47, 10.55, 8.05 and 16.83 with a percent reduction over control of 68.83, 62.34, 22.08 and 38.96, respectively. The fourth spray was carried out at 133 DAS with spirotetramat 25.31% w/w OD and the pre and post spray data analysis revealed that the number of thrips per flower are of 5.12, 5.75, 9.5, 8.5 and 18.22 in T1, T2, T3, T4 and T5 and the percent reduction over control in T1, T2, T3 and T4 are 66.59, 61.68, 40.89 and 46.92, respectively. During the four sprays, it was observed that in all treatments, there was no phytotoxicity due to these chemicals spraying and the NDVI values recorded were 0.77, 0.76, 0.64, 0.72 and 0.34, respectively in the treatments T1, T2, T3, T4 and T5. The yields recorded were found to be 58.6, 55.2, 34.5, 53.8 and 14.1 q $ha^{-1}$. The incremental cost-benefit ratio (ICBR) was found to be highest (4.46) in 75% RDP spray with drone, when compared to 3.58 in 100% RDP, 2.82 in 50% RDP and 2.98 in 100%

*Corresponding Author E-mail i.d: sambaiah3103@angrau.ac.in

RDP with human backpack sprayer respectively. The bio-efficacy of all the chemicals revealed that 100% RDP and 75% RDP sprayed with drone are on par with each other, which offers an opportunity to reduce the dosage by25% if sprayed with drone for the same bio-efficacy with highest ICBR.

**Key Words***:* Chilli, Fipronil 80% WG, Spinetoram 11.7% SC, Spirotetramat 25.31% w/w OD, Flubendiamide 19.92% + Thiacloprid 19.92% SC, *Thrips parvispinus*, UAV spraying

## INTRODUCTION

Chilli (*Capsicum annuum L.*) is one of the important spices used all over the world in one or other form. The origin of chillies is considered to be New Mexico. India is not only the largest producer but also the largest consumer and exporter of chilli in the world. India is the largest producer with 1.98 million tonnes and contributes 43% of world chilli productionfollowed by China, Ethiopia, Thailand, Pakistan and Bangladesh. Important chilli growing states in India are Andhra Pradesh(tops the list with 4.07 lakh tonnes covered under 2.25 lakh ha with 1809 kg $ha^{-1}$ productivity), followed by Telangana, Madhya Pradesh, Karnataka and West Bengal.Guntur district in Andhra Pradesh alone produces 15% of all the chilli produced in India and the state of Andhra Pradesh as a whole contributes 26% of India's chilli production (Chilli Outlook 2021, des.ap.gov.in, 2021).The cultivation of chilli has become capital intensive due to main constraints of which the losses caused by insect pests and mites are significant.Major insects which damages chillicrop are *Thrips parvispinus*, Aphids and Mites. Beside pests, different pathogens (fungi, viruses, bacteria and nematodes) also cause various diseases in chilli crop and reduce yield of chilli.

*Thrips parvispinus* which is designated as one of the notorious pest species in South East Asia has become serious pest on numerous agriculture and horticulture crops in India. It was invadedto India and first reported

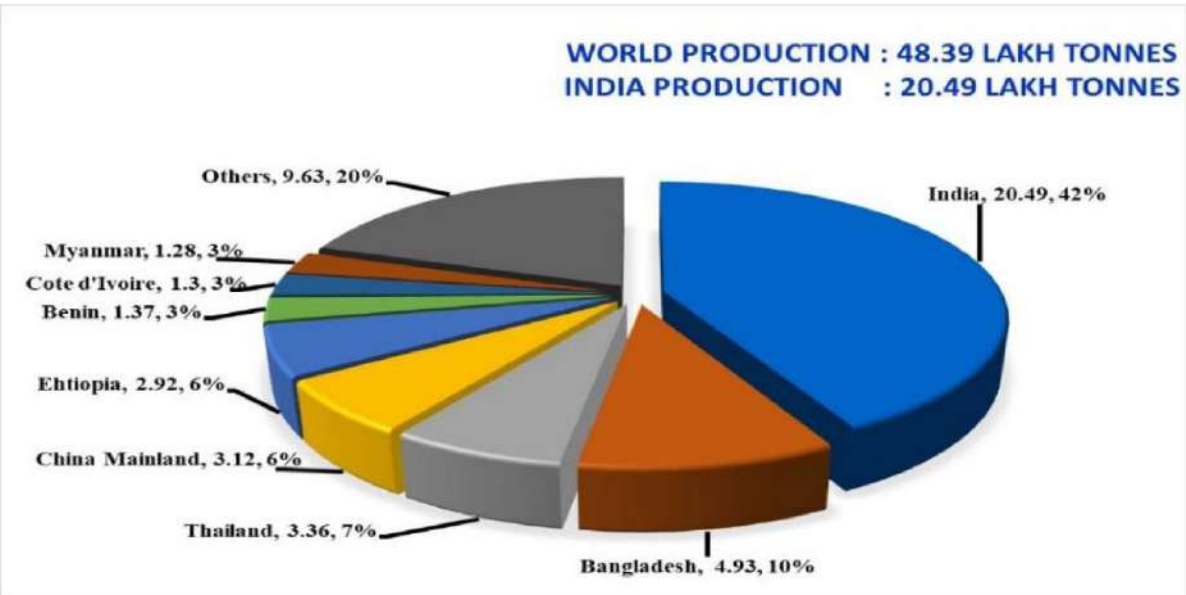



**Figure 1. Chilli production in the world during 2021 (production in lakh tonnes)**

in papaya in Bangalore during 2015(Tyagi *et al.,* 2015) and has since then spread to several other host species and states, including Andhra Pradesh.It was reported first time and noticed that it caused severe damage40-80% tochilli - capsicum crop ecosystemin Andhra Pradesh in 2021(Sireesha *et al.,* 2021). This pest was also observed in Telangana state during November,2021 (Anitha *et al.,* 2021) and Karnataka in December 2021 (Nagaraju *et al.* 2021) and spread to all chilli growing states (Rashmi *et al.,* 2022).

In the recent past, since 2020-21 onwards, the invasive pest *Thrips parvispinus* has caused significant damage to the chilli crop interms of productivity and production and compelled the farmers to increase the frequency of pesticide spraying schedules to control the same, which has increased the cost of cultivation. The availability of labour to take up intensive and frequent sprayings for controlling thrips is an important factor for timely crop protection. The labour problem for plant protection in chilli and other crops is found to be four-folded issuein terms of quantity, quality, cost and timely access.

This calls for efficient precision spraying technology which is more effective and efficient than human operated sprayers. According to Phang *et al.* (2014), an UAV has greater benefits over terrestrial vehicles such as tractors in terms of mobility. It is 40 times faster than the conventional backpack sprayer and can replace it. Using a drone sprayer results in a 90% reduction in water usage and a 30–40% reduction in insecticides.In this context, the present study of standard operating protocols, phytotoxicity and efficacy of UAV sprayer was initiated at Centre for Andhra Pradesh Sensors and Smart Applications Research in Agriculture (APSARA) of Acharya N. G. Ranga Agricultural University, Guntur to test the efficacy of spraying.

## MATERIALS AND METHODS

The research was conducted at Regional Agricultural Research Station, Lam, ANGRAU, Guntur during the year 2022-23 in *kharif* season. The phytotoxicity, bio-efficacy, plant and yield parameters were studied during the UAV spraying of CIB & RC recommended chemicals against *Thrips parvispinus* management.

### Design of plant protection UAV for Spraying

A hexacopter UAV was designed and standardized specifically for plant protection spraying in agricultural crops by Acharya N.G Ranga Agricultural University. The UAV built by ANGRAU with the specifications as discussed in Table 1, below was designated as “ANGRAU-Pushpak-01”, a model RPAS (Remotely Piloted Aircraft System). The registration approval pertaining to the “ANGRAU-Pushpak-01” was obtained based on guidelines issued by Directorate General of Civil Aviation (DGCA) for its usage in agricultural operations for research purpose.The specifications pertaining to technical parameters and payload data are detailed (Table 1).

Standardization of spraying height, time, direction of spray, drift, ambient temperature, time taken for drone flight, spray fluid volume and regularity of distribution of droplet deposition (vertical distribution) with ANGRAU Pushpak-01-UAV were done following the procedures given by DGCA, New Delhi.

### Bio efficacy studies on *Thrips parvispinus*

The bio-efficacy studies were conducted for four insecticides and their dosages recommended by CIB&RC sprayed with drone and human back pack sprayer against thrips in chilli crop were sequentially applied at seven days interval from 58$^{th}$ day after transplanting, *i.e.* 112$^{th}$ days after sowing, when the peak

**Table 1. Technical parameters of Remotely Piloted Aircraft System (RPAS) "ANGRAU-Pushpak-01" for plant protection research**

| S. No. | Classification | | Parameters |
|---|---|---|---|
| 1 | Official Designation | : | Model Remotely Piloted Aircraft System (RPAS approved by DGCA, Govt. of India) |
| 2 | Size (mm) | : | 1495 mm X1308 mm X500 mm (Arms unfolded with motor and without propellers) |
| 3 | Category of drone | : | 'Small' category with all up weight of 24.8 kg |
| 4 | Motors Type and Specification | : | BLDC (Brushless Direct Current) with 180 KV rating; Input Current: 80A; IPX7 |
| 5 | Maximum Thrust of each Motor | : | 12 kg/Axis (48V, Sea Level) |
| 6 | Battery Specification | : | 16,000 MAH capacity with charging C rating 5C and discharging C rating :15 C and Burst Discharge rating: 30C; 6S1P; 22.2 V and 355.2 Wh |
| 7 | Spray width | : | 2.8 m |
| 8 | Pay Load capacity | : | 12 kg |
| 9 | Maximum working efficiency | : | 6 minutes per acre |
| 10 | Spray system | : | Flatfan |
| 11 | Operation method | : | Autonomous |
| 12 | Positioning mode | : | Dual GPS (Global Positioning Systems) |
| 13 | Forward speed of the UAV | : | 5.5 m/s |
| 14 | Tank capacity | : | 12 L |
| 15 | Nozzle type | : | Flat fan |
| 16 | Number of nozzles | : | 4 Numbers (110015 VP) |
| 17 | Nozzle flow rate | : | 0.42 to 0.45 L per minute |
| 18 | Spraying direction | : | Vertically down |
| 19 | Spray angle | : | 110 degrees |
| 20 | Spray fluid volume | : | 25 L $ha^{-1}$ (Low volume and high concentration) |
| 21 | Spraying | : | Drone spraying (Aerial spraying) |
| 22 | Radio communication frequency | : | 2.40GHz -2.4833GHz |

**Figure 2. An UAV spraying of recommended chemicals for bio-efficacy and phytotoxicity studies**

population of *Thrips parvispinus* was noticed on chilli flowers (Figure 2).

The insecticides were tested for their efficacy against thrips at 100%, 75% and 50% recommended doses of pesticide (RDP) using drone, 100% RDP with human back power spray and water spray with human back power spray as control. The experimental design details are given.

The chilli variety-F1 hybrid which has semi erect and strong plant structures, resistance to chilli leaf curl virus, fruit surface is semi wrinkled, fresh fruit starting from 45-50 days after transplant, suitable for fresh and dry purpose which is 54 days old seedlings were transplanted on 25.09.2022 with 75 cm X 45 cm was sown in *kharif* 2022-23 in clay loam with 5 acres in restricted randomized block design with five treatments and replicated four times with 100% RDP sprayed from 0.6 -1.0 m above crop canopy, 75% RDP sprayed from 0.6 -1.0 m above crop canopy, 50% RDP sprayed from 0.6 -1.0 m above crop canopy, 100% RDP sprayed with human back pack sprayer and Control (Water Spraying with UAV

**Table 2. Details of the chemicals sprayed using UAV to control *Thrips parvispinus***

| S.No. | Chemical insecticide sprayed (Ref: CIB & RC) | Recommended Dosage of Pesticide gm/ml/acre (100 % RDP) | Days after sowing for Spraying (DAS) | Days after Trans-planting (DAT) |
|---|---|---|---|---|
| 1 | Spinetoram11.70 % SC | 200 ml | 112 | 58 |
| 2 | Flubendiamide 19.92% + Thiacloprid 19.92% SC | 100 ml | 119 | 65 |
| 3 | Fipronil 80% WG | 25 g | 126 | 72 |
| 4 | Spirotetramat 15.31% w/w OD | 160 g | 133 | 79 |

**Table 3. Treatment details and Insecticides dosages**

| S.No. | Treatment details | Insecticides and their dosages | | | |
|---|---|---|---|---|---|
| | | Spinetoram 11.7% SCml /acre | Flubendi-amie de 19.92% + Thiacloprid 19.92% SC, ml/acre | Fipronil 80% WG, ml/acre | Spirotet-ramat 15.31% w/w OD, ml/acre |
| 1 | T1 | 200 | 100 | 25 | 160 |
| 2 | T2 | 150 | 75 | 18.75 | 120 |
| 3 | T3 | 100 | 50 | 12.5 | 80 |
| 4 | T4 | 200 | 100 | 25 | 160 |
| 5 | T5 | Only Water | Only Water | Only Water | Only Water |

sprayer).All the recommended agronomical practices were followed for raising the crop except plant protection for chillithrips, *Thrips parvispinus*.

**Insecticide Sprays Description:** The list of insecticides and their dosages for control of *Thrips parvispinus* which were sprayed using drone and human back pack sprayer is presented (Table 2 and Table 3).

**Bio-efficacy studies**

Observations were recorded on number of flower thrips(3 flowers per plant) from ten randomly selected plants in each plot at one day before spraying and at 1,3 and 5 days after each spray andthe per cent reduction of population over control (% ROC) was calculated by modified Abbott's formula followed by Flemming and Retnakaran (1985).

**Percentage reduction of aphids population over control (% ROC)**

**Yield**: Chili dry pod weight was recorded from each experimental plot leaving the border rows and expressed yield in q $ha^{-1}$. Incremental Benefit Cost ratios were calculated.

**Phytotoxicity Studies:** Observations for phytotoxicity were taken on 1, 3 and 5days after the insecticide application for the specific parameters like chlorosis, necrosis, wilting, scorching, hyponasty and epinasty (Table 4).

**Normalized Difference Vegetation Index (NDVI):**

The NDVI values were used to monitor the crop growth, health and to identify potential diseased parts in the fields. The NDVI readings were measured using Green Seeker™

**Table 4. Grading scale for phytotoxicity measurement**

| S.No. | Score | Phytotoxicity (%) | Score | Phytotoxicity (%) |
|---|---|---|---|---|
| 1 | 0 | No phytotoxicity | 6 | 51 – 60 |
| 2 | 1 | 0 – 10 | 7 | 61 – 70 |
| 3 | 2 | 11 – 20 | 8 | 71 – 80 |
| 4 | 3 | 21 – 30 | 9 | 81 – 90 |
| 5 | 4 | 31 – 40 | 10 | 91 – 100 |
| 6 | 5 | 41 – 50 | | |


**Figure 3. ANGRAU-PUSHPAK 01 - An UAV standardized for agricultural spraying**

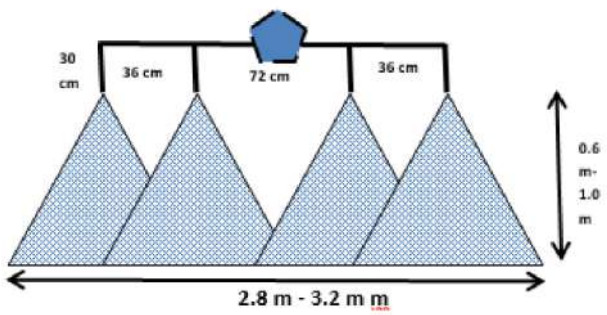
**Table 5. The standard operating procedures of ANGRAU – PUSHPAK 01: An UAV Agricultural spraying**

| I. SOP's for UAV Spraying Parameters | Standard Operating Procedures (SOPs) |
|---|---|
| 1. Height of drone flight, width and speed of spraying | The height, width and forward speed of the drone for spraying in chilli are as follows (Ambient wind speeds 10 kmph wind speeds): |

| S. No. | Item | Height, m above crop canopy | Width of Spra-ying | Speed of UAV, m/s1. |
|---|---|---|---|---|
| 1 | Upto Vegetative Stage | 0.6 | 2.8 | 5.5 |
| 2. | Vegetative stage to final picking | 1.0 | 3.2 | 4.5 |

| | |
|---|---|
| 2. Diurnal Time schedule of Drone Spraying | Recommended to spray morning and late in the evening. |
| 3. Direction of Drone travel | Longest straight path / Longest side of the field was preferred for operational optimization upto 10 kmph wind speeds. Under wind conditions more than 10 kmph, the direction of travel was parallel to the direction of winds. |
| 4. Drift | Effectively 0.5-1 m on either side at 5-7.5 kmph wind speeds and temperature of about 35-40 $^{o}$C is found. |

| | |
|---|---|
| 5. Optimum ambient wind conditions for drone spraying | 0 - 5 kmph, but can spray upto 10 kmph except for herbicides |
| 6.Ambient temperature | 35-40 °C |
| 7. Time taken for drone flight per acre | Net Time: 6 minutes /acre. Gross Time: 10 min. / acre (Including chemical filling, nozzle checking, battery replacement and pilot instructions to the farmers). |
| 8. Recommended Spray fluid Volume (Optimum and safe volume of spray fluid / acre for drone spraying of insecticides, fungicides, herbicides and foliar micro nutrients) | ***Low Volume Spraying:*** 10 L /acre or 25 L/ha. At this spray fluid volume, there is no phytotoxicity and the good bio-efficacy is achieved with the chemicals tested. |
| 9. Spacing, vertical distance and arrangement of 4 nozzles on the drone. (Under 5 Kmph wind speed and 35$^0$C-static condition at 0.6-1.0 m height above crop canopy). | Beneath the rotors at 30 cm from the arms axis. Distance between nozzles from each other on either side at 36 cm. The nozzle flow fan should be vertically downwards without any obliqueness. The nozzles should be adjusted accordingly.<br>All the nozzle tips must be aligned to be in horizontally parallel |




handheld sensor which is easy to use optical sensor that instantly measures plant health and vigor. The sensor was held 24-48" (60-120 cm) above the crop canopy and observed the reading on the display. The higher the NDVI value the greater plants density and health.

## RESULTS AND DISCUSSION

The standard operating procedures (Table 5) for operating the drone in field conditions of chilli crop considering the minimum to maximum plant heights ofchilliranging from 30 cm at 54 DAS to 120 cm were used. The following standard operating procedures developed for operation of ANGRAU PUSHPAK- 01; An UAV (Figure 3) were used for spraying of the chemicals on chilli crop.

## BIO-EFFICACY STUDIES

Number of thrips per chilli flower at one day before spraying was ranged from 7.55-8.05 per flower without any significant differences indicating the uniform spread of pest across the treatments. At three days after spraying of spinetoram 11.7% SC, lowest thrips population

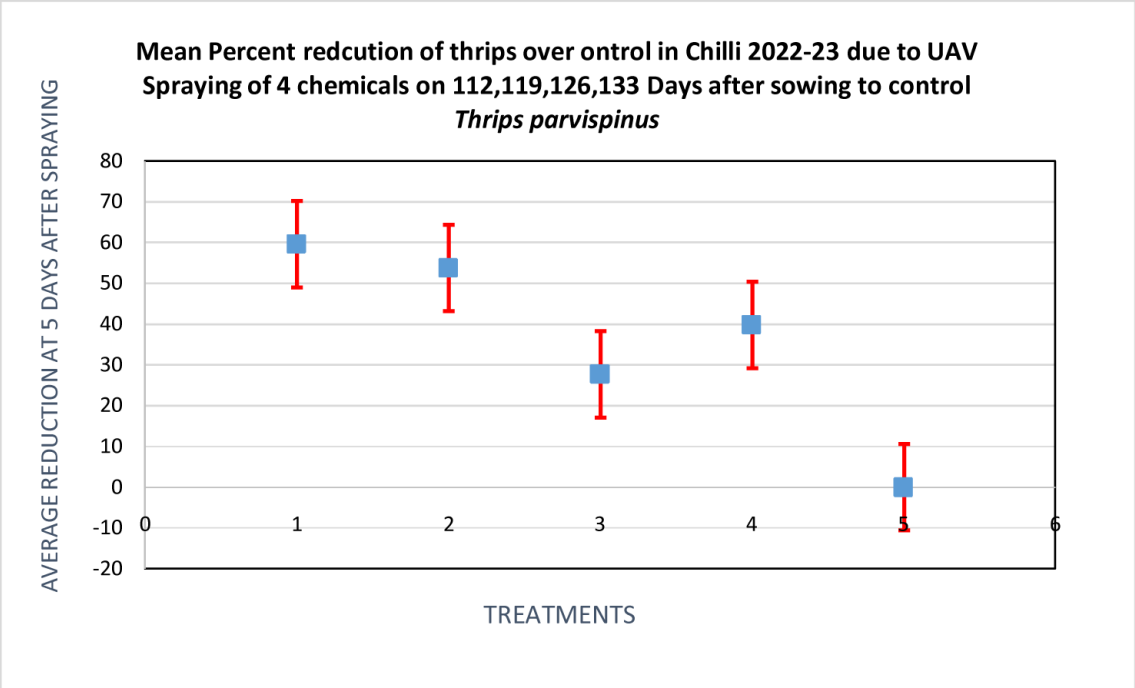



**Figure 4. Mean reduction over control (ROC) of thrips population over control**

(5.35) per flower were recorded with 100% RDPapplied through drone which is at par with 75% RDP applied through drone (6.00) and 100% RDP applied through human back power spray 7.30 with 52.71%, 48.03% and 33.33% reduction of thrips population over control, respectively. Untreated control recorded highest population of 12.25 thrips per flower. At 5 days after spray even though increasing trend of population was observed in all the treatments, the reduction of thrips population over control was high (50.75%) at 100 % RDP applied through drone followed by 75% RDP through drone (46.19%). Singh *et al.* (2012) and Matharu *et al.* (2020) documented the efficacy of Spinetoram against *T.tabaci* and Spodoptera*spp* owing to its quick knock down effect at 3 days after spraying. Sharanappa *et al.* (2020) also reported 86.24% control of thrips *T. tabaci* in chilli by Spinetoram 11.70% SC. Shimokawatoko *et al.* (2012) experimented the properties and reported that it has beneficial mechanism which can control insects by its direct exposure or on ingestion of treated surface and also through systemic in action in plant.

Five days after the second spray with flubendiamide 19.92% + thiacloprid 19.92% SC, low thrips per flower was recorded in 100% RDP and 75% RDP with drone and 100% RDP with human back power sprayer with reduction percent of 52.22%,44.88% and 36.78%, respectively over control. The results of third spray with fipronil 80% WG @ 25g/acre revealed that the three treatments viz., 100%RDP with drone, 75% RDP with drone and 100% RDP with human back power sprayer (HMBS) were at par and recorded low thrips population of 5.0, 7.2 and 8.0 per flower. Similarly, at 5 DAS, T-1 has 68.83% followed by T-2 with 64.71% reduction over control. The results were incoherence with Deepak kumar *et al.* (2019) and Sharanappa *et al.* (2020) in which they reported the efficacy of fipronil 80% WG against chilli thrips (*T.tabaci*) with 62.97% and 76.12% reduction which were superior to other treatments. Since fipronil is broad

**Table 6. Bio-efficacy of number of thrips per flower at flowering and fruit initiation stage**

| Treat-ments | Pre-Treat-ment | No. of *Thrips parvispinus* population/ flower at 3 and 5 Days after Spraying (DASp.) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Spineto-ram 11.70 % SC | | Flubendiamide 19.92% + Thiacloprid 19.92% | | Fipronil SC 80% WG | | Spirote-tramat 15.3 % w/w/ OD. | | Mean of 4 Sprays | |
| | | 3 | 5 | 3 | 5 | 3 | 5 | 3 | 5 | 3 | 5 |
| T1 | 7.57 | 5.35 (2.51) | 5.8 (2.60) | 6.00 (2.64) | 7.37 (2.89) | 5.00 (2.44) | 5.27 (2.50) | 4.30 (2.34) | 5.12 (2.44) | 5.16 | 5.89 |
| T2 | 7.55 | 6.00 (2.71) | 6.4 (2.71) | 7.41 (2.89) | 8.32 (3.05) | 7.20 (2.80) | 6.47 (2.73) | 4.75 (2.39) | 5.75 (2.60) | 6.34 | 6.7 |
| T3 | 7.55 | 9.00 (3.16) | 10.22 (3.35) | 11.74 (3.60) | 12.12 (3.62) | 10.00 (3.00) | 10.55 (3.31) | 7.37 (2.89) | 9.5 (3.20) | 9.5 | 10.5 |
| T4 | 8.05 | 7.3 (2.88) | 8.22 (3.05) | 8.29 (3.04) | 10.25 (3.35) | 8.00 (2.98) | 8.05 (2.87) | 5.5 (2.25) | 8.5 (3.08) | 7.2 | 8.7 |
| T5 | 8.05 | 12.25 (3.64) | 12.95 (3.73) | 15.95 (4.11) | 16.03 (4.12) | 16.68 (4.20) | 16.83 (4.22) | 17.83 (4.33) | 18.22 (4.38) | 15.6 | 16.1 |
| CD | N/A | 0.29 | 0.101 | 0.18 | 0.307 | 0.31 | 0.36 | 0.21 | 0.37 | | |
| CV @ 5% | 2.64 | 6.36 | 2.39 | 3.36 | 5.705 | 6.32 | 7.25 | 4.24 | 7.65 | | |

*(value in the parenthesis are square root transformed values)*

**Table 7. Percent reduction over control (ROC) of *Thripsparvispinus*population per flower at 3 and 5 Days after Spraying (DASp.)**

| S.No. | Treat-ment | Percent ROC of *Thripsparvispinus*. population / flower at 3 and 5 Days after Spraying (DASp.) | | | | | | | | Mean of 4 Sprays | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Spineto-ram 11.70 % SC | | Flubendiamide 19.92% + Thiacloprid 19.92% | | Fipronil 80% WG | | Spirote-tramat 15.3 % w/w/ OD. | | | |
| | | 3 | 5 | 3 | 5 | 3 | 5 | 3 | 5 | 3 | 5 |
| 1 | T1 | 52.71 | 50.75 | 61.33 | 52.22 | 70.59 | 68.83 | 72.70 | 66.59 | 64.33 | 59.60 |
| 2 | T2 | 48.03 | 46.19 | 51.15 | 44.88 | 64.71 | 62.34 | 68.69 | 61.68 | 58.15 | 53.77 |
| 3 | T3 | 18.80 | 23.65 | 26.90 | 24.29 | 41.18 | 22.08 | 53.78 | 40.89 | 35.17 | 27.73 |
| 4 | T4 | 33.33 | 36.57 | 48.56 | 36.78 | 52.94 | 38.96 | 65.49 | 46.92 | 50.08 | 39.81 |
| 5 | T5 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

spectrum systemic insecticide with contact and stomach poison activity. Italiya *et al.* (2023) reported the effectiveness of reduction in chilli thrips population of fipronil (5.09 *Thrip s tabaci* per 3 leaves) with human back knapsack sprayer.

In the fourth spray done with Spirotetramat 15.3% w/wOD, 100 percent recommended dose of Spirotetramat 15.3% was applied through drone recorded lowest number of thrips (4.30*Thrips parvispinus* per flower) and it was on par with 75% RDP with Drone (4.75) and 100% RDP HMBS (5.5) with 72.70% and 68.69%, 65.49% reduction over control at three days after the spray. At five days after spray high reduction of thrips population over control was recorded in 100 % RDP with drone (66.59%) followed by 75% RDP with drone (61.68%) in flowers in T1, T2 which are significantly at par with each otherand next best inT4 with 46.92% reduction over control. The 50% RDP drone recorded 40.89% and untreated control recorded with 18.22 thrips per flower (Figure 4,Table 6 and Table 7). Juvenile stages are highly prone to exposure and gives good control of hidden pests and protects new shoots appearing after foliar spraying. This study is in line with Kotresh *et al.* (2020) who reported 45.01% reduction over control and Mandal and Mondal (2022) reported 68.90 % reduction of thrips in chilli.

**Phytotoxicity**

The data regarding phytotoxic effects such as chlorosis, necrosis, epinasty, hyponasty, wilting and scorching at 1, 3 and 5days after spraying revealed that, Spinetoram 11.70 % SC @ 200 ml/acre, Spirotetramat 15.31% w/w OD @ 160 ml/acre, Fipronil 80% WG @ 25g/acre,Flubendiamide 19.92% + Thiacloprid 19.92% SC@120 ml/acre at50, 75 and 100% recommended dose sprayed with drone and 100% recommended dose with human back power sprayer did not show any

**Table 8. The NDVI Values as indicators of phytotoxicity in chilli crop observed after 5 days after spraying (DASp.)**

| S.No. | Treat-ments | Spinet-oram 11.70 % SC | Flubendi-amide 19.92% + thiacloprid 19.92% SC | Fipronil 80% WG | Spirote-tramat 15.3 % w/w/ OD. | Average NDVI |
|---|---|---|---|---|---|---|
| | | 5 DASp. | 5 DASp. | 5 DASp. | 5 DASp. | 5 DASp. |
| 1 | T1 | 0.73 | 0.77 | 0.78 | 0.79 | 0.77 |
| 2 | T2 | 0.71 | 0.76 | 0.78 | 0.79 | 0.76 |
| 3 | T3 | 0.66 | 0.65 | 0.63 | 0.62 | 0.64 |
| 4 | T4 | 0.71 | 0.72 | 0.73 | 0.73 | 0.72 |
| 5 | T5 | 0.37 | 0.34 | 0.33 | 0.32 | 0.34 |

**Table 9. Yield and incremental cost-benefit ratio with treatments**

| Treat -ments | Yield q. ha$^{-1}$ | Increased yield over control | Increased returns over control /ha * | Net Returns/ ha | Cost of Plant protection | ICBR RATIO |
|---|---|---|---|---|---|---|
| T1 | 58.6 | 44.5 | 890500 | 696155 | 194345 | 1:3.58 |
| T2 | 55.2 | 40.7 | 813500 | 671492 | 150508 | 1:4.46 |
| T3 | 34.5 | 20.4 | 408000 | 301327.5 | 106672.5 | 1:2.82 |
| T4 | 53.8 | 41.1 | 822000 | 594905 | 199095 | 1:2.98 |
| T5 | 14.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

*Considerations: 1. The labour charges for 1 spray per acre is considered as Rs.500/- per acre and drone spraying charges for 1 spray per acre @ 400/- per acre 2.Chilli market prices was considered for ICBR Calculation i.e. 20000.00 per quintal at current prices*

phytotoxicity in chilli even up to harvesting. High NDVI values (0.77) (Table 8) were recorded in the treatments T1,T2 and T4 after the spray schedule indicated the healthy crop growth and no phytotoxicity in the plant canopy. It was reported that if the NDVI value was more than 0.2, no phytotoxicitywas observed due to spraying the enlisted chemicals using drone with 25 L ha$^{-1}$ spray fluid volume concentration.

**Yield and ICBR**: High yield of 58.6 q ha$^{-1}$ was recorded (Table 9) in the treatment with 100% recommended dose of insecticide applied through drone followed by 75 % RDP with drone, 100% recommended dose with human back power sprayer (55.2 q ha$^{-1}$ and 53.80 q ha$^{-1}$).Very low yields of14.1 q ha$^{-1}$ were recorded in untreated control. The Incremental Cost-Benefit Ratio was high (1:4.46) with 75% of RDP applied through drone followed by

100% RDP with drone (1:3.58) due to the 25% reduction of the insecticide cost which was the major share in cost of cultivation (Table 9).

## CONCLUSIONS

The Unmanned Aerial Vehicle (UAV) spraying to control *Thrips parvispinus* was found effective and efficient in managing the pests and utilizing the pesticide substance delivery and deposition when compared to human backpack spraying. The spray fluid volume of 25 L $ha^{-1}$ was found sufficient without affecting the bio-efficacy and without causing phytotoxicity on the crop. The thrips population were effectively controlled both at 100% RDP and 75% RDP sprayed with UAV and offers an opportunity to save 25% of the pesticide. All the insecticides applied have effectively managed the thrips population. High efficacy was observed at three days after each spray and a slight increase in thrips population was recorded at five days after each spray. As per as method of application of insecticide in concerned, 100% recommended dose of insecticide applied through drone recorded numerically low number of thrips population (5.89) which was statistically at par with 75% dose applied with drone (6.7) and 100% insecticide dose applied through human back power spryer (8.7) at five days after the completion of four sequential sprays. In case of untreated control, three times higher thrips population (16.1 thrips per flower) bisected the yield (14.1 q $ha^{-1}$) compared to spraying of insecticides using drone with 100% and 75% RDP.

## REFERENCES

Anitha Kumari, D., Bhasker, K and Suresh, V. 2021. A new invasive chillithrips (*Thrips parvispinus*) in Telangana State. Insect Environment. 24(4): 520-522.

Chilli Outlook.2021. January- December 2021. Agriculture Market Intelligence Centre, ANGRAU, Guntur.

Deepak Kumar, Kamal Ravi Sharma and Raju. S.V.S. 2019. Field efficacy of insecticidal combinations against chillithrips, *Scirtothrips dorsalis* (Hood) and *Aphis gossypii* (Glover). Annals of Plant Protection Sciences.27 (3): 324-328.

Fleming, R and Ratnakaran, A. 1985. Evaluating single treatment data using Abbot's formula with modification. Journal of Economic Entomology. 78:1179.

Italiya, J. V., Kalasariya, R. L., Dodiya, R. D., Barad, A. H and Patel, N. A. 2023. Economically management of thrips by insecticides in chilli under field condition.The Pharma Innovation Journal. 12(4): 1371-1374.

Kotresh, S., Raghuraman, M and Srushtideep, A. 2020. Management of chilli thrips using newer formulations. Journal of Entomology and Zoology Studies. 8(4): 669-673.

Mandal, L andMondal, P. 2022. Bio-efficacy of some newer generation insecticides against chilli thrips, *Scirtothrips dorsali*s Hood. International Journal of Bio-Resource & Stress Management. 13(11): 1130-1140.

Matharu, K. S andTanwar, P. S. 2020. Bioefficacy of novel insecticides against cotton thrips, *Thrips tabaci* (Thysanoptera: Thripidae). International Journal of Chemical Studies. 8(3): 1167-1170.

Nagaraju, D.K., VivekUppar., Ranjith, M., Sriharsha Ramesh, G., Om Prakash Verma and Ravi Prakash. 2021 Occurrence of *Thrips parvispinus* (Karny) (Thripidae: Thysanoptera) in major chilli (*Capsicum annum*) growing areas of Karnataka. Insect Environment. 24(4): 523- 532.

Phang, S. K., Li, K., Chen, B. M., Lee, T. H., Valavanis, K. P and Vachtsevanos, G. J. 2015. Systematic design methodology and construction of micro aerial quadrotor vehicles. Handbook of Unmanned Aerial Vehicles. The Netherlands. pp.181–206.

Rashmi, M. A, Sireesha, Kand Verghese. A. 2022. Need for surveillance in case of the invasive thrips, *Thrips parvispinus* (Karny) on chilli (*Capsicum annuum*) (including IPM recommendations). Insect Environment. 25 (2):60-61.

Sharanappa, C. H., Katti, P., Arunkumar, H., Sushila, N., Desai, B. K and Pampanna, Y. 2020. Evaluation of insecticides against thrips (Thripidae: Thysanoptera) and mites (Tarsonemidae: Trombidiformes) infesting capsicum. Journal of Entomology and Zoology Studies. 8(2): 1221-1225.

Shimokawatoko, Y., Sato, N., Yamaguchi, Y and Tanaka, H. 2012. Development of the novel insecticide spinetoram (Diana®). Sumitomo Kagaku. pp.14-15.

Singh, V., Verma, J. R., Bhati, D. S., Kumar, S and Sanp, R. K. 2012. Bioefficacy of Spinetoram 12% SC against thrips and boll worm complex on Cotton. Journal of Progressive Agriculture. 3(1): 66-68.

Sireesha, K., Prasanna, B. V. L., Vijaya Lakshmi, T and Reddy, R. V. S. K. 2021. Outbreak of invasive thrips species *Thrips parvispinus* in chilli growing areas of Andhra Pradesh. Insect Environment. 24(4): 514-519.

Tyagi, K., Kumar, V., Singha, D and Chakraborty, R. 2015. Morphological and DNA barcoding evidence for invasive pest thrips, *Thrips parvispinus* (Thripidae: Thysanoptera), newly recorded from India. Journal of Insect Science. 15(1):105-106. DoI: https://doi.org/10.1093/jisesa/iev087

Sambaiah, A., Prasanthi, L., Madhuri, Ch., Purna Chandra Rao, K., Kamakshi, N., Venkata Lakshmi, N and Gurava Reddy, K. 2023. Performance evaluation of hexacopter UAV (ANGRAU-Pushpak spraying for management of chilli thrips (*Thrips parvispinus).* The Journal of Research ANGRAU. 51 (3):61-74.
DoI: https://doi.org/10.58537/jorangrau.2023.51.3.08

DoI: https://doi.org/10.58537/jorangrau.2023.51.3.09

J. Res. ANGRAU 51 (3) 75-81, 2023

# RAGI HEALTH MIX FOR MANAGING POLYCYSTIC OVARIAN SYNDROME - FORMULATION AND NUTRIENT ANALYSIS

**T. T. JOLLY* and A. THIRUMANI DEVI**

Department of Food Science and Nutrition, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore - 641 043

Date of Receipt : 03.5.2023 Date of Acceptance : 21.7.2023

## ABSTRACT

Polycystic Ovarian Syndrome, the most common endocrine disorder affecting women of reproductive age, affects between 5–10% of women globally. All PCOS-affected women should engage in lifestyle interventions including diet and exercise since losing weight decreases PCOS symptoms. Because of their greater concentrations of phenolic compounds, fibre, flavonoids, and phytosterols, millets outperform other cereals in terms of nutrition, health advantages, and phytochemical makeup.This study was conducted in May 2023. In this study, aim was to develop and assess a ragi-based nutritional supplement, high in micronutrients and fibre, for women with PCOS. The supplement was prepared in clean, and sanitary conditions. A panel of 30 judges conducted the organoleptic tests. Standard techniques were used to evaluate microbial activity and nutrient content.The prepared health mix was statistically significant ($P< 0.05$). After five days, the microbiological tests revealed that it was microbe-free. The health mix was shown to be abundant in fibre and micronutrients after a nutritional analysis. The results showed that the ragi supplement may be used to manage PCOS.

**Key Words:** Nutrient Analysis, PCOS, Ragi, Sensory Evaluation, Supplement

## INTRODUCTION

About 5–10% of women worldwide are affected by PCOS, a prevalent endocrine condition in women at reproductive age. Numerous metabolic complications, including obesity, hyperlipidemia, hyperinsulinemia, insulin resistance (IR), and an increased risk of cardiac diseases and endometrial cancer, are also present in PCOS-affected women in addition to irregular menstrual cycles, chronic anovulation, and hyperandrogenism. Metabolic syndrome (MetS) can be highlighted as a chronic danger if PCOS is not treated on a long-term basis. (Abbasi *et al.,* 2000)

Various strategies and characteristics of PCOS have been studied in research studies, however patient response to therapy varies greatly (Berek, 2012). Obesity worsens PCOS symptoms (Berrini *et al*., 2001) and 30 % to 75% of the PCOS-affected women are obese (Brooks *et al.,* 2004).Weight loss improves PCOS characteristics, and all PCOS-affected women should undertake lifestyle therapies such as diet and exercise, according to international evidence-based guidelines for PCOS testing and management. (De *et al.,* 2011). Since there is currently no cure for PCOS, care of overweight/obese women with PCOS focuses on weight loss through consistent exercise and diet to reduce the condition's clinical symptoms and the associated risk of T2DM and cardiovascular disease (CVD) (Giampaolino *et al.,* 2018).

*Corresponding Author E-mail i.d: 22phfnf001@avinuty.ac.in; Ph.D. thesis submiteed to Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore - 641 043

Diet and lifestyle choices seem to have an impact on PCOS, especially on how they affect body weight, insulin resistance, inflammation, oxidative stress, and, ultimately, androgen activity. Women with PCOS frequently have extra body fat, especially central adiposity, even when they are not obese. Between 30% and 75% of the PCOS patients are obese. (Hahn *et al.,* 2005). The targets of dietary objectives should be insulin resistance and excess weight. A low-fat, plant-based diet reduces insulin resistance, which affects 50–70% of women with PCOS (Holte, 1998 and Kataoka *et al.,* 2017). Low-fat, high-fibre diets efficiently treat dyslipidemia (elevated triglycerides, low HDL), elevated C-reactive protein and homocysteine, and circulating testosterone levels while increasing SHBG and decreasing and rogen levels (Lim *et al.,* 2013). Consuming a diet rich in fruits, vegetables, whole grains, and legumes also lowers inflammation and oxidative stress.

In case of PCOS-affected women who are overweight or obese, a range of balanced dietary regimens may be advised to decrease dietary energy intake and promote weight loss (De *et al.,* 2011). Micronutrients such as vitamins and minerals aid in improving ovulatory function and reducing inflammation.

Millets are superior to other cereals in terms of nutrients, health benefits, and phytochemical composition because they include higher levels of phenolic compounds, fibre, flavonoids, and phytosterols. These dietary elements boost the host's health due to their prebiotic properties, antioxidative actions, anti-inflammatory effects, and hypoglycemic profiles. These characteristics are enhancing PCOS when we analyze the role of millet in this disorder.The best millets for PCOS include ragi, jowar, bajra, and korra. These millets reduce cholesterol and blood sugar levels and are beneficial for PCOD. They naturally lack gluten, which is advantageous for PCOS. Millet is a rich source of iron, calcium, protein, and amino acids, all of which are necessary for PCOS.

In this study, the researcher attempted to formulate and evaluate a ragi-based nutrient supplement, rich in micronutrients and fibre by using underutilized, easily available and affordable ingredients for women with PCOS.

## MATERIALS AND METHODS

The study was conducted during May, 2023 at Coimbatore. Standardization was carried out to find out if the supplement was palatable. Utilizing safe and standardized methods, the supplement powder was prepared. To determine the palatability, shelf life, and nutrient composition of the developed health mix, organoleptic evaluation, microbiological and nutrient analyses were performed.

### Step 1: Procurement

Ingredients such as sesame (*Sesamu-m indicum),* jaggery *(Saccharum officinarum),* ragi *(Eleusine coracana),*whole oats *(Avena sativa),* flax seeds *(Linum usitatissiumum),* groundnut *(Arachis hypogaea),* sunflower seed *(Helianthus annus)* and pumpkin seed *(Curcubita maxima)* were procured from a nearby departmental store located in Coimbatore city.

### Step 2: Formulation of Health mix

Using an electronic blender, all the ingredients were blended into a fine powder after being roasted at 120 °C for 10 to 15 minutes. Ragi was gradually increased from 30 g to 40 g, and whole oats were gradually decreased from 20 g to 10 g. The other ingredients remained constant. The health mix was prepared in three different proportions, namely Treatment I, Treatment II and Treatment III. The amount of ingredients used in each Treatment is listed in (Table 1).

### Step 3: Organoleptic evaluation of Health mix

The most important factor in determining whether a food product is desirable in its quality. Organoleptic techniques can be used to assess food quality. When picking food, organoleptic quality—a concoction of various modalities of perception—comes into play. The acceptance of the food is influenced by its appearance, flavour, texture, and mouth feel (Moran *et al.,* 2013). A group of 30 semi-trained panellists evaluated the

**Table 1. Amount of Ingredients**

| S.No. | Ingredients | Treatments (g) | | |
|---|---|---|---|---|
| | | I | II | III |
| 1 | Whole Ragi | 30 | 40 | 35 |
| 2 | Whole oats | 20 | 10 | 15 |
| 3 | Flax seed | 10 | 10 | 10 |
| 4 | Groundnut | 10 | 10 | 10 |
| 5 | Sunflower seed | 8 | 8 | 8 |
| 6 | Sesame | 8 | 8 | 8 |
| 7 | Jaggery | 8 | 8 | 8 |
| 8 | Pumpkin seed | 6 | 6 | 6 |
| | **Total** | **100** | **100** | **100** |

sensory properties of the produced health mix using a 5-point hedonic scale (liked a lot, liked a little, neither liked nor disliked, disliked a little and disliked a lot) for several sensory aspects. Different supplement formulations were coded as I, II, and III to avoid making any presumptions. Sensory characteristics included appearance, aroma, taste, texture, and overall accessibility. The panelists had received some training and were all in good health. The panel members were given a score card to measure their preferences and likeliness, with scores ranging from 'extremely liked to extremely disliked' and instructions. The panellists were provided with fresh supplements in odourless containers and a glass of water to rinse their mouths between tests.

**Step 4: Assessment of nutrient composition**

A macronutrient and micronutrient analysis of the supplements was performed. Triplicate measurements of each nutrient were used for the analysis of nutrients. The Association of Official Analytical Collaboration's standard procedure (2018) was used to analyse these nutrients.

**Step 5: Physico chemical andmicrobiological analysis of the selected health mix**

In addition, the physicochemical and microbiological properties of the chosen health mix were examined. Total microbial counts (5 days) were determined using standard operating procedures (SOPs), and pH was determined using an electrometric method.

**Statistical methods**

One-way ANOVA was performed to examine the relationship between the various metrics utilized in the hedonic scale. SPSS (Statistical Package for the Social Sciences) Version 21.0 was used for the study.

**RESULTS AND DISCUSSION**

**Organoleptic evaluation of the health mix**

Consumer acceptance of food products was evaluated using the hedonic rating test. The mean scores of the several health mix compositions are depicted in Figure 1, and it can be seen that treatment III received the most significant marks for appearance, aroma, taste, texture, and overall acceptance. A total score of 681 out of 750 indicated that the product was favourably received. Organoleptic evaluation comments for samples indicated that Variation III was regarded as the best among the variants.

The created health mix's mean and standard deviation showed that the three variations' average overall acceptability was 2.63, 3.53, and 4.73 for variations I, II, and III, respectively (Table 2). The produced supplement was shown to be statistically significant ($P< 0.05$) when one-way ANOVA was

performed to examine the significance between the various metrics employed in the hedonic scale

**Assessment of nutrient composition**

For the nutritional analysis and total microbial count study, treatment III, which had the best overall score, was taken into account. Table 3 indicates the nutrients found in 100 g as well as the various techniques employed for nutritional analysis. The data clearly shows that formulated health mix was a rich source of fibre and micronutrients

**Physico-chemical and microbiological analysis of selected health mix**

In addition, the selected health mix's physicochemical and microbiological characteristics were investigated. SOPs were used to calculate the total microbial counts (5 days), and an electrometric approach was used to calculate pH. The results of the physicochemical and microbiological examination are shown in the Table 4. On the fifth day, the chosen health mix was plain and devoid of any bacterial or fungal counts. Fig. 2 and Fig. 3 depict microbiological analysis.

**Recommended dietary allowances comparision**

The nutrient profile of the supplement was compared to the Recommended Dietary Allowances (RDA) for adult women and was shown (Table 3). The supplement, shown in the table to be an energy-dense food, should be consumed to avoid a negative energy balance. It provides 451 kcal, which satisfies 27% of the daily energy needs of an adult woman. There are 14.8 g of fat and 16.5 g of protein in it. There was a sufficient amount of micronutrients in the developed health mix.

The micronutrients in the health mix have been shown to reduce blood sugar levels, boost insulin production, and control menstruation irregularities. The created health mix's enhanced magnesium and calcium content improves insulin sensitivity, boosts progesterone production in women, and reduces stress. The other minerals, such as zinc, selenium, and B vitamins, which are present in abundance in supplements, aid in weight reduction, boost immunity, regulate blood sugar levels, guard against free radical damage, and control other PCOS symptoms, such as inflammation and mood swings. According to De Groot *et al.* (2018), calcium and vitamin D directly

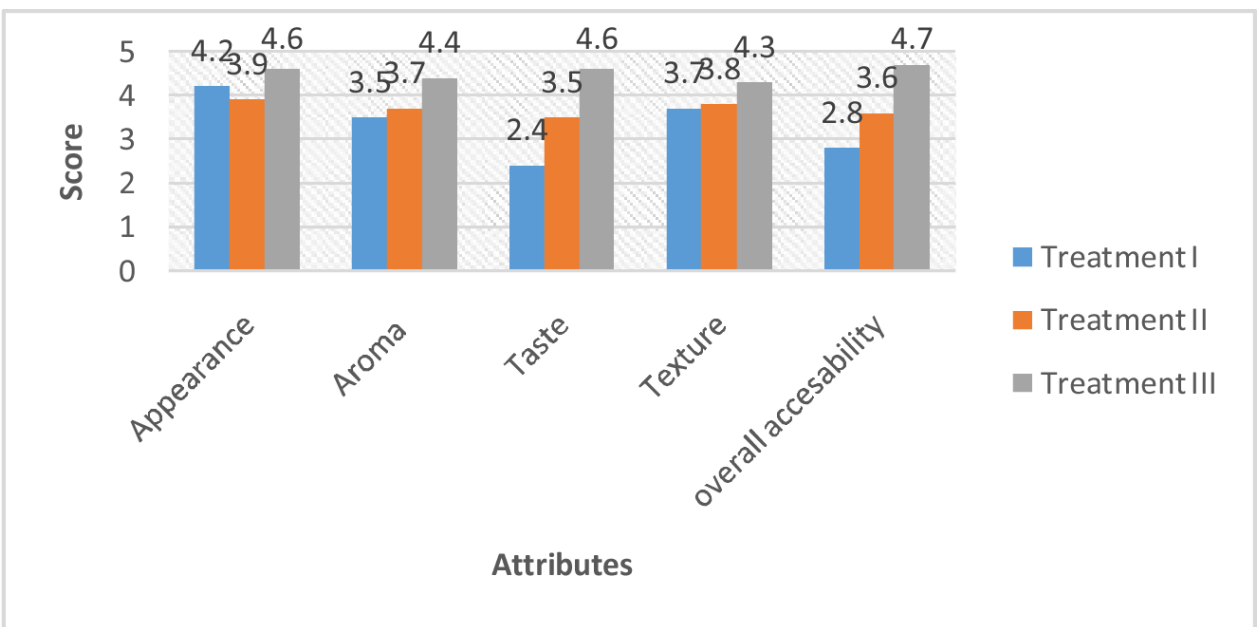



**Figure 1. Mean scores of different variations**

**Table 2. Statistical analysis of standard and developed supplement**

| S. No. | Variation | Mean ± Standard Deviation | F Test | P Value |
|---|---|---|---|---|
| **1** | Treatment I | 2.63 ± 0.890 | | |
| **2** | Treatment II | 3.53 ± 0.819 | 7.210 | 0.001 |
| **3** | Treatment III | 4.73 ± 0.521 | | |

**Table 3. Nutrient composition of ragi based health mix and comparision with RDA**

| S. No. | Nutrient | Procedure | Result | RDA | RDA % for 100 g |
|---|---|---|---|---|---|
| 1 | Energy (Kcal) | Calculation Method | 451 | 1660 | 27.2 |
| 2 | Fat (g) | AOAC 18th Edition / FSSAI | 14.8 | 20 | 74 |
| 3 | Carbohydrate (g) | Calculation method | 63 | 130 | 48.5 |
| 4 | Protein (g) | FSSAI Manual of Methods | 16.5 | 45.7 | 36 |
| 5 | Fibre (g) | AOAC/BIS | 8.2 | 33 | 25 |
| 6 | Calcium (mg) | AOAC/BIS/FSSAI | 230 | 1000 | 23 |
| 7 | Magnesium (mg) | AOAC/BIS/FSSAI | 74 | 325 | 23 |
| 8 | Iron (mg) | AOAC/FSSAI | 19.1 | 29 | 65 |
| 9 | Zinc (mg) | AOAC | 4.8 | 13.2 | 36 |
| 10 | Selenium (mcg) | FSSAI | 20 | 40 | 50 |
| 11 | Vitamin A | Biochemical Methods/AOAC | 35 | 840 | 4.1 |
| 12 | Thiamine (Vit B1) (mg) | AOAC/FSSAI | 1.2 | 1.4 | 85 |
| 13 | Riboflavin (Vit B2) (mg) | AOAC/FSSAI | 1.8 | 1.9 | 94 |
| 14 | Niacin (Vit B3) (mg) | AOAC/FSSAI | 2.7 | 11 | 24 |
| 15 | Phosphorus (mg) | AOAC/BIS/FSSAI | 210 | 1000 | 21 |
| 16 | Potassium (mg) | AOAC 18thEdn/ FSSAI | 628 | 3500 | 18 |

**formulated health mix was a rich source of fibre and micronutrients**

affect the ovarian tract, and the production of adrenal steroid hormones may be responsible for the observed drop in circulating testosterone levels.

The general acceptance of the ragi-based health mix (Treatment III) was rated on a 5-point hedonic scale and accepted as 'extremely liked'. Ingredients such as sesame, jaggery, ragi, whole oats, flax seeds, peanuts, sunflower seeds, and pumpkin seeds—all of which are rich in calcium, magnesium, zinc, selenium, B vitamins, and fibre—make up this health mix. The supplement is helpful for the treatment of PCOS due to its nutritious makeup.

Pasquali and Gambineri (2004) demonstrated that dietary fibre also regulates hormone metabolism by reducing insulin secretion by delaying the rate of glucose absorption after meals. Consumption of fibre shows a favorable connection with blood SHBG levels as well. Modern diets that are heavy in refined carbs and lacking in fiber cause insulin resistance and obesity (Reddy *et al.,* 2016).

**Table 4. Physico-chemical and microbiological analysis of health mix**

| Physico-chemical analysis | | | |
|---|---|---|---|
| **S.No.** | **Parameter** | **Specification** | **Result** |
| 1 | Appearance | Good | Good |
| 2 | Colour | as it is | whitish brown |
| 3 | Odour | Agreeable | Agreeable |
| 4 | pH | 6.5 - 8.0 | 6.8 |
| **Microbiological analysis** | | | |
| **S.No.** | **Parameter** | **Specification** | **Result** |
| 1 | Total bacterial Count | Max 10x10³cfu/g | 200x10¦”cfu/g |
| 2 | Total Fungal Count | <10cfu/g | <10cfu/g |

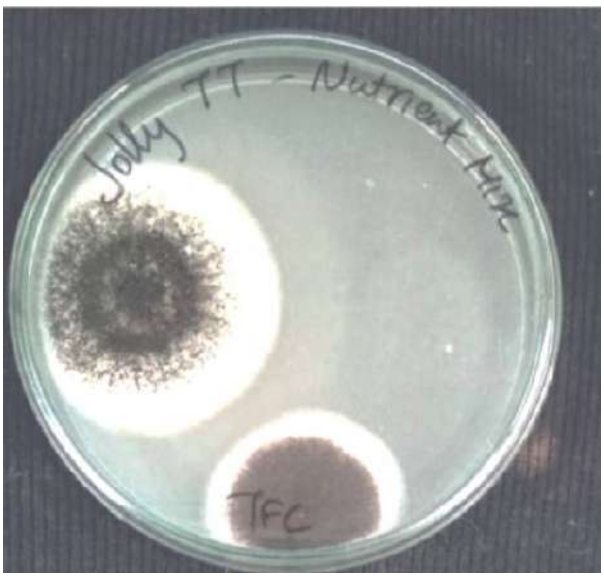



**Figure 2. Total Fungal Count**

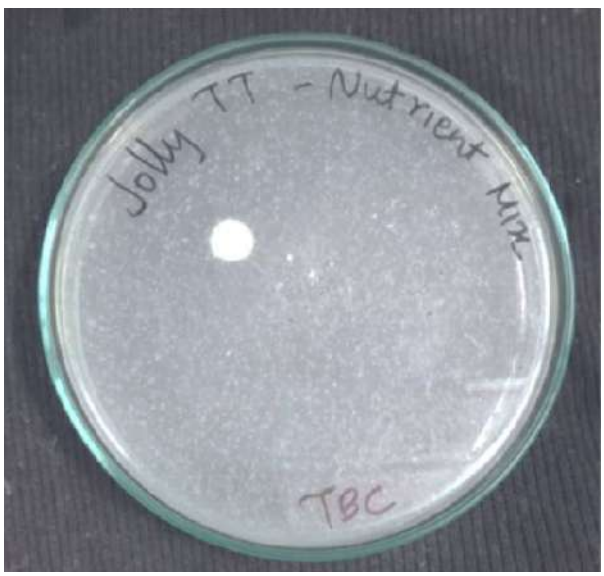



**Figure 3. Total Bacterial Count**

High concentrations of dietary lignin and lignin secoisolariciresinoldiglucoside (SDG) may be found in flaxseeds. By drastically lowering the ovarian volume and follicle count with a usual dose of 15 g of flax powder, menstruation frequency can be improved (Srilakshmi, 2015). Additionally, pumpkin seeds contain the advantageous omega-3 fatty acids that might aid in lowering the increased insulin and cholesterol levels linked to PCOS. They also include beta-sitosterol, which helps alleviate PCOS symptoms including hirsutism, acne, and weight gain by lowering too much androgen (Teede *et al.,* 2018).

## CONCLUSIONS

Three different micronutrient-rich powder formulations have been developed as a result of this study. Treatment III was found to have superior qualities, including colour, texture, flavuor, and general acceptance. It contained sesame (8 g), jaggery (8 g), ragi (35 g), whole oats (15 g), flax seeds (10 g), peanuts (10 g), sunflower seeds (8 g) and pumpkin seeds (6 g). The nutrient analysis showed that formulated health mix is a rich source of fibre and micronutrients.This ragi-based supplement might be used to manage PCOS.

## REFERENCES


Abbasi, F., McLaughlin, T., Lamendola, C., Kim, H, S., Tanaka, A and Wang, T. 2000. High carbohydrate diets, triglyceride-rich lipoproteins, and coronary heart disease risk. The American Journal of Cardiology. 85(1): 45-48.

Berek, J, S. 2012. Berek and Novak's Gynaecology. Berek, J, S. and Novak, E. (Editors), 15th Edition. Tehran: Golban Nashr Company: pp. 1384.

Berrino, F., Bellati, C and Secreto, G. 2001. Reducing bioavailable sex hormones through a comprehensive change in diet: the diet and androgens (DIANA) randomized trial. Cancer Epidemiology, Biomarkers and Prevention. 10 (1): 25-33.

Brooks, J, D., Ward, W, E., Lewis, J, E., Hilditch, J and Nickellm, 2004. L. Supplementation with flaxseed alters estrogen metabolism in postmenopausal women to greater extent than does supplementations with equal amount ofsoy. American Journal of Clinical Nutrition. 79: 318-325.

De, Groot, P, C., Dekkers, O,M., Romijn, J, A., Dieben, S, W and Helmerhorst, FM. 2011. PCOS, coronary heart disease, stroke and the influence of obesity: A systematic review and meta- analysis. Humun Reproduction. 17: 495-500.

Giampaolino, P., Della., Corte, L., De, Rosa, N., Mercorio, A., Bruzzese, D and Bifulco, G. 2018. Ovarian volume and PCOS: A controversial issue. Gynecological Endocrinology. 34(3): 229–232.

Hahn, S and Tan, S., Elsenbruch, S. 2005. Clinical and biochemical characterization of women with polycystic ovary syndrome in North Rhine- Westphalia. Hormone and Metabolic Research. 37(7): 438-44.

Holte, J. 1998. Polycystic ovary syndrome and insulin resistance:thrifty genes struggling with over-feeding and sedentary lifestyle. Journal of Endocrinological Investigation. 21(9): 589-601.

Kataoka, J., Tassone, E, C., Misso, M., Joham, A., Stener, Victorin, E., Teede, H and Moran, L. 2017. Weight management interventions in women with and without PCOS: A systematic review. Nutrients. 9(9):996.

Lim, S, S., Norman, R, J., Davies, M, J and Moran, L, J. 2013. The effect of obesity on polycystic ovary syndrome: A systematic review and meta-analysis. Obesity Reviews. 14 (2): 95–109.

Moran, L, J., Ko, H and Misso, M. 2013. Dietary composition in the treatment of polycystic ovary syndrome: A systematic review to inform evidence-based guidelines. Journal of the Academy of Nutrition and Dietetics. 113(4): 520-45.

Pasquali, R and Gambineri, A. 2004. Role of changes in dietary habits in polycystic ovary syndrome. Reproductive Biomedicine Online. 8(4):431-439.

Reddy, P. S., Begum, N., Mutha, S and Bakshi, V. 2016. Beneficial effect of curcumin in Letrozole induced polycystic ovary syndrome. Asian Pacific Journal of Reproduction. 5(2): 116–122.

Srilakshmi, B. 2015. Food Science. New Delhi: New Age International Private Limited. pp. 308.

Teede, H, J., Misso, M, L., Costello, M, F., Dokras, A., Laven, J., Moran, L., Piltonen, T., Norman, R, J., Andersen, M and Azziz, R. 2018. Recommendations from the international evidence-based guideline for the assessment and management of polycystic ovary syndrome. Human Reproduction. 33(9):1602–1618.


Jolly, T.T and Thirumani, Devi, A. 2023. Ragi health mix for managing polycystic ovarian syndrome: Formulation and nutrient analysis. The Journal of Research ANGRAU. 51(2):75-81.
DoI: https://doi.org/10.58537/jorangrau.2023.51.3.09

DoI: https://doi.org/10.58537/jorangrau.2023.51.3.10

J. Res. ANGRAU 51 (3) 82-92, 2023

# KNOWLEDGE, ATTITUDE AND PRACTICES (KAP) ON NUTRITION AMONG TRIBAL ADOLESCENT GIRLS OF KEONJHAR DISTRICT, ODISHA

**VIJAYETA PRIYADARSHINI* and GAYATRI BISWAL**

Dhenkanal Mahila Mahavidyalaya, Dhenkanal,(Affiliated to Rama Devi Women's University, Bhubaneswar, Odisha), Dhenkanal, Odisha – 759 001

Date of Receipt : 03.5.2023 Date of Acceptance : 08.7.2023

## ABSTRACT

This study was conducted in the year 2021 – 22 in the Keonjhar district of Odisha, in which 45% of the population belongs to the tribal community. To assess the nutritional knowledge, attitude, and practice (KAP), 301 adolescent girls aged 16-18 were selected from the tribal-dominant blocks of Keonjhar. The study revealed that 41.2% of the respondents had average and 58.8% had poor nutritional knowledge, and the mean score was 10.8 ± 2.9.A total of 99% of the respondents had an average nutritional balanced diet practice, with a mean score of 37.7 ± 1.8 out of a maximum of 60 points. The overall nutritional practice of the tribal adolescent girls was categorised as average (mean score 9.7 ± 1.3). In the nutritional knowledge element, there was a statistically significant relationship ($p < 0.05$) between the respondents' education level and Kuppuswamy's socio-economic status of the respondents' family. In the case of nutritional attitude and practice with Kuppuswamy's socio-economic status, a statistically significant association was found between the education level of the respondents and the total family income of the respondents, respectively. The analysis revealed a significant difference in the nutritional practice score concerning family income and socio-economic status ($p < 0.05$).

**Key Words:** Adolescent Girls, Attitude, Balanced diet Knowledge, Odisha Tribal Girls

## INTRODUCTION

After infancy, adolescence is a phase of increasing growth in terms of height, weight, hormonal changes and sexual maturation. During this stage, there is an increase in internal activities such as secretion, hormonal functions, basal metabolism, and biochemical reactions, leading to increased nutritional needs. Due to the significant stress that puberty brings with it because of the physical and psychological changes, the importance of a healthy and balanced diet is profound. Adolescent girls of all age groups require all nutrients in adequate quantities to meet rapid growth andattain optimal storage to fulfil future needs during pregnancy and breastfeeding. The qualitative and quantitative aspects of food intake and the following meal patterns are regarded as the markers for nutrient intake and diet quality. Proper nutritional knowledge, good eating habit and food behaviour are the key factors in optimal growth and development and maintenance of physical and psychological stability. Hence, sound nutritional knowledge is vital for a healthy life. But disappointingly, numerous studies have shown that many teenage diets do not adhere to the dietary recommendations given by the ICMR (Radhakrishnan *et al*., 2021, Radhika *et al*., 2018,

*Corresponding Author E-mail i.d: vijayeta.priyadarshini@gmail.com; Ph.D thesis submitted Rama Devi Women's University, Odisha -759 001

Pooja *et al*., 2022), leading to malnutrition and many other chronic health-related problems. Scare knowledge about the importance of a balanced diet and its relation to health, various cultural myths and fads relating to food, family diet habit, and financial vulnerability lead to food insecurity and unhealthy food practice in terms of avoidance, inaccessibilityis some of the significant determinants behind non-consumption of balanced diet among the adolescent girls of underprivileged section.Adolescent females in nations like India experience severe health issues because of socio-economic and environmental factors, poor nutrition, and gender discrimination. Increased physical activity, bad eating habits, and starting menstruation accentuate the potential danger of adolescents' poor nutrition. A balanced diet contains all the nutrients in approved amounts and proportions for the fulfilment of a person's daily nutritional needs, along with the provision of the reserve to meet the requirements in case of scarcity of food or increased demand by the body. Hence, proper nutritional knowledge is vital for a healthy life. Improved nutritional knowledge, attitude and practice by adolescent girls will not only improve the overall health situation of human resources of a country but also can be a gainful investment towards the future generation (Jalambo *et al*., 2017).

Sixty-two Indian tribes (including thirteen primitive tribes) live in Odisha, with a population of 9.59 million (GoI, 2011). These tribes represent 22.8% of the state's population and 9.19 % of the country's tribes. People from tribal groups are among the poorest and most marginalised groups and suffer from extreme levels of health deprivation. Among the tribal-concentrated districts in Odisha, Keonjhar district, which was selected to conduct this study, has almost half of its total population of 818,878 (45.4%) as tribals. The literacy rate among the tribals is 44.06%, and the tribal female literacy rate is 41.56% in the Keonjhar district (GoI, 2011). Few researchers have explored balanced diet knowledge, attitudes, behaviour and practice of Indian adolescents, particularly in tribal India. Hence the study was conducted to determine the knowledge, attitude and practice of a balanced dietamong tribal adolescent girls. Assessing the nutritional KAP among adolescent girls can provide valuable information for developing effective interventions to improve their nutritional status and prevent future health problems. Keeping these in view, the study aimed to assess socio-demographic data and the knowledge, attitude and practice of a balanced diet among tribal adolescent girls of Keonjhar district, Odisha.

## MATERIALS AND METHODS

The study focused on five blocks in the Keonjhar district, namely Banspal, Keonjhar, Harichandanpur, Joda, and Ghatgaon, where the tribal population was more concentrated. The study involved collecting data between 2021-22 from 301 adolescent girl respondents belonging to these tribes who were between the ages of 16 and 18 and neither pregnant nor lactating. Apre-structured interview schedule was prepared to collect general and socio-economic information aligned with the study's objectives. For information about nutritional knowledge, attitude and practice (KAP), a previously used and validated questionnaire (Patimah *et al*., 2016) was undertaken. The interview schedule contained 18 questions for nutritional knowledge, 15 for nutritional attitude and 12 for nutritional practices. The range of scores for nutritional knowledge and practices was 0-2. The score was "0" if the response was about not knowing and not practicing a nutritionally balanced diet. Similarly, the score was "1" when the response was "false" for the knowledge category and "sometimes" for the practices category, and the score was "2" if the answer was "true" for knowledge and "every day" for practices. Four-point Likert scale was used for attitude scoring. For positive questions, the scoring was 4, 3, 2, and 1 for strongly agree, agree, disagree and strongly disagree, respectively and vice-versa for negative

**Table 1. Socio-economic and demographic profile of tribal adolescent girls (n= 301)**

| S. No. | Variables | Number of the Respondents | Percentage (%) |
|---|---|---|---|
| 1 | 2 | 3 | 4 |
| | **Age** | | |
| 1 | 16 years | 116 | 38.54 |
| | 17 years | 112 | 37.21 |
| | 18 years | 73 | 24.25 |
| | **Type of Family** | | |
| 2 | Joint | 56 | 18.60 |
| | Nuclear | 245 | 81.40 |
| | **Total Number of Family Members** | | |
| 3 | 5 or less | 40 | 13.29 |
| | 6 – 7 | 194 | 64.45 |
| | More than 7 | 67 | 22.26 |
| | **Educational Status** | | |
| | Illiterate | 52 | 17.2 |
| | Primary (Completed Grade 5) | 149 | 49.5 |
| 4 | Upper primary (Completed Grade 7) | 40 | 13.29 |
| | Secondary (Class 8 to Class 10) | 58 | 19.27 |
| | Higher Secondary | 02 | 0.67 |
| | Graduation | 00 | 0 |
| | **Marital Status** | | |
| 5 | Married | 74 | 24.6 |
| | Unmarried | 227 | 75.4 |
| | **Occupation of the head of the family (Modified Kuppuswamy's SES Scale)** | | |
| 6 | Skilled Agricultural and Fishery Workers | 15 | 4.9 |
| | Craft and Related Trade Workers | 51 | 16.9 |
| | Plant and Machine Operators and Assemblers | 25 | 8.4 |
| | Elementary Occupation | 210 | 69.8 |
| | Unemployed | 0 | 0 |
| | **Total Monthly Family Income (Rs.)** | | |
| | Less than Rs.5000 | 0 | 0 |
| 7 | In between Rs.5000 – Rs 8000 | 205 | 68.1 |
| | In between Rs.8000 – Rs 10,000 | 79 | 26.25 |
| | More than Rs.10,000 | 17 | 5.65 |

*Table 1 contd...*

*Table 1 contd...*

| S. No. | Variables | Number of the Respondents | Percentage (%) |
|---|---|---|---|
| 1 | 2 | 3 | 4 |
| | **Kuppuswamy's Socioeconomic Status** | | |
| | Upper (I) | 0 | 0 |
| **8** | Upper Middle (II) | 0 | 0 |
| | Lower Middle (III) | 00 | 0 |
| | Upper Lower (IV) | 107 | 35.55 |
| | Lower (V) | 194 | 64.45 |

questions. The highest and lowest possible scores for nutritional knowledge, attitude and practices were 36-0, 60-15, and 24–0, respectively. Statistical analysis such as arithmetic mean, standard deviation, percent distribution, chi-square test, t-test and ANOVA were conducted. A p-value of 0.05 was considered the threshold for statistical significance.

**RESULTS AND DISCUSSION**

Table 1 displays information about the respondents, categorised according to their age group, family type, number of family members, monthly household income, educational attainment, and marital status. The socio-economic status of the family members was evaluated using the Modified Kuppuswamy's SES Scale (Saleem, 2020).

The study reported that the mean age of the respondents was 17 years, with the majority (38.54%) being 16 years old. It also revealed a shift from joint families to nuclear families, with only 18.6% of the adolescent girls belonging to joint families and the remaining 81.4% being from either nuclear or extended families. Nanda and Dhar (2017) and Santhanam and Maheswari (2022) reported similar results in their studies. Most families (64.45%) had 6-7 members, and only 22.26 percent and 13.29 percent had more than seven members and five or fewer members, respectively. Regarding education, 49.5% of the respondents had upto primary level education, while 17.2 percent were illiterate, and 32.58 percent had upper primary or secondary level education. The Census of India (2011) revealed a gender gap in literacy in Keonjhar district, with a low female literacy rate of only 41.56 percent. The study found that parents' financial status, negative attitude towards education, early marriage, linguistic barriers, and the unwillingness of parents to allow the girl child to attend school were some of the reasons for low enrollment and high dropout rates of tribal girls.The majority (75.4%) of the respondents were unmarried and one-fourth (25%) were married. Early marriage among adolescent girls is a common problem in tirbal regions of India, leading to malnutrition, maternal and neonatal mortality, and other health-related issues. The study also found that the heads of families were primarily engaged in elementary occupations *viz.,* agricultural labour, labour in mines, and collection of forest products, with only a small percentage (4.9%) engaged in skilled agricultural farming & fisheries. More than half (68%) of the respondent's families had a monthly income between Rs.5000-8000 and only 5.65% had a monthly income of more than Rs. 10,000. The Modified Kuppuswamy's SES Scale (Saleem, 2020) revealed that 64.45 percent of the respondents' families belonged to the lower socio-economic group, and (35.55%) belonged to the upper-lower socio-economic group and lacked basic household amenities. The findings of this study are consistent with those reported by Devi and Patil (2019), Mallick *et al*. (2021), and George

*et al.* (2022). The tribal economy is still marginalised due to illiteracy, geographical isolation, and a lack of knowledge about using modern techniques, as noted by Singh and Sadangi (2012).

Table 2 indicated that 41.2% of the respondents had average nutritional knowledge, and the rest, 58.8 percent had poor knowledge. The mean score was found to be 10.8 ± 2.9. The majority of the respondents answered "false" or "don't know" to the questions which ought to be "true". After enquiry, it was found that they didn't know similar foods that can be replaced for a particular food (food exchange list); the response was driven by their preference for noodles rather than knowledge. All the respondents replied "don't know" to the questions "ideal body weight monitoring is an indicator of nutritional adequacy and compliance of health status", "a balanced diet is the composition of the food consumed daily contains nutrients in the types and amounts according to the needs of the body with due regard to the principle of diversity, physical activity, hygiene and ideal body weight" and "a balanced diet is a guide to daily food consumption and healthy behaviour".

The overall nutritional attitude of the tribal adolescent girls was found to be negative. The mean score was 37.7 ± 1.8 out of a maximum of 60 score. A total of 91% of the respondents believed that expensive foods were better/ good for health than cheaper foods. Generally, the foods such as meat, fish, milk, pulses, etc. are considered suitable for health, and the higher price of these foods makes them inaccessible to most of the tribal population. Lack of proper nutritional education/awareness makes them ignorant about the various cheap alternative sources of nutritious foods. Hence, their positive response as "agree/ strongly agree" to questions such as "animal protein is better than vegetable protein" and "fish eating is good for health" was customarily driven by their belief that price determines the qualitative, nutritive aspects of any food. Negative questions such as "drinking milk alone are enough to make a healthy body" and "exercising just once a week" was responded as "agreed" by most of the respondents.

The overall nutritional practice of the tribal adolescent girls was categorised as average (mean score 9.7±1.3), reflecting a lack of knowledge and negative attitude towards a balanced diet. Though 58.8% of the respondents had poor nutritional knowledge, only 2.3% fell into the poor category of nutritional practices, which suggested the family's food habits greatly influenced the food

**Table 2. Nutritional knowledge, practices and attitude scores along with mean and standard deviation scores of tribal adolescent girls (n= 301)**

| S.No. | Particulars | Good | Average | Poor | Total | Mean & standard deviation | Max score possible |
|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 1 | Nutritional knowledge | 0 | 124 (41.2%) | 177 (58.8%) | 301 | 10.8 ± 2.9 | 36 |
| 2 | Nutritional attitude | 3 (0.9%) | 298 (99.1%) | 0 | 301 | 37.7 ± 1.8 | 60 |
| 3 | Nutritional practices | 0 | 294 (97.7%) | 07 (2.3%) | 301 | 9.7 ± 1.3 | 24 |

practices. Only 21 % of the respondents had the habit of eating breakfast daily. However, none of them (who were attending school) were carrying lunch with them to school. None of the respondents were in the habit of consuming fruits daily, and approximately two-thirds consumed fruits "sometimes". However, the respondents consumed vegetables every day and coloured vegetables sometimes, but not every meal of their had vegetables. Their food habit disclosed more quantities of roots and tubers such as potatoes and onion than vegetables.

Table 3 depicts the association between different socio-economic variables with nutritional knowledge, attitude and practices of the tribal adolescent girls of Keonjhar district. A Chi-square test for correlation was carried out to know the association. In nutritional knowledge, a statistically significant association was found between the education level of the respondents and Kuppuswamy's socio-economic status of the family of respondents ($p < 0.05$). Education serves as a key factor in the development of any person/ community. As most respondents were illiterate in primary education, they hardly knew about the importance of a balanced diet or the proper nutrition requirements for healthy living. Respondents with higher educational qualifications showed better knowledge and understanding regarding food and nutrition.Similarly, the indicators of socio-economic status as the number of family members, educational qualification, type of occupation of the parents, monthly household income etc., often play an essential role in the education of a girl child. The results indicated adolescent girls from better socio-economic backgrounds had better access to education and awareness, leading to better nutritional knowledge. A significant association was found between the education level of the respondents and their attitude towards nutrition. Attitude has been defined as a person's belief, motivation, and perception towards anything/ anybody which positively or negatively influences their behaviour or practice either positively or negatively. Most of the time, the child's attitude is greatly influenced by the parental/family attitude and belief system. Most of the respondents were first-generation literate; they had an overall negative attitude towards nutrition. They neither knew nor were aware of the importance of proper nutrition in a person, especially during nutritional stress periods such as adolescence, mainly because of their parental ignorance. Their understanding of health, hygiene, wellness, etc., with education, had improved compared to those with little or no educational exposure.

Lastly, a significant association was found between the respondents' nutritional practices and their family's monthly income. The type and quantum of expenditure is directly associated with income. In tribal communities, the issue of indebtedness has been deeply rooted due to their traditional cultural habits of spending large sums for bride-price, marriage, birth and death rites and

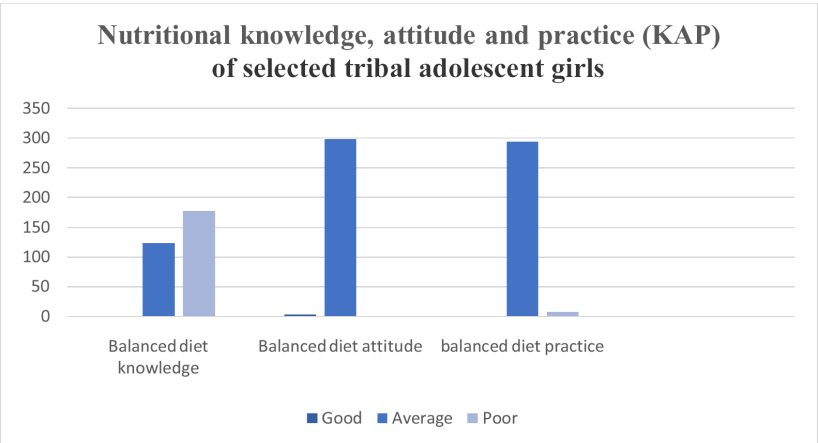


**Table 3. Association of different socioeconomic variables with nutritional knowledge, attitude and practices (n= 301)**

| | Variables | NUTRITIONAL KNOWLEDGE | | | | | | NUTRITIONAL ATTITUDE | | | | | | NUTRITIONAL PRACTICE | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Good | Average | Poor | Total | $X^2$ (Chi-Square) | p-value | Good | Average | Poor | Total | $X^2$ (Chi-Square) | p-value | Good | Average | Poor | Total | $X^2$ (Chi-Square) | p-value |
| | | >25 | 12 - 25 | <12 | | | | 40-60 | 20-39 | <20 | | | | >16 | 8 -15 | <8 | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| 1 | **Age (Years)** | | | | | **0.35** | **0.99** | | | | | **1.46** | **0.83** | | | | | **2.44** | **0·66** |
| | 16 | 0 | 50 | 66 | 116 | | | 1 | 115 | 0 | 116 | | | 0 | 112 | 4 | 116 | | |
| | 17 | 0 | 44 | 68 | 112 | | | 2 | 110 | 0 | 112 | | | 0 | 109 | 3 | 112 | | |
| | 18 | 0 | 30 | 43 | 73 | | | 0 | 73 | 0 | 73 | | | 0 | 73 | 0 | 73 | | |
| 2 | **Education** | | | | | **27.84** | **0.0000*** | | | | | **50.20** | **0.0*** | | | | | **4.45** | **0.82** |
| | Illiterate | 0 | 17 | 35 | 52 | | | 0 | 52 | 0 | 52 | | | 0 | 50 | 2 | 52 | | |
| | Primary (Completed Grade 5) | 0 | 50 | 99 | 149 | | | 2 | 147 | 0 | 149 | | | 0 | 148 | 1 | 149 | | |
| | Upper primary (Completed Grade 7) | 0 | 20 | 20 | 40 | | | 0 | 40 | 0 | 40 | | | 0 | 39 | 1 | 40 | | |
| | Secondary (Class 8 to Class 10) | 2 | 35 | 21 | 58 | | | 0 | 58 | 0 | 58 | | | 0 | 55 | 3 | 58 | | |
| | Higher Secondary | 0 | 2 | 0 | 2 | | | 1 | 1 | 0 | 2 | | | 0 | 2 | 0 | 2 | | |

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **3** | **Marital Status** | | | | | **0.17** | **0.9** | | | | | **0.99** | **0.61** | | | | | **0.06** | **0.97** |
| | Married | 0 | 29 | 45 | 74 | | | 0 | 74 | 0 | 74 | | | 0 | 72 | 2 | 74 | | |
| | Unmarried | 0 | 95 | 132 | 227 | | | 3 | 224 | 0 | 227 | | | 0 | 222 | 5 | 227 | | |
| **4** | **Total Number of Family Members** | | | | | **0.83** | **0.93** | | | | | **0.57** | **0.97** | | | | | **0.20** | **0.99** |
| | 5 or less | 0 | 19 | 21 | 40 | | | 0 | 40 | 0 | 40 | | | 0 | 39 | 1 | 40 | | |
| | 6 – 7 | 0 | 79 | 115 | 194 | | | 2 | 192 | 0 | 194 | | | 0 | 190 | 4 | 194 | | |
| | More than 7 | 0 | 26 | 41 | 67 | | | 1 | 66 | 0 | 67 | | | 0 | 65 | 2 | 67 | | |
| **5** | **Total Monthly Family Income** | | | | | **1.09** | **0.9** | | | | | **1.42** | **0.96** | | | | | **3.36** | **0.76 *** |
| | Less than Rs 5000 | 0 | 0 | 0 | 0 | | | 0 | 0 | 0 | 0 | | | 0 | 0 | 0 | 0 | | |
| | In between Rs 5000 – Rs 8000 | 0 | 85 | 120 | 205 | | | 3 | 202 | 0 | 205 | | | 0 | 198 | 7 | 205 | | |
| | In between Rs 8000 – Rs 10,000 | 0 | 34 | 45 | 79 | | | 0 | 79 | 0 | 79 | | | 0 | 79 | 0 | 79 | | |
| | More than Rs 10,000 | 0 | 5 | 12 | 17 | | | 0 | 17 | 0 | 17 | | | 0 | 17 | 0 | 17 | | |
| **6** | **Kuppuswamy's Socio-Economic Status** | | | | | **77.23** | **0.00 *** | | | | | **1.68** | **0.99** | | | | | **1.42** | **0.99** |
| | Upper (I) | 0 | 0 | 0 | 0 | | | 0 | 0 | 0 | 0 | | | 0 | 0 | 0 | 0 | | |
| | Upper Middle (II) | 0 | 0 | 0 | 0 | | | 0 | 0 | 0 | 0 | | | 0 | 0 | 0 | 0 | | |
| | Lower Middle (III) | 0 | 0 | 0 | 0 | | | 0 | 0 | 0 | 0 | | | 0 | 0 | 0 | 0 | | |
| | Upper Lower (IV) | 0 | 80 | 27 | 107 | | | 0 | 107 | 0 | 107 | | | 0 | 106 | 1 | 107 | | |
| | Lower (V) | 0 | 44 | 150 | 194 | | | 3 | 191 | 0 | 194 | | | 0 | 188 | 6 | 194 | | |

*** Chi-square value p <0.05, significant**

other religious ceremonies and consumption of handia (country liquor), alcohol, smoking, etc. (Devi and Palit, 2019). Devi and Palit (2019) also reported that in 80% of the tribal households in the Keonjhar district, their expenditure on food items was less than Rs.2000 per month. The primary food was rice or cereals, and the consumption of pulses or non-vegetarian foods and vegetables was neither quantitatively nor qualitatively adequate. The significant association of monthly family income with nutritional practices indicated that spending on qualitative food increased with a better financial status of the family.

**Table 4. Mean nutritional knowledge, attitude, and practices score of selected respondents in relation to marital status (n=301)**

| S. No. | Nutritional knowledge, attitude, practice score | Marital Status | | "t" score | p-value |
|---|---|---|---|---|---|
| | | Married (n=74) | Unmarried (n=227) | | |
| 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | Knowledge | 10.770±2.763 | 11.145±2.930 | 0.9693 | 0.3332 |
| 2 | Attitude | 35.595±1.345 | 35.683±1.972 | 0.3575 | 0.7210 |
| 3 | Practice | 9.919±1.353 | 9.621±1.293 | 1.7021 | 0.0898 |

***Significant at p < 0.05**

**Table 5. Mean nutritional knowledge, attitude, and practices score of respondents in relation to their monthly family income (n=301)**

| S. No. | Nutritional knowledge, attitude, practice score | Monthly income of the family | | | "F" score | p-value |
|---|---|---|---|---|---|---|
| | | Between Rs. 5000 – Rs. 8000 (n=205) | Between Rs. 8000 – Rs.10,000 (n=79) | More than Rs.10,000 (n=17) | | |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| 1 | Knowledge | 10.985±2.929 | 11.316±2.928 | 10.674±2.113 | 0.54705 | 0.579236 |
| 2 | Attitude | 35.624±2.046 | 35.747±1.278 | 35.706 ±1.318 | 0.13061 | 0.877614 |
| 3 | Practice | 9.180±0.906 | 10.557±1.357 | 11.882±0.832 | 88.92033 | <0.00001* |

***Significant at p < 0.05**

**Table 6. Mean nutritional knowledge, attitude, and practice score of selected respondents in relation to their socioeconomic status (n=301)**

| S.No. | Nutritional knowledge, attitude, practice score | Socio-economic status | | "t"score | p-value |
|---|---|---|---|---|---|
| | | Upper Lower (IV) (n=107) | Lower (V) (n=194) | | |
| 1 | 2 | 3 | 4 | 5 | 6 |
| 1 | Knowledge | 11.224±2.904 | 10.959±3.078 | 0.7293 | 0.4664 |
| 2 | Attitude | 35.674±1.326 | 35.665±2.551 | 0.0416 | 0.9669 |
| 3 | Practice | 10.636±1.423 | 9.175±0.956 | 10.6094 | 0.0001* |

The mean scores for nutritional knowledge, attitude, and practice among selected tribal adolescent girls were examined based on their marital status (Table 4). The mean score for nutritional knowledge was 10.770±2.763 for married and 11.145±2.930 for unmarried respondents. Similarly, the mean scores for nutritional attitude were 35.595±1.345 for married girls and 35.683±1.972 for unmarried girls, while, the mean scores for nutritional practices were 9.919±1.353 for married girls and 9.621±1.293 for unmarried girls. It was found that unmarried girls had slightly higher mean scores for nutritional knowledge and practice compared to married girls. However, there was no statistically significant difference in the scores for nutritional knowledge, attitude, and practice between married and unmarried tribal adolescent girls.

Table 5 represents the mean nutritional knowledge, attitude, and practice scores among selected tribal adolescent girls based on their monthly family income. For respondents in the Rs. 5000 – Rs.8000 monthly income group, the mean scores for nutritional knowledge, attitude, and practice were 10.985±2.929, 35.624±2.046, and 9.180±0.906, respectively. Among respondents in the Rs. 8000 – 10,000 monthly income category, the mean scores for nutritional knowledge, attitude, and practices were 11.316±2.928, 35.747±1.278, and 10.557±1.357, respectively. In case of respondents with more than Rs 10,000 monthly income , the mean scores for nutritional knowledge, attitude, and practices were 10.674±2.113, 35.706±1.318, and 11.882±0.832, respectively. The highest mean nutritional knowledge and attitude score in the Rs. 8000 – Rs.10,000 monthly income category was observed. In contrast, the highest mean score for nutritional practice was found in the more than Rs.10,000 monthly income group. There was a statistically significant difference in the mean scores for nutritional practice among different monthly family income groups.

Table 6 represents the mean nutritional knowledge, attitude, and practice scores among selected tribal adolescent girls based on socio-economic status. The mean scores for nutritional knowledge, attitude, and practice for upper-lower category respondents were 11.224±2.904, 35.674±1.326 and 10.636±1.423, respectively. The scores for the lower socio-economic category were 10.959±3.078, 35.665±2.551 and 9.175±0.956. The mean scores for the upper-lower socio-economic class were slightly higher than the lower socio-economic category. Statistical significance in the difference in mean scores in the two socio-economic groups was found in case of nutritional practices scores.

## CONCLUSIONS

The tribal adolescent girls of Keonjhar district had average to poor nutritional knowledge (mean score 10.8 ± 2.9). The nutritional practices were meagre (mean score 9.7 ± 1.3). A significant association ($p < 0.05$) between nutritional knowledge and attitude with education showed girls with higher levels of education had a better understanding of the nutrition topics when compared to those with lower levels of education. This highlights the need for educational interventions to improve nutrition knowledge and practices among the tribal population. The analyses also revealed a significant difference for nutritional practices score with family income and socio-economic status ($p < 0.05$).

## ACKNOWLEDGEMENTS

The researchers thanks the respondents and their families for their cooperation in conducting the study.

## REFERENCES

Devi, S.K and Palit, S. 2019. Assessing the perpetuity of tribe indebtedness: An empirical analysis. Academic Journal of Interdisciplinary Studies. 8(2):102 116. DoI: 10.5901/ajis.2019.v8n2r

George, L., D'Souza, S. R. B and Sequira, L. 2022. A study to determine the nutritional status, quality of life and explore the epidemiological factors affecting nutrition among young adolescent tribal girls of Namkum block, Jharkhand: A mixed method study. Retrieved from the website (https://ssrn.com/abstract=4090269) on 25.4.2023.

Jalambo, M.O., Sharif, R., Naser, I.A and Karim, N.A. 2017. Improvement in knowledge, attitude and practice of iron deficiency anaemia among iron-deficient female adolescents after nutritional educational intervention. Global Journal of Health Science. 9:15–23.

Mallick, M., Khatua, P and Swain, R. N. 2021. An analysis of the living standards of the Kandha people in Kandhamal district of Odisha. International Journal of Economic Perspectives.15(1): 249–264.

Nanda, S and Dhar, R.N. 2017. A study on nutritional status of adolescent girls of Dongria Kondh tribe. International Journal of Community Medicine and Public Health. 4:1573-1576.

Patimah, S., Royani, I., Mursaha, A and Thaha, A.R. 2016. Knowledge, attitude and practice of balanced diet and correlation with hypochromic microcytic anaemia among adolescent school girls in Maros district, South Sulawesi, Indonesia. Biomedical Research. 27 (1): 165-171.

Pooja, A., Rajeswari, M and Lakshmi, V. 2022. A study on BMI status, dietary habits and frequency of food consumption by indigenous tribes. International Journal of Food and Nutritional Sciences. 11:21-26.

Radhakrishnan, T., Babu, P.K and Xavier, M. 2021. Undernutrition of adolescent girls in India: A public health menace. International Journal of Multidisciplinary Educational Research. 10:9(5): 51 -57. DoI: http://ijmer.in.doi./2021/10.09.91

Radhika, M.S., Swetha, B., Kumar, B.N., Balakrishna, N and Laxmaiah A. 2018. Dietary and non-dietary determinants of nutritional status among adolescent girls and adult women in India. Annals of the New York Academy of Sciences. 1416: 5 - 17. DOI: 10.1111/nyas.13599

Saleem, S.M. 2020. Modified Kuppuswamy socio-economic scale updated for the year 2020. Indian Journal of Forensic and Community Medicine.7(1):1-3. DoI: https://doi.org/10.18231/j.ijfcm.2020.001

Santhanam, G and Maheswari, K. 2022. Socio-demographic profile of the selected scheduled tribe adolescent girls in Kodaikanal-Tamil Nadu. International Journal of Food and Nutritional Sciences. 11:126-132. DOI: 10.4103/ijfans_186_22.

Singh, A and Sadangi, B.N. 2012. Livelihood patterns and resource rise of tribals in Koraput and Rayagada district of Odisha. Indian Research Journal of Extension Education. Special Issue. (1): 307-312.

Vijayeta, P and Biswal, G. 2023. Knowledge, attitude and practice (KAP) on nutritional aspects among tribal adolescent girls of Keonjhar district, Odisha. The Journal of Research ANGRAU. 51(3):83-92. DoI: https://doi.org/10.58537/jorangrau.2023.51.3.10

DoI: https://doi.org/10.58537/jorangrau.2023.51.3.11

J. Res. ANGRAU 51 (3) 93-102, 2023

# OPTIMIZATION AND EVALUATION OF QUALITY OF THE PEARL MILLET NUTRI WAFFLES

**P. PRIYA.,E. R ANEENA,SEEJA THOMACHAN, P. S LAKSHMY and P. PRAMEELA**

Department of Community Science, College of Agriculture,
Kerala Agricultural University, Vellanikkara, Thrissur – 680 656

Date of Receipt :29.4.2023 Date of Acceptance : 16.6.2023

## ABSTRACT

The study was carried out (2019-2022) to formulate nutritionally superior waffles with pearl millet. Pearl millet was used as the major ingredient in varying proportions starting from 90% to 50% along with 10% to 50% refined wheat flour and tapioca flours. Based on the organoleptic evaluation, nutri waffles prepared with pearl millet flour and refined wheat flour (RWF), $PWT_3$ (70% PMF + 30% RWF) had good sensory qualities. Pearl millet centered nutri waffles with tapioca flour (TF), the treatment $PTT_4$ (60% PMF + 40% TF) secured the top mean score of 8.47 for overall acceptability. The study showed the scope for value addition of pearl millet for nutri waffles incorporated with refined wheat flour and tapioca flour.

**Keywords** : Pearl millet flour, Refined wheat flour, Tapioca flour, Waffles

## INTRODUCTION

Millets are labelled “yesterday’s coarse grains and today’s nutri-cereals” and those are the options for dryland farming. They are high resistance crops, have a low carbon foot print and can grow in barren soils with minimum inputs. The common popular millets are more nutritious (3-5 times) than staple grains such as rice, wheat and maize. Higher content of vitamins, fibre, proteins and minerals in millets can be a solution to decrease the aggravating incidence of undernourishment and lifestyle diseases in Indian population.

Recognizing the prominence of millets, the Government of India observed 2018 as the year of millets to boostup and supportthe production of millets. To make national and international demand and also to provide nutritious food, the Indian Government spearheaded the United Nations General Assembly (UNGA) and declared 2023 as the “International Year of Millets” (GoI, 2022).

Today’s consumers demand nutritious convenient foods and food processing ventures are increasingly targeting the production of nutritionally improved food items. To promote food crops and for increasing employment opportunities, the Government of India has approved the Production Linked Incentive Scheme for food processing industries. Millet based ready to eat products are preferred under this scheme and it has aimed to introduce at least one new product every year (GoI, 2022).

Pearl millet is a source of micronutrients and has nutraceutical components and is most widely grown millet. Their consumption has a positive effect on health concerning several lifestyle diseases. In today’s modern life, various ready-to-eat (RTE) foods have become an integral part of

*Corresponding Author E-mail i.d: riya-2019-16-007@student.kau.in; M.Sc thesis submitted to Kerala Agricultural University, Thrissur - 680 656

our food habits. Among the variety of RTE products, waffles occupy a significant place. Waffles are convenient foods eaten either as bites or as a breakfast item. Waffle is a product prepared from leavened batter or dough that cooked between two patterned hot plates to give a characteristic size, shape and surface impression. Hence, the study entitled 'Optimization and evaluation of quality of the pearl millet nutri waffles' is proposed to develop nutri waffles from pearl millet with different composite mixes and to evaluate its quality parameters.

## MATERIALS AND METHODS

### Selection and collection of raw materials

The study was conducted between 2019 and 2022 at KAU, Vellanikkara, Kerala. Pearl millet (*Pennisetum glaucum*) was selected as the major ingredient for developing nutri waffles. Tapioca flour and refined wheat flour (maida) were also used with pearl millet flour for developing nutri waffles. Sugar, oil and vanilla essence were used as the other ingredients and were collected from a local market.

### Standardization of pearl millet incorporated nutri waffles

The collected pearl millet grains were cleaned, washed and germinated. The pearl millet was soaked for 12 h with the water being changed at 4-hour intervals. The moist grains were tied in a wet cloth and sprinkled with water at 12-hour intervals. After 48 h, germinated grains were dried and powdered.

Tapioca flour was prepared by slicing and blanching the raw tapioca in boiling water for 5-10 minutes. The blanched tapioca was then dried. The dried chips were milled into flour and sieved through a 40-mesh size to get a fine powder. Pearl millet

**Table 1. Details of combinations of pearl millet and refined wheat flour for nutri waffles**

| S. No. | Treatments | Combination |
|---|---|---|
| 1. | $T^{w}_{0}$ (Control) | 100% Refined wheat flour (RWF) |
| 2. | $PWT_{1}$ | 90% PMF + 10% RWF |
| 3. | $PWT_{2}$ | 80% PMF + 20% RWF |
| 4. | $PWT_{3}$ | 70% PMF + 30% RWF |
| 5. | $PWT_{4}$ | 60% PMF + 40% RWF |
| 6. | $PWT_{5}$ | 50% PMF + 50% RWF |

(*PMF - Pearl millet flour, RWF - Refined wheat flour)

**$T^{T}_{0}$ – $PTT_{5}$ :** The same treatments $T^{W}_{0}$ – $PWT_{5}$ were repeated using tapioca flour instead of refined wheat flour ($T^{T}_{0}$ - $PTT_{5}$) in Table 2.

**Table 2. Details of combinations of pearl millet and tapioca flour for nutri waffles**

| S. No. | Treatments | Combination |
|---|---|---|
| 1. | $T^{T}_{0}$ (Control) | 100% Tapioca flour (TF) |
| 2. | $PTT_{1}$ | 90% PMF + 10% TF |
| 3. | $PTT_{2}$ | 80% PMF + 20% TF |
| 4. | $PTT_{3}$ | 70% PMF + 30% TF |
| 5. | $PTT_{4}$ | 60% PMF + 40% TF |
| 6. | $PTT_{5}$ | 50% PMF + 50% TF |

(*PMF - Pearl millet flour, TF - Tapioca flour)

**Table 3. Prepared nutri waffles ingredients**

| S.No. | Treatments | Flour | Sugar | Oil | Flouring agent | Salt | Water |
|---|---|---|---|---|---|---|---|
| 1. | Control (100% RWF) | 60 g | 26 g | 10 ml | 2 ml | 2 g | 100 ml |
| 2. | Control (100% TF) | 60 g | 26 g | 10 ml | 2 ml | 2 g | 125 ml |

(RWF - Refined wheat flour, TF – Tapioca flour)

flour, refined wheat flour and tapioca flour were used in the preparation of waffles.

**Pearl millet nutri waffles**

Two sets of nutri waffles were prepared using pearl millet flour (PMF) as the major ingredient added with two different flours in varying proportions ranging from 10 percent to 50 percent. Refined wheat flour (RWF) and tapioca flour (TF), were used. Treatment $T^{w}_{0}$ (control) contained 100 percent refined wheat flour and $T^{T}_{0}$ (control) contained 100 percent tapioca flour. The proportions of treatments and combinations are detailed in Table 1.

All the ingredients were measured and mixed well with warm water. A batter was prepared with desirable consistency, then, the batter was transferred into the preheated waffle machine. The mix was baked for one minute and 30 seconds at 180 $^{o}$C. After the baking, the flat waffles were made into desirable shapes. The ingredients used for making waffles are specified in Table 3 andpreparation method of nutri waffles is represented in Figures 1a and 1b.

**Organoleptic evaluation**

A series of acceptability trials were carried out by a selected board of fifteen judges between the age group of 18- 35 years, who were selected using a simple triangle test at thelaboratory level. The sensory evaluation of the nutri waffles wascarried out. The reconstituted nutri waffles were valued organoleptically by the judgesvia 9-point hedonic scale.

**Physico-chemical analysis**

The physicochemical qualities like moisture, protein, total carbohydrate, starch, total fibre, fat, calcium, iron, sodium and potassium levels of best-selected pearl millet flour incorporated nutri waffles were determined initially. Analyses were carried out in triplicate.

**Statistical analysis**

The interpretations were tabularized and statistically analysed as T-test by using GRAPES statistical software version 11.0. The sensory evaluationscores were evaluated by Kendall's coefficient of concordance (w).

**Cost of production**

The budget of production of the best combinations of pearl millet flour incorporated nutri waffles were computed based on the market price of procured ingredients used for the production along with labour charges, fuel charges, electricity charges and packaging costs. The cost was calculated for 100 g of the product with similar products available in the market.

**RESULTS AND DISCUSSION**

**Organoleptic evaluation**

Sensory evaluation is used to measure, analyse and interpret how the attributes of a product are perceived by people. These sensory attributes are the combination of characteristics that together produce a sensory experience (texture, aroma, colour, flavour) and the human senses such as sight, hearing, taste, smell and touch are measuring the attributes. The suitability of pearl millet flour in refined wheat flour and tapioca flour combinationfor the improvement of nutri waffles was evaluated.

The nutri waffles based on pearl millet flour were standardised with unlike proportions of refined wheat flour (Fig. 2). The mean scores and rank scores for dissimilar quality features of pearl millet

Conditioning of waffle mix flour (100 g)
↓
Addition of other ingredients
↓
Preparation of batter
↓
Baking (waffle machine 180 °C for 1 min and 30 sec)
↓
Waffle cone
↓
Packing

**Figure 1a. Flowchart for the formulation of nutri waffles**

nutri waffles with refined wheat flour are presented (Table 4).

Among the pearl millet (PMF) nutri waffles prepared with refined wheat flour (RWF), $T_3$ (70% PMF + 30% RWF) scored higher mean scores for appearance (8.70), colour (8.56), flavour (7.45), texture (7.95), taste (7.35) and overall acceptability (8.07) than other combinations and scored total mean score of 48.08 out of 54. Based on this result, pearl millet-refined wheat flour combination as 70 percent pearl millet and 30 percent refined wheat flour incorporation would form acceptable waffles.

Vimalarani *et al*. (2016) formulated extruded product from pearl millet (30%) with wheat flour

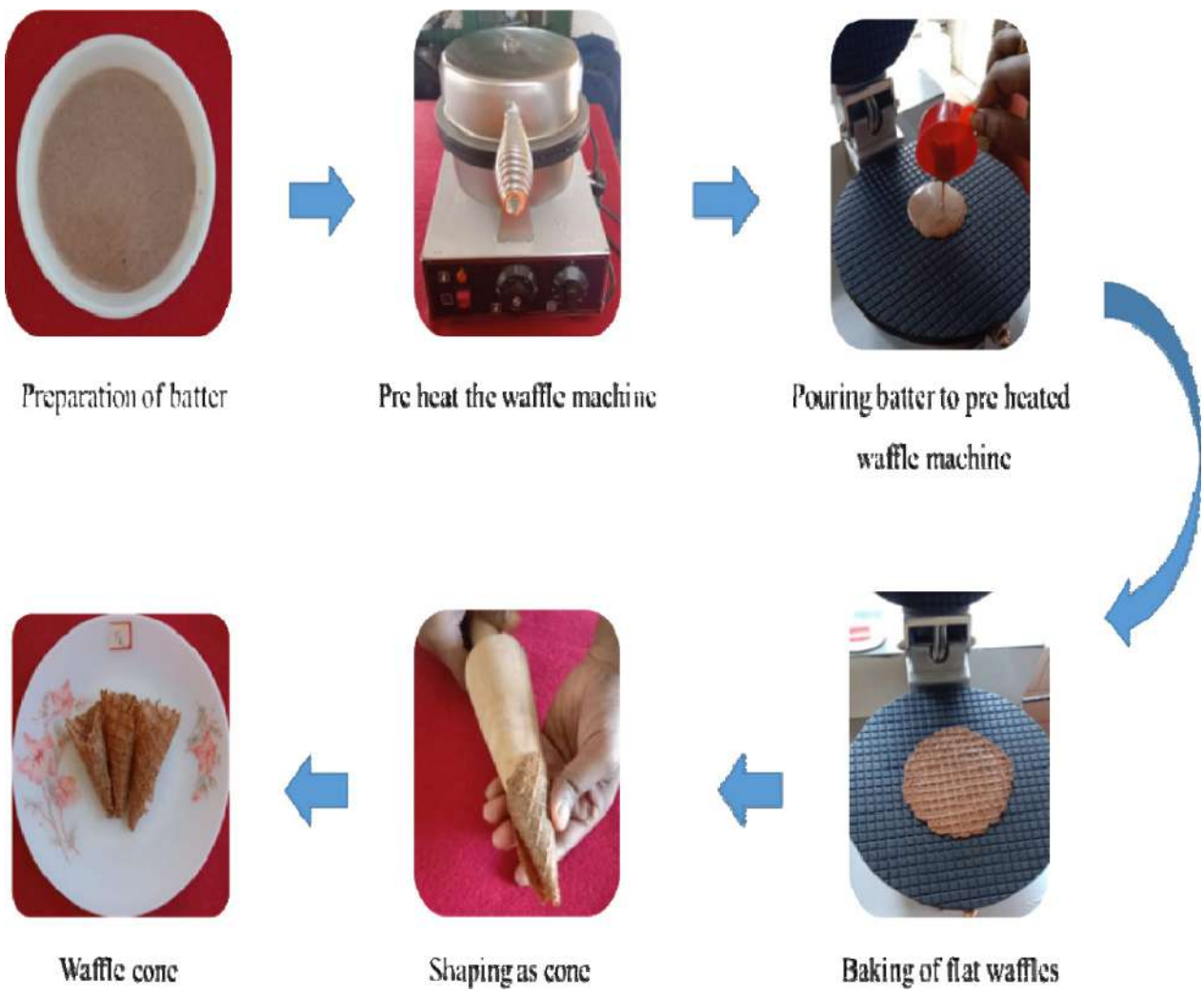



**Figure 1b. Flowchart for the formulation of nutri waffles**

(50%) and soya or chickpea flour (20%) and it was found to have the highest mean score (8) in terms of overall acceptability. Johari (2017) developed processed and unprocessed pearl millet instant noodles and pasta. The blanched pearl millet pasta recorded greater values for all organoleptic attributes than unprocessed pasta. The blanched pearl millet pasta scored good values for taste (8), overall acceptability (7.9), texture (7.8), colour (7.7) and appearance (7.6).

The pearl millet nutri waffles were standardised using pearl millet flour blended with different proportions of tapioca flour (Fig.3). The mean scores and rank scores for each quality attributes of pearl millet nutri waffles incorporated with tapioca flour ( Table 5).

Among the pearl millet nutri waffles incorporated with tapioca flour (TF), $T_4$ (60% PMF + 40% TF) scored a total mean score of 50.83 and also acquired the best mean scores for appearance (8.44), colour (8.33), flavour (8.75), texture (8.60) and overall acceptability (8.47). This combination also obtained a good mean score for taste (8.24). For best quality waffles with 60 percent pearl millet and 40 percent tapioca flour is the best choice, because this combination resulted in good scores for quality parameters in sensory evaluation.

For gluten intolerance patients, Devi *et al.* (2015) prepared sweet vermicelli using pearl millet, sorghum and mung bean, which had good sensory and nutritional properties. Hence, the incorporation of tapioca flour by substituting refined wheat flour into waffles can reduce gluten content and this combination is suitable for celiac patients also. Singh *et al*. (2019) formulated 50 percent bajra flour with 50 percent chickpea flour biscuits and this combination was also successful.

From the data, the colour of the $T_1$ (90% PMF + 10% TF) was different from $T_4$ (60% PMF + 40% TF). This may be because of the Maillard reaction and caramelisation of the sugars, taking place during the baking of waffles. Differences in colour properties can be caused by protein content and type of protein also and the reaction of amino acids with reducing sugar in ingredients, which gives darker colour to the waffles (Shevkani *et al*., 2015). The score for the texture of the nutri waffles was slightly lower in the higher proportioned pearl millet combination. An increase in pearl millet incorporation marginally increased textural properties like hardness, cohesiveness and chewiness (Samuel and Peerkhan, 2020). The total score obtained was almost on par for it can be concluded that . From this, it is clear that, the incorporation of pearl millet flour in a range between 50 percent and 90 percent was excellent for nutri waffle making.

Based on the organoleptic qualities, the most acceptable treatments from each set were selected. Selected combinations of nutri waffles from sets 1 and 2 are specified as nutri waffle 1 (NW.1) and nutri waffle 2 (NW.2), which were shown in Table 6.

**Physico-chemical analysis of nutri waffles**

The nutritional qualities of pearl millet-refined wheatflour combined nutri waffles (NW.1) and its control waffles ($T^W_0$) were tabulated (Table 7).

The moisture, total carbohydrate and starch of control waffles were significantly different and higher than those of NW.1, such as 5.87 percent (moisture), 70.56 g/100 g (total carbohydrate) and 42.02 g/100 g (starch) were existing in control waffles and for NW.1, the moisture, total carbohydrate and starch content were found to be 3.11 percent, 65.10 g/100 g and 35.79 g/100 g, respectively.

Other nutrients such as protein, total fat, total fibre, calcium, iron, sodium and potassium contents were greater in pearl millet-refined wheat flour nutri waffles and the nutrient contents were 7.46 g/100 g (protein), 4.52 g/100 g (total fat), 5.32 g/100 g (total fibre), 15.16 mg/100 g (calcium), 2.33 mg/100 g (iron), 2.27 mg/100g (sodium) and 180.46 mg/100 g (potassium). The nutritional composition of waffles (control) was 6.22 g/100 g, 2.56 g/100 g, 1.66 g/100 g, 12.24 mg/100 g, 0.06 mg/100 g, 1.18 mg/100 g and 89.32 mg/100 g in protein, total fat, total fibre, calcium, iron, sodium and

**Table 4. Mean scores for organoleptic qualities of pearl millet nutri waffles incorporated with refined wheat flour**

| S. No. | Treatment | Appear-ance | Colour | Flav-our | Text-ure | Taste | Overall accepta-bility | Total score |
|---|---|---|---|---|---|---|---|---|
| 1. | $T_0$(100% RWF) | 8.67 (3.33) | 8.51 (4.00) | 8.24 (5.97) | 8.67 (5.67) | 8.47 (5.67) | 8.67 (6.00) | 51.23 |
| 2. | $T_1$(90% PMF + 10% RWF) | 8.67 (3.27) | 8.55 (2.80) | 6.67 (1.00) | 7.13 (1.33) | 6.24 (1.33) | 7.45 (1.00) | 44.71 |
| 3. | $T_2$(80% PMF + 20% RWF) | 8.73 (3.67) | 8.55 (3.13) | 7.23 (2.23) | 7.66 (2.20) | 7.11 (3.07) | 7.98 (2.03) | 47.26 |
| 4. | $T_3$(70% PMF + 30% RWF) | 8.70 (3.67) | 8.56 (3.93) | 7.45 (4.37) | 7.95 (4.43) | 7.35 (4.37) | 8.07 (4.57) | 48.08 |
| 5. | $T_4$(60% PMF + 40% RWF) | 8.67 (3.40) | 8.53 (3.67) | 7.45 (4.37) | 7.90 (4.17) | 7.35 (4.37) | 8.05 (4.27) | 47.95 |
| 6. | $T_5$(50% PMF + 50% RWF) | 8.70 (3.67) | 8.55 (3.47) | 7.38 (3.07) | 7.84 (3.20) | 7.27 (3.07) | 8.04 (3.13) | 47.78 |
| 7. | Kendall's value | 0.014** | 0.087** | 0.921** | 0.732** | 0.751** | 0.962** | |

**(PMF- Pearl millet flour, RWF- Refined wheat flour); Value in parentheses are mean rank scores based on Kendall's W test; ** Significant at 1% level**

potassium, respectively. As per t-test statistics, the difference between the control and NW.1 waffle was found to be significant in the case of protein, total fat, total fibre, calcium and potassium content and iron and sodium content of waffles were found to be non-significant.

Mamta (2015) developed pearl millet centered convenience food blends like *halwa, laddoo and paushtik atta* mix with a mishmash of refined wheat flour. Calcium and iron content in established traditional convenient foods ranged from 25.94 to 959.38 and 0.68 to 10.15 mg/100 g. The crispies supplemented with pearl millet, rice and maize in a proportion of 30:35:35 (type 1) and 40:30:30 (type 2) have 2.09 and 1.82 g/100 g moisture content, which is lower than the control value (2.40 g/100 g). Other nutrients in control crispies (50% rice and 50% maize) such as crude protein (9.12 g/100 g), crude fat (14.88 g/100 g), dietary fibre (7.27 g/100 g), calcium (44.20 mg/100 g), iron (2.73 mg/100 g) and zinc (1.09 mg/100 g) were greater in type 1 and type 2. Starch and reducing sugar values of control are upper than type 1 (48.10 and 0.46 g/100g) and type 2 (47.96 and 0.37 g/100 g) crispies.

The pearl millet instant noodles have 8.94 and 9.02 (g /100 g) moisture content in type 1 and type 2 noodles with proportions of 60:40 and 70:40 of pearl millet with refinedwheat flour combinations. From these noodles, type 1 had 9.88 g/100 g protein, 3.38 g/100 g fat, 8.89 g/100 g dietary fibre, 36.85 mg/100g calcium and 4.26 mg/100 g iron. The type 2 noodles had 9.02 g/100 g moisture, 10.10 g/100g protein, 3.50 g/100 g fat, 9.04 g/100 g dietary fibre, 37.12 mg/100 g calcium and 4.78 mg/100 g iron (Mamta, 2015).

The nutritional qualities of pearl millet nutri waffles incorporated with tapioca flour (NW.2) were analysed and compared with that of the control waffles (Table 8).

**Table 5. Mean scores for organoleptic qualities of pearl millet nutri waffles incorporated with tapioca flour**

| S. No. | Treatment | Appear-ance | Colour | Flav-our | Text-ure | Taste | Overall accepta-bility | Total score |
|---|---|---|---|---|---|---|---|---|
| 1. | $T_0$(100% TF) | 7.13 (2.53) | 7.87 (3.33) | 7.67 (3.23) | 7.47 (3.07) | 8.27 (4.17) | 7.68 (3.07) | 46.09 |
| 2. | $T_1$(90% PMF + 10% TF) | 7.60 (1.97) | 7.73 (2.70) | 7.73 (2.17) | 8.10 (3.70) | 7.27 (2.40) | 7.69 (2.53) | 46.12 |
| 3. | $T_2$(80% PMF + 20% TF) | 8.15 (3.93) | 8.08 (3.50) | 8.15 (2.57) | 8.25 (4.00) | 6.93 (1.60) | 7.91 (2.63) | 47.47 |
| 4. | $T_3$(70% PMF + 30% TF) | 8.00 (3.10) | 8.31 (4.17) | 8.31 (3.03) | 7.07 (2.20) | 8.53 (4.97) | 8.04 (3.33) | 48.26 |
| 5. | $T_4$(60% PMF + 40% TF) | 8.44 (5.27) | 8.33 (4.37) | 8.75 (4.43) | 8.60 (5.07) | 8.24 (3.87) | 8.47 (5.33) | 50.83 |
| 6. | $T_5$(50% PMF + 50% TF) | 8.27 (4.20) | 7.91 (2.93) | 9.00 (5.57) | 7.67 (2.97) | 8.27 (4.00) | 8.22 (4.10) | 49.34 |
| 7. | Kendall's value | 0.473** | 0.133** | 0.512** | 0.290** | 0.465** | 0.325** | |

**(PMF- Pearl millet flour, TF- Tapioca flour); Value in parentheses are mean rank scores based on Kendall's W test; ** Significant at 1% level**

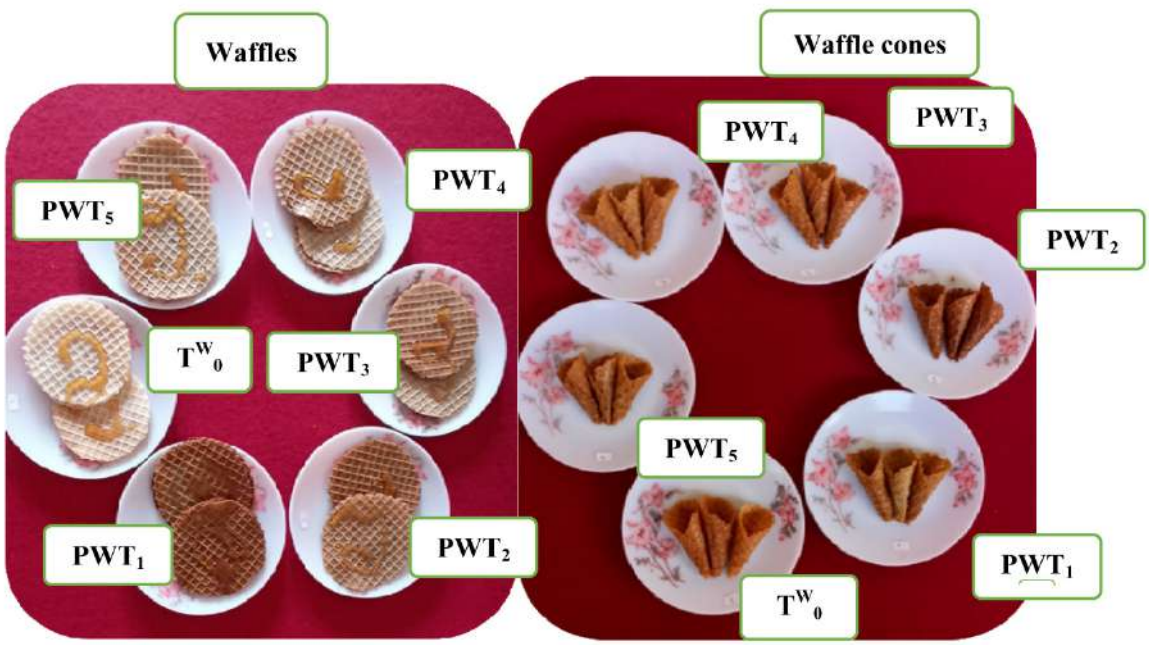



**Figure 2. Pearl millet nutri waffles incorporated with refined wheat flour**

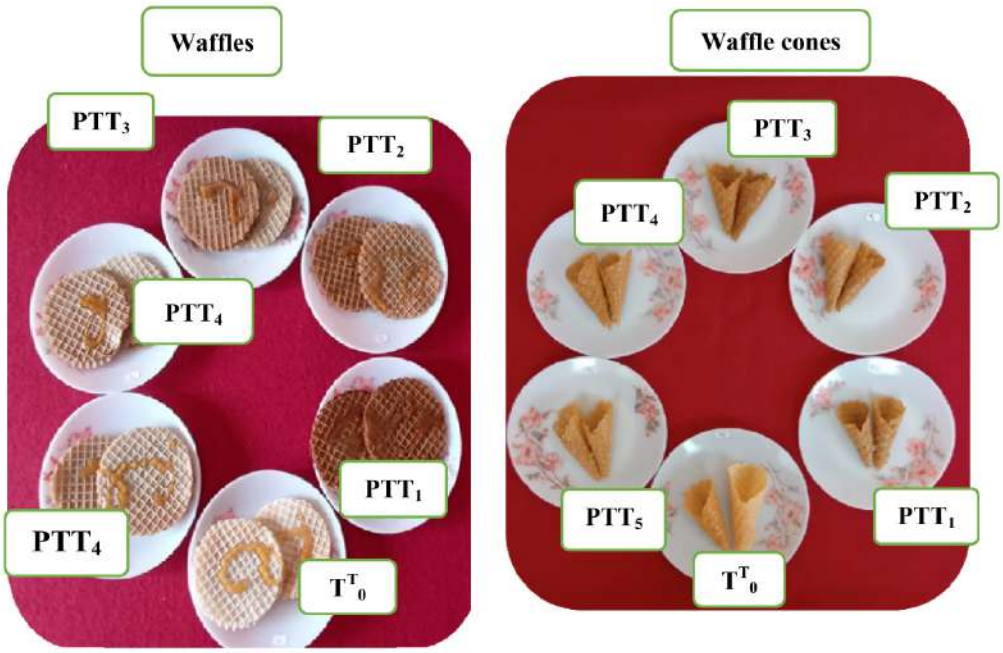



**Figure 3. Pearl millet nutri waffles incorporated with tapioca flour**

**Table 6. Combinations of selected nutri waffles**

| S.No. | Sets | Nutri waffles | Selected treatment | Combinations |
|---|---|---|---|---|
| 1. | Set 1 | Nutri Waffles 1 (NW.1) | $PWT_3$ | (70% Pearl millet flour + 30% Refined wheat flour) |
| 2. | Set 2 | Nutri Waffles 2 (NW.2) | $PTT_4$ | (60% Pearl millet flour + 40% Tapioca flour) |

**Table 7. Nutritional qualities of pearl millet nutri waffles incorporated with refined wheat flour ($PWT_3$)**

| S.No. | Treatment | $T^W_0$ | NW.1 | t value |
|---|---|---|---|---|
| 1. | Moisture (%) | 5.87 | 3.11 | 5.39* |
| 2. | Total carbohydrate (g/100 g) | 70.56 | 65.10 | 63.23* |
| 3. | Protein (g/100 g) | 6.22 | 7.46 | 17.74* |
| 4. | Total fat (g/100 g) | 2.56 | 4.52 | 4.91* |
| 5. | Total fibre (g/100 g) | 1.66 | 5.32 | 2.76* |
| 6. | Starch (g/100 g) | 42.02 | 35.79 | 31.37* |
| 7. | Calcium (mg/100 g) | 12.24 | 15.16 | 20.92* |
| 8. | Iron (mg/100 g) | 0.06 | 2.33 | $0.65^{NS}$ |
| 9. | Sodium (mg/100 g) | 1.18 | 2.27 | $0.81^{NS}$ |
| 10. | Potassium (mg/100 g) | 89.32 | 180.46 | 7.74* |

**($T^W_0$ - 100% RWF; NW.1- 70% PMF + 30% RWF; PMF- Pearl millet flour, RWF-Refined wheat flour and NW-Nutri waffles); t-test (t) values are significant at 5% level**

**Table 8. Nutritional qualities of pearl millet nutri waffles incorporated with tapioca flour ($PTT_4$)**

| S.No. | Treatment | $T^T_0$ | NW.2 | t value |
|---|---|---|---|---|
| 1. | Moisture (%) | 7.03 | 6.43 | 23.73* |
| 2. | Total carbohydrate (g/100g) | 36.69 | 52.33 | 14.52* |
| 3. | Protein (g/100 g) | 0.62 | 5.22 | $1.60^{NS}$ |
| 4. | Total fat (g/100 g) | 2.22 | 4.10 | 4.13* |
| 5. | Total fibre (g/100 g) | 1.20 | 4.62 | $2.10^{NS}$ |
| 6. | Starch (g/100 g) | 9.22 | 23.56 | 5.48* |
| 7. | Calcium (mg/100 g) | 15.53 | 16.06 | 66.84* |
| 8. | Iron (mg/100 g) | 0.05 | 1.82 | $1.47^{NS}$ |
| 9. | Sodium (mg/100 g) | 6.78 | 4.35 | 8.19* |
| 10. | Potassium (mg/100 g) | 153.52 | 193.12 | 22.95* |

**($T^T_0$ - 100% TF; NW.2- 60% PMF + 40% TF; PMF- Pearl millet flour, TF-Tapioca flour and NW-Nutri waffles); T-test (t) values are significant at 5% level**

The highest nutritional content was observed in NW.2 for total carbohydrate (52.33 g/100 g), protein (5.22 g/100 g), total fat (4.10 g/100 g), total fibre (4.62 g/100 g), starch (23.56 g/100 g), calcium (16.06 mg/100 g), iron (1.82 mg/100 g) and potassium (193.12 mg/100 g). Other nutritional qualities like moisture (6.43%) and sodium (4.35 mg/100 g) were found to be lower in NW.2 than control. As per the t-test, the nutrients such as moisture, total carbohydrates, total fat, starch, calcium, sodium and potassium content of waffles were significantly different and there was no significant difference in protein, total fibre and iron content of waffles.

Yadav *et al.* (2014) formulated pasta by using pearl millet and by adding barley flour and whey protein concentrate. The values for protein, calcium and iron content of developed pasta were 16.47 g/ 100 g, 98.53 mg/100 g and 5.43 mg/100 g respectively. Pradeep *et al*. (2014) formulated nutritious ready-to-eat snack mix prepared by popped pearl millet and legumes with sugar and other ingredients (30:20:27:23) and this product contained 14.02 g of protein, 14.50 g of fat, 59 g of carbohydrates and 6.30 g of dietary fibre per 100 g of mix.

Kumari *et al*. (2019) developed Ready-to- Eat (RTE) popped up pearl millet breakfast cereal. The sensory aspects of breakfast cereal were acceptable. Developed breakfast cereal had 22.8 percent for energy, 12.80 percent for protein, 13 percent for fat, 34.5 percent for calcium and 20.5 percent for iron as per a serving.

## CONCLUSIONS

Pearl millet can be effectively used in the improvement of pearl millet based nutri waffles combined with refined wheat flour ($PWT_3$) and tapioca flour ($PTT_4$). The study also reported that millet incorporated waffles are nutritionally superior and hence can be included in the diet.

## REFERENCES

Devi, P., Prema, R. S., Vaidheswaran, H., Sudha, A and Sangeetha, V. 2015. Quality evaluation of non-wheat sweet vermicelli. International Journal of Agricultural Engineering. 6(1): 151-156.

GoI. 2022. Guidelines on Production Linked Incentive Scheme for Millet Based Products, Ministry of food processing industries (MoFPI). Retrived from the website [https:/

/www.mofpi.gov.in/announcements/guidelines-production-linked-incentive-scheme-millet-based-products chapter01. PDF on 22.04.2023].

GoI. 2022. International year of millets:India leading the way- Significant rise in MSP over last five years helps raise production of millets,boost farmers' income in the country[on-line]. Retrived from website [https://static.pib.gov.in/WriteReadData/specificdocs/documents/2022/feb/doc202222418701.pdf on 24.4.2023].

Johari, A. 2017. Utilization of processed pearl millet (*Pennisetum glaucum*) in the development of gluten-free convenience foods. PhD. (Foods and Nutrition) thesis submitted to CCS Haryana Agricultural University, Hisar, Haryana, India. pp.89-90.

Kumari, R. I. T. U., Singh, K., Singh, R., Bhatia, N., and Nain, M. S., 2019. Development of healthy ready-to-eat (RTE) breakfast cereal from popped pearl millet. International Journal of Agricultural Science. 89 (5): 877-881.

Mamta. 2015. Development and nutritional evaluation of pearl millet (*Pennisetum gluacum*) based convenience foods. Ph.D. (Foods & Nutrition) thesis submitted to CCS Haryana Agricultural University, Hisar, Haryana, India; pp.102-103.

Pradeep, P. M., Dharmaraj, U., Rao, B. S., Senthil, A., Vijayalakshmi, N. S., Malleshi, N. G., and Singh, V. 2014. Formulation and nutritional evaluation of multigrain ready-to-eat snack mix from minor cereals. Journal of Food Science and Technology. 51 (12): 3812-3820.

Samuel, K. S and Peerkhan, N. 2020. Pearl millet protein bar: nutritional, organoleptic, textural characterization, and in-vitro protein and starch digestibility. Journal of Food Science and Technology. 57:3467-3473.

Shevkani, K., Kaur, A., Kumar, S and Singh, N. 2015. Cowpea protein isolates: Functional properties and application in gluten-free rice muffins. LWT – Food Science and Technology. 63: 927-933.

Singh, R., Nain, M. S and Manju. 2019. Nutrient analysis and acceptability of different ratio pearl millet (*Pennisetum glaucum*) based biscuits. Indian Journal of Agricultural Sciences. 90(2): 428-30.

Vimalarani, M., Subaiah, G., Thenmozhi, P. G., and Nisha, P. R. 2016. Development and shelf-life evaluation of pearl millet based extruded product. Indian Journal of Science. 23(83): 595-600.

Yadav, D. N., Balasubramanian, S., Kaur, J., Anand, T., and Singh, A. K. 2014. Non-wheat pasta based on pearl millet flour containing barley and whey protein concentrate. Journal of Food Science and Technology. 51(10): 2592-2599.

Riya, P. P., Aneena, E. R., Seeja, T., Lakshmy, P. S and Prameela, P. 2023. Optimization and evaluation of quality of the pearl millet nutri waffles. The Journal of Research ANGRAU. 51(2):.93-102. DoI: https://doi.org/10.58537/jorangrau.2023.51.3.11

DoI: https://doi.org/10.58537/jorangrau.2023.51.3.12

J. Res. ANGRAU 51 (3) 103-112, 2023

# PROCESS OPTIMIZATION AND EVALUATION OF QUALITY OF THE BARNYARD MILLET INCORPORATED SYNBIOTIC YOGHURT

**U. A. AMRUTHA*, C. L. SHARON, P. SEEJA THOMACHAN, P. S. LAKSHMY and A. K. BEENA**

Department of Community Science, College of Agriculture, Kerala Agricultural University, Vellanikkara, Thrissur- 680 656

Date of Receipt : 13.4.2023 Date of Acceptance : 24.6.2023

## ABSTRACT

The study was conducted for three years (2019-2022) to optimize and evaluate the three treatments with various combinations of barnyard millet and other ingredients. Several combinations were tried, among which 50% milk and 50% barnyard millet slurry with 3% of inulin and 3% polydextrose was selected as the best with mean sores for overall acceptability of 8.72 for probiotic yoghurt, 8.85 for inulin and 8.75 for polydextrose added synbiotic yoghurts. The viability of *L. acidophilus* was 11.15 log CFU/ml for probiotic, 11.16 log CFU/ml for inulin added synbiotic yoghurt and 11.17 log CFU/ml for polydextrose added probiotic yoghurt. The nutrients of synbiotic barnyard millet based yoghurt along with inulin and polydextrose added yoghurt were assessedand it was found to have major nutrients of carbohydrate 8.58 g/100 g , 8.47 g/100 g and 8.41 g/100 g, protein content of 3.52 g/100g, 3.63 g/100 g and 3.61 g/100 g, fat content of 0.63 g/100 g, 0.69 g/100 g and 0.66 g/100 g.

**Keywords:** Barnyard Millet, Inulin, *L. acidophilus*, Polydextrose, Probiotic, Yoghurt

## INTRODUCTION

Millets, also known as coarse grains are widely cultivated around the world for a variety of uses, including fodder and primarily for human food due to their high nutritional content. In dry and arid parts of the developing world, particularly in Africa and Asia, millets constitute a significant source of food for impoverished farmers. The term millet was derived from "*mille*" (French term) means a handful of millet containing thousands of seed grains. There are a wide variety of millets such as pearl millet, finger millet, little millet, kodo millet, foxtail millet, barnyard millet and proso millet.Recent research suggests that some bioactive substances combined with nutrients, such as oligosaccharides, lipids, antioxidants (phenolic acids, avenanthramide, flavonoids), hormonally active substances (lignans, phytosterols) and anti-nutrients (such as phytic acid, tannins, etc.), may produce more positive health effects.

*Echinochlo afrumentacea,* also known as Japanese barnyard millet, Oodo, Oadula, Sawan, and Sanwank, is a minor millet that is relevant due to its slightly high protein content (12%) and high digestibility (81.13%), as well as its low carbohydrate content (58.56%) and slow digestion (25.88%). These are a good source of nutraceutical compounds and micronutrients.

Probiotics are living microorganisms that when taken in sufficient amounts, boost the host's

*Corresponding Author E-mail i.d: amrutha-2019-16-003@student.kau.in; M.Sc . thesis, submitted to KAU, Thrissur - 680 656

health by inhibiting pathogenic microorganisms, boosting the immune system and lowering blood cholesterol.A prebiotic is defined as “a non-digestible dietary item that has a positive impact on the host by selectively promoting the development and/or activity of one or a small number of bacteria in the colon, which enhances human health”. The common prebiotics used is inulin and its derivatives are fructo-oligosaccharides, soluble corn fibre, galacto-oligosaccharides, polydextrose, pyrodextrin, lactulose and lactosucrose.

The health benefits of inulin include mineral absorption, stimulation of immune function, reduce the risk of irritable bowel disease, constipation and colorectal cancer and improvement in gut microbiota. Prebiotics also help to improve the functioning of gastrointestinal micro flora by increasing the number of micro flora i.e. Lactobacilliand Bifidobacteria. The combination of probiotic and prebiotic is said to be synbiotic.

Polydextrose is prepared by thermal polymerization of glucose, sorbitol and citric acid. Polydextrose is neutral in taste. In baking foods, confectionery, dairy products and functional beverages polydextrose is used as a bulking agent. It can be used as a curing agent for itchy skin, diabetes, prediabetes and infant development. Synbiotics involves the combination of probiotics and prebiotics. The length of life of probiotic bacteria extends in this combination and colonises better in the colon.

With this background, the study was undertaken for three years (2019-2022) to develop synbiotic yoghurt incorporating barnyard millet and to evaluate its acceptability, nutritional and health qualities.

## MATERIALS AND METHODS

### Collection of materials

The cow’s milk required for the preparation of yoghurt was procured from the dairy plant of Kerala Veterinary and Animal Science University, Mannuthy, Thrissur, Kerala. Barnyard millet and milk powder were purchased from the local market. The yoghurt culture was purchased from the Department of Dairy Microbiology, College of Dairy Science and Technology, Kerala Veterinary and Animal Science University, Mannuthy and the probiotic culture *L. acidophilus* was procured from IMTECH Chandigarh. The study was conducted for three years between 2019 and 2022.

### Standardization of proportion of ingredients in the yoghurt

### Pre treatment

The millet purchased from the local market was washed, cleaned and oven dried (65 ºC-75 ºC) for 4 - 5 h. It was then powdered in a local mill and sieved in a fine mesh sieve with mesh size of 0.5 mm. The slurry was prepared by adding 7-8 g of millet flour (barnyard) to 100 ml of distilled water. Fifty percent of milk was replaced with this prepared millet slurry for the preparation of millet based yoghurt.

### Standardization of synbiotic yoghurts using millet

Millet based yoghurts were prepared by the standard procedure suggested by Sarabhai (2012) with modifications. Millet based yoghurt was prepared by using 50 % milk and 50 % barnyard millet slurry. The barnyard millet based probiotic yoghurt was prepared by the addition of 2 ml of yoghurt culture with 1 ml of probiotic culture which was incubated at 38 ºC for 6 h. This prepared probiotic yoghurt served as control. The different proportions of prebiotics were standardised by the addition of inulin and polydextrose in various proportions (Table 1) and the best yoghurt was selected based on the organoleptic evaluation.

### Organoleptic evaluation

The prepared yoghurts of four treatments was evaluatedby sensoryby a panel of 20 selected

**Table 1. Proportions of prebiotics in barnyard millet probiotic yoghurts**

| S.No. | Prebiotics | Treatments | | |
|---|---|---|---|---|
| | | 1% | 2% | 3% |
| 1 | Inulin | $T_1$ | $T_2$ | $T_3$ |
| 2 | Polydextrose | $T_4$ | $T_5$ | $T_6$ |

judges using a nine-point hedonic scale. Quality attributes such as appearance, colour, flavour, texture, taste and overall acceptability were evaluatedduring the sensory evaluation.

**Selection of the most acceptable millet based synbiotic yoghurts**

On the basis of organoleptic scores using nine-point hedonic scale, the yoghurts with maximum quality attributes were selected for further studies.

**Viability of *L. acidophilus***

MRS medium was used to test the viability of probiotic species in the yoghurt. One gram of the sample was weighed and placed in a test tube with 9 ml sterile distilled water ($10^{-1}$ dilution). The sample was then serially diluted up to a dilution of $10^{-9}$. The results of the microbial enumeration were expressed as $10^9$ cfu/g and were obtained using the pour plate method with MRS agar (Agarwal and Hasija, 1986).

**Nutrient composition**

The probiotic and symbiotic yoghurts were assessed for their physico-chemical properties like moisture, acidity, pH, carbohydrate, protein, fat, TSS, reducing sugar, total sugar, crude fibre and total ash.

**RESULTS AND DISCUSSION**

Tables 2 and 3 reveal the mean scores and mean rank scores obtained for several qualitative parameters of synbiotic yoghurt made with inulin and polydextrose added barnyard millet yoghurts when compared to probiotic yoghurt based on the organoleptic evaluation .The treatment $T_3$ and $T_6$ (3% inulin and 3% polydextrose added synbiotic yoghurt) yielded the highest mean score among the several combinations assessed for the preparation of synbiotic yoghurts.

**Preparation of synbiotic barnyard millet based yoghurt with inulin**

The mean scores and mean rank scores obtained for several qualitative parameters of symbiotic yoghurt made from barnyard millet when compared to probiotic yoghurt are detailed (Table 2).

The treatment $T_3$ (3 % inulin added synbiotic yoghurt) yielded the highest mean score (8.75) for appearance and colour (8.83) among the several combinations assessed for the preparation of inulin added synbiotic yoghurt. The mean score for appearance and colour was found to be 8.70 and 8.79, respectively for control yoghurt (probiotic yoghurt without inulin). Treatment $T_3$ had the highest mean score for flavour (8.81) and taste (8.84) among the three treatments used to make barnyard millet based inulin added synbiotic yoghurt, followed by $T_2$. The texture of inulin added barnyard millet based yoghurt ($T_3$) made with 3 % inulin obtained the highest mean and mean rank scores of 8.82 and 3.97, respectively. The texture of barnyard millet based probiotic yoghurt ($T_0$) had an average score of 8.66, with a mean rank score of 3.77. The highest mean and rank score (8.85 and 3.93) for overall acceptability among the three treatments of barnyard millet based yoghurt was for treatment $T_3$. However, this was shown to be higher than the control's mean and mean scores

**Table 2. Mean scores for organoleptic evaluation of inulin added barnyard millet based yoghurts**

| S.No. | | Appea-rance | Col-our | Flav-our | Taste | Tex-ture | Overall accep-tability | Total mean score |
|---|---|---|---|---|---|---|---|---|
| 1 | Control(Probiotic barnyard millet yoghurt) | 8.70 (3.37) | 8.79 (3.37) | 8.65 (3.57) | 8.64 (3.67) | 8.66 (3.77) | 8.72 (3.84) | 8.69 |
| 2 | $T_1$ | 8.49 (3.20) | 8.44 (3.30) | 8.44 (3.40) | 8.53 (3.40) | 8.35 (3.01) | 8.51 (3.27) | 8.46 |
| 3 | $T_2$ | 8.51 (3.27) | 8.80 (3.42) | 8.53 (3.47) | 8.68 (3.70) | 8.80 (3.81) | 8.65 (3.33) | 8.66 |
| 4 | $T_3$ | 8.75 (3.63) | 8.83 (3.67) | 8.81 (3.87) | 8.84 (3.86) | 8.82 (3.97) | 8.85 (3.93) | 8.82 |
| 5 | Kendall's W Value | 0.924** | 0.728** | 0.774** | 0.982** | 0.955** | 0.923** | |

**Figures in parenthesis indicate mean rank scores; *Significantat1%level; **Significant at 5%level**

**$T_0$ – 50 % M + 50 % BMS; $T_1$ – 50 % M + 50 % BMS + 1 % I; $T_2$ –50 % M + 50 % BMS + 2 % I; $T_3$ 50 % M + 50 % BMS + 3 % I; M: Milk, BMS: Barnyard millet slurry, I: Inulin**

(8.72 and 3.84). The highest total mean score among the three treatments was ranked for $T_3$ with a score of 8.82 followed by $T_2$ and $T_1$. The total mean score for the control was 8.69 which was less than $T_3$ yoghurt. Significant agreement among the judges was seen in the evaluation of several sensory attributes of barnyard millet based yoghurt as measured by Kendall's (W) value.

In the study conducted by Falah *etal*. (2021) cereal based synbiotic yoghurt was prepared with 1%, 2.5 % and 5 % of inulin and *L. brevis*. When the concentration of inulin increased the mean score for the synbiotic yoghurt increased by 2.5 percent (6.8) and then it decreased to 5 percent (6.4) for inulin added yoghurt. The maximum mean score was seen in 2.5 percent of inulin added synbiotic yoghurt.

**Preparation of synbiotic barnyard millet based yoghurt with polydextrose**

The mean scores and mean rank scores obtained for several sensory parameters ofsynbioticyoghurt made from barnyard millet when compared to its probiotic yoghurt (Table 3).

The mean scores for the appearance of barnyard millet based synbiotic yoghurt with polydextrose ranged between 8.55 and 8.75 and 8.61 to 8.83 for colour. The treatment $T_6$(3 % polydextrose added synbiotic yoghurt) yielded the highest mean score among the several combinations assessed for the preparation of polydextrose added synbiotic yoghurt. Treatment $T_6$ had the highest mean score for flavour (8.73) and taste (8.68) among the three treatments used to make barnyard millet based polydextrose added yoghurt, followed by $T_5$and $T_4$ .The texture of

polydextrose added barnyard millet based yoghurt ($T_6$) made with 3% polydextrose obtained the highest mean and mean rank scores of 8.71 and 3.53, respectively. The highest mean and rank score (8.75 and 3.84) for overall acceptability across nts of barnyard millet based yoghurt was for treatment $T_6$. However, this was shown to be higher than the probiotic yoghurt's mean and mean scores (8.72 and 3.47). The highest total mean score among the three treatments was ranked $T_6$ with a score of 8.74 followed by $T_5$ and $T_4$. The total mean score for the control was 8.69 which was less than $T_6$ yoghurt.

Significant agreement among the judges was seen in the evaluation of several sensory attributes of barnyard millet based yoghurt and measured by the Kendall's (W) value.

Huang *et al.* (2020) prepared prebiotic yoghurt with polydextrose (fat-free buffalo set yogurts). The concentration of polydextrose used for the study was 1.5%, 3 %and 5 percent. The best treatment selected was 3 percent of polydextrose added prebiotic yoghurt with a total mean score of 7.80. The total mean score for both 1.5% and 5% of polydextrose added yoghurt was 7.10 and for control yoghurt the total mean score was 6.40.

**Viability of *L. acidophilus* in probiotic and synbiotic yoghurts**

The viability of *L. acidophilus* was found that 11.15 log cfu/ml for probiotic, 11.16 log cfu/ml for inulin added synbiotic yoghurt and 11.17 log cfu/ml for polydextrose added synbiotic yoghurt (Table 4).

**Table 3. Mean scores for organoleptic evaluation of polydextrose added barnyard millet based yoghurts**

| S.No. | Treatment | Appearance | Colour | Flavour | Taste | Texture | Overall acceptability | Total mean score |
|---|---|---|---|---|---|---|---|---|
| 1 | Control (Probiotic barnyard millet yoghurt) | 8.70 (3.37) | 8.79 (3.61) | 8.65 (3.57) | 8.64 (3.67) | 8.66 (3.13) | 8.72 (3.47) | 8.69 |
| 2 | $T_4$ | 8.55 (3.23) | 8.61 (3.53) | 8.42 (3.43) | 8.44 (2.87) | 8.56 (2.67) | 8.31 (2.87) | 8.48 |
| 3 | $T_5$ | 8.62 (3.27) | 8.73 (3.57) | 8.64 (3.55) | 8.51 (3.30) | 8.63 (2.97) | 8.58 (3.53) | 8.62 |
| 4 | $T_6$ | 8.75 (3.50) | 8.83 (3.83) | 8.73 (3.60) | 8.68 (3.74) | 8.71 (3.53) | 8.75 (3.84) | 8.74 |
| 5 | Kendall's W value | 0.564** | 0.188** | 0.552** | 0.437** | 0.622** | 0.671** | |

Figures in parentheses indicate mean rank scores; *Significantat 1% level; **Significant at 5% level

$T_0$ – 50 % M + 50 % BMS; $T_4$– 50 % M + 50 % BMS + 1 % P; $T_5$–50 % M + 50 % BMS + 2 % P; $T_6$– 50 % M + 50 % BMS + 3 % P: M: Milk, BMS: Barnyard millet slurry, P: Polydextrose

**Table 4. Viable count of *L. acidophilus* in barnyard millet based yoghurts**

| S.No. | Treatments | Viability of L. acidophilus |
|---|---|---|
| 1. | Barnyard millet based probiotic yoghurt | 11.15 log cfu/ml |
| 2. | Barnyard millet based inulin added synbiotic yoghurt | 11.16 log cfu/ml |
| 3. | Barnyard millet based polydextrose added synbiotic yoghurt | 11.17 log cfu/ml |

Sukarminah *et al*. (2019) developed sorghum based synbiotic yoghurt with *L. acidophilus*. The maximum vicability of *L. acidophilus* (7.89 log cfu/ml) was in 5% of sorghum flour added synbiotic yoghurt, whereas, in control yoghurt it was 7.40 log cfu/ml.

**Nutrient composition of probiotic and synbioitc yoghurt**

The proximate analysis of the selected best combination (50% milk and 50% millet slurry + 3 % of inulin and 3 % of polydextrose) of synbiotic barnyard millet based yoghurt and its control were analysed (Table 5).

The moisture content of both synbiotic yoghurt (both inulin and polydextrose) was higher than probiotic yoghurt (Table 5). The moisture content of barnyard millet based probiotic yoghurt was 87 percent, inulin added barnyard millet based synbiotic yoghurt had moisture content of 87.67 percent and polydextrose added barnyard millet based synbiotic yoghurt had moisture content of 87 percent. A significant difference was observed in the moisture content of the yoghurts. The addition of prebiotic in probiotic yoghurt may increase the growth of probiotic organism. So the chance of increase in moisture is high in synbiotic yoghurt compared to probiotic yoghurt. Abd-Rabou *et al*. (2020) developed probiotic and synbiotic cheese and studied its nutritional qualities. Here, the probiotic microorganisms used were *L. rhamnosus and Bifidobacterium* and the prebiotic was inulin. The moisture content of probiotic with *L. rhamnosus was* 71.73 percent and for synbiotic yoghurt the moisture content was 73.05 percent. The *Bifidobacterium used probiotic cheese contained* 72.70 percent of moisture and for synbiotic cheese the moisture content was 74.84 percent.

Probiotic yoghurt had a lower carbohydrate than synbiotic yoghurt made with inulin and polydextrose(Table 5). A significant difference was observed in the carbohydrate of the yoghurts. Hauly *et al*. (2015) prepared soy yoghurt without prebiotic addition and soy yogurt containing inulin (14.43 percent) and oligofructose (14.24 percent). The addition of prebiotic influenced the carbohydrate content of the yoghurt. In this study, yoghurt with prebiotics had reduced carbohydrate levels, this is due to the high survivability of the microorganisms which lowers the viability of carbohydrate because it was used by them for their growth.

Inulin and polydextrose based synbiotic yoghurt both had greater protein content than probiotic yoghurt (Table 5). Barnyard millet based probiotic yoghurt had protein content of 3.52 percent, inulin added synbiotic yoghurt had protein content of 3.63 percent and polydextrose added synbiotic yoghurt had protein content of 3.61 percent. The results were observed to be on par according to DMRT study. The presence of prebiotics in probiotic yoghurt increased the viability of probiotic organisms so that the acidity of the yoghurt increases and it helps in proteolysis so the presence of protein increases in synbiotic yoghurt than probiotic yoghurt. The protein content

in the control (probiotic milk) samples was 3.96 percent, the sample containing inulin was 4.24 percent. The honey incorporated sample had a protein content of 4.15 percent and the FOS-incorporated sample had a protein level of 4.05 percent. This led to the conclusion that the addition of prebiotics were the best growth stimulants for culture organisms (*L. acidophilus* + *B. bifidum*) (Mariammal, 2016).

Probiotic yoghurt had a lower fat content than synbiotic yoghurt made with inulin and polydextrose (Table 5). The presence of prebiotics in probiotic yoghurt increased the viability of probiotic organisms so that the acidity of the yoghurt increases and it helps in lipolysis so the presence of fat increases in synbiotic yoghurt than probiotic yoghurt. Synbiotic butter milk has more fat than probiotic butter milk (control). The fat content of the control butter milk was 0.23 percent, that of the synbiotic butter milk with honey was 0.28 percent and that of the synbiotic butter milk with oligosaccharide addition was 0.28 percent (Malarkannan, 2019).

Probiotic yoghurt showed higher crude fibre than inulin and polydextrose based synbiotic yoghurt (Table 5). Probiotic yoghurt made from barnyard millet had a crude fibre of 0.50 percent, synbiotic yoghurt with inulin added had crude fibre of 0.45 percent and synbiotic yoghurt with polydextrose added had a crude fibre of 0.43 percent. The results were observed on par according to DMRT study. The presence of prebiotic decreases the crude fibre of fermented food. This is because of the increased viability of probiotics present in the fermented food. In carrot based synbiotic beverage prepared by Alwis *et al*. (2015) the crude fibre content was 1.01 percent and that of control beverage was 1.02 percent.

Compared to synbiotic yoghurt made with inulin and polydextrose, probiotic yoghurt had a lower total ash (Table 5). The results were observed on par according to DMRT study. The addition of prebiotic in fermented food increases the presence of ash. So that the ash content was high in synbiotic food than probiotic food. Al-Shawi (2020) studied synbiotic yoghurt and said that mint alcoholic extract added synbiotic yoghurt treatment had a higher ash content (0.93 percent), which differed significantly from plain yoghurt (0.55 percent) followed by mint aqueous extract added synbiotic yoghurt (0.92 percent).

**Table 5. Proximate composition of barnyard millet based synbiotic yoghurts**

| S.No. | Particulars | Probiotic yoghurt without prebiotic | BM based probiotic yoghurt + 3 % inulin | BM based probiotic yoghurt + 3 % polydextrose | CD Value |
|---|---|---|---|---|---|
| 1 | Moisture (%) | 87.03 [a] | 87.67 [b] | 87.27 [c] | 0.030 |
| 2 | Carbohydrate [g/100g (%)] | 8.58 [a] | 8.47 [b] | 8.41 [c] | 0.030 |
| 3 | Protein [g/100g (%)] | 3.52 [a] | 3.63 [b] | 3.61 [bc] | 0.025 |
| 4 | Fat [g/100 g (%)] | 0.63 [a] | 0.69 [b] | 0.66 [c] | 0.028 |
| 5 | Crude fibre [g/100g (%)] | 0.50 [a] | 0.45 [b] | 0.43 [b] | 0.025 |
| 6 | Total ash (%) | 0.69 [a] | 0.76 [b] | 0.71 [b] | 0.030 |

DMRT row wise comparison (significant at 5 % level)(a, b, bc and c represents grouping of parameters)

**Table 6. Chemical analysis of barnyard millet based synbiotic yoghurts**

| S.No. | Particulars | Probiotic yoghurt without prebiotic | BM based probiotic yoghurt + 3 % inulin | BM based probiotic yoghurt + 3 % polydextrose | CD Value |
|---|---|---|---|---|---|
| 1 | Acidity (%) | 0.81[a] | 0.89[b] | 0.86[c] | 0.023 |
| 2 | pH | 3.88[a] | 3.76[b] | 3.74[b] | 0.021 |
| 3 | TSS (º Brix) | 11[a] | 10[b] | 9[c] | 0.998 |
| 4 | Reducing sugar [g/100g (%)] | 7.55[a] | 6.46[b] | 6.67[c] | 0.024 |
| 5 | Total sugar [g/100g (%)] | 10.99[a] | 9.56[b] | 9.45[c] | 0.027 |

DMRT row-wise comparision (significant at 5 % level) (a, b, bc and c represents grouping of parameters)

Inulin and polydextrose based synbiotic yoghurt both had higher acidity than probiotic yoghurt (Table 6). Barnyard millet based probiotic yoghurt had an acidity of 0.81 percent, inulin added synbiotic yoghurt had an acidity of 0.89 percent and polydextrose added synbiotic yoghurt had an acidity of 0.86 percent. A significant difference was observed in the acidity of the yoghurts. The presence of prebiotic, influence the acidity of yoghurt. The addition of prebiotics in yoghurt enhances the growth of the probiotic organism, so the acidity of yoghurt increases. Reshma*et al*. (2022) developed synbiotic yoghurt with oat flour and the acidity of normal yoghurt was 0.81 percent, for probiotic yoghurt the acidity was 0.80 percent, 1percent oat flour added symbiotic yoghurts acidity was 0.82 percent. The probiotic organism which was used in this study was *Bifidobacterium bifidum*.

Probiotic yoghurt showed lower pH than inulin and polydextrose based synbiotic yoghurt (Table 6). Probiotic yoghurt made from barnyard millet had a pH of 3.88, synbiotic yoghurt with inulin added had pH of 3.76 and synbiotic yoghurt with polydextrose added had a pH of 3.74. The results were observed to be on par according to DMRT study. Falah *et al*. (2021) produced synbiotic yoghurt with 2.5 percent of inulin with a strain of *L. brevis* from fermented dairy and cereal products. The pH of control probiotic yoghurt was recorded as 4.41 and for synbiotic yoghurt it was 3.82. Here, the addition of prebiotic (inulin) in probiotic yoghurt decreased the pH of synbiotic yoghurt.

Probiotic yoghurt showed higher TSS than inulin and polydextrose based synbiotic yoghurt (Table 6). Probiotic yoghurt made from barnyard millet had TSS of 11º Brix, synbiotic yoghurt with inulin added had TSS of 10º Brix and synbiotic yoghurt with polydextrose added had TSS of 9º Brix. A significant difference was observed in the TSS of the yoghurts. During fermentation, the homo fermentative Lactobacillus converts the fermentable sugar into lactic acid. So, the sugar content of fermented food products is decreased. With the addition of prebiotics in fermented food products, the viability of microbes increases. Carrot based synbiotic beverage was prepared by Alwis *et al*. (2015) and studied its nutritional content. The TSS of control beverage was 12p Brix and for synbiotic beverage the TSS was 11.50p Brix. The probiotic organism used here was *L. casei* and prebiotic was sucrose.

Also, when compared to synbiotic yoghurt made with inulin and polydextrose, probiotic yoghurt had a higher reducing and total sugar (Table 6). A significant difference was observed in both reducing and total sugar of the yoghurts. Carrot

based synbiotic beverage was prepared by Alwis *et al*. (2015) and its nutritional content was studied. The reducing sugar content of control beverage was 0.47 percent and for synbiotic beverage the reducing sugar was 0.41 percent. The probiotic organism used here was *L. casei* and prebiotic was sucrose. After 72 h of fermentation, the total sugar content of the fermented juice (a mixture of cucumber and tomato juice with 3 percent inulin) was reduced to 179 g /ml, because they served as substrates for microbial growth (*L. acidophilus*) and increased acid production, which caused the juice's pH to drop and total sugars in the juice were decreased during fermentation (Priya, 2018).

## CONCLUSIONS

Good quality synbiotic yoghurt can be produced by mixing 50% milk and 50% barnyard millet slurry with 3% inulin and 3% polydextrose with overall acceptability of 8.72 for probiotic yoghurt, 8.85 for inulin added and 8.75 for polydextrose added synbiotic yoghurts, respectively with a viability of 11.15 log cfu/ml for probiotic, 11.16 log cfu/ml for inulin added yoghurt and 11.17 log cfu/ml for polydextrose added barnyard millet yoghurt (fermented with 25 g of yoghurt sample with 1 ml of probiotic culture with 2 ml of yoghurt culture incubated for 6 h at 38 ºC). The inulin and polydextrose added barnyard millet based yoghurt had moisture content of 87.67% and 87.27%, acidity of 0.89% and 0.86%, pH of 3.76 and 3.74, carbohydrate of 8.47 g/100 g and 8.41 g/100g, protein of 3.63 g/100 g and 3.61 g/100g, fat of 0.69 g/100g and 0.66 g/100 g, TSS of 10º Brix and 9º Brix, reducing sugar of 6.46 g/100 g and 6.67 g/100g, total sugar of 9.56 g/100 g and 9.45 g/100g crude fibre of 0.45 g/100 g and 0.43 g/100 g and total ash of 0.76% and 0.71%. It is noticed that incorporating probiotics into millet based probiotic yoghurt can improve the nutritional profile of the food products.

## REFERENCES

Abd Rabou, H.S., Shehata, M.G., Sohaimy, S.A and Awad, S. A. 2020. Functional probiotic quinoa camel milk kishk. Journal of Food Processing and Preservation. 44(9): 1-8.

Agarwal, G.P. and Hasija, S.K. 1986. Microorganisms in the Laboratory.Print house India Ltd, Lucknow. pp.155.

Al-Shawi, S.G. 2020. The possibility of producing synbiotic yogurt containing mint extracts. Eurasian Journal of Medical and Biological Sciences. 14 (1): 13-21.

Alwis, A.D.P.S., Perera, O.D.A.N and Weerahewa, H. L. D. 2015. Development of carrot-based synbiotic beverage. Journal of Agricultural Science. 11 (3): 178-186.

Falah, F., Vasiee, A., Alizadeh B.B., Tabatabaee Y.F and Mortazavi, S. A. 2021. Preparation and functional properties of synbiotic yoghurt fermented with *Lactobacillus brevis* PML1 derived from a fermented cereal-dairy product. BioMed Research International. 9(6): 3317-3326.

Hauly, M.C.D.O., Fuchs, R.H.B and Prudencio-Ferreira, S.H. 2015. Soymilk yogurt supplemented with fructooligosaccharides: Probiotic properties and acceptance. Journal of Nutrition. 18 (5): 613-622.

Huang, L., Abdel-Hamidb, M., Romeihb, E., Zenga, Q., Yanga, P., Walkerc, G and Li, L. 2020. Textural and organoleptic properties of fat-free buffalo yogurt as affected by polydextrose. International Journal of Food Properties. 23(1) 1-8.

Malarkannan, S. P. 2019. Development of cultured low fat synbiotic buttermilk. Ph.D. thesis submitted to Agriculture and Animal Husbandry University, Dindigul. pp.126.

Mariammal, S. 2016. Development of synbiotic acidophilus milk. Ph. D.thesis submitted to Manonmaniam Sundaranar University, Abhishekapatti. pp.74-75.

Priya, S. N. 2018. Development and evaluation of probiotic juices fortified with nutraceuticals. Ph. D. thesis submitted to Anna University, Chennai. pp.104.

Reshma, E.K., Geetha, R., Lejaniya, A.S and Sathian, C.T. 2022. Development and quality evaluation of synbiotic yoghurt incorporated with oat flour and *Bifidobacterium bifidum* NCDC-255. Indian Journal of Science and Technology. 15(17): 811-818.

Sarabhai, S. 2012. Standardization and quality evaluation of rice based fermented dairy products. M.Sc. thesis submitted to Kerala Agricultural University, Thrissur. pp.103.

Sukarminah, E., Lanti, I., Wulandari, E., Lembong, E and Utami, R. 2019. The effect of sorghum flour (*Sorghum bicolor* L. Moench) addition to characteristic quality of goat milk synbiotic yoghurt candidate. Environmental Earth Sciences. 347 (1): 120-130.

Amrutha, U.A., Sharon, C.L., Seeja, T.P., Lakshmy, P.S and Beena, A.K. 2023. Process optimization and evaluation of the quality of barnyard millet incorporated synbiotic yoghurt The Journal of Research ANGRAU. 51(3):103-112.
DoI: https://doi.org/10.58537/jorangrau.2023.51.3.12

DoI: https://doi.org/10.58537/jorangrau.2023.51.3.13

J. Res. ANGRAU 51 (3) 113-120, 2023

# THE RELATIONSHIP BETWEEN TEACHERS' KNOWLEDGE, ATTITUDE AND PRACTICES TOWARDS LEARNING DISABILITIES OF THE STUDENTS

**S. RAJKUMARI* and RAMYA BHASKAR**

Department of Human Development, Avinashilingam Institute For Home Science For Higher Education for Women, Coimbatore- 641 025

Date of Receipt : 03.5.2023 Date of Acceptance : 21.7.2023

## ABSTRACT

The research was conducted with the aim of understanding the relationship between teachers' knowledge, attitude, and practice towards learning disabilities of the students. For this study, 133 primary school teachers were chosen at random in 2022. The information on primary school teachers' Knowledge, Attitude, and Practices (KAP) was collected by a KAP scale developed by the researcher. The scale was validated and verified for reliability using Cronbach's Alpha. The reliability score of the constructed KAP scale was 0.829, 0.854, and 0.700 correspondingly suggesting good reliability. Results showed that more than half of teachers (69.2%) had a moderate degree of knowledge and 54.9% were found to have a neutral attitude towards learning disability of the students. In terms of practices, a good level of practices among nealry three-fourth(72.9%) of the teachers was noted. A significant association was recorded between the knowledge and attitude of primary school teachers towards learning disabilitiesof the students. However, the results did not record practices being significantly interrelated to the knowledge and attitude towards learning disabilities of the students among primary school teachers, implying that knowledge or attitude might not influence practices as the practices remains self-regulated.

**Keywords**: KAP, learning disability, Primary School Teachers, Relationship, Students

## INTRODUCTION

Learning Disability (LD) is an unnoticed barrier. It interferes with every aspect of life, academic performance, social relationships, mobility, and employment. It is one of the concerns that require special consideration. In India, no special efforts are made to determine the prevalence of LD, but it is estimated that 13-14 percent of our school children have learning disabilities (Deshmukh *et al*., 2021).

The child's teachers are the first to notice when they believe they are not learning as they should. Arifa and Siraj (2019) stated in their study that, present a significant problem for educators and members of the households. The way the teachers respond to these kids' needs will determine how successful they are and they become.

For the teachers to respond to the needs of the children, should be aware of the challenges children face. Hence, their knowledge of learning disability is most important for identifying them. Several scholars have highlighted the fact that primary school teachers exhibited lower levels of

*Corresponding Author E-mail i.d: anrajkumari@gmail.com; Ph.D thesis submitted to Avinashilingam Institute For Home Science For Higher Education for Women, Coimbatore - 641 043

knowledge with regard to specific learning abilities (Shari and Vranda, 2016; Ghimire, 2017). According to Moothedath and Vranda (2015), Among teachers, only 5% are solely seemed to be having sufficient knowledge regarding learning disability which is a very low number to take into account. A professional degrees needed to work as a teacher in a school in India is a teacher training degree. Dhindsa *et al.* (2021) in their study reported that many teachers lack the training, expertise, and experience/knowledge required to identify at-risk young children. Often teachers lack the necessary knowledge to recognize students with learning disabilities; or struggle to recognize students who are at risk, which could lead to an increase in the prevalence of LD. According to Singh *et al*. (2017), recent investigations on learning disabilities found that there is a 5% -15% prevalence in India, which is a highly frightening number. As teachers being the ones to recognize obstacles among children, their ability to support children is significantly impacted by the lack of knowledge and comprehension of particular learning difficulties. According to WHO (2012), certainly being more knowledgeable will lead an alteration in behavior (Sitrakool, 2017). From this statement, it could be understood that knowledge may influence a behaviour of a person.

A study by Madhamani and Joseph (2021) stated that teachers in schools have some knowledge regarding learning difficulties, but lack the necessary practice to effectively manage school children. Though they lack knowledge, teachers are more aware of learning difficulties and have a favourable attitude. The study by Soni (2020) reported that instructors' knowledge and attitudes were positively correlated. Because knowledge is a significant truth that affects or influences an individual's own attitude and practice, rather than being a single component or detached fact.

Few studies sustained the results of the investigations that teachers had insufficient knowledge on learning disabilities. The study by Asok *et al.* (2021) stated that teachers belonging to government schools had insufficient knowledge of learning disability while the vast majority had positive attitudes. Soni (2020) reported that most teachers had insufficient knowledge and highly favourable attitude toward learning disability. The K-A-P Model, which is based on the social psychology theory of cognitive-affective-behaviour, suggested that knowledge influences attitude, and, in turn, practices (Luo *et al.,* 2022). With these perspectives, the study was proposed to record the the relationship between teachers' knowledge attitude and practices (KAP) towards learning disabilities of students.

After parents, teachers are the greatest influence on a child's life. To cater the needs of various learner types, teachers can adapt their teaching methods. A teacher must be knowledgeable about the different types of learning disorders to recognise one in a student who is not making sufficient progress in class. Teachers' knowledge, attitudes, and practices affect students' learning in many ways. Learning disability seriously impede educational actions that require reading, math, or writing abilities. Ten to fourteen percent of children in India suffer from a specific learning disability. In comparison to teachers with general pedagogy backgrounds, those with enough knowledge of learning difficulties and the necessary skills or competencies can serve better. If teachers' fall short in awareness and knowledge affects these children as these children go unattended in a group. Since teachers are the learned people with whom the children spend the vast majority of their active time, it is extremely crucial for teachers, notably primary school teachers, to be aware of this unseen disability that enables early detection and

intervention. Also, teachers' attitudes toward these students are essential in facilitating them in coping with this disability.

## MATERIALS AND METHODS

Human Ethical Committee clearance from the institute was sought to conduct the study. The study used a cross-sectional research design and a descriptive research approach. A total of 133 primary school teachers from 13selected schools in Coimbatore City, Tamil Nadu were considered for the study using a convenient sampling technique. Data was collected between the months of October and November, 2022 using a self-structured interview schedule. Data collection involved two sections. Section I - Socio-demographic variables that were taken into consideration for the study; Section II-A rating scale for knowledge and attitude, along with a checklist for practices. The description of the study tools is as follows:

**The teacher's knowledge of the learning disability of the students scale** was constructed with 57 statements. Basic information about the qualities, conditions, and misconceptions are the scale's primary statements. A Likert scale with five possible responses namely strongly disagree, disagree, uncertain, agree, and agree strongly was used in the interview schedule consisting both positive and negative statements.

**The teacher's attitude on the learning disability of the students scale** was developed with 35 statements. Myths and general inferences about learning disabilities of the students were presented as statements. Agree, Neutral, and Disagree are the responses on a three-point Likert scale with both positive and negative statements.

**Teacher's classroom teaching practices A** checklist with 24 statements in total, with both positive and negative statements was developed. Information about common classroom practices and teaching pedagogy of teachers were included in the statement. Through content validity, the self-developed tool was validated. The tool's content was reviewed by experts. In the first step, a committee of two senior academia and two primary school teachers were included in the discussion for checking the scale content statements. The scale was refined according to the suggestions given by them. Nine experts were chosen from various disciplines based on the subject which included two developmental pediatricians, one neurologist, one professor from the Department of Special Education, two professors from the department of Human Development, one clinical psychologist, and one special educator. Review and face validity was obtained and the scale was refined further. Cronbach's Alpha test was used for the estimation of the reliability. A range from above 0.700 in the Cronbach's alpha test is considered to be reliable, therefore, the scales were reliable with scores of 0.829 for the knowledge scale, 0.854 for the attitude scale, and the practices scale had 0.700 score. The gathered data was scored and compiled. Frequency and percentages were calculated and the results were interpreted using ANOVA test to check the relationship between KAP.

## RESULTS AND DISCUSSION

As per Table 1, those between the ages of 31 and 40 made up nearly half of the teachers (39.8%), followed by those between the ages of 41 and 50 (26.3%), 21 to 30 (24.1%), and those between the ages of 51 and 60 were up to 9.8%. A total of 96.2% of the teachers were women. Majority of teachers (69.9%) belonged to a nuclear family, while 30.1% lived in a joint family. More than half of the respondents (54.9%) came from urban areas. More than half (65.4%) of the teachers had a B.Ed degree. Only 39% had less than five years of teaching experience, others had more than five years of teaching experience (61%).

Socio-demographic features play a significant part in the development of KAP. Several

research studies have hypothesized the influence of the socio-demographic conditions of teachers on their KAP. However, this study was limited only to seeing the relationship between KAP, nevertheless accepting the fact that certain socio-demographic aspects impact the KAP owing to the available literature. The study by Shari and Vranda (2015) identified variations in overall knowledge levels on LD under age, education, classes taught, type of school, and number of teaching years of experience of teachers. Dada and Sulyman (2021) brought out the significant influence of gender, school type, and specialization of teachers on their knowledge of LD in the Ilorin South local government area, Kwara State. The study conducted in Saudi Arabia by Nsreen and Mogeda (2019) reflected on a significant relationship between levels of knowledge and socio-demographic variables. Ranjeetha and Shobha (2019) also recorded the association between socio-demographic variables and classroom practices of teachers related to LD.

Table 2 indicated that nearly three-fourth teachers (69.2%) had a moderate knowledge level and 27.1% exhibited a high knowledge level. A higher number (54.9%) of the respondents had a neutral attitude, and 40.6% had a favourable attitude regarding learning disabilities of the students. Majority (72.9%) had satisfactory classroom practices, whereas, the remaining teachers (27.1%) had average classroom teaching practices.

The KAP level demonstrated that the great majority of teachers had a moderate knowledge level (69%), a neutral attitude towards LD(55%), and good teaching practices (73%). However, the cause for concern here is the moderate levels of knowledge and neutral attitudes which should be enhanced to higher and favorable levels, as the

**Table 1. Primary school teachers' socio demographic information (n=133)**

| S.No. | Variables | Category | Number | Percentage(%) |
|---|---|---|---|---|
| 1. | Age (in years) | 21- 30 | 32 | 24.1 |
| | | 31 – 40 | 53 | 39.8 |
| | | 41 – 50 | 35 | 26.3 |
| | | 51 – 60 | 13 | 9.8 |
| 2. | Gender | Female | 128 | 96 |
| | | Male | 5 | 4 |
| 3. | Family Type | Joint | 40 | 30.1 |
| | | Nuclear | 93 | 69.9 |
| 4. | Area of Living | Urban | 73 | 54.9 |
| | | Semi Urban | 60 | 45.1 |
| 5. | Educational Qualification | Degree with B.Ed | 87 | 65.4 |
| | | Degree without B.Ed | 46 | 34.6 |
| 6. | Years of Experience | < 5 years | 52 | 39.1 |
| | | 6-10 years | 35 | 26.4 |
| | | 11-15 years | 18 | 13.5 |
| | | >15 years | 28 | 21.1 |
| | **Total** | **133** | **100** | |

**Table 2. Level of teachers' KAP towards learning disabilities of the students**

| S.No | Variables | Categories | Number | Percentage |
|---|---|---|---|---|
| 1. | Knowledge | High | 36 | 27.1 |
| | | Moderate | 92 | 69.2 |
| | | Low | 5 | 3.8 |
| 2. | Attitude | Favourable | 54 | 40.6 |
| | | Neutral | 73 | 54.9 |
| | | Unfavourable | 6 | 4.5 |
| 3. | Practices | Good / Satisfactory | 97 | 72.9 |
| | | Average | 36 | 27.1 |
| | | Poor / Unsatisfactory | 0 | 0 |
| | **Total** | **133** | **100** | |

possibility of the moderate levels going down to low and neutral attitudes becoming unfavorable cannot be ruled out. Hence, constant monitoring of the knowledge and attitudes of the teachers might help in facilitating the enhancement and avoiding deviation or debilitating the acquired knowledge and attitudes.

The study carried out by Shari and Vranda (2015) with teachers belonging to primary schools at Bangalore South revealed that most of the teachers responded to having a favourable attitude towards specific learning disabilities of the students which is found to be contradictory from the results of this study.

The findings of this study highlighted that knowledge interacted with attitude in a statsitically significant way. This suggested that a teacher's attitude is influenced by their level of knowledge. Additionally, the findings showed that a teacher's teaching practices is unaffected by their knowledge level. Practices and attitude also did not show a significant relationship or did not influence one another. Regardless of the type of attitude, the teaching practices were found to be good and satisfactory. Elizabeth and Seema (2019) compared knowledge and attitude depending on the teaching division and educational sub-districts. They reported that there is a strong connection between teachers' inclusive education knowledge and attitudes. The study by Neha and Roopa (2018) on 60 teachers on Knowledge, Attitude, and Practices in dealing with Learning Disability among children found that the majority of the teachers showed a moderate knowledge level, unfavourable attitude and a moderate level of practices in dealing with learning disabilities among children which is in line with this study for knowledge level.Subi and Archana (2019) with 225 teachers on their attitudes and knowledge of learning disabilities of children in Trivandrum concluded that a good number of primary school teachers had positive attitudes and good knowledge of learning disabilities of students.

Table 3 depicts the relationship between knowledge, attitude, and practices. The results of the ANOVA test indicated that the three knowledge levels (High, Moderate, and Low) corresponded to the mean attitude scores of the teachers with 87.42, 81.76, and 84.20, respectively. The majority of the teachers with a moderate knowledge level exhibited a neutral attitude towards learning disabilities of the students. Additionally, a statistically significant relationship was observed between the teachers' knowledge and attitudes toward learning disability at 5% levels with F (2) =

**Table 3. Relationship between teachers' Knowledge, Attitude and Practices (KAP) towards learning disabilities of the students**

| S.No. | KAP | Classification | N | Mean±SD | F(df) | Significance |
|---|---|---|---|---|---|---|
| **Relationship of Knowledge with Attitude and Practices** | | | | | | |
| 1. | Attitude | High | 36 | 87.42±8.817 | 3.305(2) | 0.040* |
| | | Moderate | 92 | 81.76±12.111 | | |
| | | Low | 5 | 84.20±8.319 | | |
| 2. | Practices | High | 36 | 20.83±3.682 | 2.824(2) | 0.063$^{NS}$ |
| | | Moderate | 92 | 19.77±3.530 | | |
| | | Low | 5 | 17.00±3.937 | | |
| **Relationship of Attitude with Knowledge and Practices** | | | | | | |
| 1. | Knowledge | Favourable | 54 | 54.74±12.225 | 2.540(2) | 0.083$^{NS}$ |
| | | Neutral | 73 | 50.52±10.354 | | |
| | | Unfavourable | 6 | 49.00±4.858 | | |
| 2. | Practices | Favourable | 54 | 20.06±3.873 | 2.151(2) | 0.121$^{NS}$ |
| | | Neutral | 73 | 19.64±3.541 | | |
| | | Unfavourable | 6 | 22.83±2.639 | | |
| **Relationship of Practices with Knowledge and Attitude** | | | | | | |
| 1. | Knowledge | Good | 97 | 53.18±10.585 | 2.991(1) | 0.086$^{NS}$ |
| | | Average | 36 | 49.44±12.248 | | |
| | | Poor | 0 | - | | |
| 2. | Attitude | Good | 97 | 83.40±12.081 | 0.001(1) | 0.976$^{NS}$ |
| | | Average | 36 | 83.33±9.508 | | |
| | | **Poor** | **0** | **-** | | |

**NS – Not Significant ; * Significant at 5% level**

3.305, P=0.040 suggesting that knowledge influences attitudes among teachers. Another noteworthy finding was the relationship between knowledge and practices; it was observed that the teachers with low knowledge levels exhibited a mean score of 17.00 which denoted average classroom practices; however, it was not found to be statistically significant.

Pertaining to the relationship of attitude with knowledge and practice, it can be noted that the greater part of teachers had neutral attitudes followed by favourable and unfavourable attitudes respectively. However, regardless of the attitude type, the mean scores of knowledge levels remained in the high range. Subsequently, no significant relationship was found statistically between attitude and knowledge. The same trend can be observed with regard to the relationship of attitude with practice, regardless of attitude type, the teachers' practice scores were found to be in the range of good teaching practices and no statistically significant relationship between attitude and practice was noted.

Focusing on the relationship of practice with knowledge and attitude, Table 3 makes it evident that the majority of the primary school teachers' practices were at good levels followed by average levels. The knowledge levels mean scores who practiced good and average levels of teaching were 53.18 and 49.44, respectively indicating a high knowledge level on learning disabilities. Similarly, the attitude scores were found to be favourable with a mean of 83.40 and 83.33 among the teachers who practiced good and average teaching methods respectively. However, no significant relationship was found in practice involving knowledge and attitude. The results indicated that knowledge influenced the attitude of a teacher (Table 3). However, the teaching practices may not be influenced by knowledge. Similarly, attitude has no influence on either knowledge or practice and also practice is not found to be influencing the knowledge and attitude of teachers. However, literature as suggested that teachers' knowledge attitude and practice depend upon many factors which cannot be overlooked when deliberating the KAP of teachers such as issues related to socio-demographic aspects which need to be explored to uphold other significant factors that impact the KAP of teachers.

## CONCLUSIONS

Knowledge interacted with attitude of primary school teachers toward learning disabilities of the students but not on practices. Similarly, attitude did not interact with knowledge or practices, neither practices interacted with knowledge and attitude which was directed at practice being self-regulated among the teachers. It is seen that there was a dearth of knowledge and favourable attitude among teachers towards learning disabilities. KAP of teachers was insufficient and the reason may be the teachers might not have received the required training. The researcher felt the need for sensitization or intervention training and workshops on LD are much essential for teachers to deal with children at the primary school level.

## REFERENCES

Arifa, S and Siraj, S.S. 2019. A descriptive study to assess the knowledge and attitude of primary school teachers regarding learning disabilities among children in selected schools of district Pulwama Kashmir. Journal of Paediatrics and Nursing Science. 2(10):19-32.

Asok, A.S., Akoijam, P., Gupta, A and Akoijam, B.S. 2021. A knowledge and attitude of school teachers towards learning disabilities in Bishnupur district, Manipur: A cross sectional study. International Journal of Community Medicine and Public Health. 8(2):823- 826.

Dada, O.C and Sulyman, H.T. 2021. Teachers knowledge of pupil with learning disability in Ilorin south local government area, Kwara state. African Journals Online. 29(2):79-88.

Deshmukh, P.S and Gautam, A. 2021. A study to assess the attitude and effectiveness of structured teaching programme on knowledge of primary school teachers regarding learning disabilities in children among selected schools at Sangli, Miraj, Kupwad Corporation Area. World Journal of Pharmaceutical Research. 10(7):850-863.

Dhindsa, H., Borana, H., Yadav, J., Jangid, J., Gharu, K., Khawa, S.P and Kumar, A. 2022. Knowledge regarding learning disabilities in children among primary school teachers. International Journal of Community Medicine and Public Health. 9(1):235-239.

Elizabeth, K.T and Seema, P. 2019. Knowledge and attitude of primary school teachers towards inclusive education of children with specific learning disabilities. Journal of

Social Work Education and Practice. 4(2):23-32.

Ghimire, 2017. Knowledge of primary school teacher regarding learning disabilities in school children. Journal of Nobel Medical College. 6(1):29-35.

Luo, Y., Chen, L.C., Yang, S.C and Hong, S. 2022. Knowledge, attitude and practice (KAP) towards COVID-19 pandemic among the public in Taiwan: a cross-sectional study. International Journal of Environmental Research and Public Health. 19(5):1-13.

Madhamani, A and Joseph. 2021. Assessment of knowledge and awareness on public school teachers towards learning disabilities in children –An institutional based cross-sectional study in Dharmapuri district, Tamil Nadu. Journal of Family Medicine and Primary Care. 10(7):2524-2528.

Moothedath, S and Vranda. 2016. Attitude of primary school teachers towards children with learning disabilities. Journal of Indian Association for Child and Adolescent Mental Health. 12(4):323-33.

Neha and Roopa, K.S. 2018. Knowledge, attitude and practices of primary school teachers in dealing with learning disabilities among children, Research Review International Journal of Multidisciplinary. 03(11):634-638.

Nsreen, A. A and Mogeda, E.S. 2019. Assessing primary school teacher's knowledge of specific learning disabilities in the Kingdom of Saudi Arabia. Journal of Educational and Developmental Psychology. 9(2):9-22.

Ranjeetha, G.V and Shobha, G. 2019. Classroom practices of teachers on learning disabilities in children. International Journal of Educational Management. 34(3):562-575.

Shari, M and Vranda, M. N. 2015. Knowledge of primary school teachers in identifying children with learning disability. Disability CBR & Inclusive Development. 26(3):68-76.

Singh, S., Sawani, V., Deokate, M., Panchal, S., Subramanyam, A.A., Shah, H.R and Kamath, R.M. 2017. Specific learning disability: A 5 year study from India. International Journal of Contemporary Pediatrics. 4(3):863-868.

Sitrakool, B. 2017. Assessment of community pharmacists' knowledge, attitude and practice regarding non-prescription antimicrobial use and resistance in Thailand. M.Sc. Thesis submited to University of Hertfordshire, United Kingdom.

Soni, S.S. 2020. A study to assess the knowledge and attitude of school teachers regarding learning disability among children in selected schools at Churu. GFNPSS International Journal of Multidisciplinary Research. 1(2):81- 88.

Subi, S and Archana, K.R. 2019.Knowledge and attitude of primary school teachers on learning disabilities in children: A descriptive study. GJRA - Global Journal For Research Analysis 8(4):71-73.

World Health Organisation (WHO). 2012. Health education: theoretical concepts, effective strategies and core competencies: A foundation document to guide capacity development of health educators, Printed by WHO Regional Office for the Eastern Mediterranean, Cairo. pp.7-8.

Rajkumari, S and Ramya Bhaskar. 2023. The relationship between teachers' knowledge, attitude and practices towards learning disabilities of the students. The Journal of Research ANGRAU. 51(3): 113-120.
DoI: https://doi.org/10.58537/jorangrau.2023.51.3.13

DoI: https://doi.org/10.58537/jorangrau.2023.51.3.14

J. Res. ANGRAU 51 (3) 121-129, 2023

# PHYSICAL AND MENTAL HEALTH STATUS OF TEACHERS AND SOFTWARE PROFESSIONALS WORKING FROM HOME DURING COVID-19

**G. SRAVANI, BILQUIS* and S. PRASANTHI**

Department of Human Development and Family Studies, College of Community Science, Acharya N. G. Ranga Agricultural University, Guntur-522 034

Date of Receipt : 29.4.2023 Date of Acceptance : 01.7.2023

## ABSTRACT

The study attempted to investigate the physical and mental health of teachers and software professionals working from home since the start of COVID-19. The data was collected between March and April months of 2022.The study was conducted in the Bheemadol, Tanuku ,Tadepalligudem mandals of West Godavari district, Andhra Pradesh.The sample consisted of 120 respondents (60 teachers and 60 software professionals). The age group of the respondents was 25-35 years. Equal number of male and female respondents were selected for the study. The questionnaire developed by Verma and Pershad (1985) was used to measure the physical and mental health of teachers and software professionals the data was used analyzed by descriptive and inferential statistics. The study concluded that teachers were experiencing good physical and mental health status when compared to IT professionals. Interestingly nearly 50% of the respondents irrespective of gender were found to have good physical and psychological health status while working from home. However, significant difference was found in the physical and mental health status of teachers and software professionals.

**Keywords:** COVID-19, Mental health, Physical health, Software professionals,Teachers, Working from home.

## INTRODUCTION

The COVID-19 pandemic had changed every aspect of work and life. During lockdown the National and local companies, organizations, institutions, schools etc. encouraged their employees to work remotely at home to stay safe. Physical health is the normal functioning and biological process. The World Health Organization defined mental health as a condition of wellbeing characterised by self-awareness, the ability to manage everyday stresses, the capacity for productive work, and the capacity to contribute to one's community. During the pandemic and lockdown the physical problems of the many employees were altered and disturbed due to social isolation (Alsharji, 2020).Though working from home saves daily commuting time and offers more flexibility for employees to take care of their families,it deprived the opportunity to socialize with relatives, colleagues and decreased physical movements such as daily walking, exercises, social interactions. At the same time extended hours of screen exposure lead to fatigue, tiredness, headaches and eye-related symptoms.

*Corresponding Author E-mail i.d: bilquis@angrau.ac.in; M.Sc thesis submitted to Acharya N. G. Ranga Agricultural University, Guntur-522 034

Recent studies have pointed out that during lockdown, teachers and software professionals had suffered stress due to changes in work culture. This stress had often been accompanied by symptoms of anxiety, depression, and sleep disturbance as a consequence of the increased workload. Not many studies were conducted during the pandemic to measure the symptoms of stress, anxiety, and depression among teachers and software professionals. Hence an attempt was made to explore the physical and mental health status of teachers and software professionals working from home during pandemic.

## MATERIALS AND METHODS

The study analysed the physical and mental health status of the teachers and software professionals working from home. This study was conducted in the West Godavari district of Andhra Pradesh during March and April, 2022. The sample consisted of 120 respondents with 60 teachers working in private schools and 60 software professionals. Exploratory and retrospective research design was adopted for the study. Purposive and snowball sampling techniques were used to select the respondents.The questionnaire developed by Verma and Pershad (1985) was used to measure the physical and psychological health and was collected the data through personal interviews and emails. The data was analysed using mean difference, frequency and percentage analysis and Z-test.

## RESULTS AND DISCUSSION

**Age:** Forty-seven percentage of the teachers who were in the age group of 25-30 years had good physical health followed by average (28%) and poor (25%). Interestingly, 31-35 years age group of teachers had good physical health (50%) followed by poor (28%) and average (14%). The teachers who were in the age group of 31-35 years had more prevalence of hand/wrist pain, headache, tiredness. Abbaszadeh *et al.* (2019) also revealed that lower back pain, tiredness, leg pain, voice disorder, headache, neck pain, anxiety, shoulder pain, varicose veins of lower limbsand sleep problems were the frequent health complaints among the teachers during COVID -19 pandemic.

**Gender:** Fifty percent of the male teachers had good physical health followed by poor and average (23%), whereas, forty-six percent of female teachers had good physical health followed by poor

**Table 1. Physical health status of Teachers based on demographic variables (n=60)**

| S. No | Demographic variables | Extremely poor health | | Poor health | | Average | | Good health | | Extremely good health | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | F | % | F | % | F | % | F | % | F | % |
| 1. | **Age (years)** | | | | | | | | | | |
| | 25-30 | - | | 8 | 25 | 9 | 28 | 15 | 47 | - | |
| | 31-35 | 1 | 4 | 8 | 28 | 4 | 14 | 14 | 50 | 1 | 4 |
| 2. | **Gender** | | | | | | | | | | |
| | Male | - | | 7 | 23 | 7 | 23 | 15 | 50 | 1 | 4 |
| | Female | 1 | 4 | 9 | 30 | 6 | 20 | 14 | 46 | - | |
| 3. | **Education** | | | | | | | | | | |
| | Degree | - | | 4 | 50 | 2 | 25 | 2 | 25 | - | |
| | PG and above | 1 | 2 | 12 | 23 | 11 | 21 | 27 | 52 | 1 | 2 |
| 4. | **Marital status** | | | | | | | | | | |
| | Unmarried | - | | 3 | 38 | 2 | 25 | 3 | 37 | - | |
| | Married | 1 | 2 | 13 | 25 | 11 | 21 | 26 | 50 | 1 | 2 |

Table 1 indicates the physical health status of teachers with respect to their demographic variables age, gender, education and marital status.

(30%) and average (20%). Female teachers expressed poor physical health during the pandemic and also difficulty in falling sleep because of their excessive household work, back pain and neck pain than male teachers.

**Education:** The data indicated that fifty-two percent of the teachers with post-graduation had good physical health followed by poor (23%) and average physical health (21%). Interestingly, fifty percent of teachers with degree qualifications had poor physical health followed by average and good physical health (25%). This difference could be implied to the number of hours spent in teaching online. Teachers with higher qualification were dealing with the higher classes and restricted to only teaching their respective subjects and exposure to screen time and number of hours spent for work from home was less than the teachers with degree qualification who teach to the lower classes from morning to evening.

**Marital status:** The relationship between the marital status of the teachers and physical health clearly indicated that both married and unmarried teachers had good physical health followed by poor and average. The unmarried teachers were engaged in improving their qualifications and competencies by attending extra online classes during lockdown period.

**Age:** Sixty percent of the software professionals who were in the age group of 31-35 years had good physical health followed by average (20%) and poor (10%). Whereas, thirty-eight percent of software professionals in the age group of 25-30 years had good physical health followed by poor (28%) and average (24%). The respondents expressed that they took care of health by doing yoga and exercises.

**Gender:** The data revealed that forty-three percent of male software professionals had good physical health followed by poor (33%) and average (17%). Whereas, female software professionals had poor physical health (34%) followed by health good and average (30%). The male respondents told that they were physically active and eating a

**Table 2 . Physical health status of software professionals based on demographic variables(n=60)**

| S.No | Demographic variables | Extremely poor health | | Poor health | | Average | | Good health | | Extremely good health | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | F | % | F | % | F | % | F | % | F | % |
| 1. | Age (years) | | | | | | | | | | |
| | 25-30 | 2 | 4 | 19 | 38 | 12 | 24 | 16 | 32 | 1 | 2 |
| | 31-35 | 1 | 10 | 1 | 10 | 2 | 20 | 6 | 60 | - | |
| 2. | Gender | | | | | | | | | | |
| | Male | 2 | 7 | 10 | 33 | 5 | 17 | 13 | 43 | - | |
| | Female | 1 | 3 | 10 | 34 | 9 | 30 | 9 | 30 | 1 | 3 |
| 3. | Education | | | | | | | | | | |
| | Degree | 2 | 7 | 8 | 28 | 7 | 24 | 11 | 38 | 1 | 3 |
| | PGand above | 1 | 3 | 12 | 39 | 7 | 23 | 11 | 35 | - | |
| 4. | **Marital status** | | | | | | | | | | |
| | Unmarried | 2 | 7 | 13 | 43 | 5 | 17 | 10 | 33 | - | |
| | Married | 1 | 3 | 7 | 24 | 9 | 30 | 12 | 40 | 1 | 3 |

Note: The values in parentheses indicates percentages

**Table 3. Overall Physical health status of teachers and software professionals working from home**

| S.No. | Physical health | Teachers (n=60) | | Software professionals (n=60) | |
|---|---|---|---|---|---|
| | | F | % | F | % |
| 1. | Extremely poor | 1 | 2 | 3 | 5 |
| 2. | Poor | 16 | 26 | 20 | 33 |
| 3. | Average | 13 | 22 | 14 | 23 |
| 4. | Good | 29 | 48 | 22 | 37 |
| 5. | Extremely good | 1 | 2 | 1 | 2 |

healthy diet and female respondents reported that they had suffered headaches, back pain, neck pain because they had to balance the house hold activities and professionals work.

**Education:** Thirty-nine percent of the software professionals who completed their post-graduation had poor physical health status followed by good (35%) and average (23%). Whereas, thirty-eight percent of graduated software professionals had good physical health status followed by poor (28%) and average (24%). The respondents with higher qualification suffered with more health problems due to extended working hours lead to tiredness and eye related problems.

**Marital status:** It was interesting to note that forty-three percent of unmarried software professionals had poor physical health followed by good (33%) and average (17%). Whereas, forty percent of married software professionals had good physical health status followed by average (30%) and poor (24%). The unmarried respondents had the difficulty in falling asleep and suffered eye

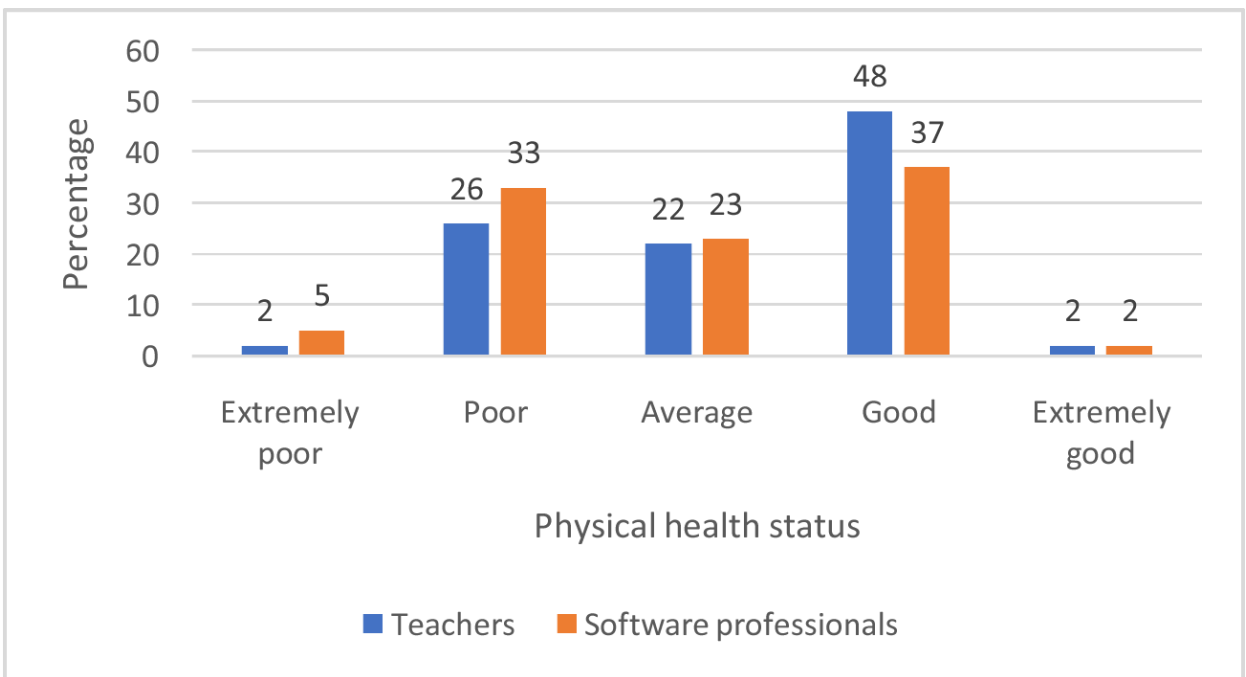



**Figure 1. Distribution of teachers and software professionals based on physical health status**

**Table 4 . Mental health status of teachers based on demographic variables (n=60)**

| S.No | Demographic variables | Extremely poor health | | Poor health | | Average | | Good health | | Extremely good health | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | F | % | F | % | F | % | F | % | F | % |
| 1. | **Age (Years)** | | | | | | | | | | |
| | 25-30 | - | | 3 | 9 | 9 | 28 | 20 | 63 | - | |
| | 31-35 | - | | 7 | 25 | 10 | 36 | 10 | 36 | 1 | 3 |
| 2. | **Gender** | | | | | | | | | | |
| | Male | - | | 5 | 17 | 11 | 37 | 13 | 43 | 1 | 3 |
| | Female | - | | 5 | 17 | 8 | 27 | 17 | 56 | - | |
| 3. | **Education** | | | | | | | | | | |
| | Degree | - | | 2 | 25 | 1 | 12 | 5 | 63 | - | |
| | PG and above | - | | 8 | 15 | 18 | 35 | 25 | 48 | 1 | 2 |
| 4. | **Marital status** | | | | | | | | | | |
| | Unmarried | - | | 1 | 12 | 2 | 25 | 5 | 63 | - | |
| | Married | - | | 9 | 17 | 17 | 33 | 25 | 48 | 1 | 2 |

related problems because of long hours of work.Similar findings were found by Shimura *et al.* (2021).

It was interesting to note that teachers had good physical health compared to software professionals because of the standard work timings and limited exposure to computer screen. These findings were in line with Apperribai *et al.* (2020) who found that practice of yoga and meditation during lockdown had improved the physical health.

**Age:** Sixty-three percent of teachers who were in the age group 21-30 years had good mental health followed by average (28%) and poor mental health (9%). Teachers who were in the age of 31-35 years had good to average level of mental health (36%) followed by poor (25%). The teachers who were 25-30 years had poor mental health and experienced inconvenience and could not take decisions quickly. The respondents of 31-35 years could concentrate and easily manage the work. Vasquez *et al*. (2021) also found that working more than 35 hours per week was associated with poor mental health.

**Gender:**The data revealed that more than fifty-six percent of female teachers had good

**Table 6. Mental health status of teachers and software professionals working from home**

| S.No. | Mental health | Teachers (n=60) | | Software professionals (n=60) | |
|---|---|---|---|---|---|
| | | f | (%) | f | % |
| 1. | Extremely poor | - | | 1 | 2 |
| 2. | Poor | 10 | 16 | 20 | 33 |
| 3. | Average | 19 | 32 | 14 | 23 |
| 4. | Good | 30 | 50 | 24 | 40 |
| 5. | Extremely good | 1 | 2 | 1 | 2 |

**Table 5. Mental health status of software professionals based on demographic variables(n=60)**

| S.No | Demographic variables | Extremely poor | | Poor | | Average | | Good | | Extremely good | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | F | % | F | % | F | % | F | % | F | % |
| **1.** | **Age( Years)** | | | | | | | | | | |
| | 25-30 | 1 | 2 | 18 | 36 | 13 | 26 | 17 | 34 | 1 | 2 |
| | 31-35 | - | | 2 | 20 | 1 | 10 | 7 | 70 | - | |
| **2.** | **Gender** | | | | | | | | | | |
| | Male | 1 | 3 | 9 | 30 | 6 | 20 | 14 | 47 | - | |
| | Female | - | | 11 | 37 | 8 | 27 | 10 | 33 | 1 | 3 |
| **3.** | **Education** | | | | | | | | | | |
| | Degree | 1 | 3 | 7 | 24 | 9 | 32 | 11 | 38 | 1 | 3 |
| | PG and above | - | | 13 | 42 | 5 | 16 | 13 | 42 | - | |
| **4.** | **Marital status** | | | | | | | | | | |
| | Unmarried | 1 | 3 | 12 | 40 | 9 | 30 | 8 | 27 | - | |
| | Married | - | | 8 | 27 | 5 | 17 | 16 | 53 | 1 | 3 |

mental health followed by average (27%) to poor (17%). Whereas forty-three percent of male teachers had good mental health followed by average (37%) to poor (17%). The female teachers do take care of children and attend household chores. Similarly Etxebarria*etal.* (2021) study indicated that there were high levels of stress and anxiety among women in comparison with men.

**Education:** Sixty-three percent of teachers who had completed their graduation had good mental health followed by poor (25%) and average (12%). Whereas, more than forty-eight percent of teachers who completed post-graduation had good mental health status followed by average (35%) to poor (15%). The reasons for poor health of the graduated teachers was they were taking the classes full day and fell depressed, worry a lot and ask advises from colleagues. Post-graduate teachers deal with limited subjects only. Kita *etal.* (2022) stated that the number of classes taught online and class preparation time were major predictors of mental health among faculty during the pandemic.

**Marital status:** It was interesting to note that unmarried teachers had good mental health compared to married teachers. Teachers who were married had to take care of their family, gets easily irritated and sometimes feel depressed because of work load.

**Age:** The software professionals in the age group of 31-35 years showed good mental health compared to 25-30 years of age group. The reasons for good mental health status of software professionals who were in age group of 31-35 years was due to less work time and absence of nightshifts.Whereas,31-35 years age group of respondents had more night shifts, project deadlines and family responsibilities.

**Gender:** Forty-seven percent of male software professionals had good mental health followed by poor (30%) to average (20%). Whereas

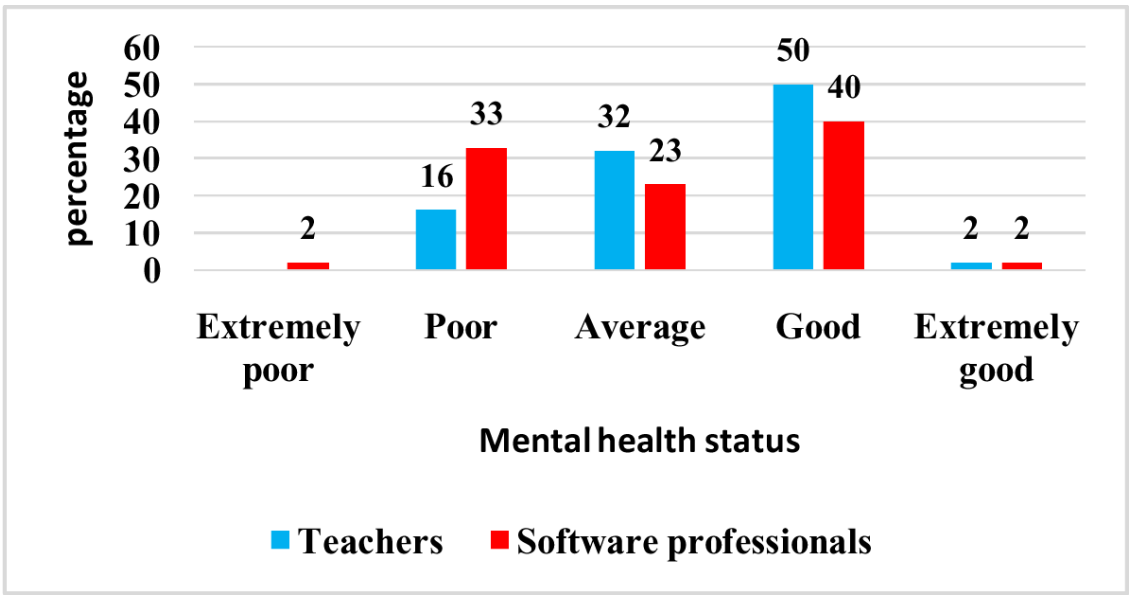



**Figure 2. Distribution of teachers and software professionals based on Mental health status**

thirty-seven percent of female software professionals were found to have poor mental health followed by good (33%) to average (27%). Clear gender difference in the mental health status was observed. The female software professionals expressedthat they had to do the multiple tasks like attending household chores and taking care of family. They have more work pressure compared to male software professionals. Joshi and Gour (2020) stated that dissatisfaction and depression takes place in the minds of people because of keeping regular schedule, working for more than prescribed hours and time-consuming household chores.

**Education:**Education did play a significant role in keeping the mental health. The post-graduate respondents had better computer skills and handle the system related works very fast compared to graduate respondents who are less skilled and had less experience in handling problems.

**Marital status:**The data revealed married software professionals had good psychological health compared to unmarried software professionals. The reasons of good mental health of the married professionals was family support and time spent with children and family members.

**Table 7. Mean differences in physical health, psychological health of teachers and software professionals (n=120)**

| S.No. | Dependent variable | Occupation | Mean± S.D | Z-value |
|---|---|---|---|---|
| 1. | Physical health | Teachers | 14.3±5.57 | -4.13** |
| | | Software professionals | 13.4±5.00 | |
| 2. | Mental health | Teachers | 19.5±5.53 | -4.68** |
| | | Software professionals | 16.16±5.36 | |

** Significant at 0.01 level

The data showed that more than fifty percent of teachers had good mental health followed by average (32%) to poor (16%). Similarly, forty percent of software professionals had good mental health followed by poor (33%) to average (23%). Overall, the teachers had good mental health compared to software professionals. Koujageri*etal.*(2021) stated that during covid employees were feeling isolated, lonely or disconnected from other people socially and professionally.

Table 7 indicates the mean differences in Physical and Mental health status of teachers and software professionals working from home.

**Physical health:** The data revealed the significant difference in physical health of teachers and software professionals where teachers had better physical health compared to software professionals. The teachers expressed that they were taking care of health by taking breaks and eyes relaxation exercises if suffer from headaches, giddiness. Whereas the software professionals told that they had physical problems like severe headache and eye strain due to prolonged exposure to screen.

**Mental health:** The teachers and software professionals had significant differences in their mental health status. Teachers had better mental health compared to software professionals because they were happy working from home as they could spend time with family, could finish household chores slowly without any hurry and took classes in time. These findings were consistent with those of Hofmann *et al.* (2020) who found that flexible and convenient work hours was related to good psychological health .

## CONCLUSIONS

The COVID -19 pandemic had resulted in social isolation, life style changes, work pattern alteration.This affected physical and psychological health of people. The study highlighted how the work from home scenario had impacted the physical and mental health status of teachers and software professionals during COVID-19 lockdown period. The study concluded that there was a significant difference in physical and mental health status of teachers and software professionals where teachers were experienced good physical and mental health compared to software professionals. Hence, the study highlights the importance for providing congenial working environmental and flexible working hours to reduce the work stress and mental health of professionals working from home.

## REFERENCES

Abbaszadeh, S., Jahangiri, M and Hassanipour, S. 2019. Work-related health problems among primary and secondary school teachers: A cross-sectional study. Shiraz E-Medical Journal. 20(6): 83-87.

Alsharji, E. K. 2020. Anxiety and depression during the COVID-19 pandemic in Kuwait: The importance of physical activity. Middle East Current Psychiatry. pp. 57- 60.

Apeeribai, L., Cortabarria, L., Aguirre, T., Verche, E and Borges, A., 2020. Teachers physical activity health during lockdown due to the COVID-19 pandemic. Frontiers in Psychology. 11(5): 77 -88.

Etexbarria, N.O., Santxo, N.B., Mondragon, N.I and Santamaria, M.D. 2021. The psychological state of teachers during the covid-19 crisis: The Challenge of returning to face-to face teaching. Frontiers in Psychology. 11(6) :20-25.

Hofmann, H., Grob, D and Walter Kohlmann, C. 2022. On the role of mental health activities for teachers' work and life. Applied Research in Quality of Life. 17( 5) :205-227.

Joshi, A and Gour, S. 2020. A study of work-life balance during COVID-19. Journal of Critical Reviews.7(11): 2394-5125.

Kita, Y., Yasuda, S and Gherghel, C. 2022. Online education and the mental health of faculty during the COVID-19 pandemic in Japan. Scientific Reports. 12 ( 2) :89-90.

Koujageri, J., Manjunath, S., Arelingaiah, M., Garady, L and Chandrath, N. 2021. A study on employees working from home during COVID-19 in Karnataka. International Journal of Business, Management and Allied Sciences. 8(2): 2349-4638.

Shimura, A., Yokoi, K., Ishibashi, Y., Akatsuka, Yand Inoue, T. 2021. Remote work decreases psychological and physical stress responses, but full-remote work increases Presenteeism. Frontiers in Psychology. 12( 7) :730-736.

Vasquez, P. C., Carrasco, D and Hernando-Rodriguez, J. C. 2021. Mental health of teachers who have teleworked due to COVID-19. Investigation in Health Psychology and Education.11:515-528.

Verma, S.K., Wig, N.N and Pershad, D. 1978. Manual for PGI Health Questionnaire N-1. Agra, National Psychological Corporation.

Sravani, G., Bilquis and Prasanthi, S.2023.Physical and mental health status of teachers and software professionals working from home during COVID-19. The Journal of Research ANGRAU. 51(3): 121-129.
DoI: https://doi.org/10.58537/jorangrau.2023.51.3.14

DoI: https://doi.org/10.58537/jorangrau.2023.51.3.15

J. Res. ANGRAU 51 (3) 130-135, 2023

# MARKET INTEGRATION OF SWEET LIME BETWEEN DOMESTIC AND INTERNATIONAL MARKETS

**RAGINI NAIKOTI, SATYVEER SINGH MEENA AND VIKASH***

Dr. Yashwant Singh Parmar University of Horticulture and Forestry,
Nauni, Himachal Pradesh- 173 230

Date of Receipt : 28.4.2023 Date of Acceptance : 30.6.2023

## ABSTRACT

The study focused on the integration of domestic and international markets for sweet limes during 2021. The co-integration of commodity prices was considered to be necessary for the implementation of a successful marketing reform for which both domestic and international market prices are required. Due to the lack of information regarding international prices, export price information was gathered from the website of the Agricultural and Processed Food Products Export Development Authority (APEDA), and secondary data regarding domestic prices of sweet lime was gathered from the website of the Agricultural Marketing Information Network (AGMARKNET). The annual average prices data for the chosen markets were gathered, and the Pearson correlation coefficient and Johansen's co-integration analysis approaches were used to analyse the relationship between the chosen market pair. Both markets were found to be correlated through correlation analysis, and the findings of the Johansen Co-integration rank, trace test, and eigen value statistics test were used to analyse the integration among the markets. The study's findings on market integration reveal how closely related the selected market places' pricing are to one another. Additionally, this research demonstrated that the model's variables exhibited an equilibrium long-run co-movement with the market price series.

**Keywords:** Co-integration, Correlation, Johansen Co-integration Test, Market, Prices

## INTRODUCTION

The agricultural market environment is undergoing rapid changes, both on a local and global scale, at an unprecedented pace. Farm prices are impacted by market volatility and consequently, farm income. Market integration influences fruit items' prices as well. Due to seasonality, inelastic demand, variable production, and perishability, fruit prices are volatile. Additionally, there are many marketing intermediates involved in agricultural marketing, which raises the cost of marketing and ultimately drives up prices (FAO, 2017).

Gouel and Laborde (2021) examined how market-mediated changes can help mitigate the impacts of the changing climate. The findings reveal that climate-induced yield fluctuations cause considerable price movements, which encourage production and trade modifications. Both production and trade adjustments lead to world welfare losses, with production adjustments contributing the most.

Beag and Singla (2014) used Johansen's multivariate co-integration approach to examine market integration across five significant wholesale apple marketplaces in the nation: Ahmedabad,

*Corresponding Author E-mail i.d: vikash.kayla@gmail.com

Bengaluru, Delhi, Hyderabad, and Kolkata. The results of co-integration and Granger causality were also supported using impulse response functions, but in some geographically integrated market pairs, the amplitude of price transmission was found to be rather modest. Khatkar *et al.* (2014) using Johansen Granger Causality Tests, one may determine the degree of market co-integration of paddy prices in the key Punjab markets of Amritsar and Haryana, as well as how quickly paddy markets adapt to changes in long-term equilibrium. Patil *et al.* (2014) examined the seasonal variation, price volatility, and co-integration among the major mung bean market places in Maharashtra. All of the selected markets had higher pricing for mung bean during the months of October through December. The cycle-related volatility in prices of green gram in the markets that are selected.Wani *et al.* (2015) through a co-integration analysis of the wholesale weekly prices of three commercial apple varieties, however the analysis discovers no co integration for the American super variety in two pairings of markets. Additionally, the results of the Vector Error Correction Model (VECM) show a mix of positive and negative coefficients, albeit the positive coefficients are greater than the negative coefficient. Paul *et al.* (2016) studied into the key pulses' market integration across five Indian regions. The amalgamation of the wholesale and retail marketplaces was investigated by using the VECM. Using the Johansen co-integration method, Kumar and Jha (2017) examined the co-movement and causation between the prices of agricultural commodities and energy. David *et al.*(2019) investigated the co-integration of the price series for ethanol and agricultural commodities. They also demonstrated how the co-integrated price series' efficiency and predictability are impacted by this relationship.Qiang and Fan (2016) findings shows the world crude market for oil was integrated. Moreover, the world crude market for oil has a geographic and organisational framework. While OPEC is indeed-integrated, crude market for oil in neighbouring nations and areas tend to be linked together. It was discovered that the ties between South and North America, as well as Africa, are relatively stable.

The market integration of sweet lime between domestic and international markets presents challenges and opportunities that need to be addressed. Despite the potential and growing demand for sweet lime as a traded commodity on an international level, knowledge of the extent of market integration, the forces that are driving it, and its effects on producers, consumers, and market dynamics is lacking. Therefore, a detailed examination of the sweet lime market integration is necessary to identify challenges, assess market effectiveness, and create plans to enhance the integration process for the benefit of each stakeholder involved. The objective of this research was to study market integration of prices between international and domestic market.

The study concentrated on the integration of domestic and international markets for sweet limes. The co-integration of commodity prices was crucial to the price determination process. It was considered to be required for the effective execution of a marketing reform.

## MATERIALS AND METHODS

The study was conducted during the year 2021. The details of price data was gathered using the reliable secondary sources for domestic and international prices *i.e.,* AGMARKNET and APEDA respectively for the past 10 years between January 2012 and December 2021. Hyderabad's Gaddiannaram market was chosen based on judgmental sampling-market with highest arrivals in the state. Yearly averages were considered for analysis.

### Market integration

To establish an association between market pairing, the annual average price statistics of a selected markets were gathered and examined using Pearson's correlation coefficient and

Johansen's Co-integration analysis approach.The following formula was employed to determine the correlation coefficient between the markets.

$$r = \frac{n\sum XY - (\sum X)(\sum Y)}{\sqrt{n\sum X^2 - (X)^2}\sqrt{n\sum Y^2 - (Y)^2}}$$

Where, r = correlation coefficient,

n=number of observations.

X = Yearly average prices of selected crop (Rs/qt) in one market.

Y = Yearly average prices of selected crop (Rs/qt) in another market.

Correlation coefficient (s) ranges in value from -1 to +1. The positive number denotes a favourable correlation among markets, meaning that rising prices in one market will raise prices in the other. Stronger degree of association when value is nearer to +1. Depending on the value's sign, a perfect connection can be either positive or negative if the value is exactly +1.

**Co-integration**

Evaluating the co-integration of market prices was done using the multivariate Johansen approach. To prevent erroneous or arbitrary regression, prior to conducting the co-integration test, the stationarity of the price time series was assessed. The unit roots and stationarity properties of the time series were supported by the ADF test. Concerning the discrepancies in the level and initial price series, an ADF test was performed. The integrated time series variables might be of identical order, but the unit root test identifies which time series variables are incorporated of order one, or I. Analysis was done on the following ADF regression equation for stationarity:

$$\Delta y_t = \beta_1 - \beta_{2t} + \delta y_{t-1} + \Sigma\alpha_i \Delta y_{t-i} + \varepsilon t$$

——————————(1)

Where $\Delta y_t = (y_t - y_{t-i})$ and $\varepsilon t$ are pure white noise error terms, $Y_t$ represents a vector that needs to have been assessed for co-integration, and t is the time or trend variable. The alternative hypothesis, $\delta$<0, indicates that the time series is stationary, rejecting the null hypothesis, whereas the null hypothesis, $\delta$=0; denoting unit root, states that the time series is non-stationary.

According to the error-correction representation, the Johansen's Co-integration test equation is given following:

$$\Delta z_t = \varphi k \Delta z_{t-k} + \pi z_{t-1} + \mu + \varepsilon t$$

——————————(2)

$z_t$ is a vector of I (1) processes with a n*1 size (price of n market), The number of co-integrating vectors determines its rank of $\pi$, which is verified using the maximum eigenvalue, trace value, and likelihood ratio test statistics. To account for the variables that were left out, a constant term called $\mu$ was utilised. The Akaike Information Criterion AIC was used to determine the number of lags to be considered in the model. The Johansen's trace test was used in this research to establish the rank of a.

$$\lambda_{grace} = -T\sum_{i=r+1}^{n} \ln(1 - \lambda i) \text{for r=0, 1, n-1}$$

—————————— (3)

Where the Eigen values for $\lambda_i$ indicate how strongly the first difference and the error-correction diverge from one another. The following hypotheses were then studied:

$H_o$: rank of $\pi$=r (null hypothesis),

$H_y$: rank of $\pi$>r (alternate hypothesis)

Where "r" denotes the number of co-integration equations. The test was run under the presumption that the original data had a linear, deterministic trend and that the co-integrating equation contained only an intercept. The original price series has a trend since the variance and mean are not stable over a period of time (non-stationary), however, the co-integrating expression only has the intercept as the price series had been separated while being examined for stationarity.

**Table 1. ADF Test for Export Market and Domestic Market**

| S.No. | ADF Test for Export Market | Stationary Test | | | | |
|---|---|---|---|---|---|---|
| | **Test** | **Score** | **P-Value** | **C.V.** | **Stationary** | **0.05** |
| **ADF** | | | | | | |
| 1 | No Constant | -1.2 | 2.15 | -2.0 | FALSE | |
| 2 | Constant-Only | 942.4 | 0.01 | -3.0 | TRUE | |
| 3 | Constant + Trend | -2.6 | 3.53 | -3.6 | FALSE | |
| | ADF Test for Domestic Market | Stationary Test | | | | |
| | **Test** | **Score** | **P-Value** | **C.V.** | **Stationary** | **0.05** |
| **ADF** | | | | | | |
| 1 | No Constant | -1.5 | 1.36 | -2.0 | FALSE | |
| 2 | Constant-Only | -2.6 | 1.12 | -3.0 | FALSE | |
| 3 | Constant + Trend | -2.5 | 3.93 | -3.6 | FALSE | |

**Source: Researcher's calculations based on the secondary data**

## RESULTS AND DISCUSSION

### Market integration

The co-integration test analyses the long-run equilibrium while determining whether a group of non-stationary series are co-integrated or not. The co-integration test analyses the long-run equilibrium relationship between the variables and establishes whether a group of non-stationary series are co-integrated. There are numerous ways to check for co integration of variables. Among the techniques that is widely used is the Johansen approach.

A statistical characteristic of time series variables or when the error term in a regression model is stationary is co-integration. There must be a stationary linear combination of non-stationary random variables for the variables to be co-integrated.

To determine if the price sequence of sweet lime were stationary or not, the ADF based unit root testing method was employed (Table 1).

Mahadika *et al*. (2017) used Augmented Dickey Fuller (ADF) test, which depicts that data was not stationary. The series went through in the Johansen co-integration test after being converted from non-stationary I (0) to stationary I (1).The results demonstrate a sustained association between FDI, export volume, and GDP. The variables FDI, Export Volume, and GDP have a long-term association.

### Correlation coefficient of domestic and international markets of sweet lime

The correlation coefficient of both domestic and international market pairs was used to calculate the extent of market integration between two markets (Table 2). The findings showed the correlation coefficient between the two markets, meant that the domestic pricing of sweet lime was linked with the international market; if the price of sweet lime increased in one market, it caused the value of sweet lime to rise in other markets, demonstrating the markets' positive price integration.

Uysal and Mohamoud (2018) analyzed the determinants of export performance. The results depict that between the factors that were considered, industry has the strongest correlation with export performance. With a correlation coefficient of 0.6094, it was possible to conclude

**Table 2. Correlation between export prices and domestic prices**

| S. No. | | Export prices | Domestic prices |
|---|---|---|---|
| 1 | Export Prices | 1 | |
| 2 | Domestic Prices | 0.98 | 1 |

Source: Researcher's calculations based on the secondary data

**Table 3. Johansen's co-integration test results for sweet lime markets**

| S.No. | Co-integration (Johansen) Test | | | | 0.05 | Maximum Eigen value Test (r=1) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Test** | **Score** | **C.V.** | **Pass** | | **Test** | **Score** | **C.V.** | **Pass** |
| | Trace Test (r=0) | **0** | | **r>0** | | | | | |
| 1 | No Constant | 25.0 | 12.3 | TRUE | | No Constant | 1.2 | 4.1 | FALSE |
| 2 | Constant-Only | 13.9 | 15.5 | FALSE | | Constant-Only | 0.3 | 3.8 | FALSE |
| 3 | Constant + Trend | 17.0 | 18.4 | FALSE | | Constant + Trend | 5.2 | 3.8 | TRUE |

Source: Researcher's calculations based on the secondary data

that industrialization possesses a 60% deciding influence on a country's export performance.

**The integration between the markets for sweet lime prices**

Using the numxl tool in MS-Excel, the integration between the markets was examined through Johansen co-integration process. The sweet lime price trace test results shown in Table 3 depicts that the trace statistics value exceeded the acute value at a level of 5 percent. As a result, the researcher was able to build co-integrating equations with a 5% threshold of significance. This suggested that during the study period, long-run equilibrium co-movement between the market price series and the model variables existed. Co-integration must exist for markets to function well over the long run.

For price series of sweet lime in domestic and foreign markets, the co-integration was explored. Table 3 displays the trace test and the Eigen value statistics derived from the Johansen Co-integration rank test.

The Johansen co-integration test results showed that co-integration links exist at a 5 percent level of significance of the chosen markets. As per the prior discussion, regardless of whether the markets are integrated, there could still be short-term disequilibrium since price changes on different markets might not occur instantly or simultaneously.

Ibrahim (2015) in his study, Johansen Co-integration test employed to test whether variables are co-integrated or not. According to the Johansen Co-integration test, there was only a single co-integration equation between citrus export, area, and production.This suggests there was a long-run link (equilibrium) between citrus export area and citrus production.

**CONCLUSIONS**

For the purpose of evaluating market integration, the domestic and international prices of sweet lime were compared. The findings revealed a strong correlation between the two markets which meant that the domestic pricing of sweet lime was linked with the international market; if the price of

sweet lime increased in one market, it caused the price of sweet lime to rise in other markets, demonstrating the markets' positive price integration.Through Johansen co-integration process, trace test, and eigen value statistics produced from the Johansen Co-integration rank test results, the integration between the markets was analysed. The findings showed that co-integration links exist at a 5% level of significance among the chosen markets.The market integration finding demonstrated that the studied markets are strongly associated and that there is opportunity for exporting the goods but since producer can only expect to make a little profit.

## REFERENCES


Beag, F. A and Singla, N. 2014. Cointegration, causality and impulse response analysis in major apple markets of India. Agricultural Economics Research Review. 27(2): 289-298. DoI: 10.5958/0974-0279.2014.00032.9

David, S.A., Inácio, C.M.C and Machado, A.J.T. 2019. Quantifying the predictability and efficiency of the cointegrated ethanol and agricultural commodities price series. Applied Sciences. 9(24):1-14. https://doi.org/10.3390/app9245303

FAO. 2017. Agricultural Productivity and Innovation. The future of food and agriculture-Trends and challenges. Edition 2017.FAO, Rome. pp. 46-55.

Gouel, C and Laborde, D. 2021. The crucial role of domestic and international market-mediated adaptation to climate change. Journal of Environmental Economics and Management. 106: 102408.https://doi.org/10.1016/j.jeem.2020.102408

Ibrahim, M. 2015. Relationship between cultivated area, production and export of citrus fruit of Pakistan: a time series approach. M. Phil thesis submitted to Minhaj University, Lahore, Pakistan.

Khatkar, R. K., Karwasra, J. C., Singh, V. K and Bhatia, J. K. 2014. Market co-integration, price discovery and causation of basmati paddy in Haryana. Indian Journal of Economic Development.10 (1a): 38-44. DoI: 10.5958/j.2322-0430.10.1a.019

Kumar, R.R and Jha, G.K. 2017. Examining the co-movement between energy and agricultural commodity prices in India. Journal of the Indian Society of Agricultural Statistics. 70(3): 241-252.

Mahadika, I. N., Kalayci, S and Altun, N. 2017. Relationship between GDP, foreign direct investment and export volume: Evidence from Indonesia. International Journal of Trade, Economics and Finance. 8(1): 51-54.Doi: 10.18178/ijtef.2017.8.1.538

Patil, V. K., Tingre, A. S and Chaudhari, D. J. 2014. Mungbean price movement across major markets of Maharashtra, Journal of Food Legumes. 27(3): 233-237.

Paul, R. K., Saxena, R and Bhat, S. A. 2016. How price signals in pulses are transmitted across regions and value chain? Examining horizontal and vertical market price integration for major pulses in India. Agriculture Economics Research Review. 22:75-86. DoI: 10.22004/ag.econ.253167

Qiang, J and Fan, Y. 2016. Evolution of the world crude oil market integration: A graph theory analysis. Energy Economics. 53: 90-100, https://doi.org/10.1016/j.eneco.2014.12.003

Uysal, O and Mohamoud, A. S. 2018. Determinants of export performance in East Africa countries. Chinese Business Review. 17(4): 168-178.DoI:10.17265/1537-1506/2018.04.002.

Wani, M.H., Paul, R.K., Bazaz, N.H and Manzoor, M. 2015. Market integration and price forecasting of apple in India. Indian Journal of Agricultural Economics. 70 (2): 169-181.


Naikoti, R., Meena, S. S and Vikash. 2023. Market integration of sweet lime between domestic and international markets. The Journal of Research ANGRAU. 51(3): 130-135.
DoI: https://doi.org/10.58537/jorangrau.2023.51.3.15

DoI: https://doi.org/10.58537/jorangrau.2023.51.3.16

J. Res. ANGRAU 51 (3) 136-146, 2023

# ANALYSIS OF JOB SATISFACTION OF TEA PLANTATION WORKERS OF KERALA USING A STRUCTURAL EQUATION MODELLING APPROACH

**ARYA V. CHANDRAN*, DIGVIJAY SINGH DHAKRE, DEBASIS BHATTACHARYA AND KADER ALI SARKAR**

Department of Agricultural Statistics, Palli Siksha Bhavan,
Visva-Bharati University, Sriniketan-731 236

Date of Receipt :01.5.2023 Date of Acceptance : 11.7.2023

## ABSTRACT

The study aimed to identify the effects of different factors on job satisfaction of tea plantation workers. Like any other industry, the satisfaction of labours have significant role in the development of tea industry. The tea plantation workers in India are covered by Plantation Labour Act (PLA) 1951, which prescribes the standards of working and living conditions. The data regarding the satisfaction of different factors including working and living conditions were collected from 400 respondents of Kerala through structured interview schedule. To determine the influence of various factors influencing job satisfaction, appropriate statistical approaches, such as Exploratory Factor Analysis (EFA) and Structural Equation Modelling (SEM) technologies, were employed.The goodness of fit for the fitted model was checked by fitness indices. Using SEM, it was observed that the company's provision of facilities such housing, water, electricity, protective clothing, health care, and recreational activities has an effect on the job satisfaction of plantation workers.

**Keywords**: Exploratory factor analysis, Job satisfaction, Structural equation modelling, Tea plantation workers

## INTRODUCTION

Tea is one of the popular and low-cost beverages that have worldwide consumption.The tea industry is very labour-intensive and that constitutes of mainly plantation labours. Kerala has 35871 ha of area under tea plantations, engaging about 40773 plantation workers. Among the 14 districts, Idukki and Wayanad districts together cover a major portion of tea plantation area of Kerala. For any industry, identification of factors which affect the satisfaction of labours is an important thing for the growth of that industry.Thus, identifying the root cause of dissatisfaction will help to measure the extend of the job satisfaction and thus will help increase the productivity of labours. The satisfaction of a labour towards their job depends on different monetary benefits and working conditions prevailing in the company. In this context, it is noteworthy to mention that the plantation Labour Act, 1951 and Kerala Plantations Labour Rules, 1959 govern the working conditions of tea plantation labour of Kerala (Kumar, 2018). Job characteristics such as safety and welfare measures, incentives, promotional opportunity, task clarity and significance, household facilities and

*Corresponding Author E-mail i.d: aryavc2926@gmail.com; Ph.D. thesis submitted to Visva-Bharati University, Sriniketan, West Bengal, India

skills utilization, as well as organizational characteristics have significant effects on job satisfaction of tea plantation labours (Priyadarshan, 2019). A structured interview schedule was constructed to collect information regarding availability of different facilities to the plantation workers.The data regarding availability of salary and service benefits, which includes leave with wages, PF, pension scheme, loan, advance payment, allowances, increment and on time availability of these benefits were collected from the sample respondents. Information on the availability of different facilities from company including housing facility, water, electricity, health facility, recreation facilities, different equipments and protective clothings were also collected. In addition to all these, satisfaction of labours towards the working time, working environment, type of work, wages they receive and finally on the company as a whole were also collected during the study. The majority of the respondents were women and workers engaged in plucking of tea leaves which is the major labour intensive work in tea plantations. The present study aims to identify different factors affecting the job satisfaction of tea plantation workers by using suitable statistical techniques. Exploratory factor analysis (EFA) used to recognize the factors underlying the observed variables. These factors are considered to be the construct in the structural equation modelling (SEM).The researcher must operationally describe the latent variable in terms of an observable variable in order to represent it as latent variables cannot be directly observed or measured. As a result, the measurement of the unobserved variable is made possible because it is connected to an observable variable (Byrne, 2016). SEM is based on the routes between theoretical constructs, which are represented by latent factors, and the latent constructs are measured by observed variables (Unal, 2021). SEM, in contrast to other statistical techniques, considers potential measurement errors and evaluates the model accordingly. This allows for the elimination of indicators with high error terms and/or low loadings and, as a result, enhances the quality of the model's constructs (Hair *et al.*, 2014).

## MATERIALS AND METHODS

The details of data sets used and the methodology adopted for the study are outlined under this section.

**Source of data:** The data regarding the availability of different working and living facilities provided by the company and the level of satisfaction towards job and different itemswere collected from 400 tea plantation labours. The respondents belonging to different plantation areas in Idukki and Wayanad districts of Kerala were interviewed in the survey. The data were obtained through a structured interview schedule method. A 5-point scale (1 indicating highly satisfied and 5 indicating highly dissatisfied) was employed to measure the job satisfaction level and the remaining variables were measured by a 2 point scale, where '1' indicated the presence of a factor and '2' indicated the absence of that factor.

### (a) Factor analysis

The factors are random variables that cannot be observed, counted or measured directly. Each variable is represented as a linear combination of underlying factors. Variables having low factor loading (generally less than 0.5) are excluded from further analysis.

### (b) Structural equation modelling (SEM)

SEM is a powerful, multivariate technique found increasingly in scientific investigations to test and evaluate multivariate causal relationships (Fan *et al.,* 2016). SEM can be considered a combination of factor analysis and regression methods which requires proper specification of a model to be estimated and tested.Structural equation modelling determines whether the data match a theoretical model or not (Gupta *et al*., 2022). A model is a statistical statement regarding the relationships between the variables.In the

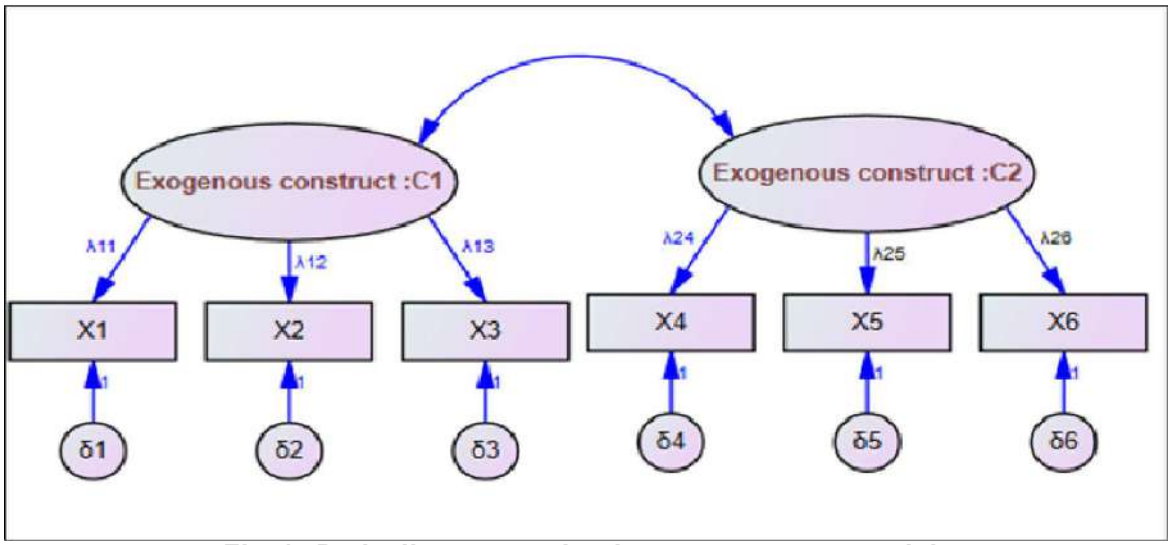



**Fig 1. Path diagram – simple measurement model**

current study the SEM technique has been used to identify different factors such as salary and service, company facility, satisfaction towards company etc. which have some impact on job satisfaction of labours.A path diagram is a graphical representation of a theory connecting measurable and potentially latent variables. It is useful for illustrating the conceptual connections between those components as well as for specifying the statistical model (Mueller and Hancock, 2019). The SEM can decompose into two parts, structural part and measurement part. The measurement part specifies the relationship of the latent to the observed variables and the structural part of a model specifies the relationships among the latent variables (Loehlin and Beaujean, 2017). SEM can assesses the assumed causation among a set of dependent and independent constructs and the loadings of observed items on their expected latent variables (Elangovan and Rajendran, 2015).The parameter in SEM indicates the nature and extend of the relationship between two variables under study. The study examines how each variable is associated with different factors andthe effect of these factors on job satisfaction.

$$\alpha = \left(\frac{k}{k-1}\right)\left(\frac{S_x^2 - \sum_{i=1}^{k} S_i^2}{S_x^2}\right)$$

**Defining constructs**

Defining constructs and the identification of associated indicator variables should be based on model. In this study, salary and service benefits provided, facilities provided by the company, satisfaction towards company and job satisfaction were taken as constructs. Related associated measurement variables are obtained through interviews. In addition to this exploratory factor analysis helps to identify the common factors and underlying measured variables. The measured variables having high factor loading were considered for further analysis.

**Reliability Analysis**

Cronbach's alpha analyzes the degree of internal consistency among variables within a construct. Scale reliability of qualitative variables is done using reliability test analysis. Cronbach's alpha is obtained by correlating the score for each scale item (observed variable) with the total score for each observation (usually individual survey respondents) andthen compare that to the variation for each item's score individually (Goforth, 2015). $\alpha$ coefficient value between 0.65 and 0.8 (or higher in many cases) is acceptable. Cronbach's alpha is obtained as where *k* is the number of scale items, $S^2_x$ is the variance associated with total

observed scores and $S^2_i$ is the variance associated with each scale item.

**Defining Measurement model**

It entails allocating the appropriate indicator variable to each construct and allows for the evaluation of construct validity. In SEM, it is assumed that the constructs are the cause of the observed variables, and as the constructs are not able to fully explain the observed variables, this results in errors.Therefore, the arrows are drawn from the constructs to the observed variables. Each observed variable in measurement model can be expressed as

$Xi = \lambda i\ F + e_i$ $X_i$ is the $i^{th}$ observed variable, $\lambda_i$ is the factor loading, $F$ is the factor and $e_i$ is the error term associated with $i^{th}$ observed variable.

Drawing arrows from each construct to the observed variables that represent that construct shows how the observed variables are assigned to each construct graphically. The constructs are believed to be correlated in the measurement model, and the loadings indicate how closely each measured variable is related to its common factor. A simple measurement model is given in Figure 1.

Since the construct is not observed, the scale of the construct should be set up to indicate the observed variables for each construct.This can be set either by fixing one of the factor loadings to one or by fixing the construct variance. In addition to Cronbach's alpha, composite reliability (CR) can also be used to measure the reliability of a construct. The construct reliability is measured as

$$CR = \frac{(\sum_{i=1}^{p} \lambda_i)^2}{(\sum_{i=1}^{p} \lambda_i)^2 + (\sum_{i=1}^{p} \delta_i)}$$

where CR indicates composite reliability, $\lambda$ indicates standardized factor loading, $\delta$ is the error variance and $p$ indicates number of observed variables. A CR value of 0.7 or higher is acceptable.

The convergent validity of a construct can be measured by Average Variance Extracted (AVE). AVE is the variance of the indicator variable that the construct can explain.The convergent validity of the construct is shown by an AVE score of 0.5 or above.

$$AVR = \frac{\sum_{i=1}^{p} \lambda_i^2}{\sum_{i=1}^{p} \lambda_i^2 + \sum_{i=1}^{p} \delta_i}$$

where $\lambda i$ the standardized factor loading, is the error variance and $p$ indicates number of observed variables.

The discriminant validity is obtained when each item is found to be strongly related with its own construct and weakly related with other constructs. To determine discriminant validity between two constructs, AVE should be greater than the squares of correlations between the constructs.

Assessing the validity of measurement

For each observed variable Xi we have,

$$Xi = \lambda i\ F + e_i$$

$X_i$ is the $i^{th}$ observed variable, $\lambda i$ is the factor loading, $F$ is the factor and $e_i$ is the error term associated with $i^{th}$ observed variable. Therefore,

$$Var(X_i) = Var(\lambda i\ F + e_i)$$

$$Var(X_i) = \lambda_i^2 + \sigma i$$

Where $\sigma i$ is the error variance. Similarly $Var\ (X_1, X_2) = \lambda_1 \lambda_2$ (when variables having same common factor)

$Var\ (X_1, X_2) = \lambda_1 \lambda_2 \sigma_{12}$ (when variables having different common factor,

$\sigma_{12}$ = covariance between F1 and F2

By this way, the researcher developed a co-variance matrix $\sum$ of the observed variables whose elements are functions of model parameters. This $\sum$ matrix is referred to as model implied variance covariance matrix. Each element in the covariance

matrix $\sum$ has a counterpart corresponding numerical value in the observed sample variance covariance matrix S based on observed variables. As the elements of $\sum$ are all functions of model parameters, equating model implied variance covariance matrix $\sum$ and sample variance covariance matrix S will provide the parameter estimates. Fitting structural equation modelling means solving these equations to get the parameter estimates. The goodness of fit measures how accurately the provided model reflects the variance covariance matrix of the measured data.The closer the two matrices, better the model is. Chi- square is a frequently used method to evaluate the fitness of model. It tests differences in the observed and expected covariance matrices.

$$\chi^2 = (n-1)(S - \sum)$$

For SEM the degrees of freedom (df) is obtained by

$$df = \frac{1}{2}[(p(p+1)] - k$$

where *p* indicates the number of observed variables and *k* indicates the number of estimated parameters. The chi-square value increases with sample size and number of indicator variables and thus introduces bias in the fit. Fitting of a model should be decided on the basis of fit indices. Important fit indices are given in Table 1(Hair *et al*., 2018).

**Specification of the structural model and assessing its validity**

Researcher proceeded to build the structural model once we obtain the validity for the measurement model. In structural model, emphasis is given to nature and magnitude of the relationships between the constructs. The measurement model is altered on the basis of the relationship between the constructs found inthe structural model. The fit indices will also change in the structural model and the model fitness can be assessed by the same indices as explained above.

## RESULTS AND DISCUSSION

### Exploratory factor analysis

Exploratory factor analysis of the data derived from the questionnaire helps identify a small number of factors underlying the observed variables. The Kaiser-Meyer-Olkin(KMO) is a measure of sampling adequacy which indicate the proportion of variance in the data that might be explained by the factors identified. KMO value above 0.70 is acceptable. In the present case,the Kaiser-Meyer-Olkin (KMO) value of 0.788 indicates the suitability of data for exploratory factor analysis. The significance of Bartlett's test also indicates the same with Chi-square value of 4198.68 with 91 degrees of freedom and *p* value less than 0.01 (Table 2).

The first two components of factor analysis accounted for 51.54% of the total variation (Table 3) and all these components have an *eigen value* greater than one. The observed variables with factor loading more than 0.5 in the first two components were selected for further analysis. Four constructs were identified on the basis of the rotated component matrix of factor analysis, which indicates the relevance of each variable to different factors under study. The rotated component matrix of selected variables are given in Table 4.

Corresponding to the four components obtained after rotation, four constructs such as service and salary benefits (S), Facilties from the company (C), satisfaction towards the company (J) and satisfaction toward work (W) and their associated indicator variable were identified. Fig. 2 shows the path diagram of identified construct and their indicator variables.

### Reliability analysis

Reliability and consistency of identified constructs were calculated by using Cronbach's alpha coefficient. The results showed that the constructs are reliable. Cronbach's alpha values for the constructs are presented (Table 5).

**Table1. Fit Indices and suggested values**

| S.No. | Fit indices | Suggested value |
|---|---|---|
| | 1 | 2 |
| 1 | Mean Chi square (CMIN) | ≤ 5 |
| 2 | Goodness of fit index (GFI) | ≥ 0.90 |
| 3 | Comparative fit index (CFI) | ≥ 0.90 |
| 4 | Normated fit index(NFI) | ≥ 0.90 |
| 5 | Root mean square error approximation (RMSEA) | ≤ 0.08 |

**Table 2. KMO and Bartlett's Test**

| S.No. | Statistics | | Observed value of the statistics |
|---|---|---|---|
| | 1 | | 2 |
| 1 | Kaiser-Meyer-Olkin Measure of Sampling Adequacy | | 0.788 |
| 2 | Bartlett's Test of Sphericity | Approx. Chi-Square | 4198.68 |
| | | Degrees of freedom | 91 |
| | | Significance | 0.00 |

**Table 3. Factor Analysis**

| S.No. | Components | Eigenvalue | Percentage of variance explained | Cumulative variance explained |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| 1 | 1 | 4.455 | 31.819 | 31.819 |
| 2 | 2 | 2.761 | 19.721 | 51.540 |

**Structural Equation Model: Model reliability and validity**

Composite reliability, convergent validity and discriminant validity measures of the obtained model are given in the Table 6. The Composite reliability (CR) for all constructs was found to be more than 0.7 indicating the high reliability of each construct. The AVE value above 0.50 showed that the observed variables converge on the same construct. The distinctiveness of constructs is shown by the higher square root value of AVE than that of corresponding correlations (Table 7).

**Structural equation modelling: Measurement model**

A four-factor measurement model was generated by allowing covariance relationships among above-mentioned constructs. The model is having a $\div^2$ value of 118.487 with 38 degrees of freedom. The CMIN, GFI, AGFI, NFI, CFI and RMSEA values are obtained as 3.118, 0.951, 0.916, 0.970, 0.980 and 0.073, respectively. The values of fitness measures indicated that the fitted model is acceptable. The results are given in Table 8.

**Table 4. Rotated component matrix (under varimax rotation)**

| S.No. | Items | Components | | | |
|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 |
| | 1 | 2 | 3 | 4 | 5 |
| 1 | Availability of Service benefits like leave with wages, PF etc( S1) | 0.949 | | | |
| 2 | Pension scheme (S2) | 0.941 | | | |
| 3 | Facilities like advance payment, loans and others (S3) | 0.939 | | | |
| 4 | Company facilities such as Housing facility, water, electricity, etc (C1) | | 0.911 | | |
| 5 | Company facilities like health and recreation (C2) | | 0.886 | | |
| 6 | Company facilities like protective clothing, types of equipment, etc (C3) | | 0.819 | | |
| 7 | Satisfaction towards Company (J1) | | | 0.854 | |
| 8 | Satisfaction toward working wages (J2) | | | 0.773 | |
| 9 | Satisfaction towards environment (J3) | | | 0.745 | |
| 10 | Satisfaction toward working time (W1) | | | | 0.873 |
| 11 | Satisfaction towards type of work (W2) | | | | 0.866 |

***Rotation method: Varimax rotation**

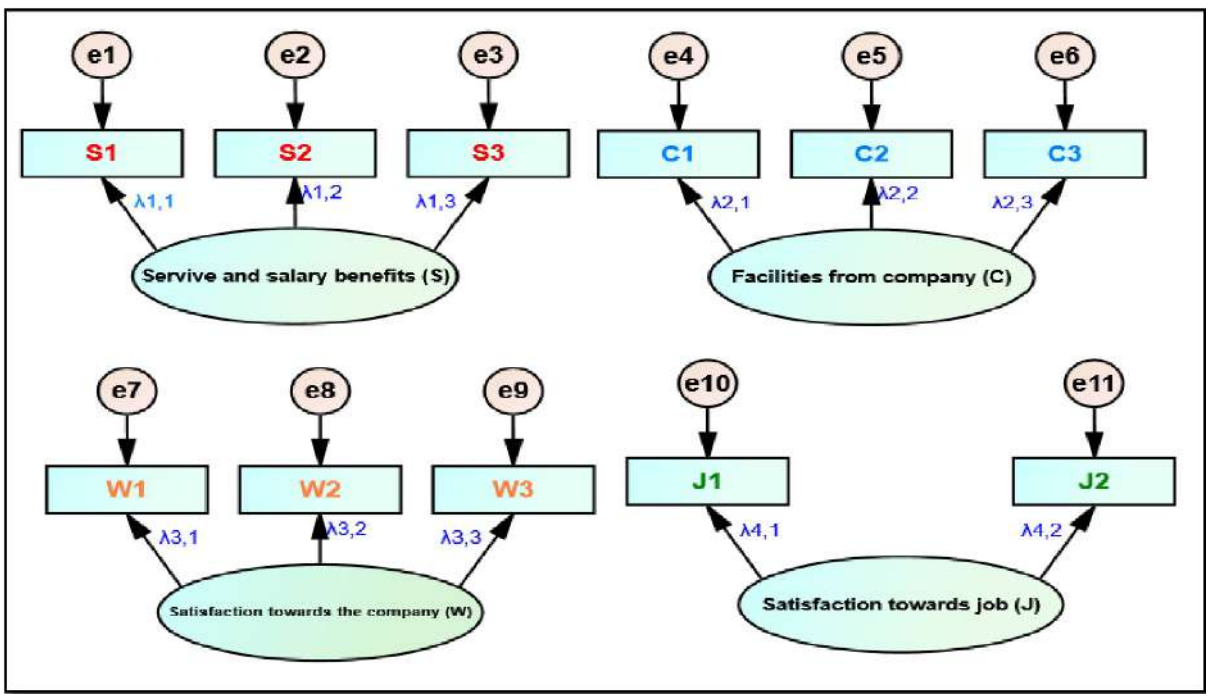



**Figure 2. Path diagram of constructs**

**Table 5. Cronbach's alpha value for constructs**

| S.No. | Constructs | Number of attributes contributing the factors | Cronbach's alpha values |
|---|---|---|---|
| | 1 | 2 | 3 |
| 1 | Service and salary benefits (S) | 3 | 0.982 |
| 2 | Faculties from the company (C) | 3 | 0.898 |
| 3 | Satisfaction toward the company (W) | 3 | 0.723 |
| 4 | Satisfaction toward work (J) | 2 | 0.735 |

**Table 6. Reliability and validity values for constructs**

| S. No. | Constructs | Composite Reliability (CR) | Average variance extracted (AVE) |
|---|---|---|---|
| | 1 | 2 | 3 |
| 1 | Salary and service benefits (S) | 0.983 | 0.949 |
| 2 | Facilities from the company (C) | 0.903 | 0.757 |
| 3 | Satisfaction toward the company (W) | 0.751 | 0.509 |
| 4 | Satisfaction toward the job (J) | 0.746 | 0.595 |

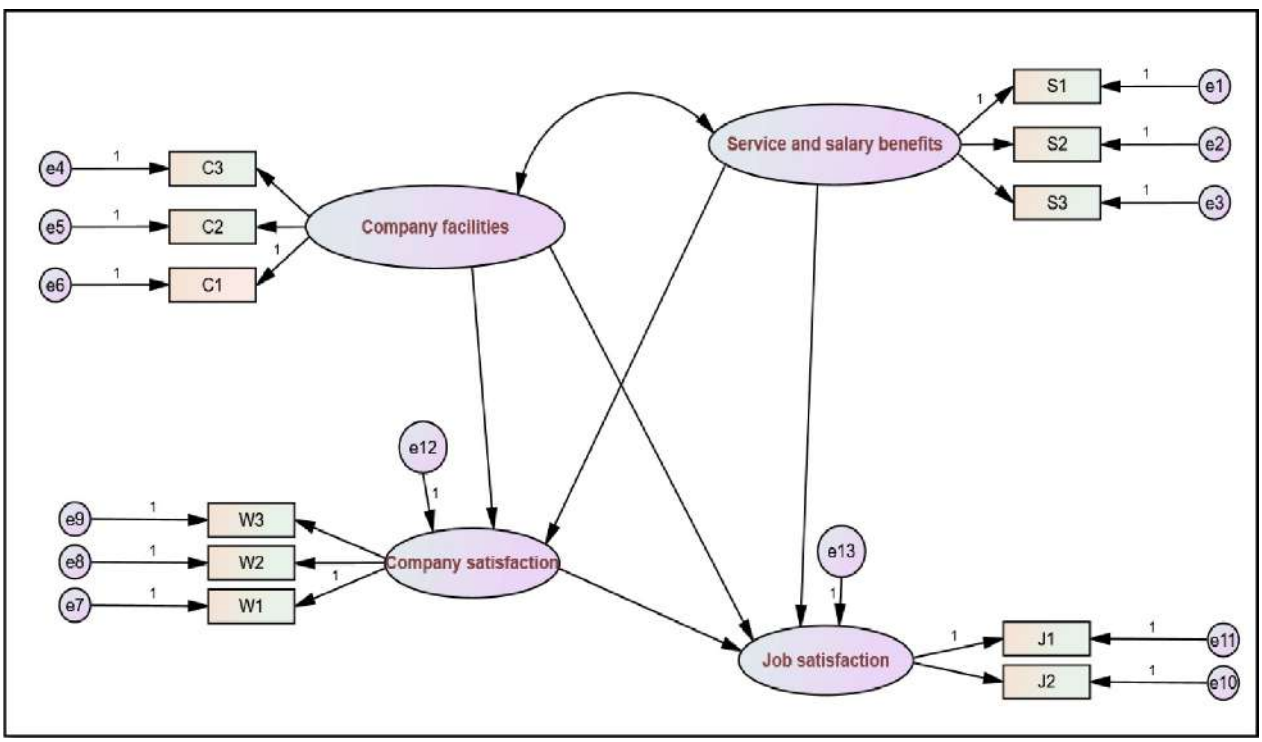



**Figure 3. Structural model- Job Satisfaction**

**Table 7. Correlation between constructs**

| S.No. | Constructs | Salary and service benefits (S) | Facilities from the company (C) | Satisfaction toward the company (W) | Satisfaction toward the job (J) |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 1 | Salary and service benefits (S) | **0.974** | | | |
| 2 | Facilities from the company (C) | 0.567*** | **0.870** | | |
| 3 | Satisfaction toward the company (W) | -0.016 | 0.233*** | **0.714** | |
| 4 | Satisfaction toward the job (J) | -0.091 | 0.013* | 0.479*** | **0.771** |

**Table 8. Regression estimates of items in Measurement model**

| S.No. | | Estimate | p |
|---|---|---|---|
| | 1 | 2 | 3 |
| 1 | S1<—Salary and service benefits | 1.000 | |
| 2 | S2<—Salary and service benefits | 0.996 | HS |
| 3 | S3<—Salary and service benefits | 0.930 | HS |
| 4 | C1<—Company facilities | 1.000 | |
| 5 | C2<—Company facilities | 1.154 | HS |
| 6 | C3<—Company facilities | 1.000 | HS |
| 7 | W1<—Company satisfaction | 1.000 | |
| 8 | W2<—Company satisfaction | 0.739 | HS |
| 9 | W3<—Company satisfaction | 0.594 | HS |
| 10 | J1<—Work satisfaction | 1.000 | |
| 11 | J2<—Work satisfaction | 1.107 | HS |

*HS- Highly significant

The regression estimate of Salary and service benefits on S1 was fixed at 1. This is done to setting the scale of construct. The regression estimate of salary and service benefits on S2 indicated that when service and salary benefits goes up by 1, S2 goes up by 0.996. Similarly , for others estimates also. The results showed that all the estimates are significant indicating significant effect of constructs on its observed variables.

**Structural equation modelling: Structural model**

The structural model has been developed as shown in the path diagram (Fig 3). The

**Table 9. Model fit indices**

| S. No. | Fit indices | Results |
|---|---|---|
| | 1 | 2 |
| 1 | CMIN | 3.118 |
| 2 | CFI | 0.980 |
| 3 | GFI | 0.951 |
| 4 | AGFI | 0.916 |
| 5 | NFI | 0.970 |
| 6 | RMSEA | 0.073 |

suggested model is found to fit well as the fit indices are within the satisfactory range. The model is having $\div^2$ value of 118.487 with 38 degrees of freedom. The CMIN value for the model is 3.118 which is less than the highest acceptable value 5. The fitness of the model was further indicated by GFI, AGFI, CFI, NFI and RMSEA values. All these fitness values lie in the acceptable region (Table 9).

As specified in the model, satisfaction toward the company (W) has a significant influence on the Job satisfaction of the plantation workers with a path estimate of 0.254 with *p* value less than 0.05. Which means that when satisfaction toward the company goes up by 1, Job satisfaction goes up by 0.254. Company facilities is also having significant positive relation to company satisfaction with a path estimate of 1. 354. When company facilities goes up by 1, satisfaction toward the company goes up by 1.354. Salary and service benefits was having negative relation with company satisfaction while salary and service benefits have a significant covariance with company facilities which in turn have a positive impact on job satisfaction with a path estimate of 0.054 (Table 10).

## CONCLUSIONS

The aim of this study was to identify the impact of different working and living conditions provided to the job satisfaction of plantation workers in tea estates.Exploratory factor analysis used to identify the four constructs (factors). SEM used for finding out the relationship between constructs and impact of different variables on job satisfaction. The magnitude and significance of loading estimates showthat the company facilities have a significant impact on company satisfaction and job satisfaction. It means that the satisfaction of labour towards company and job is influenced by the company's provision of facilities such housing, water, electricity, protective clothing, health care, and recreational activities has an impact on the job satisfaction of plantation workers.

**Table 10. Regression estimates of items**

| S.No. | Relation between constructs | Estimate | S.E. | C.R. | p |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| 1 | Company satisfaction<—Service and salary benefits | -0.544 | 0.168 | -3.240 | HS |
| 2 | Company satisfaction<—Company facilities | 1.354 | 0.271 | 4.994 | HS |
| 3 | Job satisfaction<—Company satisfaction | 0.254 | 0.040 | 6.351 | HS |
| 4 | Job satisfaction<—Company facilities | 0.133 | 0.155 | .857 | NS |
| 5 | Job satisfaction<—Service and salary benefits | -0.165 | 0.094 | -1.756 | NS |
| 6 | Company facilities <—> Service and salary benefits | 0.054 | 0.006 | 9.298 | HS |

*HS- Highly significant, NS- Not significant

## REFERENCES


Byrne, B.M. 2016. Structural equation modeling with AMOS: Basic concepts, applications, and programming. 3rd Edition. Routledge. New York. pp. 3-15. https://doi.org/10.4324/9781315757421

Elangovan, N and Rajendran, R. 2015. Structural equation modeling- A second-generation multivariate analysis. 3rd National Confernce on Indian Business Management. January 1, 2015. Coimbatore. Available at SSRN: https://ssrn.com/abstract=3515941

Fan, Y., Chen, J., Shirkey, G., John, R., Wu, S. R., Park, H and Shao, C. 2016. Applications of structural equation modeling (SEM) in ecological studies: an updated review. Ecological Processes. 5(19): 1-12.

Goforth, C. 2015. Using and interpreting Cronbach's alpha. Research Data Services + Sciences. Retrieved from the website (https://data.library.virginia.edu/using-and-interpreting-cronbachs-alpha) on 14.4.2023.

Gupta, R. K., Saha, A and Dhakre, D. S. 2022. Perception of tribal and non-tribal dairy farmers towards the dairy farming in Chhattisgarh state: structural equation modeling approach. The Journal of Research ANGRAU. 50(4): 100-115.

Hair, J. F., Gabriel, M. L. D. S and Patel, V. K. 2014. AMOS covariance-based structural equation modeling (CB-SEM): Guidelines on its application as a marketing research tool. Brazilian Journal of Marketing. 13(2): 44-55.

Hair, J., Black, W.C., Babin, B.J and Anderson, R.E. 2018. Multivariate data analysis. Cengage Learning. 8th Edition,United Kingdom. pp. 834.

Kumar, S. S. 2018. A study on the impact of current crisis in tea industry on the plantation workers in Kerala. Project report submitted to Kerala Institute of Labour and Employment, Tiruvanathapuram. pp.1-118.

Loehlin, J.C and Beaujean, A.A. 2017. Latent variable models: An introduction to factor, path, and structural equation analysis. 5th Edition. Routledge. New York. pp. 95-131. https://doi.org/10.4324/9781315643199

Muller, R. O and Hancock, G. R. 2018. Structural equation modeling. In: Hancock, G.R., Stapleton, L.M and Mueller, R.O. (Eds.). The reviewer's guide to quantitative methods in the social sciences. 2nd Edition. Routledge. New York. pp. 445-456. https://doi.org/10.4324/9781315755649

Priyadarshan, S. 2019. Workers satisfaction on the facilities provided by the plantation companies- with special reference to Kerala state. Journal of Management. 6(3):157-178.

UmutUnal. 2021. Structural equation modeling as a marketing research tool: A guideline for SEM users about critical issues and problematic practices. Journal of Statistics and Applied Science. 2(2): 65-77.


Chandran, A.V., Dhakre, D.S., Bhattacharya, D and Sarkar, K.A. 2023. Analysis of job satisfaction of tea plantation workers of Kerala using structural equation modelling approach. The Journal of Research ANGRAU. 51(3): 136-146.
DoI: https://doi.org/10.58537/jorangrau.2023.51.3.16

DoI: https://doi.org/10.58537/jorangrau.2023.51.3.17

J. Res. ANGRAU 51 (3) 147-157, 2023

# COMPARATIVE ANALYSIS OF THE ROLE OF MAIZE FARMING AND AGRICULTURAL MARKET REFORMS IN RAISING FARMERS' INCOME IN INDIA

**RAVI KUMAR* and PUSHPA M. SAVADATTI**

Department of Economic Studies and Planning, School of Business Studies,
Central University of Karnataka (CUK), Kalaburagi- 585 367

Date of Receipt : 27.4.2023 Date of Acceptance :04.7.2023

## ABSTRACT

The study aimed to investigate the compound annual growth rate (CAGR) of area, production, and yield of rice, wheat, and maize in India from 1950-51 to 2019-20, divided into four periods based on the vital year of the Indian economy from an agricultural perspective. It revealed that the CAGR of maize productionwas highest than rice and wheat before the green revolution *i.e.* 6.39 %. Still, this trend has completely reversed after adopting the green revolution, as it mainly focused on wheat and rice production. The study also reported that maize output in India had an unprecedented increase following the economic reforms of 1991 due to the adoption of single cross hybrids and ongoing demand in the domestic and export markets. Its annual growth rate is higher than that of rice and wheat.Due to its numerous uses as food and feed, its demand increased significantly in the twenty-first century.Additionally, the agricultural market reforms brought about by the APMC act of 2003, the model APMC act of 2007, and e-NAM (Electronic National Agricultural Marketing) in 2016 encouraged farmers to cultivate more maize. Also, from 2010-11 to 2020-21, the annual growth rate in MSP (Minimum Support Price) of maize is the highest than rice and wheat *i.e.*7%. The study noticed that, although not by 2022, maize production can soon assist farmers in increasing their income and achieving the government-set goal of doubling their income.

**Keywords:** APMC, CAGR, e-NAM, Economic reforms, Green Revolution, MSP

## INTRODUCTION

India's economy is primarily based on agriculture. Agriculture continues to be the primary source of income for most Indian families, accounting for about half of the country's workforce**.** Despite being the most significant sector, it is plagued by numerous issues. Farmers' condition is pathetic as their income has declined drastically since the independence, which is less than non-farm activities(Tripathi and Prasad, 2009)**.**

Unfavorable market conditions, lack of supply chain integration, and weak marketing channels influence farmers' income levels. Farmers commit suicide because the situation is worse than ever(Sandhu and Kaur, 2020).In the wake of these problems farmers face, the Prime Minister of India announced doubling farmers' income by 2022 on February 28, 2016. Hence, to achieve this target,Maize cultivationcan play a vital role because it is the second most important cereal crop globally and India's third most important crop

*Corresponding Author E-mail i.d: ravikumar1996pcp@gmail.com; Ph.D thesis submitted to Central University of Karnataka (CUK), Kalaburagi - 585 367

after rice and wheat in terms of acreage**.** In most states, it is grown all year long for various products, including grain, feed, fodder, green cobs, sweet corn, baby corn, popcorn, and industrial goods(Birhanu and Sekhar. 2016)**.** Its production's compound annual growth rate (CAGR) is higher than rice and wheat, especially after the economic reform of 1991 and the implementation of the APMC act of 2003(Researcher's analysis).

Presently, huge areas of once-arable land have changed to problem soils that are now physically and chemically acidic, alkaline, and saline. A major production-related constraint is the lack of water. Climatic conditions force the farmer to take coping and adaptation measures, yet after doing so, the markets do not reward him with remunerative returns on his produce (Rachappanavar Yashwant Singh Parmar, 2020). Maize requires less water for production, can give a higher yield in a shorter period, and is insensitive to changing climate scenarios; it is a viable choice for diversifying agriculture in India's upland areas. Also, it has various use, from food to feed. It has the potential for establishing agro-based industries, which will increase farmers' income by getting a reasonable price for their products and boost the economy.

In 2020, the total maize production in the world was 1.2 billionmetric tons (BMT). The leading producer was the USA producing 31.52% of the global output, followed by China, Brazil, Argentina, and Ukraine, accounting for 71% of the worldwide maize production. India is the world's sixth-largest maize producer, accounting for 2.71% of the global output(Statista.com).

It is produced almost everywhere in the nation and has various ecological adaptations(Yadav *et al.*,2016).However, according to the Economic Survey 2020-21, three Indian states,*i.e.,* Karnataka (16.45%), Madhya Pradesh (11.37%), and Maharashtra (10.91%), produce around 38% of the nation's total maize. Maize Vision 2022 is also announced by FICCI for double the maize production in India to fulfill the growing demand.

There are strategies to promote maize cultivation by encouraging rabi maize farming and using single cross hybrids (SCH). Also,the strategiessuch as public-private partnership, Value-added/specialty corn, and post-harvest management to cut down on waste, promoting maize drier usage. And most importantly, harnessing India's export potential because India is considerably closer to the major importing nations like Japan, Korea, and China than to the USA, Brazil, and Argentina (top exporting countries) (Malhotra, 2017).

The APMC Act of 2003, the APMC Model Act of 2007, the e-NAM (Electronic National Agriculture Market) in 2016, and the three new farm laws that the central government enacted in September 2020 are examples of agricultural marketing reforms were implemented, particularly after the year 2000. These laws will ensure that farmers receive fair and remunerative prices without distortion.However,the new farm laws wereofficially repealed on December 01, 2021, after seven months of framer's protests. Therefore,the e-NAM can potentially increase the farm's income as it operates as a uniform electronic market place for farmers to sell their goods to consumers everywhere in the nation, where the role of intermediariesis minimized(Reddy, 2018).Though now, infrastructure, institutions, and information, collectively known as the 3 I's, are the main hurdles in adopting e-NAM(Bisen and Kumar, 2018).So, the government should focus more on e-NAM and make it accessible to all the country's farmers to achieve a doubling of farmers' income in India.

## MATERIALS AND METHODS

The study is based on the time series data of the area, production, and yield of rice, wheat, and maize crop from 1951-52 to 2019-20. The researchers broadly divide the entire period into four: (1) the pre-green revolution period from 1950-

51 to 1964-65, (2) the post-green revolution period to pre-reform period from 1965-66 to 1990-91, (3)the post-reform to pre-APMC Law period from 1991-92 to 2002-03, (4) post-APMC Law period, i.e., from 2003-04 to 2019-20, and (5) Entire period, *i.e.* from 1950-51 to 2019-20.

The data for the study was compiled from secondary sources, such as various reports from the Government of India. The data related to the area, production, and yield of principal crops was collected from the Directorate of Economics & Statistics, DAC&FW, 4th Advance Estimates, and the data related to MSP (Minimum Support Price) is compiled from the Dept. of Agriculture & Cooperation and Farmers Welfare, GOI, New Delhi.

For the analysis, the CAGR (Compound Annual Growth Rate) was calculated for all the years, *i.e.,*the pre-green revolution period, post-green revolution period to reform period, post-reform period to pre-APMC period, and post-APMC period.

The below equation was used to calculate the growth rate:

**logYt = a+bt**

Where,

Y =acreage/production/productivity ofRice/ Wheat/Maize

a = constant

b = expresses the rate of change, and when multiplyingby 100, gives the percentage growth rate

t = time variable in year (1, 2……n)

The formula gives the growth rate.

r = antilog (b^ – 1).100

Where b^ = estimated value of b.

## RESULTS AND DISCUSSION

Trends in India's area, production, and productivity growth rates for rice, wheat, and maize from 1950–1951 to 2019–20:

### Pre-green revolution period from 1950-51 to 1964-65

Throughout this period, the area, production, and yield of rice, wheat, and maize increased significantly. For rice, the area increased from 30.81 to 36.46 million hectares, production increased from 20.58 to 39.31 million tonnes, and the yield raised from 668 to 1078 kg $ha^{-1}$.Similarly, for wheat, area, production, and yield rose from 9.75 to 13.42 million hectares, 6.46 to 12.26 million tonnes, and 663 to 913 kg $ha^{-1}$, respectively, and for Maize, it is 3.16 to 4.62 million hectares, 1.73 to 4.66 million tonnes, and 547 to 1010 kg $ha^{-1}$.

In terms of growth rate, the CAGR for maize, wheat, and rice is shown in Table 1. The annual growth rates for the area, production, and yield for rice were 1.45 percent, 4.35 percent, and 2.38 percent, respectively. It was 2.27 percent, 5.82 percent, and 1.53 percent annually for wheat, and 2.68 percent, 6.39 percent, and 3.62 percent annually for maize. Even though the annual growth rate of maize output was the highest, followed by rice and wheat, this indicates that productivity and area are equally responsible for the increase in rice, wheat, and maize production.

Eventhough the area, production, and yield of rice, wheat, and maize considerably expanded during this time, India could not produce enough crops to feed its growing population. Indian agriculture was not heavily automated, and traditional farming practices were widely used. Because maize needed less water and could even be grown in highland and arid places, rice and wheat production rates were lower than maize. India imported vital cereals from other nations to feed its population during this time. As a result, the government at the time considered bringing the green revolution to India.

### Post-green revolution period from 1965-66 to 1990-91

It is known that the green revolution focused on wheat and rice production. The following initiatives were part of the "green revolution": (1)

**Table 1. Significant growth rate identified for area, production, and yield of rice, wheat, and maize**

| S.No. | Period | RICE | | | WHEAT | | | MAIZE | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Area (million hectares) | Production (million tonnes) | Yield (kg $ha^{-1}$) | Area (million hectares) | Production (million tonnes) | Yield (kg $ha^{-1}$) | Area (million hectares) | Production (million tonnes) | Yield (kg $ha^{-1}$) |
| 1. | 1950-51 to 1964-65 | 1.45 | 4.35 | 2.85 | 2.69 | 4.26 | 1.53 | 2.68 | 6.39 | 3.62 |
| 2. | 1965-66 to 1990-91 | 0.63 | 3.03 | 2.38 | 2.27 | 5.82 | 3.46 | 0.31 | 1.76 | 1.44 |
| 3. | 1991-92 to 2002-03 | 0.32 | 1.12 | 0.79 | 0.81 | 2.18 | 1.35 | 1.15 | 3.34 | 2.01 |
| 4. | 2003-04 to 2019-20 | 0.14 | 1.89 | 1.75 | 1.012 | 2.69 | 1.66 | 1.67 | 4.68 | 2.96 |
| 5. | 1950-51to 2019-20 | 0.52 | 2.41 | 1.87 | 1.62 | 4.24 | 2.58 | 1.26 | 3.33 | 2.04 |

**Source:** Authors' calculation based on the data collected from the Directorate of Economics and Statistics, DAC&FW* 4th Advance Estimates

the program for high-yielding varieties, (2) the program for multiple crops, (3) the program for integrated development of dry areas, (4) the program for plant protection (5) the increased use of fertilizers and (6) the program for new irrigation techniques (Tripathi and Prasad, 2009).

During this period, the production of rice and wheat increased more than the production of maize as the green revolutionwas more focused on these two crops. The area, production, and yield of rice increased from 35.47 to 42.69 million hectares, 30.59 to 74.29 million tonnes, and 862 to 1740 kg $ha^{-1}$, respectively. Similarly, wheat area increased from 12.57 to 24.17 million hectares, 10.40 to 55.14 million tonnes, and 827 to 2281 kg $ha^{-1,}$ respectively, and maize increased from 4.80 to 5.90 million hectares, 4.82 to 8.96 million tonnes, and 1005 to 1518 kg $ha^{-1}$, respectively.

In India, the CAGRs for the area, production, and productivity of rice during this period were 0.63 percent, 3.03 percent, and 0.79 percent annually, respectively. It was 2.27 percent, 5.82 percent, and 3.46 percent annually, respectively, for wheat, while it was 0.31 percent, 1.76 percent, and 1.44 percent annually for maize. It implies that area and productivity are equally accountable for the raise in wheat production. The production of wheat and rice has the most significant annual growth rate, whereas, maize has the lowest, despite having the highest output before the green revolution (Table 1). Also, it happened because of the focus on wheat and rice rather than maize. The agricultural output in India grew due to the Green Revolution, particularly in Haryana, Punjab, and Uttar Pradesh. Significant accomplishments in this research included the development of rust-resistant wheat strains and a high-yielding wheat seed varieties.

**The post-reform period from 1991-92 to 2002-03**

India, one of the biggest economies with an agricultural base, was not given priority until the early 1990s. A typical critique of India's economic

reforms is that they have prioritized industrial and trade policy while ignoring agriculture, which supports 60% of the country's population. Deregulation, less government involvement in economic activity, and liberalization were all components of the economic reform process. Despite the absence of direct reforms, the devaluation of the currency, the liberalization of international trade, and the deregulation of the industrial sector all indirectly impacted the agriculture sector. Another development that affected agriculture during this time was the opening up of the home market as a result of the WTO and new foreign trade agreements (Tripathi and Prasad, 2009).

During the last decade of the 20$^{th}$ century, India undertook significant economic changes that increased the amount of excess wheat and rice that the nation had on hand. However, this resulted in the degradation of both water and soil resources. The dramatic drop in the price of these two key grains on a global scale forced the agricultural community to diversify agriculture partially. Because of this, maize production became much more significant, and its CAGR exceeded that of rice and wheat.

During this period, rice's area, production, and yield changed from 42.65 to 42.59 mha, 74.68 to 71.82 million tonnes, and 1751 to 1744 kg ha$^{-1}$, respectively. It means in the actual term, the area, production, and yield for rice decreased. In case of wheat, it increased from 23.26 to 25.32 mha, 55.69 to 65.76 million tonnes, and 2394 to 2610 kg ha$^{-1}$, respectively, and for maize, it increased from 5.86 to 6.64 mha, 8.06 to 11.15 million tonnes, and 1376 to 1681 kg ha$^{-1}$, respectively.

It can be noted from Table 1 that the CAGR of area, production, and productivity of rice in India were 0.32 percent, 1.12 percent, and 2.38 percent per annum, respectively. For wheat, it was 0.81 percent, 2.18 percent, and 1.35 percent per annum, respectively, and similarly, for maize, it was 1.15 percent, 3.34 percent, and 2.01 percent per annum, respectively. It indicated how the growth rates of maize substantially outpaced those of wheat and rice. This took place as a result of India's market becoming more integrated with the world market due to the LPG reform in 1991 and the establishment of the WTO in 1995, which led to lower prices for import-accessible grains like rice and wheat in other nations.

Government of India has implemented many agrarian marketing reforms since the LPG (Liberalization, Privatization, and Globalization) reforms of 1991, which were biased and unfavorable to the agricultural sector because agriculture is a state subject according to the Indian constitution (Chand and Singh, 2016).

**Post- APMC period (2003-04 to 2019-20)**

The union government made its first attempt at agricultural market reforms in 2003 by creating a model Agricultural Produce Marketing Committee (APMC) Act. This legislation legalized new distribution channels for goods and services, including direct sales, private wholesale markets, and contract farming (CF)(Singh, 2018). State governments established the Agricultural Produce Market Committee (APMC) as a marketing body to prevent farmers from being taken advantage of by intermediaries and forced to sell their produce at exorbitant prices.

During this period, the area, production, and yield of rice increased from 42.59 to 43.78 million hectares, 88.53 to 118.43 million tonnes, and 2079 to 2705 kg ha$^{-1}$, respectively. Similarly, wheat raised from 26.59 to 31.45 million hectares, 72.16 to 107.59 million tonnes, and 2713 to 3421 kg ha$^{-1}$; In case of maize, it was 7.34 to 9.72 million hectares, 14.98 to 28.64 million tonnes, and 2041 to 2945 kg ha$^{-1}$, respectively.

Table 1 demonstrates that India's annual CAGRs for rice area, production, and productivity were 0.14 percent, 1.89 percent, and 1.75 percent annually, respectively. It was 1.012 percent, 2.69 percent, and 1.76 percent annually for wheat, while

it was 1.67 percent, 4.8 percent, and 2.96 percent, respectively, for maize.It showed that maize output is increasing more significantly than rice and wheat, primarily due to rising yields rather than an increase in area.

**Entire Period (1950-51 to 2019-20)**

Agricultural growth is one of the primary drivers of India's economic development and national food sufficiency policy. In India, maize has registered an increase in area and production since its independence. Its production has increased more than 15 times from a mere 1.73 million tons in 1950-51 to 28.64 million tons in 2019-20 ($4^{th}$ advance estimate), which is more than the increase in rice and equal to the wheat production through the green revolution was focused on these two crops. During this long period, the area, production, and yield for rice increased from 30.81 to 43.78 million hectares, 20.58 to 118.43 million tonnes, and 668 to 2705 kg $ha^{-1}$, respectively. Similarly, wheat area has risen from 9.75 to 31.45 million hectares, 6.46 to 107.59 million tonnes, and 663 to 3421 kg $ha^{-1}$, respectively;In case ofmaize, it increased from 3.16 to 9.72 million hectares, 1.73 to 28.64 million tonnes, and 547 to 2945 kg $ha^{-1}$, respectively.

Table 1 shows that over this time, the CAGR for rice's area, production, and productivity in India was 0.52 percent, 2.41 percent, and 1.87 percent annually, respectively. For wheat, it was 1.62 percent, 4.24 percent, and 2.58 percent annually, while for maize, it was 1.26 percent, 3.33 percent, and 2.04 percent, respectively. It suggested that for the entire era, the growth rate of wheat's area, production, and productivity was at its highest, primarily due to the green revolution's implementation in the 1960s. But maize's growth rate is the highest during three out of the four periods, *i.e.* before the green revolution, after the reform, and after the APMC.

Notably, after the 1991 LPG reforms, its output and yield have significantly increased, and its MSP (Minimum Support Price) has recently risen more than rice and wheat (Author's analysis). The MSP for rice rose from 1000 to 1940, wheat from 1120 to 2015, and maize from 800 to 1870 from 2010 to 11 to 2020 to 21. Even though maize has a lower MSP than rice and wheat, it is more relevant and profitable to grow maize than rice and wheat because of its lower production costs, fertility of land aspects, and favorable environmental conditions.

The Indian government is now moving on the right path by seeking all APMCs to be on the national board. Still, the farmers-producers would only see a doubled income when merchants and purchasers from other states engage in online trading on e-NAM platforms(Meena *et al*., 2019).So, agricultural marketing reform, *i.e.* e-NAM, can be a game changer for the farmers as it ensures a uniform market and reasonable prices.

**CONCLUSIONS**

The study was undertaken to analyze the CAGR of area, production, and productivity of rice, wheat, and maize in different periods. It is noticed that maize production, yield, and area had all significantly increased since India's independence. Area and yield effects contributed to the increase in maize production, but the latter was more responsible. However, despite this significant rise in production, its productivity is still much lower than that of the top maize-producer countries(Sharma and Mehta, 2012).

Out of the four-time periods, the annual growth rate in maize production is higherin three periods than in rice and wheat*i.e.* during the pre-green revolution, post-reform, and post-APMC period. The annual growth rate in wheat production was higher than rice and maize during the green revolution to the pre-reform period. The annual growth rate in the area and yield of maize are highest for three periods out of four too.However, due to a lack of effective implementation of previous agricultural marketing reforms, farmers' situations

**Table 2. Area, Production, and Yield of Rice, Wheat, and Maize in India**

| | | RICE | | | WHEAT | | | MAIZE | | |
|---|---|---|---|---|---|---|---|---|---|---|
| S.No. | Period | Area (million ha) | Production (million tonnes) | Yield (kg $ha^{-1}$) | Area (in million hectare) | Production (million tonnes) | Yield (kg $ha^{-1}$) | Area (million ha) | Production (million tonnes) | Yield (kg $ha^{-1}$) |
| 1. | 1950-51 | 30.81 | 20.58 | 668 | 9.75 | 6.46 | 663 | 3.16 | 1.73 | 547 |
| 2. | 1951-52 | 29.83 | 21.30 | 714 | 9.47 | 6.18 | 653 | 3.31 | 2.08 | 627 |
| 3. | 1952-53 | 29.97 | 22.90 | 764 | 9.83 | 7.50 | 763 | 3.61 | 2.87 | 796 |
| 4. | 1953-54 | 31.29 | 28.21 | 902 | 10.68 | 8.02 | 750 | 3.87 | 3.04 | 785 |
| 5. | 1954-55 | 30.77 | 25.22 | 820 | 11.26 | 9.04 | 803 | 3.75 | 2.98 | 794 |
| 6. | 1955-56 | 31.52 | 27.56 | 874 | 12.37 | 8.76 | 708 | 3.70 | 2.60 | 704 |
| 7. | 1956-57 | 32.28 | 29.04 | 900 | 13.52 | 9.40 | 695 | 3.76 | 3.08 | 819 |
| 8. | 1957-58 | 32.30 | 25.53 | 790 | 11.73 | 7.99 | 682 | 4.08 | 3.15 | 772 |
| 9. | 1958-59 | 33.17 | 30.85 | 930 | 12.62 | 9.96 | 789 | 4.27 | 3.46 | 812 |
| 10. | 1959-60 | 33.82 | 31.68 | 937 | 13.38 | 10.32 | 772 | 4.34 | 4.07 | 938 |
| 11. | 1960-61 | 34.13 | 34.58 | 1013 | 12.93 | 11.00 | 851 | 4.41 | 4.08 | 926 |
| 12 | 1961-62 | 34.69 | 35.66 | 1028 | 13.57 | 12.07 | 890 | 4.51 | 4.31 | 957 |
| 13 | 1962-63 | 35.69 | 33.21 | 931 | 13.59 | 10.78 | 793 | 4.64 | 4.61 | 992 |
| 14 | 1963-64 | 35.81 | 37 | 1033 | 13.5 | 9.85 | 730 | 4.58 | 4.56 | 995 |
| 15 | 1964-65 | 36.46 | 39.31 | 1078 | 13.42 | 12.26 | 913 | 4.62 | 4.66 | 1010 |
| 16 | 1965-66 | 35.47 | 30.59 | 862 | 12.57 | 10.4 | 827 | 4.8 | 4.82 | 1005 |
| 17 | 1966-67 | 35.25 | 30.44 | 864 | 12.84 | 11.39 | 887 | 5.07 | 4.89 | 964 |
| 18 | 1967-68 | 36.44 | 37.61 | 1032 | 14.99 | 16.54 | 1103 | 5.58 | 6.27 | 1123 |
| 19 | 1968-69 | 36.97 | 39.76 | 1075 | 15.96 | 18.65 | 1169 | 5.72 | 5.7 | 997 |
| 20 | 1969-70 | 37.68 | 40.43 | 1073 | 16.63 | 20.09 | 1208 | 5.86 | 5.67 | 968 |
| 21 | 1970-71 | 37.59 | 42.22 | 1123 | 18.24 | 23.83 | 1307 | 5.85 | 7.49 | 1279 |
| 22 | 1971-72 | 37.76 | 43.07 | 1141 | 19.14 | 26.41 | 1380 | 5.67 | 5.1 | 900 |
| 23 | 1972-73 | 36.69 | 39.24 | 1070 | 19.46 | 24.74 | 1271 | 5.84 | 6.39 | 1094 |
| 24 | 1973-74 | 38.29 | 44.05 | 1150 | 18.58 | 21.78 | 1172 | 6.02 | 5.8 | 965 |
| 25 | 1974-75 | 37.89 | 39.58 | 1045 | 18.01 | 24.1 | 1338 | 5.86 | 5.56 | 948 |
| 26 | 1975-76 | 39.48 | 48.74 | 1235 | 20.45 | 28.84 | 1410 | 6.03 | 7.26 | 1203 |
| 27 | 1976-77 | 38.51 | 41.92 | 1089 | 20.92 | 29.01 | 1387 | 6 | 6.36 | 1060 |
| 28 | 1977-78 | 40.28 | 52.67 | 1308 | 21.46 | 31.75 | 1480 | 5.68 | 5.97 | 1051 |
| 29 | 1978-79 | 40.28 | 53.77 | 1328 | 22.64 | 35.51 | 1568 | 5.76 | 6.2 | 1076 |

*Table 2 contd...*

*Table 2 contd...*

| | | RICE | | | WHEAT | | | MAIZE | | |
|---|---|---|---|---|---|---|---|---|---|---|
| S.No. | Period | Area (in million hectare) | Production (in million tonnes) | Yield (in kg $ha^{-1}$) | Area (in million hectare) | Production (million tonnes) | Yield (kg $ha^{-1}$) | Area (million hectares) | Production (million tonnes) | Yield (kg $ha^{-1}$) |
| 30 | 1979-80 | 39.42 | 42.33 | 1074 | 22.17 | 31.83 | 1436 | 5.72 | 5.6 | 979 |
| 31 | 1980-81 | 40.15 | 53.63 | 1336 | 22.28 | 36.31 | 1630 | 6.01 | 6.96 | 1159 |
| 32 | 1981-82 | 40.71 | 53.25 | 1308 | 22.14 | 37.45 | 1691 | 5.94 | 6.9 | 1162 |
| 33 | 1982-83 | 38.26 | 47.12 | 1232 | 23.57 | 42.79 | 1816 | 5.72 | 6.55 | 1145 |
| 34 | 1983-84 | 41.24 | 60.1 | 1457 | 24.67 | 45.48 | 1843 | 5.86 | 7.92 | 1352 |
| 35 | 1984-85 | 41.16 | 58.34 | 1417 | 23.56 | 44.07 | 1870 | 5.8 | 8.44 | 1456 |
| 36 | 1985-86 | 41.14 | 63.83 | 1552 | 23 | 47.05 | 2046 | 5.8 | 6.64 | 1146 |
| 37 | 1986-87 | 41.17 | 60.56 | 1471 | 23.13 | 44.32 | 1916 | 5.92 | 7.59 | 1282 |
| 38 | 1987-88 | 38.81 | 56.86 | 1465 | 23.06 | 46.17 | 2002 | 5.56 | 5.72 | 1029 |
| 39 | 1988-89 | 41.73 | 70.49 | 1689 | 24.11 | 54.11 | 2244 | 5.9 | 8.23 | 1395 |
| 40 | 1989-90 | 42.17 | 73.57 | 1745 | 23.5 | 49.85 | 2121 | 5.92 | 9.65 | 1632 |
| 41 | 1990-91 | 42.69 | 74.29 | 1740 | 24.17 | 55.14 | 2281 | 5.9 | 8.96 | 1518 |
| 42 | 1991-92 | 42.65 | 74.68 | 1751 | 23.26 | 55.69 | 2394 | 5.86 | 8.06 | 1376 |
| 43 | 1992-93 | 41.78 | 72.86 | 1744 | 24.59 | 57.21 | 2327 | 5.96 | 9.99 | 1676 |
| 44 | 1993-94 | 42.54 | 80.3 | 1888 | 25.15 | 59.84 | 2380 | 6 | 9.6 | 1602 |
| 45 | 1994-95 | 42.81 | 81.81 | 1911 | 25.7 | 65.77 | 2559 | 6.14 | 8.88 | 1570 |
| 46 | 1995-96 | 42.84 | 76.98 | 1797 | 25.01 | 62.1 | 2483 | 5.98 | 9.53 | 1595 |
| 47 | 1996-97 | 43.43 | 81.73 | 1882 | 25.89 | 69.35 | 2679 | 6.26 | 10.77 | 1720 |
| 48 | 1997-98 | 43.45 | 82.54 | 1900 | 26.7 | 66.35 | 2485 | 6.32 | 10.82 | 1711 |
| 49 | 1998-99 | 44.8 | 86.08 | 1921 | 27.52 | 71.29 | 2590 | 6.2 | 11.15 | 1797 |
| 50 | 1999-00 | 45.16 | 89.68 | 1986 | 27.49 | 76.37 | 2778 | 6.42 | 11.51 | 1792 |
| 51 | 2000-01 | 44.71 | 84.98 | 1901 | 25.73 | 69.68 | 2708 | 6.61 | 12.04 | 1822 |
| 52 | 2001-02 | 44.9 | 93.34 | 2079 | 26.34 | 72.77 | 2762 | 6.58 | 13.16 | 2000 |
| 53 | 2002-03 | 41.18 | 71.82 | 1744 | 25.32 | 65.76 | 2610 | 6.64 | 11.15 | 1681 |
| 54 | 2003-04 | 42.59 | 88.53 | 2079 | 26.59 | 72.16 | 2713 | 7.34 | 14.98 | 2041 |
| 55 | 2004-05 | 41.91 | 83.13 | 1984 | 26.38 | 68.64 | 2602 | 7.43 | 14.17 | 1907 |
| 56 | 2005-06 | 43.66 | 91.79 | 2102 | 26.48 | 69.35 | 2619 | 7.59 | 14.71 | 1938 |
| 57 | 2006-07 | 43.81 | 93.36 | 2131 | 27.99 | 75.81 | 2708 | 7.89 | 15.1 | 1912 |
| 58 | 2007-08 | 43.91 | 96.69 | 2202 | 28.04 | 78.57 | 2802 | 8.12 | 18.96 | 2335 |

*Table 2 contd...*

| | | RICE | | | WHEAT | | | MAIZE | | |
|---|---|---|---|---|---|---|---|---|---|---|
| S.No. | Period | Area (million ha) | Production (million tonnes) | Yield (kg $ha^{-1}$) | Area (million ha) | Production (million tonnes) | Yield (kg $ha^{-1}$) | Area (million ha) | Production (million tonnes) | Yield (kg $ha^{-1}$) |
| 59 | 2008-09 | 45.54 | 99.18 | 2178 | 27.75 | 80.68 | 2907 | 8.17 | 19.73 | 2414 |
| 60 | 2009-10 | 41.92 | 89.09 | 2125 | 28.46 | 80.8 | 2839 | 8.26 | 16.72 | 2024 |
| 61 | 2010-11 | 42.86 | 95.98 | 2239 | 29.07 | 86.87 | 2988 | 8.55 | 21.73 | 2542 |
| 62 | 2011-12 | 44.01 | 105.3 | 2393 | 29.86 | 94.88 | 3177 | 8.78 | 21.76 | 2478 |
| 63 | 2012-13 | 42.75 | 105.23 | 2461 | 30 | 93.51 | 3117 | 8.67 | 22.26 | 2566 |
| 64 | 2013-14 | 44.14 | 106.65 | 2416 | 30.47 | 95.85 | 3146 | 9.07 | 24.26 | 2676 |
| 65 | 2014-15 | 44.11 | 105.48 | 2391 | 31.47 | 86.53 | 2750 | 9.19 | 24.17 | 2632 |
| 66 | 2015-16 | 43.5 | 104.41 | 2400 | 30.42 | 92.29 | 3034 | 8.81 | 22.57 | 2563 |
| 65 | 2016-17 | 43.99 | 109.7 | 2494 | 30.79 | 98.51 | 3200 | 9.63 | 25.9 | 2689 |
| 68 | 2017-18 | 43.77 | 112.76 | 2576 | 29.65 | 99.87 | 3368 | 9.38 | 28.75 | 3065 |
| 69 | 2018-19 | 44.16 | 116.48 | 2638 | 29.32 | 103.6 | 3533 | 9.03 | 27.72 | 3070 |
| 70 | 2019-20 | 43.78 | 118.43 | 2705 | 31.45 | 107.59 | 3421 | 9.72 | 28.64 | 2945 |

Area- Million hectares; Production- Million tonnes; Yield- kg $ha^{-1}$

**Source:** Directorate of Economics and Statistics, DAC&FW* 4th Advance Estimates

**Table 3. Minimum Support Price (MSP) for Rice, Wheat, and Maize from 2010-11 to 2021-22 (in Rupees per quintal)**

| S. No. | Year | Rice | Wheat | Maize |
|---|---|---|---|---|
| 1. | 2010-11 | 1000 | 1120 | 800 |
| 2. | 2011-12 | 1080 | 1285 | 980 |
| 3. | 2012-13 | 1250 | 1350 | 1175 |
| 4. | 2013-14 | 1310 | 1400 | 1310 |
| 5. | 2014-15 | 1360 | 1450 | 1310 |
| 6. | 2015-16 | 1410 | 1525 | 1325 |
| 7. | 2016-17 | 1470 | 1625 | 1365 |
| 8. | 2017-18 | 1550 | 1735 | 1425 |
| 9. | 2018-19 | 1750 | 1840 | 1700 |
| 10. | 2019-20 | 1815 | 1925 | 1760 |
| 11. | 2020-21 | 1868 | 1975 | 1850 |
| 12. | 2021-22 | 1940 | 2015 | 1850 |

**Source:** Dept. of Agriculture & Cooperation and Farmers Welfare, GoI, New Delhi, 2022

**Table 4. CAGR of MSP of Rice, Wheat, and Maize from 2010-11 to 2021-22**

| S. No. | Year | Rice | Wheat | Maize |
|---|---|---|---|---|
| 1. | 2010-11 to 2021-22 | 6.01 | 5.30 | 7 |

**Source:** Authors' Analysis

were dismal, and they received little money from farm activities.

The PM of India announced in 2016 to "Double farmers' income" by 2022, which required a 10.41% annual increment in farmers' income. In the wake of this, maize cultivation is a good choice as it can be grown in both seasons, *i.e.* during *kharif* and *rabi*. Additionally, the MSP for maize has the highest annual growth rate from 2010–11 to 2021–22, at 7%, higher than the MSP for rice and wheat. It demonstrates the value the government places on maize production as well.

Also, the practical implementation of the APMC Act of 2003 and e-NAM in 2016 will certainly helped the maize growers. Though farmers' income is not doubled by 2022-23, the recent agricultural market reforms and the increase in maize cultivation might help achieve the target. CAGR has increased significantly and higher than rice and wheat, especially after the APMC Act of 2003. Therefore, maintaining the maize crop's production and properly implementing market reforms is essential for enhancing farmers' income.

**REFERENCES**

Birhanu, A and Sekhar, I. 2016. Trends and regional disparity of maize production in India. Journal of Development and Agricultural Economics. 8(9): 193–199. https://doi.org/10.5897/jdae2015.0702

Bisen, J and Kumar. R. 2018. Agricultural marketing reforms and e-national agricultural market (e-NAM) in India: A review. Agricultural Economics Research Review. 31(conf. no.): 167–176. https://doi.org/10.5958/0974-0279.2018.00032.0

Chand, R and Singh, J. 2016. Agricultural marketing and farmer-friendly reforms across Indian states and UTs. National Institution for Transforming India (NITI Ayog). pp.1–15.

GoI. 2022. Minimum support prices. Retrieved from the website Department of Agriculture & Cooperation and Farmers Welfare (https://farmer.gov.in/mspstatements.aspx ) on 10.04.2023.

Malhotra, S. K. 2017. Diversification in utilization of Maize and Production. In: Gyan Manthan-Perspective of Maize Production and Value Chain-A Compendium. Vol. 5 (Issue January): 49–57.

Meena, G. L., Burark, S. S., Singh, H and Sharma, L. 2019. Electronic-National Agricultural Market (e-NAM): Initiative towards doubling the farmers' Income in India. International Archieve of Applied Science and Technology.10(2): 162–171. https://doi.org/10.15515/iaast.0976-4828.10.2.162171.

Rachappanavar Yahswant Singh Parmar, V. 2020. Identification and management of seed-borne diseases by conventional and modern techniques. pp.83–100. Retrieved from the website (https://www.researchgate.net/publication/338330640) on 04.4.2023.

Reddy, A. A. 2018. Status of market reforms in India. SSRN Electronic Journal. (November 2016):33–37. https://doi.org/10.2139/ssrn.3037093.

Sandhu, V and Kaur. H. 2020. Marketing of agricultural produce: An attitudinal analysis of farmers. Journal of Critical Reviews. 7(2):

497–503. https://doi.org/10.31838/jcr.07.02.94.

Sharma, G and Mehta., S. 2016. Trends, growth and instability in area, production and productivity of maize crop across regions in India. Productivity. 56(4): .

Singh, S. 2018. Reforming Agricultural Markets in India. Economic and Political Weekly. Vol. 51, (December): 44–49.

Statista.2022. Retrieved from the website (https://www.statista.com/statistics/254294/distribution-of-global-corn-production-by-country-2012/) on 18.4.2023.

Tripathi, A and Prasad. A. R. 2009. Agricultural Development in India since Independence/ : A Study onprogress, performance and determinants. Journal of Emerging Knowledge on Emerging Markets. 1(1): 1–31. https://doi.org/10.7885/1946-651X.1007

Yadav, O. P., Yadava, P., Jat, S.L and Dhillon, B. S. 2016. Doubling maize (*Zea mays*) production of India by 2025 – challenges and opportunities. Indian Journal of Agricultural Sciences. 86(4): 427–434.

Kumar, R and Savadatti, P. M. 2023. Comparative analysis of the role of maize farming and agricultural market reforms in raising farmers' Income in India. The Journal of Research ANGRAU. 51(3): 147-157.
DoI: https://doi.org/10.58537/jorangrau.2023.51.3.17

DoI: https://doi.org/10.58537/jorangrau.2023.51.3.18

J. Res. ANGRAU 51 (3) 158-169, 2023

# INDIAN PULSES- PROSPECTS OF ACHIEVING SELF-SUFFICIENCY

**G. RAGHUNADHA REDDY*, K.V. GOVINDARAJU, K.V. S. D. PRAVALLIKA, S. RAMESH NAIK and K. J. V. K. SIRISHA**

Centre for Agriculture and Rural Development Policy Research (CARP), Acharya N.G. Ranga Agricultural University, Lam, Guntur- 522 034

Date of Receipt : 03.5.2023 Date of Acceptance :14.7.2023

## ABSTRACT

The trend in area, production, and yield of major pulses in India through growth rate and instability analysis from 2000-01 to 2021-22 to reveal the position with an objective to support th way forward to achieve self-sufficiency. The growth rates were calculated by fitting the semi-log linear growth function, and instability was analyzed with the help of Coppock's Instability Index (CII) for the total pulses of India along with spatial and temporal patterns of area, production, and yield among major pulses. The results have shown a significantly positive trend in area, production, and yield of major pulses over the period of time. The compound annual growth in area and production showed positive but decreased trends after 2010–11 compared to earlier period. However, the yield growth rate was found higher than the growth rate in area, implying that area allocation for pulses is increasing marginally after 2010-11 while improvement in yield noticed. The main factors responsible include improvements in technologies and government support through schemes such as NFSM. In case of stability, yield factor has comparatively larger variability in sub-periods I and II, which are 0.42 and.0.44, respectively, as in production, whereas, instability is a bit lower in the case of area under cultivation.

**Keywords:** Compound Annual Growth Rate (CAGR), Coppock's Instability Index, Markov Chain Analysis, Pulses

## INTRODUCTION

Pulses are an important group of crops in India plays significant role in food and nutrition security and are a source of income and employment for small and marginal farmers. With 22-24% protein content, they surpass wheat's protein by double and rice by triple. Pulses offer significant health benefits, combating non-communicable diseases such as colon cancer and cardiovascular issues (Curron, 2012). It can thrive in a wide variety of climatic conditions and is being cultivated across different agro-climatic zones in India. Pulses play a crucial role in crop rotation, intercropping, and soil fertility. The most important pulses chickpea (46%), redgram (17%), Urd bean (12%), Mung bean (10%), cowpea (7%), lentil (5%), and fieldpea (5%) are grown in India during two seasons: *kharif* (June-October) and *rabi* (October–April).

The pulses production rises to 26.96 million tonnes in 2021–22. Area under pulses up from 24.91 Mha in 2015-16 to 30.37 Mha in 2021-22, and yield has increased from 656 kg $ha^{-1}$ to 888 kg $ha^{-1}$. Import dependency of pulses came down from 19% in 2013–14 to around 9% in 2021–22 (PIB, 2022). The country is experiencing a revolutionary movement

*Corresponding Author E-mail i.d: g.raghunadhareddy@angrau.ac.in

towards achieving self-sufficiency in pulse production, which has been a long-standing demand. However, there exists a gap between demand and supply of pulses in India, which need to be met by imports. The per capita net availability of pulses in India is 47.9 g $day^{-1}$ in 2020, falling short of the WHO recommendation of 80 $gday^{-1}$. Therefore, the production of pulses needs to be increased on a sustainable basis to meet rising domestic necessities and the requirement will be 39 million tonnes of pulses by 2050 (IIPR, 2050). A high growth rate and low instability in production are needed for sustainable agricultural performance and has important implications for policy makers. Thus, it is important to study the current growth, instability and spatial and temporal pattern of area, production and yield of pulses in India and put forth the way forward to achieve self-sufficiency.

## MATERIALS AND METHODS

The study used time-series data from secondary sources for 22 years (2000-01 to 2021-22) pertaining to area under cultivation, production and productivity of pulses on state wise across the country along with itself were sourced for the study. The data were obtained from various issues of published sources such as Indiastat, Agriwatch, RBI's Handbook of statistics on Indian economy and states, reports of Department of Economic Affairs and Ministry of Statistics and Programme Implementation (GoI), and other published sources.

### Markov Chain Analysis

Markov chain analysis is an application of dynamic programming to the solution of a stochastic decision process that can be described by a finite number of states to study the changes in the cropping pattern (Dayakar Rao and Parwez, 2005) and to study the crop shifts in the rayalaseema region by Ragamalika *et al.* (2021).

### The Markov probability model

A stochastic process can analyze a set of trials or experiments probabilistically. For a stochastic process, it is assumed that the movements (transitions) of objects from one state (possible outcome) to another are governed by a probabilistic mechanism. A finite Markov process is a stochastic process whereby the outcome of a given trial 't' (t = 1, 2, …. T) depends only on the outcome a preceding trial (t-1) and this dependence is the same at all stages of the sequence of trials. Consistent with this definition, let the $S_i$ represent $i^{th}$ state or possible outcomes; i = 1, 2, … r, $W_{it}$represents the probability that state $S_i$ occurs on trial t or proportion observed in trial 't', in alternative outcome state i of a multinomial population based on sample size n, i.e., $P_r$ ($S_{it}$). $P_{ij}$ represent the transitional probability which denotes the probability that if for any time t the process is in state $S_i$, it moves on next trial to state $S_j$,

$$i.e., P_r(S_j, t+1/S_{it},) = P_{ij}$$

$P_r$ = ($P_{ij}$) represent transitional probability matrix which denotes transitional probability for

every pair of states (i, j = 1,2, ....., r) and has the following properties;

$$0 \leq P_{ij} \leq 1 \quad \text{..... (1)}$$

$$\sum_{j-1}^{n} P_{ij} = 1 \quad \text{..... (2)}$$

Given this set of notations and definitions for a first order Markov chain, the probability of particular sequence $S_i$ on trial t and $S_j$ on trial t + 1 may be represented by

$$P_r(S_{it}, S_{j\,t+1} = P_r(S_{it},)P_r(S_{j\,t+1}/S_{it}) = W_{it}P_{ij}$$

..... (3)

and the probability of being in state j at trial t + 1 may be represented by

$$P_r(S_{j\,t-1}) = \sum_i W_{it}P_j \quad \text{or} \quad W_{j,\ t+1} = \sum_i W_{it}P_{ij}$$

..... (4)

The data for study are the proportion of area under crops. The proportion changes from year to year as a result of factors like weather, technology, price and institutional changes *etc*. It is reasonable to assume that the combined influence of these

individually systemic forces approximates to a stochastic process and propensity of farmers to move from one crop to another differs according to the crop state involved. The process of cropping pattern change may be described in form of matrix P of first order transition probabilities. The element $P_{ij}$ indicates the probability of a crop state i in one period will move to crop state j during the following period. The diagonal element $P_{ij}$ measures the probability that the proportion share of $i^{th}$ category of crop will be retained (Ardeshna and Shiyani, 2013).

**Estimation of Transitional Probability Matrix (TPM)**

Equation (4) can be used as a basis for specifying the statistical model for estimating transitional probabilities. If errors are incorporated in equation (4), it becomes,

$$W_{it} = \sum_i W_{it}\, W_i, t-1\, P_{ij} + U_{jt} \quad \ldots\ldots (5)$$

or in matrix form it can be written as,

$$Y_j = X_j\, P_j + U_j \quad \ldots\ldots (6)$$

Where $Y_j = (T * 1)$ vectors of observations reflecting the proportions in cropping pattern j in time t,

$X_j = (T * r)$ matrix of realized values of the proportions in cropping pattern in time t – 1,

$P_j = (r * 1)$ vectors of unknown transition parameters to be estimated and

$U_j$ = vectors of random disturbances.

**Coppock's Instability Index (CII):**

CII was employed in the present study since it is a close approximation of the average year to year percentage variation adjusted for trend (Coppock, 1962). CII is also called as log variance method and it is expressed algebraically in the following form:

$$CII = (\text{Antilog } \sqrt{logV\text{-}1}) * 100)$$

Where

$$\text{Log } V = \frac{1}{N}\sum_{t=1}^{n-1}\left(\log\left(\frac{X_{t+1}}{X_t}\right) - m\right)^2$$

And the arithmetic mean, 'm' is given by

$$m = \frac{1}{N-1}\sum\left[log\frac{X_{t+1}}{X_t}\right]$$

Where,

$X_t$ =Area, Production and yield in time period t;

N =Number of years in the series;

m =Mean of the difference between logs of $X_{t+1}$, $X_t$ and

log V=Logarithmic variance of the series.

A higher value of CII will represent greater instability.

**Decomposition Analysis**

To measure the relative contribution of area and yield to the total output change for individual crops, the component analysis model was followed (Bastine and Palanisami, 1994).

$$\Delta P = A0\ \Delta Y + Y0\ \Delta A + \Delta A\ \Delta Y$$

**Change in Production = Yield effect + Area effect + Interaction effect.**

The total change in production can be decomposed into three effects such as; yield effect, area effect and interaction effect due to change in yield and area.

**RESULTS AND DISCUSSION**

**Patterns and Trends in performance of Pulses in India (2000-2021)**

The log-linear graphs (Figure 1) showed a gradual and fluctuating upward trend in pulses production over time which was driven by technological advancements and agronomic practices that enhanced yield potential.The positive growth indicates an overall increase in pulses output, although it might not follow a smooth and linear pattern.However, according to Rimal *et.al* (2015), the continuous improvement in pulses production during the post reform period can be

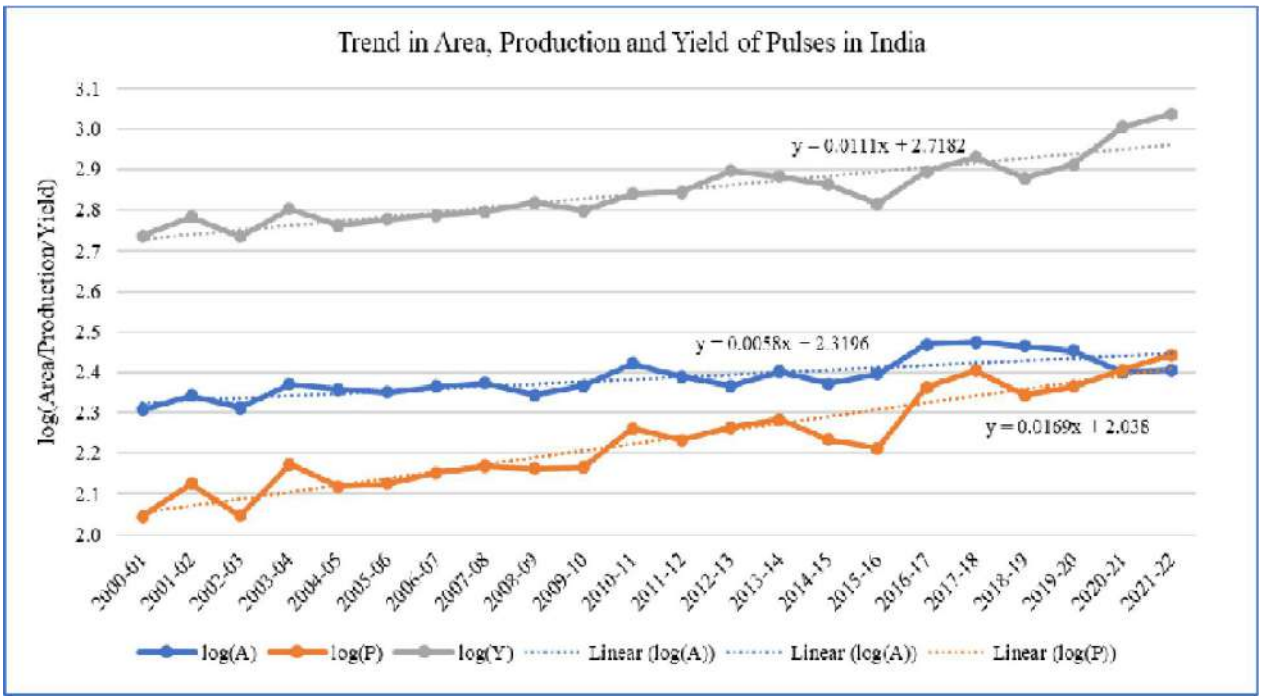



**Figure 1. Trend in area, production and productivity of pulses in India (2000-01 to 2021-22)**

attributed primarily to yield improvement, supported by area expansion and favourable rainfall conditions.

**Compound growth rates of area, production and productivity of pulses (2000-2021)**

The log-linear model analysis revealed that for both time periods (2000–2010 and 2011–2021), pulses cultivation experienced significantly positive growth in area, production, and yield. During the second period (2011–2021), while the growth rates of area and production were lower compared to the first period (2000–2010), the productivity of pulses nearly doubled. This indicates that despite a slower expansion in cultivated area, the total production was stabilized due to substantial improvement in productivity. Kumar (2018) highlighted the government's initiative in the form of the National Food Security Mission (NFSM) aimed at increasing pulses' production. The study found that this initiative had a positive impact on pulse production.

**Spatial and Temporal pattern of area, production and yield of pulses in India**

The acerage cultivation dynamics between pulses were portrayed using Markov Chain analysis and the transitional probability matrix (expressed in percent terms) from 2000-01 to 2021-22 (Table 2). Among the pulses, Chickpea had the most advantageous position with the retention of 66.2 percent of its area during the period under study. Approximately 20% of its area was lost to redgram, 10% to Mung bean, and a minor stake of 3.3% to Urd bean. Redgram could only retain 14.6 percent of its area due to its annual and risky nature (Srivastava *et al.,* 2010), and it was found to be replaced by Chickpea (46.3%), Urd bean (29.1%), and Mung bean (10%). However, this loss compensated by gaining 49.1 % of the area from Mung bean and 20.3 % of the area from chickpea. Urd bean has retained 58.5% of its previous acreage and it lost its share to only one crop, *i.e.,* Mung bean (41.5%). Mung bean has retained 23.2 % of

**Table 1. CAGR for Pulses (2000 to 2021)**

| S.No. | Period | Area | Production | Yield |
|---|---|---|---|---|
| 1 | 2000-2010 | 0.44 | 0.92 | 0.34 |
| 2 | 2011-2021 | 0.07 | 0.82 | 0.60 |

**Table 2. Transitional probability matrix for changes in area of various pulses**

| | Crop | Lost its area to | | | |
|---|---|---|---|---|---|
| | | Redgram | Chickpea | Urd bean | Mung bean |
| Gain its area from | **Redgram** | **0.146** | 0.463 | 0.291 | 0.100 |
| | **Chickpea** | 0.203 | **0.662** | 0.033 | 0.102 |
| | **Urd bean** | 0.000 | 0.000 | **0.585** | 0.415 |
| | **Mung bean** | 0.491 | 0.277 | 0.000 | **0.232** |

**Table 3. Decomposition analysis of major pulses growing in India (percentage)**

| Crops | Particulars | Period I (1970-71 to 1989-90) | Period II (1990-91 to 2009-10) | Period III (2010-11 to 2021-22) | Overall Period (1970-71 to 2020-21) |
|---|---|---|---|---|---|
| 1. Redgram | Area effect | 90.09 | 183.81 | 62.52 | 84.53 |
| | Yield effect | 7.32 | -86.70 | 32.75 | 8.23 |
| | Interaction effect | 2.59 | 2.90 | 4.72 | 7.24 |
| 2. Chickpea | Area effect | 99.01 | 67.75 | 447.63 | 15.38 |
| | Yield effect | 1.20 | 29.69 | -392.47 | 81.50 |
| | Interaction effect | -0.21 | 2.57 | 44.84 | 3.12 |
| 3. Urd bean | Area effect | 62.69 | 84.07 | 80.12 | 50.51 |
| | Yield effect | 22.97 | 18.74 | 15.25 | 24.01 |
| | Interaction effect | 14.34 | -2.81 | 4.63 | 25.48 |
| 4. Mung bean | Area effect | 83.30 | 39.11 | -3.88 | 39.55 |
| | Yield effect | 10.28 | 66.09 | 104.46 | 34.79 |
| | Interaction effect | 6.42 | -5.20 | -0.58 | 25.66 |
| 5. Lentil (masur) | Area effect | 46.51 | 113.65 | -72.36 | 20.40 |
| | Yield effect | 36.14 | -10.97 | 212.14 | 45.92 |
| | Interaction effect | 17.35 | -2.67 | -39.78 | 33.68 |
| 6. Total Pulses | Area effect | 94.62 | 106.55 | 248.98 | 70.63 |
| | Yield effect | 5.18 | -6.94 | -154.42 | 25.99 |
| | Interaction effect | 0.20 | 0.39 | 5.44 | 3.38 |

**Table 4. Coppock's Instability analysis of major pulses in India**

| S. No. | Crop | 2001-02 to 2010-11 | | | 2011-12 to 2021-22 | | |
|---|---|---|---|---|---|---|---|
| | | Area | Production | Yield | Area | Production | Yield |
| 1 | Redgram | 0.398 | 0.413 | 0.488 | 0.412 | 0.461 | 0.509 |
| 2 | Chickpea | 0.418 | 0.445 | 0.487 | 0.404 | 0.456 | 0.534 |
| 3 | Urd bean | 0.399 | 0.415 | 0.490 | 0.455 | 0.468 | 0.500 |
| 4 | Mung bean | 0.402 | 0.499 | 0.554 | 0.438 | 0.497 | 0.549 |
| 5 | Lentil | 0.389 | 0.397 | 0.484 | 0.397 | 0.436 | 0.530 |
| 6 | Total Pulses | 0.393 | 0.417 | 0.484 | 0.404 | 0.443 | 0.510 |

its area and it lost its major share of 49.1% to Redgram and 27.7 % to Chickpea. The transitional probability matrix highlights the dynamic nature of pulse crop cultivation in the region, where changes in area are influenced by shifting preferences, market conditions, and competition among different pulse crops.

The decomposition analysis was done to determine the area effect, yield effect, and interaction effect on the production of major pulses from 1970–71 to 2021–22 (Table 3). For total pulse production, the area effect is greater than the yield effect, which is 70% and 29%, respectively. A similar effect was reported in redgram and Urd bean crops. The reason for the dispensary was that a large portion of the area under these pulses has lower productivity. However, yield effect was the highest contributing factor for chickpea (81.50%) and lentil (45.92%) production in the country.The government launched the National Food Security Mission (NFSM) in May 2007. Its target was to increase the production of pulses by 2 million tonnes by the end of 2011-12. NFSM was successful and the production went up from 14.20 million tonnes in 2006-07 to 17.09 million tonnes in 2011-12. However, in 2014-15 and 2015-16, there were two successive droughts and the production of pulses fell by about 2-3 million tonnes as compared to 2013-14. This resulted in high inflation as interpreted by negative yield effect during third period.

**Instability of area, production and productivity of pulses**

Overall instability was higher in yield than area and production at all India level. Instability was higher in second period than first period (Table 4). Instability in yield of all the pulses was higher than area and it is contributing more to production instability in both the periods. Though there are no significant changes, instability of yield and area was increased in the second period compared to first period. Indicating dismal performance of new technology in reducing yield instability of pulses, whereas area sown is relatively increasing over the period of study (Reddy and Mishra, 2006). However, instability of chickpeaarea and Mung bean yield is decreased in the second period.

**Demand and supply scenario of pulses**

Researchers at the International Food Policy Research Institute (IFPRI) have highlighted that the average Indian diet has excessive consumption of cereals but is deficient in proteins, fruits, and vegetables. Rural India consumes only 194 g of protein a day, against the recommended 459 g. Urban Indians consume 242 g. Despite this, pulses will continue to remain an important source of protein for a vast majority of Indians.Table 5 indicates that all pulses, with the exception of chickpea, experienced an increase in demand for consumption in recent years. As previously mentioned, the import of pulses has been on the

**Table 5. Demand and supply gap of major pulses grown in India (in lakh tonnes)**

| | Marketing Year (March to February) | Opening stocks | Production | Imports | Supply | Exports | Consumption | Demand | Gap b/w Domestic Production and Consumption | Ending stocks |
|---|---|---|---|---|---|---|---|---|---|---|
| Redgram | **2019-20** | 7.87 | 37.19 | 4.50 | 49.56 | 0.50 | 42.00 | 42.50 | -4.81 | 7.06 |
| | **2020-21** | 7.06 | 38.8 | 5.30 | 51.16 | 0.35 | 43.27 | 43.62 | -4.47 | 7.54 |
| | **2021-22** | 7.54 | 37.11 | 6.91 | 51.56 | 0.25 | 43.75 | 44.00 | -6.64 | 7.56 |
| | **2022-23*** | 7.56 | 32.10 | 7.00 | 46.66 | 0.15 | 43.75 | 43.90 | -11.65 | 2.76 |
| Urd bean | **2019-20** | 8.75 | 19.39 | 3.95 | 32.09 | 1.72 | 28.00 | 29.72 | -8.61 | 2.37 |
| | **2020-21** | 2.37 | 23.73 | 4.00 | 30.10 | 0.50 | 27.50 | 28.00 | -3.77 | 2.10 |
| | **2021-22** | 2.10 | 22.91 | 5.65 | 30.66 | 0.57 | 28.00 | 28.57 | -5.09 | 2.09 |
| | **2022-23*** | 2.09 | 21.12 | 6.25 | 29.46 | 0.15 | 28.50 | 28.65 | -7.38 | 0.81 |
| Mung bean | **2019-20** | 5.52 | 19.06 | 0.59 | 25.17 | 0.07 | 23.00 | 23.07 | -3.94 | 2.10 |
| | **2020-21** | 2.10 | 21.42 | 1.50 | 25.02 | 0.10 | 22.82 | 22.92 | -1.4 | 2.10 |
| | **2021-22** | 2.10 | 26.53 | 1.71 | 30.34 | 0.25 | 23.50 | 23.75 | 3.03 | 6.59 |
| | **2022-23*** | 6.59 | 26.30 | 0.50 | 33.39 | 0.30 | 26.00 | 26.30 | 0.3 | 7.09 |
| Chickpea | **2019-20** | 18.22 | 106.10 | 4.00 | 128.32 | 2.00 | 105.00 | 107.00 | 1.1 | 21.32 |
| | **2020-21** | 21.32 | 105.50 | 3.00 | 129.82 | 3.50 | 105.00 | 108.50 | 0.5 | 21.32 |
| | **2021-22** | 21.32 | 97.67 | 2.04 | 121.03 | 1.06 | 100.00 | 101.06 | -2.33 | 19.97 |
| | **2022-23*** | 19.97 | 103.46 | 2.50 | 125.93 | 2.25 | 102.00 | 104.25 | 1.46 | 21.68 |

**Source: agriwatch.com; *Advance estimates**

rise, while exports have shown a contrasting trend. Domestic production falls short by 7 to 12 lakh tonnes for redgram and Urd bean to meet consumption, leading to a reliance on imports. In contrast, Mung bean and chickpea production almost balances with domestic consumption. The inadequate production of redgram and Urd bean raises concerns about import dependency, necessitating efforts to expand and stabilize their cultivation area and yield.

Despite an increase in production, India has been the largest importer of pulses since the beginning of the present millennium (NABARD). Imports increased to more than 27 percent of domestic production from 2014-15 to 2016-17, reaching a high of 36 percent in 2015-16. Following that, imports of pulses gradually declined with a rate of 0.88 percent, reaching a low of 9% of domestic production in 2021-22. This milestone can be regarded as the significant impact of high yielding varieties and integrated ISOPOM and NFSM-Pulses schemes.

The import bill for pulses also soared from Rs.7512 crores during 2010-11 to Rs.15540 crores

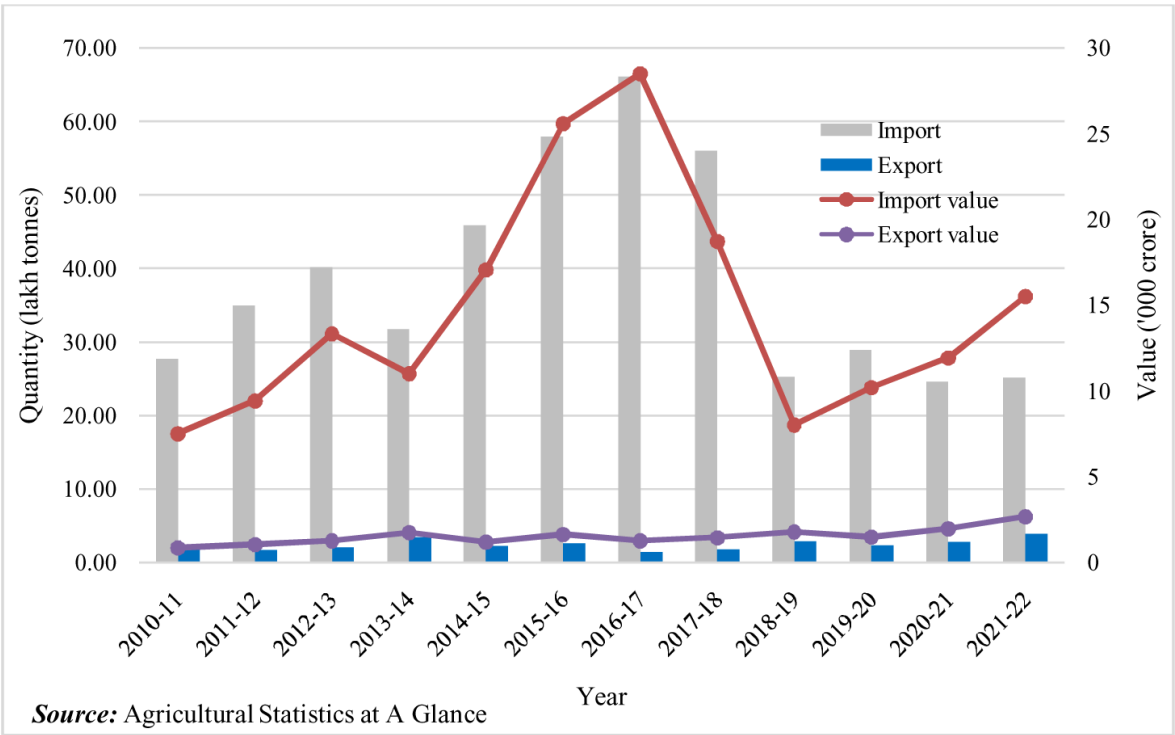



**Figure 2. Import statistics of pulses**

during 2021-22 (Figure-4), indicating a CAGR of 4.74 percent. The share of pulses in total food grain however has remained below 10 percent since 2010-11 even though it had shown tendency to go beyond 10 per cent in most of the years prior to that. Similarly, Indian pulse exports have had a bit positive upward over the period since 2010-11, having a CAGR of 6.98. Total exports estimated to be 4.1 lakh tonnes in 2021-22 (Directorate of Pulses, GoI).

**Price movement**

In the backdrop of wide mismatch between demand and supply and increased imports, it is necessary to look at the price movement of pulses. The prices of pulses have shown an upward trend in most of the recent periods. During the period from May 2020 to May 2022, prices for gram were higher (January 2022) in the wholesale domestic market than that of the international market, after which it synchronised with the latter. The domestic prices for Arhar/ Tur have been higher than that of international prices from February 2021 to September 2021. The domestic prices continued to increase from July 2021 to February 2022 for lentils. The price fluctuations occur more frequently for Urad and Moong in the domestic market. The impact of these rising prices is reflected in the inflation data (Singh, 2017).

In line with WPI inflation, CPI for pulses is also setting around the long-term average of 6.8 percent. This implies that pulses continue to remain a key contributor to food inflation for households (Jain, 2021). The government has imposed import duties and put quantitative restrictions on the various pulses to moderate the huge price fluctuations in the market. Though it is a welcoming policy measure, it is not appropriate for the long term as it becomes a huge burden for the government. Instead, increasing production with a reduced cost of production may help to manage this dispute in the long run.

**Price support**

The government should procure pulses at MSP and trend in support prices illustrated in figure

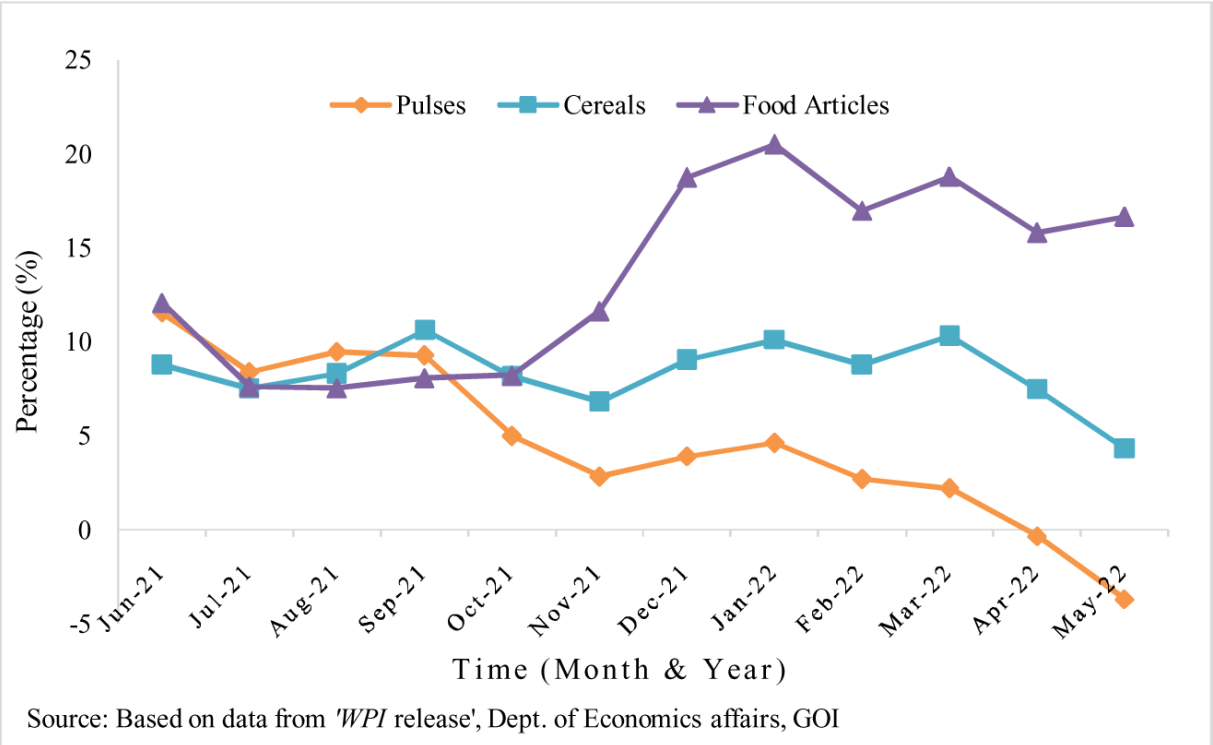



**Figure 3. WPI inflation of Pulses vs Cereals and Foodgrains (%)**

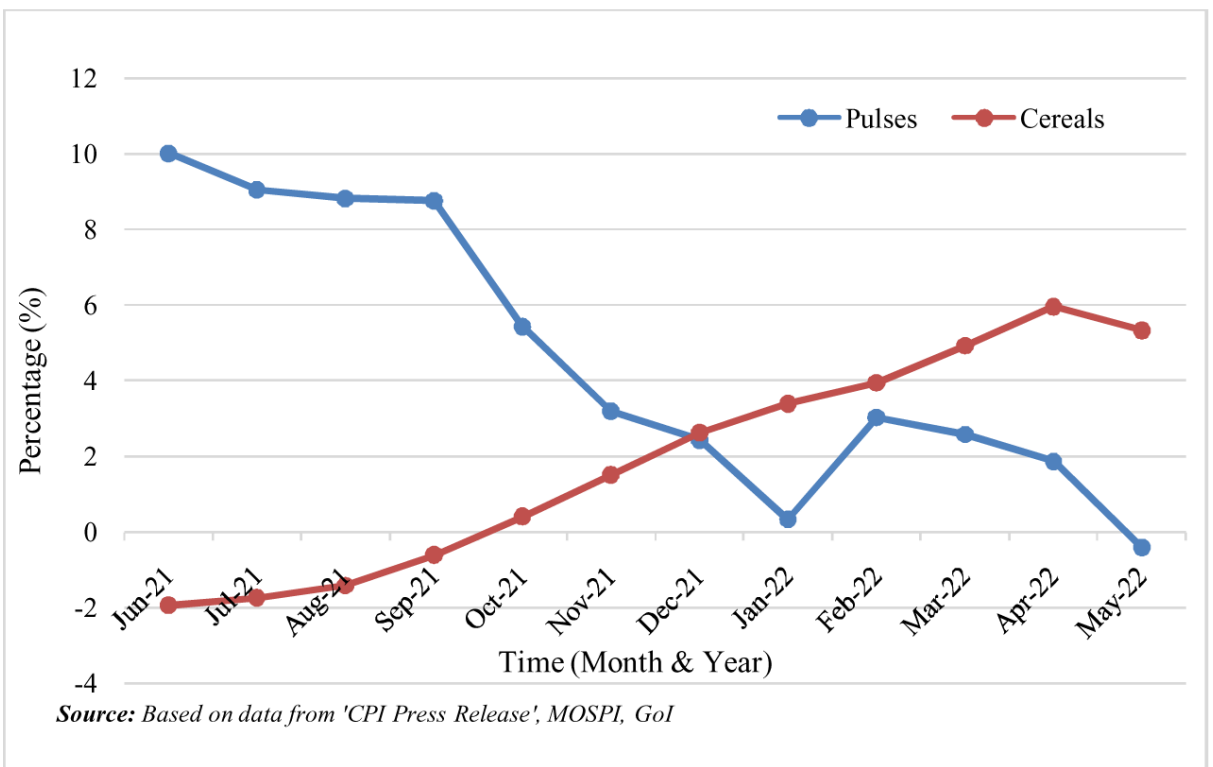



**Figure 4. CPI inflation of pulses vs cereals (%)**

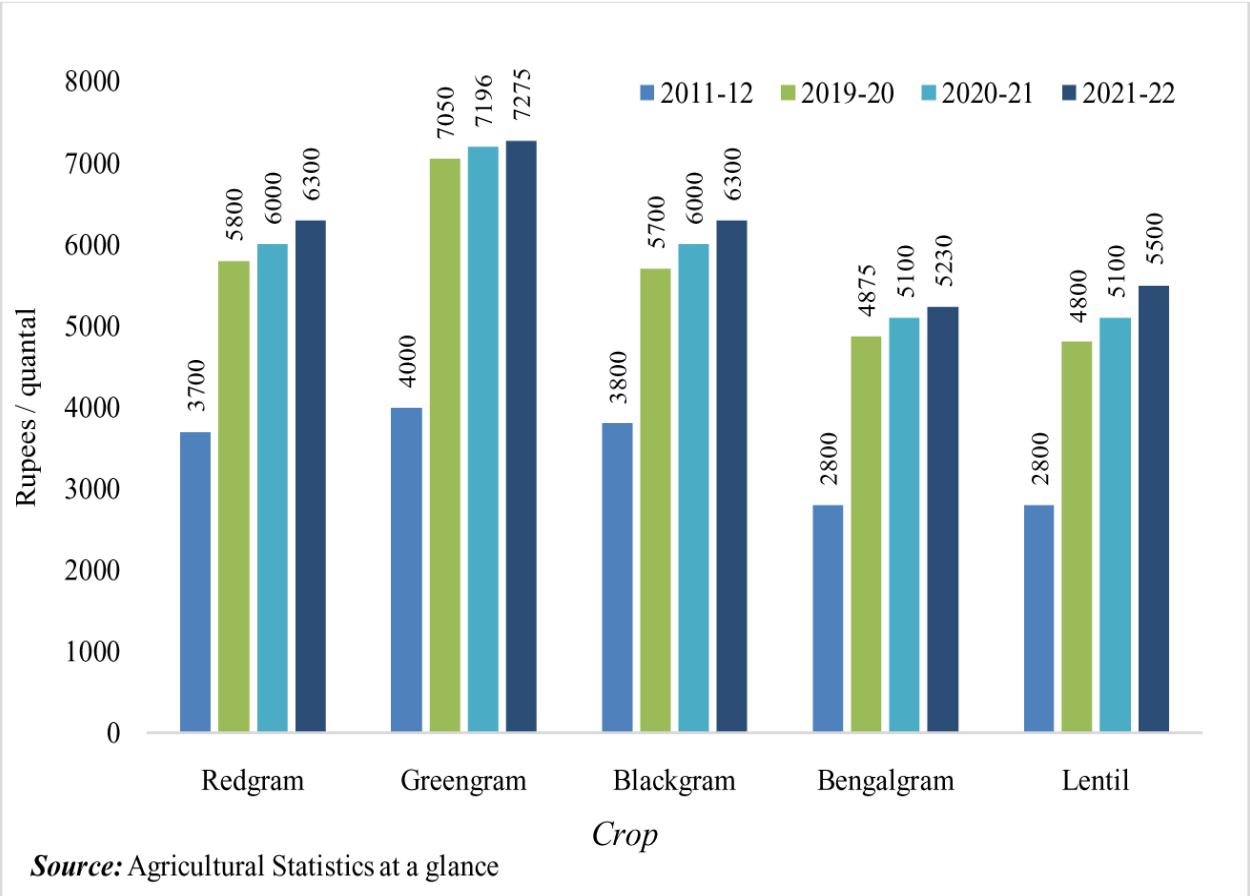



**Figure 5. Minimum Support Prices (MSP) for major pulses**

5. At present, MSP for lentils has almost doubled as compared to prices during 2011-12, with a CAGR of 6.98 percent. Similarly, the MSPs for Chickpea and Mung bean increased by more than 85%, with annual growth rates of 6.45 and 6.16 percent, respectively. Simultaneously, the MSP of redgram and Urd bean was increased by 68 percent, the least of all pulses. These pulses have CAGRs of 5.47 and 5.19 percent, respectively. The government enhanced the fund allocation under Price Support Scheme (PSS) and set up a Price Stabilization Fund (PSF) for the procurement of pulses. Procurement reached an all-time high of 41.83 lakh tonnes in 2018-19. In 2021-22 it was 12.49 lakh tonnes. However, procurement has been negligible, accounting for 4% to 10% of pulse production compared to 32% to 49% of cereal production from 2015-16 to 2021-22 (CACP 2022). As a result, it doesn't experience any markable dent on price movement. Based on surveys and secondary data sources, it has been observed that farmers received improved prices, which might lead to a potential increase in the cultivation area in the future.

## CONCLUSIONS

As of now, India remains as one of the largest producers and consumers of pulses in the world. The pulse production in India has made significant progress, but challenges persist. Addressing issues related to declining area, climate change, resource constraints, and agricultural practices is essential for sustained growth. Though India is inching towards self-reliance in pulses, the fluctuating area and yields lag into uncertainty, as interpreted by instability

index figures. The effects of technologies and government policies are enormous compared to the 1970s scenario. However, it has stagnated in the last decade.The pulses procured at MSP should be disposed of effectively as their shelf life is shorter than that of wheat and rice. The government should encourage farmers to cultivate more export-oriented varieties in the light of positive ending stock situation at national level. The time has reached that all our efforts should centric towards more production of pulses and oilseeds rather than major cereals.

Varietal and seeds replacement are the major areas that government should focus on to increase the production of pulses. The high-yielding varieties, which are available either with the central seed agencies or in the states, are distributed at a high subsidy rate and also provide monetary benefits to farmers to divert area from major cereals.The yield of pulses is lower than in other countries. For example, the yield of tur in India is only 859 kg $ha^{-1}$ (2021-22), whereas, the same in Myanmar is nearly double that. So, research should evolve location-specific cultivars with high productivity and climate resilience traits by using improved breeding technologies.

Promotion of pulses as a summer/spring crop in a cereal-based cropping system and intercropping can effectively increase the production of pulses across rice fallow areas in Assam, Bihar, Chhattisgarh, Jharkhand, Odisha, West Bengal, Andhra Pradesh, Maharashtra, Karnataka, and Tamil Nadu.The major pulse-producing states such as Andhra Pradesh, Karnataka, and Rajasthan have lower productivity and larger areas; it is important to target those states and encourage high-yielding varieties, mechanization, and modern cultivation practices to enhance production and, subsequently, reduce the cost of production.

The government needs to strengthen procurement and increase the pulses proportion in the Public Distribution System (PDS) for a balanced diet, which would concurrently reduce market inefficiencies, so that farmers prefer sowing of pulses compared to other crops. Identify and encourage commodity-based markets for each pulse and promote public-private partnership to facilitate electronic trading of pulses across the country. Also, promoting FPOs exclusively for pulses with efficient, small processing units and small storage units in rural areas can create opportunity for value-addition and thus benefits smallholder farmers by fostering horizontal and vertical linkages that integrate them into the value chain.

**REFERENCES**

Ardeshna, N.J and Shiyani, R.L. 2013. Dynamics of cropping pattern in Gujarat state: A Markov Chain Approach. International Journal of Asian Academic Research Associates. 1(9) 57-66.

Bastine, C.L and Palanisami, K.P. 1994. An Analysis of Growth Trends in Principal Crops in Kerala. Agricultural Situation in India. 48(12): 885- 891.

Curron, J. 2012. The nutritional value and health benefits of pulses in relation to obesity, diabetes, heart disease and cancer. The British Journal of Nutrition. 08(1) 145-159.

Dayakar Rao and Parwez, S. 2005. Dynamics of cropping pattern in sorghum growing states of India. Indian Journal of Agricultural Economics. 4(16).

IIPR. 2015.Vision 2050.Indian Institute of Pulse Research. Kanpur, Uttar Pradesh.

Jain, S. 2021. Why pulses continue to be a key contributor to food inflation for households?. Times of India. Sep 28, 2021.

Kumar, A. B. 2018. Growth and instability analysis of pulses production in India. International Journal of Agriculture Sciences. pp. 6722-6724.

Kumar, A.G., Mehta, R., Pullabholta, H., Prasad, S.K., Ganguly, K and Gulati, A. 2012. Demand and Supply of Cereals in India. IFFRI Discussion Paper 01158.

GoI, 2022. Press Release- India inching towards 'Atmanirbharta' in pulses. Press Information Bureau, Government of India, New Delhi. pp. 1-7.

Ragamalika, V., Rajeswari, S., Aparna, B and Ravindra Reddy, B. 2021. Crop shifts in rayalaseema region of Andhra Pradesh: A Markov Chain Approach. Andhra Pradesh Journal of Agricultural Sciences: 1-9.

Reddy, A.A and Mishra, D. 2006. Growth and instability in chickpea production in India: A State level analysis. Agricultural Situation in India. pp.130-145.

Rimal, N.S., Kumar, S. Singh, D.R., Chahal, V.P and Shaloo. 2015. Sources of Growth in Pulses Production in India. Agricultural Economics Research Review. 28(1): 91-102.

Singh, P, Shahi, B and Singh, K.M. 2017. Trends of pulses production, consumption and import in India: Current scenario and strategies. Retrieved from the website (https://mpra.ub.uni-muenchen.de/81589/) on 20.3.2023. MPRA Paper No. 81589 posted 27 Sep 2017.

Srivastava, S.K., Sivaramane, N and Mathur, V.C. 2010. Diagnosis of pulses performance of India. Agricultural Economics Research Review. 23(1): 137-148.

Raghunadha Reddy, G., Govindaraju, K.V., Pravallika, K.V. S.D., Ramesh Naik, S and Sirisha, K.J.V.K. 2023. Indian pulses- prospects of achieving self-sufficiency. The Journal of Research ANGRAU. 51 (3):158-169.
DoI: https://doi.org/10.58537/jorangrau.2023.51.3.18

Research Note
DoI: https://doi.org/10.58537/jorangrau.2023.51.3.19
J. Res. ANGRAU 51 (3) 170-173, 2023

# ASSESSMENT OF THE SOCIO-ECONOMIC AND HEALTH CONDITIONS OF WOMEN TEA PLANTATION WORKERS IN NAMBORNADI TEA ESTATE, ASSAM

**SHIKHAMONI GOGOI* and T. RADHA**

Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore- 641043

Date of Receipt :10.5.2023 Date of Acceptance : 27.7.2023

Assam has grown tea for 100 years. It began in Britain and continues today. Assam produces half of India's tea. Women tea workers live in most of Assam's remote districts (Baishya,2016). Assam's GDP is 20% from tea plantations. Assam's tea estates employ many Indians. These workers' health is considerably lower than the state average for many reasons. These workers lack schools, latrines, adequate drinking water, healthcare, and nourishment. Due to poor access, they have a higher maternal mortality rate (404 per 100,000 live births), higher risk of pregnancy-related complications, hypertension (60%), poor nutritional status, low birth weight babies (43%), and higher TB prevalence (30–40%) than the general population in the state (Rajput *et al.,* 2021). Health is total physical, mental, and social well-being. Happiness requires health. Health depends on nutrition and hygiene (Timing and Sarmah, 2013). The experiment was conducted between June and September 2022. Nambornadi Tea Estate in Assam was studied. Study used both primary and secondary data. A total of 75 women tea plantation workers were selected using simple random sampling and interviewed using a structured schedule. The Nambornadi tea estate management board, websites, magazines, and Assam Govt. archives provided secondary data. The study's interview schedule included parts on respondents' personal profiles, health, and health issues. Primary data was collected by observation and face-to-face dialogue.

**Socio-economic profile of the respondents**

The demographics revealed that 28% of the respondents belonged to the age group of 26-30 years, about 26.67% of the respondents belonged to the age group 20-25 and 31-40 years and only 18.67% of the respondent were found to be above 40 years. Hence, it could be inferred that majority of the selected women workers were young. It was observed that around 76 % of the respondents were Hindus. This finding is in line with the findings of Chowdhury *et al.* (2018). While the remaining 24% of the respondents were found to be from Christian religion.

Majority 90.67% of the tea garden women workers of the respondents were married. 8% of the respondents were unmarried and a meagre amount of 1.33% respondents were found to be widow. Although majority of the respondents were found to belong to young category, here the result showed that the number of married women was higher than the number of unmarried women. This finding was quite evident because with less education and rural background, women tend to get married at younger age than those in educated urban areas.

*Corresponding Author E-mail i.d: sikhamg90@gmail.com; Ph.D.thesis submitted to Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore- 641 043

Women workers (58.67%) were part of nuclear families and 41.33% belonged to joint families. This showed modernization in the area. Modern nuclear families are spreading on tea estates. Nearly half of them (48%) were illiterate, 22.67% had primary education, 16% had middle school education, and only 10.67% had higher secondary education. Only a small segment (2.67%) attained education up to high school. According to the respondents, their parents did not educate them, especially the women, due to ignorance and poverty. Ansari and Sheereen (2016) in their study found that 65% of the respondents were literate in West Bengal, which is also eatsern part of India. Respondent's family income is mailnly wages. They believed tea garden wages were insufficient to cover their everyday expenses. They were poor. It's well established that families with higher incomes live better. The results showed that cent percent of respondents had a monthly income of Rs.5001-7000, which was low considering the price hikes of all goods and commodities in recent times.

**Health profile of the respondents**

The respondents' health profiles were categorized into physical, occupational, biological, chemical, and mechanical hazards. It was reported that 65% of the respondents were exposed to heat, especially in summer. Except for trees, they had little cover or shade during hot heat. Majority 75% experienced frequent pain from carrying big items. Cold, which often caused illness and made work difficult, afflicted 95% of the respondents. Mechanical, chemical, biological, psychological, and environmental risks plagued tea plantation women. Due to illiteracy, poverty, and lack of medical and hygienic facilities, tea garden workers have low awareness. Similar findings were reported by Borgohain (2013) for Assam tea workers.

Regarding occupational hazards, all of the respondents were prone to occupational hazards such as body pain, which they experienced frequently because of carrying heavy loads. Furthermore, large majority 97% of the participants reported frequently experiencing headaches due to carrying these loads on their heads. A significant portion of the respondents (77%) reported suffering sometimes from respiratory diseases caused by exposure to chemicals used in tea plantations rare.

The study found that many tea plantation workers were exposed to biological dangers that endangered their health. Majority 80% of tea plantation workers reported occasional insect bites. Tea plantation workers were exposed to disease-causing insects. Due to extensive perspiration in the hot and humid weather, it was found that 88% of respondents experienced fungal infections. The labourers' continuous contact to damp tea fields allowed fungus to proliferate, causing skin diseases. Due to tea plantation insects, followed by 79% of the respondents reported occasional malaria. Malaria-causing mosquito bites are common for workers. Tea fields' lush greenery and bushy places encourage mosquito breeding and malaria.

Chemical risks endangered many tea plantation workers. Specifically, majority 84 % of the respondents reported experiencing dermatitis, a skin condition caused by exposure to chemicals. Additionally, 79 % of the participants reported being affected by eczema, another skin condition caused by exposure to chemicals. And, most of of the respondents (85%) stated getting skin rashes due to exposure to chemicals used in tea plantations. Pesticides and herbicides used in the plantation could cause skin ulcers in workers. Studies show that these chemical risks can have long-term repercussions on workers' health and well-being, therefore, it's important to wear protective gear.

The study found that many tea plantation workers were at danger of injury from mechanical hazards. Specifically, majority (85%) of the

**Table 1. Association between Physical hazards and different age groups**

| | Age group | Mean | SD | SE | F – value | Sig. |
|---|---|---|---|---|---|---|
| F1 | 20 – 25 years | 2.55 | .83 | .19 | 2.986 | 0.002* |
| | 26 – 30 years | 2.24 | .89 | .19 | | |
| | 31 – 40 years | 2.25 | .97 | .22 | | |
| | Above 40 years | 2.64 | .75 | .20 | | |

**Significant at 1% level

respondents reported experiencing cuts and scrapes while working with tea plants and cutting tea leaves. The sharp tools used in tea plantations, such as pruning shears, pose a risk of cuts and scrapes when handling tea bushes and leaves. Furthermore, the majority of the respondents (73%) reported frequently experiencing sprains while working in the tea plantations. The repetitive and physically demanding nature of the job, such as bending and lifting heavy loads increased the risk of sprains and other musculoskeletal injuries. Researchers conducted have concluded that it is essential to provide adequate safety measures and training to minimize the risk of injury to tea plantation workers. This can include the use of protective equipment, such as gloves and safety shoes, and training on proper handling techniques to prevent injury.

**Association between physical hazards with their respective age groups**

Table 1 shows One-Way ANOVA results. The research calculated the F-value and significant value as 2.986 and 0.02, respectively, establishing a significant relationship between physical hazards and respondent age group at 1% significance. This indicated that physical dangers differed by age group, as older people are more susceptible to numerous health conditions. This study was compared to Kwon *et al.*(2021) who suggested that physical hazard exposures may raise the incidence of sadness and anxiety. These connections were stronger in men than women, and the higher the age group, the greater the risk.

**CONCLUSIONS**

Women tea plantation workers at Nambornadi Tea Estate, Assam, were examined for their socio-economic and health issues. The survey found that most respondents were 26–30 years old, Hindu, married, nuclear family, illiterate, and made Rs.5001–7000 per month. Respondents faced physical, occupational, chemical, biological, and mechanical dangers due to their work. These dangers caused general illness, body and head aches, skin bacterial and fungal infections, dermatitis, and more. Seasonal effects, lifting and carrying large weights, lack of clean drinking water, sufficient nutrition, alcohol and tobacco use, salt use, etc. also worsened their health. ANOVA test showed a significant association between the aforesaid variables at 1% level of significance, indicating that physical hazards differed by the age groups. Most respondents aged above 40 years were more associated with physical health hazards because older people are more likely prone to illness.

**REFERENCES**

Ansari, S and Sheereen, Z. 2016. Socio-economic condition of tea garden workers in Alipurduar district West Bengal. International Journal of Research in Social Sciences. 6(2).

Aishya, D.2016. History of tea industry and status of tea garden workers of Assam. International Journal of Applied Research (IJAR). *2*(9): 552-556.

Borgohain, P. 2013. Occupational health hazards of tea garden workers of Hajua and Marangi Tea estates of Assam, India, The Clarion-International Multidisciplinary Journal. 2(1): 129-140.

Chowdhury, N., Ahad, M. A., Chowdhury, M., Kundu, I and Islam, T. 2018. Health and hygiene condition of female tea workers: A study in three tea gardens of Sylhet district. Asian Journal of Agricultural Extension, Economics & Sociology. 26(1): 1-9.

Kwon, D., Kwak, K., Baek, K., Chi, Y., Na, S and Park, J. T. 2021. Association between physical hazardous agent exposure and mental health in the Korean working population: the 5th Korean working conditions Survey. Annals of Occupational and Environmental Medicine, 33.

Medhi, G. K., Hazarika, N. C and Mahanta, J. 2007. Nutritional status of adolescents among tea garden workers. The Indian Journal of Pediatrics. 74: 343-347.

Pal, J. K and Hussain, M. M. 2016. Health care and hygiene practices of older people in tea garden: A study conducted in Lackatoorah tea garden of Sylhet district. Open Journal of Social Sciences. 4(5): 144-154.

Rajput, S., Hense, S and Thankappan, K. R. 2021. Healthcare utilisation: A mixed-method study among tea garden workers in Indian context. Journal of Health Research. 36 (6): 1007-1017.

Sahoo, D., Konwar, K and Sahoo, B. K. 2010. Health condition and health awareness among the tea garden laborers: A case study of a tea garden in Tinsukia district of Assam. IUP Journal of Agricultural Economics. 7(4): 11-18.

Selvi, V. D and Sunitha, J.2015. Health hazards of women in the informal sector. RAC Journal of Research. 2(11): 66 - 71.

Timing, J and Sarmah, J. 2013. Nutrition, health and hygiene practice of women tea plantation workers of Assam. Asian Journal of Home Science. 8(2): 421-424.

Shikhamoni, G. and Radha, T. 2023. An assessment of the socio economic and health conditions of women tea plantation workers in Nambornadi tea estate, Assam. The Journal of Research ANGRAU. 51(3): 170-173.
DoI: https://doi.org/10.58537/jorangrau.2023.51.3.19

## Statement about the ownership and other particulars about Journal
## THE JOURNAL OF RESEARCH ANGRAU (since 1973)
### Form IV (SEE RULE 8)

| | | |
|---|---|---|
| Place of Publication | : | Guntur |
| Periodicity of publication | : | Once in three months (Quarterly) |
| Printer's Name | : | Ritunestham Press, Guntur |
| Nationality | : | INDIAN |
| Address | : | Ritunestham Press<br>8-198, Kornepadu, Guntur - 522 017 |
| Publisher's Name | : | Dr. G. Rama Rao |
| Address | : | Dean of P.G. Studies, Administrative Office,<br>Acharya N.G. Ranga Agricultural University,<br>Lam, Guntur- 522 034, Andhra Pradesh |
| Editor -in - Chief 's Name | : | Dr. G. Rama Rao |
| Nationality | : | INDIAN |
| Address | : | Dean of P.G. Studies, Administrative Office,<br>Acharya N.G. Ranga Agricultural University,<br>Lam, Guntur- 522 034, Andhra Pradesh |
| Name and address of the individuals who own the Journal and partners or share holders holding more than one percent of the total capital | : | Acharya N.G.Ranga Agricultural University,<br>Administrative Office,<br>Lam, Guntur- 522 034,<br>Andhra Pradesh. |

I, Dr. G. Rama Rao, hereby declare that the particulars given above are true to the best of my knowledge and belief.

**Sd/- G. Rama Rao**
**Signature of the Publisher**

ANGRAU/AI & CC/ September, 2023 Regd. No. 25487/73

Printed at Ritunestham Press, Guntur and Published by Dr. G. Rama Rao, Dean of P.G. Studies and Editor-in- Chief,
The Journal of Research ANGRAU, Acharya N.G. Ranga Agricultural University, Lam, Guntur - 522 034
E-mail : journal@angrau.ac.in, Website URL: https://epubs.icar.org.in/index.php/TJRA