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BIOEFFICACY OF *Metarhizium (Nomuraea) rileyi* ON PROTEIN PROFILE DURING EMBRYOGENESIS OF *Helicoverpa armigera* (HUBNER)

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ABSTRACT

Entamopathogenic fungi, *Metarhizium rileyi* is one of the promising alternative over chemical insecticides for the management of a most serious polyphagus pest, *H. armigera*. *Metarhizium rileyi* was tested for their median lethal concentrations (LC_{50}) and qualitative proteins against *Helicoverpa armigera* was carried out at Research laboratory, P.G. Department of Zoology, YashvantaraoChavan Institute of Science,Sataraunder Shivaji University, Kolhapur in 2019. *M. rileyi* is an effective ovicide, due to its ability to penetrate the eggs actively through their shell and multiply inside them. Yolk proteins are the primary nutrient resources in eggs which maintain nutritional quality to remain viable during embryogenesis. The LC_{50} value of *M. rileyi* was recorded as 3.8×10^2 spores/ml against eggs of *H. armigera*. The LC_{50}concentration of 3.8×10^2 spores/ml of *M. rileyi* was applied to the eggs of *H. armigera* to investigate their impacts on the total protein. The qualitative analysis of protein patterns was done by using SDS-PAGE electrophoresis. The SDS-PAGE analysis of eggs demonstrated that the few of proteins get under regulated upon treatment with *Metarhizium rileyi*.

Key words- Embryogenesis, *Helicoverpa armigera, Metarhizium (Nomuraea) rileyi,* SDS-PAGE

INTRODUCTION

The cotton bollworm, *Helicoverpa armigera* Hubner (Lepidoptera: Noctuidae) is a decisive entomological polyphagous crop pest occurring at different geographical regions. The pest attacks many economically important 200 crop species and 20 families (Wang *et al.,* 2009; Bird, 2017). During the last decades, many insect species have developed resistance to chemical insecticides against wide range of insecticide groups and so is the case with *H. armigera*.This recognized resistance is proved to be one of the extensive obstacles in the successful control of insect pests (Kranthi *et al*., 2002). Entamopathogenic Fungi (EPF) are effective and relatively safe biocontrolling agent of insect pests of economic importance in agriculture. More than 171 mycoinsecticides have been produced with minimum 12 species from the over 800 fungi species aimed to bring commercially available and using them as an alternative to synthetic chemical insecticides (Maina *et al.,*

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2018). *Metarhizium rileyi* (Farlow) is a prominent fungal pathogen having worldwide occurrence that cause infection to many economically important agricultural crop pests (Fronza *et al.,* 2017). It has considerable potential for efficacious suppression of all developmental stages of *H. armigera*. Al-Kherb (2014) studied the ovicidalactivity of *B. bassiana* isolates against the beet armyworm, *Spodoptera exigua* (Hübner) (Lepidoptera: Noctuidae), causing 50% mortality with a spore concentration 1×10^5 spores/ml where *B. bassiana* showed superiority over *M. anisopliae* in controlling the eggs. However, there are limited reports on the pathogenicity of insect eggs by entamopathogenic fungi.

The bio-molecules such as proteins, carbohydrates, lipids and a number of other substances mainly amino acids and vitamins are essential for any developmental and morphogenetic processes (Nirupama, 2015). Protein metabolism takes place during embryogenesis chiefly. Eggs have yolk proteins in which vitellogenin (vg) mainly synthesized in the fat body and transported by the haemolymph through intercellular spaces to form organ specific proteins. Recently, research advancements have been achieved in the molecular mechanisms of Vg synthesis regulated by JH, 20E, miRNA and nutritional pathways (Wu *et al.,* 2021).The nutritional status of eggs is essential during embryogenesis, metamorphosis and survival of premature neonates. This stored nutrient complexity allows for a complex message between the maternal generation and the offspring.

An entamopathogenic fungus causes infection to the host by contact mechanism of action. Once enter, the fungus grew and on response comprised formation of pathogenic structures like extracellular enzymes, production of toxins, secondary metabolites, etc., which eventually caused mortality of insects (Sinha *et al.,* 2016). Changes are often expressed as metabolic changes with gradual changes in infected tissue and pathogenicity depends on the physiological state of the host. Thus, the separation and characterization of the insect proteins after infection of *M. rileyi* will be efficient in modulation of protein which can be utilized for the control of pests. A study of changes in egg protein concentration in the context of infection by *Metarhizium rileyi* fungus is too scarce. Hence, the study examined protein patterns in the healthy eggs and *M. rileyi* treated eggs of *H. armigera*. Qualitative estimation of proteins of insect eggs was of immense importance for understanding of different physiological processes. The research work was conducted to assess median lethal concentrations (LC_{50}) of *M. rileyi* and its effect on protein patterns based on molecular weight against eggs of *H. armigera* using SDS-PAGE technique.

MATERIAL AND METHODS

Insect rearing

The larvae of *H. armigera* were collected from chickpea crop field in Satara district. Stock culture of the pest was maintained in laboratory condition during November, 2019. Laboratory temperature was maintained at 25±2℃, 75±5% RH and 14-10(L:D) h photoperiod. Rearing of *H. armigera* larvae was done individually using chickpea based artificial diet (Sharma *et al.,* 2014). The adult moths were kept in cages for oviposition for 4-5 days then female moths were transferred to a container for egg laying. Freshly

laid eggs were collected for the treatment of *N. rileyi*.

***Metarhizium rileyi* (biopesticide)**

The pure culture of *M. rileyi* obtained from University of Agricultural Sciences, Dharwad. The growth of *M. rileyi* was obtained by periodically sub culturing on Sabouraud's Maltose Agar with Yeast extract (SMAY) medium (Morrow *et al.,* 1989).Continuous cultures were maintained on slants with subcultures grown for 14 days at 25 following which lids were tightly sealed and cultures stored at 4(Fig.1). A series of concentrations of 2×10^3, 2×10^4, 2×10^5, 2×10^6, 2×10^7 and 2×10^8 spore/ml were prepared. Bioassay was carried out according to earlier report with some modifications and LC_{50} values were calculated by analysing data using Probit analysis (Ingle *et al.,* 2015).

Preparation of samples

In order to investigate biopesticide activity, the *M. rileyi* dosage of 2×10^3 to 2×10^8 spores/ml was applied to eggs, next day of laying with small sprayer. Each concentration is replicated thrice. For control set, 1 ml of distilled water was sprayed on the eggs. Treated and control set of Petri dishes with eggs were maintained at temperatures of 25 ± 2 and 95±5 % RH. The hatchability was observed and recorded from 2-4 days after treatment. The unhatched eggs were observed for fungal outgrowth under microscope as an evidence of egg mortality due to fungal infection. Finally, eggs from control and eggs from test group were used for the analysis of proteins.

Statistical analysis

Biochemical data was expressed as a mean ± SD of at least three experiments. Data

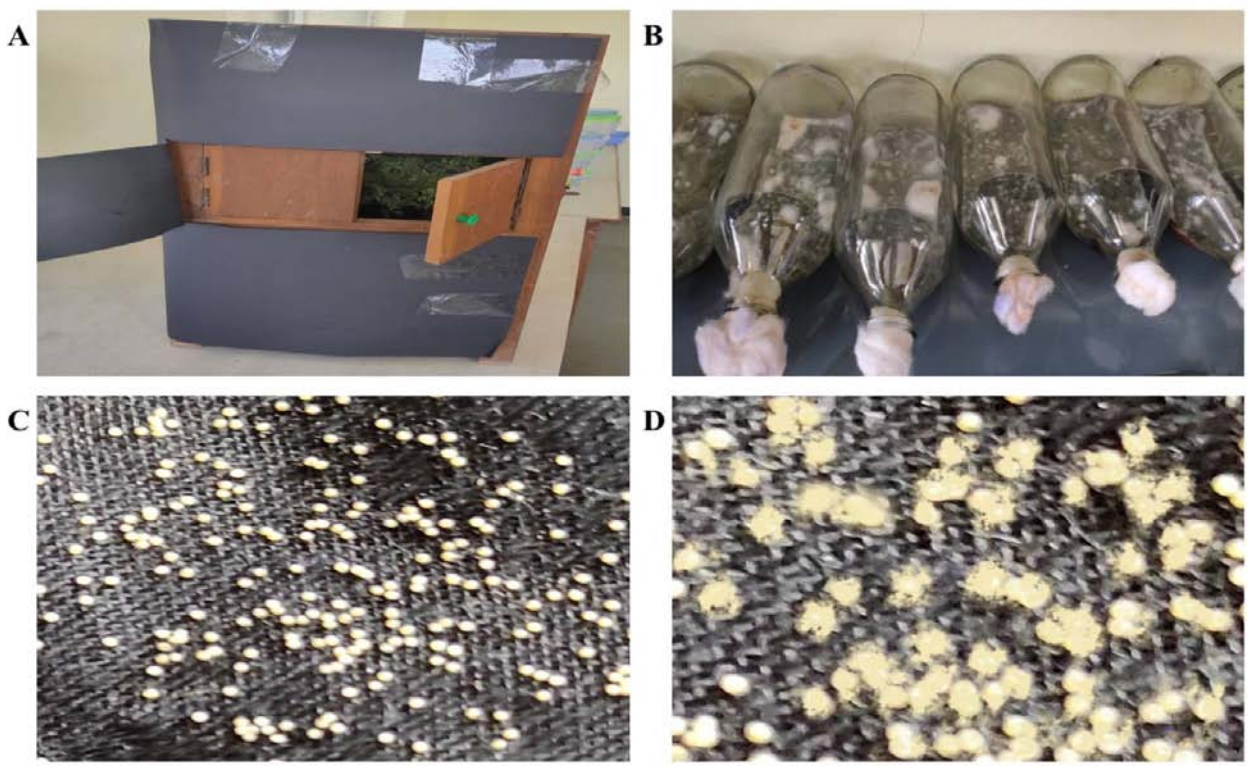


Fig. 1 Photographs shows **A)** Oviposition cage for egg laying **B)** Maintenance of *M rileyi* fungi culture **C)** Eggs of *Helicoverpa armigera* **D)** Eggs after infection of*M. rileyi*

was analyzed for one way analysis of variance (ANOVA) to test the level of significance using SPSS software package version 19. P value <0.05 was considered statistically significant.

Protein profiling by SDS-PAGE

In order to monitor the effect of *M. rileyi* spores on expression pattern of protein, total protein profiling was done for *H. armigera* eggs treated with *M. rileyi* and compared it with untreated by using SDS-PAGE analysis. Eggs were homogenised by using Phosphate buffer and centrifuged at 6000 rpm to collect supernatant. The homogenates were prepared for both control and test set.The supernatant could be used directly or stored at 4 until needed for later analysis by SDS-PAGE.Following the method for separation of protein content of *H. armigera* healthy larvae and *M. rileyi* treated larvae was done by SDS-PAGE method (Laemmli, 1970). The computer analysis was done for determination of molecular weight and quantification of protein bands using Gel analyzer 19.1 (Lazar, 2010).

RESULTS AND DISCUSSION

Effect of *M. rileyi* on *H. armigera* eggs

M. rileyi at different concentrations were able to cause death of *H. armigera* after treatment of eggs(Table 1). In bioassay studies the dose of 2×10^8 to 2×10^3 were applied to eggs and recorded 97% to 68% mortality. Mortality percentage of eggs was changed with different concentrations. The differences between mortality readings were statistically significant ($F = 130.73$; $df = 1$; $p < 0.001$). According to the findings, *M. rileyi* spores caused 50% mortality of *H. armigera* eggs at concentration of 3.8×10^2 spores/ml (Table 1). These results are in line with Khorrami *et al.* (2018) who reported that *M. rileyi* had ovicidal activity against the potato tuber moth (PTM), *Phthorimaea-operculella*. *M. rileyi* was the most effective fungus against this insect pest caused egg hatching reduction with a lethal concentration resulting in 50 % mortality (LC_{50}) 4.8×10^4 conodia/ml. Fergani and Rafaei *et al.* (2021) studied the pathogenicity of indigenous isolate of *B. bassiana* on different developmental

Table 1. Effect of different concentrations of *M. rileyi* spores on *H. armigera* eggs

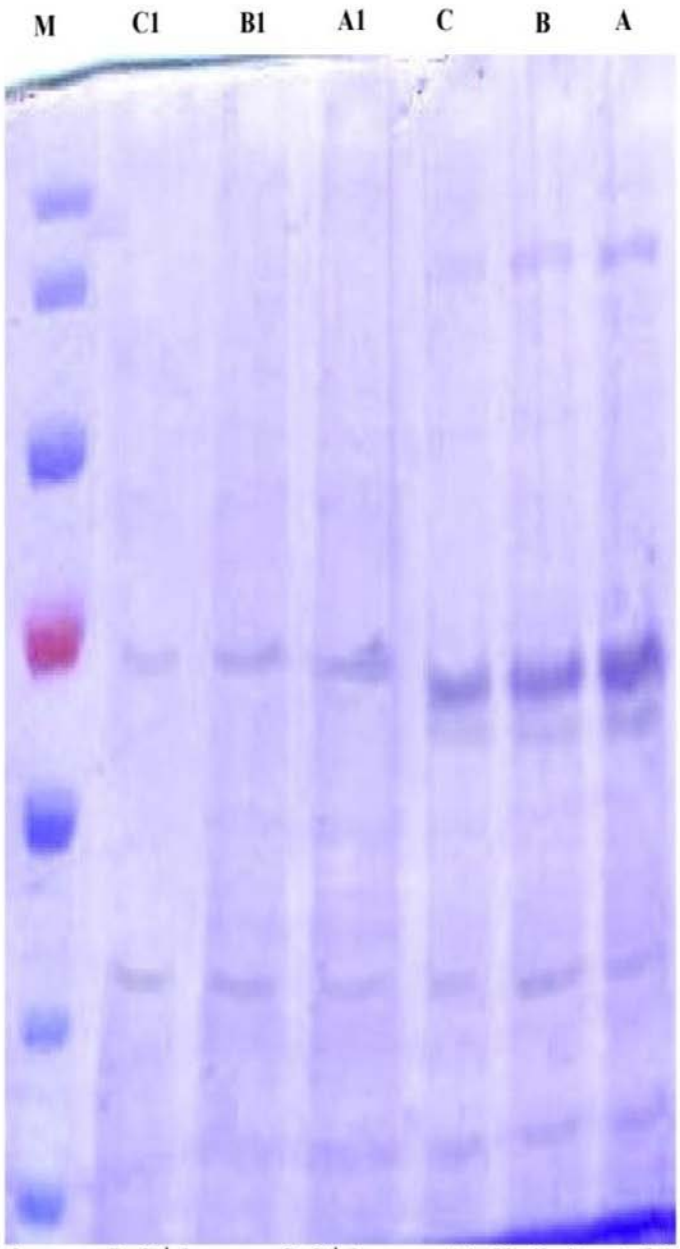
S.No.	Concentration *M. rileyi* spores/ml	Mean eggs mortality (%)
1	2×10^8	97± 1.3
2	2×10^7	92± 5.6
3	2×10^6	87.5± 7.8
4	2×10^5	80.5± 6.4
5	2×10^4	76± 3.8
6	2×10^3	68± 7.4
	LC_{50} spores/ml	3.8×10^2
	Slope (±SE)	0.37 (0.07)
	P-value	0.001

stages of *Spodoptera littoralis*. In their studies, *B. bassiana* isolate showed an ovicidal effect to the eggs of *S.littoralis* caused 100% mortality when treated with 1.0×10^8 and 1.0×10^9 spores/ml.The *M. anisopliae* (M_2 strain) causedovicidal effect on eggs of exotic whitefly *Aleurodicus disperses* which caused 37.3% mortality at 8 days after treatment. However, *L. lecanii* (L_1 strain) affected on egg hatching as minimum 23.2% at 10 days after treatment when compared with control 92.6% (Thangavel *et al.*, 2013). The *C. tenuissimum* SE-10, *P. citrinum* CTD- 24 and *B. bassiana* ZK-5 caused significant effects on egg mortality of fall armyworm, *Spodoptera frugiperda* (Idrees *et al.,* 2021).

Effect of *M. rileyi* on the protein profile of eggs of *H. armigera*

M. rileyi at LC_{50} concentration of 3.8×10^2 spores/ml was applied to the eggs of *H. armigera*. TheSDS-PAGE analysis of protein content with and without treatment of *M. rileyi* was done. The Fig.2 shows the separated protein bands. The SDS-PAGE showed total five bands without treatment of *M. rileyi* and their Rf values are mentioned in Table 2 with their corresponding molecular weight. The protein bands with molecular weight of 147 kDa, 66 kDa, 60 kDa, 44 kDa and 38 kDa were appeared in 1st day eggs. On 2nd day of eggs four protein fractions of molecular weightof 147 kDa, 60 kDa, 44 kDa and 38 kDa were observed with high band intensity. The four protein bands with molecular weight of 66 kDa, 60 kDa, 44 kDa and 38 kDa were observed with low band intensity on 3rd day of eggs. The expression pattern of proteins was significantly affected by the *M. rileyi* treatment to eggs of *H. armigera*. The effect of biopesticide showed that appearance of only three number of protein bands with molecular weight of 66 kDa, 44 kDa and 38 kDa in 1st, 2nd, and 3rd day as treated eggs.Further, the intensity of these bands was found lesser when observed for density compared to untreated eggs of *H. armigera*. In the findings, biochemical changes upon treatment of *Metarhizium rileyi* showed major changes in the total protein concentration of eggs during the course of infection.

Hamama *et al.* (2021) who studied the biological and biochemical effect of *M. anisopliae, B. bassiana* and *P. lilicanus* on the developmental stages of *Culexpipiens*. The authors found that reduction in female fecundity and number of hatched eggs. The biochemical analysis of treated larvae revealed different quantitative decrease in total soluble proteins, lipids and hydrolyzing enzymes as compared to control. The results also showed a distinct significant reduction in protein content in treated eggs of *H. armigera*. The alteration in metabolism of any organism is due to physiological anomalies and infection by pathogens. From the study evaluations, two protein bands which present in control sample were vanished from samples of the 1st day, 2nd day and 3rd day eggs treated with *N. rileyi* (Fig. 2). Five protein bands was present in control, of which two were disappeared in treated eggs and three protein bands at Rf 0.502 and 0.758 and 0.892 was observed in both control and *M. rileyi* treated eggs. However, the band intensity was found lesser when observed for density in treated eggs compared to control.



A: 1st day eggs, B: 2nd day eggs, C: 3rd day eggs, A1: *N. rileyi* treated 1st day eggs, B1: *N. rileyi* treated 2nd day eggs, C1: *N. rileyi* treated 3rd day eggs, M: Marker

Fig. 2. SDS-PAGE protein patterns of control and *N. rileyi* treated eggs of *H. armigera*

The lower protein concentration may be resulted from DNA damaged causing shut-off of some essential genes responsible for production of this protein after treatment. Valizadeh *et al.* (2021) studied the essential oils of *Thymus vulgaris, Lavandula angustifolia, Artemisia annua, Satureja hortensis, Rosmarinus officinalis,* and *Origanum vulgare* have ovicidal effects on elm leaf beetle *Xanthegaleruca luteola*. The protein concentration was decreased in the eggs after exposure to different concentrations of these essential oils. The

Table 2. Protein profile of untreated control and *N. rileyi* treated egg stage of *H. armigera*

S. No.	Rf value	Molecular weight (kDa)	Protein bands					
			A	B	C	A1	B1	C1
1	0.148	147	+ +	+ +	_	_	_	_
2	0.502	66	+	+	+	+	+	+
3	0.549	60	+	+ +	+	_	_	_
4	0.758	44	+	+ +	+	+	+	+
5	0.892	38	+	+ +	+	+	+	+

High band intensity '++', Low band intensity '+', Absence of band '_'

protein concentration fluctuation during metamorphosis is known since many years.The protein concentration and immune enzyme activity was significantly declined in *Spodoptera littoralis*, 5th instar larvae on treatment with entamopathogenic fungi *B. bassiana* and *M. anisopliae* after 2nd, 3rd and 4th day after infection (Gabarty *et al.,* 2013).

The total protein concentration in haemolymph of 4th instar larvae of red palm weevil, *Rhynchophorus ferrugieneus* decreased from 3, 5 and 7 days on treatment with entamopathogenic fungus, *B. bassiana*. The reduction in protein content was significant as compared with untreated larvae (Ragheb *et al.,* 2018).The total protein level in adult *Nezaraviridula* on exposure with *M. anisopliae* was significantly decreased than the treatment with *B. bassiana* (Nada, 2015). Elbanna *et al.,* (2012) reported that *Schistocerca gregaria* adults infected with *M. anisopliae* caused physiological imbalances in the host were led to change in enzyme activity and a quantitative reduction in haemolymph protein and other biochemical contents. There is a great deal left to find out about insect eggs and their resistance to various control techniques. The egg stage is disregarded during the execution of treatments; those eggs are passed on to hatch and potentially cause a reinfestation. Subsequently, more investigations on the efficacy of control treatments against eggs are required, particularly in cases in which the eggs are sensibly available and treatable. The absence of information on egg physiology and control contrasted with other life stages is appalling when you consider how significant this life stage is comparable to potential control methods.

CONCLUSION

Metarhizium rileyi (Farlow) biopesticide treatments produced a severe disturbance in the protein metabolism of *H. armigera* eggs. The depletion in protein content was occurred due to the toxic action upon treatment of *N. rileyi* to the eggs of its host, *H. armigera*. Accordingly, *M. rileyi* can be used as natural alternative over synthetic chemical insecticides to control *H. armigera*. The alterations in protein profile could cause physiological imbalances in the host due to *M. rileyi* infection. The biochemical changes

in the protein profiling could be considered as molecular basis of pathophysiology of the pest.

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IDENTIFICATION OF BIOACTIVE COMPOUNDS WITH ANTICANCER PROPERTIES IN *Pleurotus florida*

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ABSTRACT

Pleurotus florida mushrooms have gained immense popularity among nutritionists owing to their medicinal and nutritional properties. In recent times, the consumption of these mushrooms is tremendously increased due to their health benefits. Besides the nutritional qualities,*Pleurotus florida* possess bioactive compounds of high and low molecular weight compounds.

The bioactive fractions were processed using the Shimadzu GC-MS (Model no. Qp2010S) gas chromatography-mass spectrometry method in 2020-21. On comparing the mass spectra and retention indices of the compounds on mushroom extract using ethanol, 14 bioactive compounds were identified. In vitro cytotoxic analysis of the mushroom extract revealed that the mushroom extract possessed promising anticancer effects,and the main biologically active substances of mushrooms may be responsible for direct cytotoxicity towards cancer cell lines such as DLA and EAC cell lines. The percentage of cancer live cells decreases with an increase in the concentration of the sample.

Key words: Anticancer, bioactive, mushrooms, *Pleurotus florida.*

INTRODUCTION

Food insecurity remains the biggest challenge in the world among the lowest and middle-income countries.Therefore, it is important to improve food production among the increasing population. To alleviate poverty and improve the lifestyle of vulnerable sections, mushroom production is a better choice of consideration (Imtiaj and Rahman.,2008). According to Beetz and Kustudia (2004), mushroom production is important to tackle the problem of food shortage. Chandha and Sharma. (1995) reported that the cultivation of mushrooms is a profitable agribusiness, labor-intensiveand eco-friendly. The most efficient and economically viable bio technique is the cultivation of mushrooms. It converts lignocellulose waste materials to high-quality food and this will create new job opportunities, especially in rural areas (Hussain, 2001). Oyster mushrooms are one of the most popular edible mushrooms belonging to the genus *Pleurotus* and the family Pleurotaceae (Kong.,2004). In the Pleurotus genus, more than 40 species existed

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(Kues and Liu., 2000). These mushrooms are grown on various lignocellulosic substrates and form shell-shaped fruiting bodies of high nutritional value. They provide proteins, vitamins, and minerals that are essential for our body. The genus Pleurotusis widely cultivated due to its favorable organoleptic and medicinal properties. It is a simple and low-cost production technology with higher biological efficiency (Chirinang and Intrapichet, 2009).Oyster mushrooms are capable for control the problem of protein malnutrition in developing and underdeveloped countries reported by Chiroro. (2004).

Mushrooms have an antioxidant, anti-tumor (Jose and Janardhanan,2000), antihypertensive, anti-nociceptive (Kudahewa *et al.,* 2008), and hypocholesterolemic/anti-atherogenic properties (Bajaj *et al*., 1997) and are also good for diabetic patients (Chang and Miles, 2004). Traditional medicine present in Oyster mushrooms was considered a functional food and thus showed a positive effect on humans (Synytsya *et al*.,2008; Patel *et al.,* 2012). According to Guillamon *et al.* (2010),and Wasser (2011 and 2014), mushrooms have antineoplastic, antibacterial, antiviral, hypoglycaemic, hypocholesterolemic, and anti-inflammatory and anti-oxidative properties. The health-promoting and therapeutic properties of *Pleurotus* species mushrooms are due to the presence of secondary metabolites,isolated from both oyster mushroom fruiting bodies and mycelia (Morris *et al.,* 2017). The species of *Pleurotus* exhibit multidirectional health-promoting effects as reported in the studies in different centers (Khan and Tania. (2012), Stachowiak and Regula (2012), Deepalakshmi and Mirunalini (2014), Correa *et al.* (2016). The bioactive compounds identified in Pleurotus mushrooms can be divided into high and low molecular weight compounds. High-molecular weight bioactive compounds chiefly encompass polysaccharides, including â-glucans, peptides, and proteins. Low-molecular-weight bioactive compounds include terpenes, fatty acid esters, and polyphenols (Patel and Goyal, 2012). The bioactive substances exhibit immune-stimulatory,anti-neoplastic,anti-diabetic,anti-atherosclerotic,anti-inflammatory, hepatoprotective, and antioxidative properties (Lindequist *et al.*(2005), Alam *et al.* (2009); Jayakumar *et al.* (2011), Wasser (2014).

Mushrooms are recognised as a functional food and as a source for the development of drugs and nutraceuticals (Khatun *et al.,*, 2012) responsible for their antioxidant and antitumor properties (Jones and Janardhanan, 2000). The mushroom extracts are increasingly consumed because of their health beneficial effects including the enhancement of immune function and antitumor activity. Cancer is the most skyrocketed cause of death worldwide now and it is spreading grievously. The concern about mushrooms intrigued researchers to identify drugs that can be effective against cancer. The polysaccharide POPS-1 isolated from *Pleurotus ostreatus* showed in-vitro antitumor activity against Hela tumor cell and compared with 5-fluorouracil, exhibits significantly lower cytotoxicity to human embryo kidney 293T cells than Hela tumor cells. As a result, it may be considered a potential drug for developing a novel low toxicity tumor agent (Tong *et al.,* 2009).

MATERIALS AND METHODS

The bed spawn was procured from Krishi Vigyan Kendra, Thelliyoor and was maintained

under ambient temperature.The *Pleurotus florida* mushroom was cultivated in paddy straw using chemical treatment in the lab of Mar Athanasios College for Advanced Studies,Tiruvalla in 2021. The cultivation of edible mushrooms offers one of the most feasible and economic methods for the bioconversion of agro-lignocellulosic wastes (Cohen *et al.*, 2002).The harvested fresh mushroom was subjected to drying in a mechanical drier. The mushroom dried samples were ground into powder and subjected to reflux distillation in a Soxhlet apparatus for 8 hours. After that, the extract was stored at 4°C for further analysis.The GCMS analysis was performed at Kerala Forest Research Institute, Thrissur on a Shimadzu Qp20105 instrument in 2021. The column, Elite-5MS (Shimadzu)-fused silica capillary column(30 m long x 0.25 mm i.d. x 0.25 µm film thickness, composed of 5% phenyl methyl polysiloxane) was connected to a quadrupole detector operating in EI mode at 70 eV. Helium was used as the carrier gas at a flow of 1 ml/ min. The injector and interface temperatures were maintained at 260°C and 280°C, respectively, and the split ratio was operated at a ratio of 50: 0. The injection volume was 1µl (in ethanol) and the oven temperature program consisted of a ramp from 70°C to 200°C at 3°C/min followed by an increase to 280°C at 10°C/min and ending with 5°C/min at 280°C. The analysis was conducted with a mass range of 50 m/z to 500 m/z. The quantitative result was obtained by integrating the total ion chromatogram (TLC).The mushroom extract constituents were identified by comparing their mass spectra to those from the National Institute of Standards and Technology (NIST) and by comparing the mass spectra and the calculated linear retention indices(RI) with the corresponding values in the literature (WILEY 8).

Cytotoxicity bioassay of ethyl alcohol extract of Pleurotus florida was subjected to analysis. The test compound was studied for a short-term in vitro cytotoxicity using Dalton's Lymphoma Ascites cells (DLA). The tumor cells which was aspirated from the peritoneal cavity of tumor-bearing mice were subjected to washing thrice using PBS(Phosphate buffer saline) or normal saline. The cell viability was determined by the trypan blue exclusion method.Viable cells suspension (1×10^6 cells in 0.1 ml) was added to the tubes containing various concentrations of the test compounds and made the volume to 1ml using a phosphate-buffered cell line (PBS). The control tube contained only cell suspension. These test samples were incubated for 3 hours at 37^0C. The further cell suspension was mixed with 0.1ml of 1% trypan blue kept for 2-3 minutes and loaded on a hemocytometer. The live cells do not take up the dye, whereas, the dead cells take up the blue colour of trypan blue. Then finally counted the number of stained and unstained cells separately.

$$\% \text{ Cytotoxicity} = \frac{No\ of\ dead\ cells}{No\ of\ live\ cells + No\ of\ dead\ cells} \times 100$$

The same procedure is followed for a short-term in-vitro cytotoxicity using Ehrlich's Ascites Carcinoma cells (EAC).

RESULTS AND DISCUSSION

On comparing the mass spectra and retention indices of the compounds on mushroom extract, 14 (bioactive) compounds were identified (Table 1). The extraction was performed using ethanol.

Table 1. Bioactive compounds of *Pleurotus florida*

No. of compounds identified from *Pleurotus florida* Ethanol Extract (PFEE)	Bioactive Compounds	Retention time Seconds or minutes	Base length m/z	Area %	Area%	Height%	Height %
PFEE 1	3-Hydroxy2-methyl Gamma Butyrolactone	8.023	57.05	122492	0.93	53093	1.97
PFEE 2	Diethyl1-methyl-3-hydroxy- 5-phenylpyrrole-2,4-dicarboxylate	8.142	142.00	292321	2.22	32722	1.21
PFEE 3	1,2,3-Benzenetriol	11.365	126.05	194934	1.48	23171	0.86
PFEE 4	Pentadecanoic acid	17.119	73.05	317904	2.42	111635	4.14
PFEE 5	**Hexadecanoic acid**	**18.984**	**73.05**	**2360216**	**17.93**	**573323**	**21.26**
PFEE 6	**9,12-Octadecanoic acid, methyl ester**	**23.022**	**67.05**	**3445525**	**26.17**	**684931**	**25.39**
PFEE 7	**Octadec-9-Enoic acid**	**23.104**	**55.05**	**1620076**	**12.31**	**379710**	**14.08**
PFEE 8	Cysteamine S-Sulfate	23.558	55.05	283044	2.15	93385	3.46
PFEE 9	1(1-Adamantyl)-3-(Dimethylamino)-1-Propanone	29.274	58.05	689790	5.24	215154	7.98
PFEE 10	Octanoic acid,2-dimethylaminoethyl ester	29.342	58.05	131176	1.00	59499	2.21
PFEE 11	1,2 Benzene dicarboxylic acid	30.918	149.00	368218	2.80	131743	4.88
PFEE 12	Trilinolein	33.150	67.05	356876	2.71	82877	3.07
PFEE 13	9(11)-Dehydroergosteryl benzoate	37.416	251.10	154533	1.17	47742	1.77
PFEE 14	**Ergosterol**	**42.176**	**69.05**	**2826439**	**21.47**	**208252**	**7.72**
				13163544	100.00	2697237	100.00

Lindequist *et al.* (2005) stated that the nutritional and chemical composition of mushrooms is responsible for their medicinal values. The bioactive component analysis of edible mushrooms *Pleurotus florida* revealed the presence of bioactive components as represented in Table 1. The occurrence for 9,12-Octadecanoic acid, methyl ester was found to be highest followed by hexadecanoic acid. Fig 1 represents the relative abundance of the identified bioactive compounds in *Pleurotus florida* against their respective retention time in

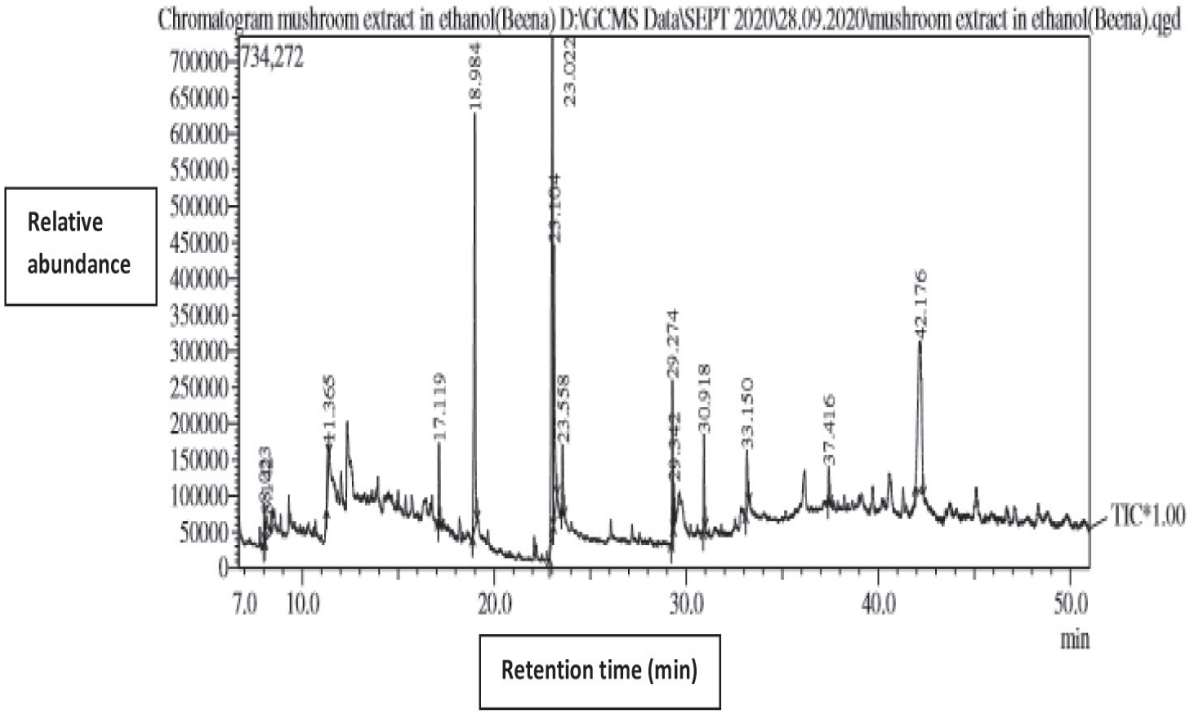

Fig. 1. Chromatogram representation of bioactive compounds anti-cancer activity

minutes. A considerable amount of Octadec-9-Enoic acid was found to be present with a retention time of 23.104 minutes. We also investigated the sterol composition in Pleurotus florida species. As expected, the predominant sterol in *Pleurotus florida* was ergosterol possessing a delta 7 double bond. In addition, the other sterols were present in substantial quantities such as 9(11)-Dehydroergosteryl benzoate.

Pleurotus florida mushroom is composed of several bioactive compounds which showed profound anticancer activity against various cancer cell lines aspirated from the peritoneal cavity of tumor-bearing mice. The results of the test compounds were studied for a short-term in vitro cytotoxicity using Dalton's Lymphoma Ascites cells (DLA) (Table 2).

Table 2. Effect of mushroom on in-vitro cytotoxicity using Dalton's Lymphoma Ascites cells (DLA)

Drug concentration (g/mL)	% Cytotoxicity - Sample A
10	14 ± 1.5
20	18.9 ± 1.5
50	56.7 ± 1.7
100	85.7 ± 1
200	95.1 ± 0.8

The results revealed (Table 2) that the mushroom sample was cytotoxic against Dalton's lymphoma Ascites cells. The percentage of cancer live cells decreases with an increase in the concentration of the sample. A dose of 200 g/ml and 100 g/ml of the sample showed the

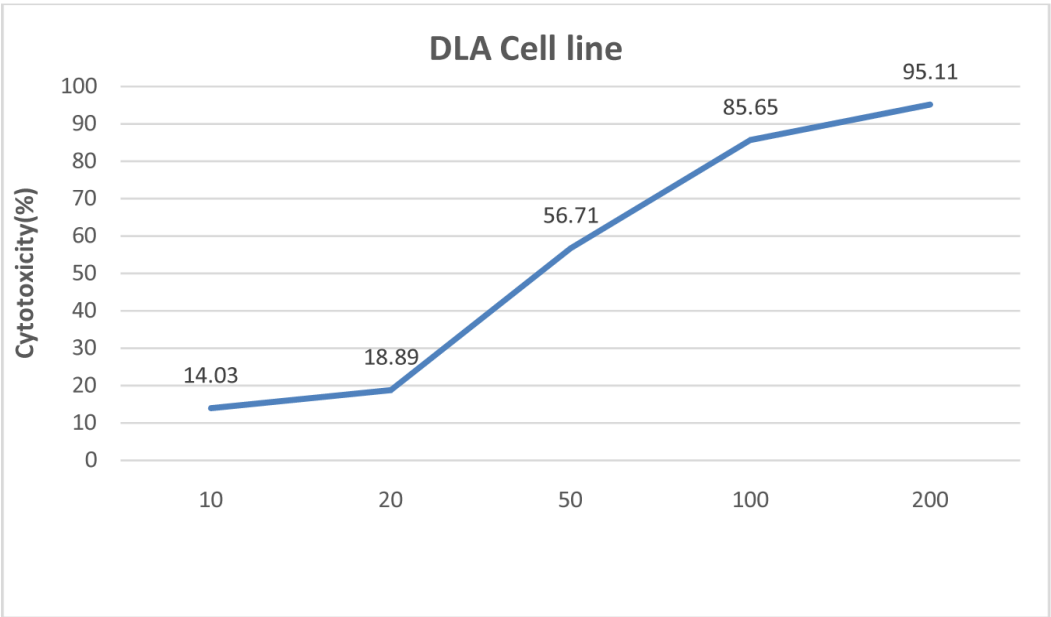

Fig. 2. Graphical representation of the cytotoxicity effect of *Pleurotus florida* bioactive compounds against DLA cell line

highest cytotoxicity percentage of 95.1±0.8% and 85.7± 1%, respectively in DLA cell lines. The dosage of 50 g/ml was observed to have 56.7% cytotoxicity in the DLA cell line. However, lower doses of 10 g/ml and 20 g/ml of the sample showed a lower percentage of cytotoxicity in cell lines. According to Sala Uddin *et al.* (2015), *Pleurotus ostreatus* has potent anticancer activity. Cibacron blue affinity-purified protein (CBAEP) extracted from *Pleurotus ostreatus*, has shown to have potent anti-cancer, immune-modulatory, and antitumor activity against Dalton lymphoma (DL) bearing mice, Sarcoma-180, and B16F0 melanoma tumor-bearing mice in the In-vitro study and in-vivo study. According to Maiti *et al.* (2011), CBAEP reduced about 35.68 and 51.43% Dalton lymphoma (DL) cell growth in 5 mg/kg and 10 mg/kg body weight, respectively and activated immune suppression conditions in DL-tumor bearing mice.

Effect of in-vitro cytotoxicity of *Pleurotus florida* mushroom against Ehrlich Ascites carcinoma

Table 3. Effect of mushroom on in-vitro cytotoxicity using Ehrlich Ascites carcinoma

	Drug concentration (g/mL)	% Cytotoxicity - Sample A
1.	10	13.95 ± 0.9
2.	20	18.56 ± 1.1
3.	50	57.04 ± 0.8
4.	100	77.73 ± 0.8
5.	200	94.89 ± 1.7

The data summarized in Table 3 reveals that the mushroom sample was cytotoxic against Ehrlich Ascites carcinoma. The percentage of cancer live cells decreases with an increase in the concentration of the sample. A dose of 200

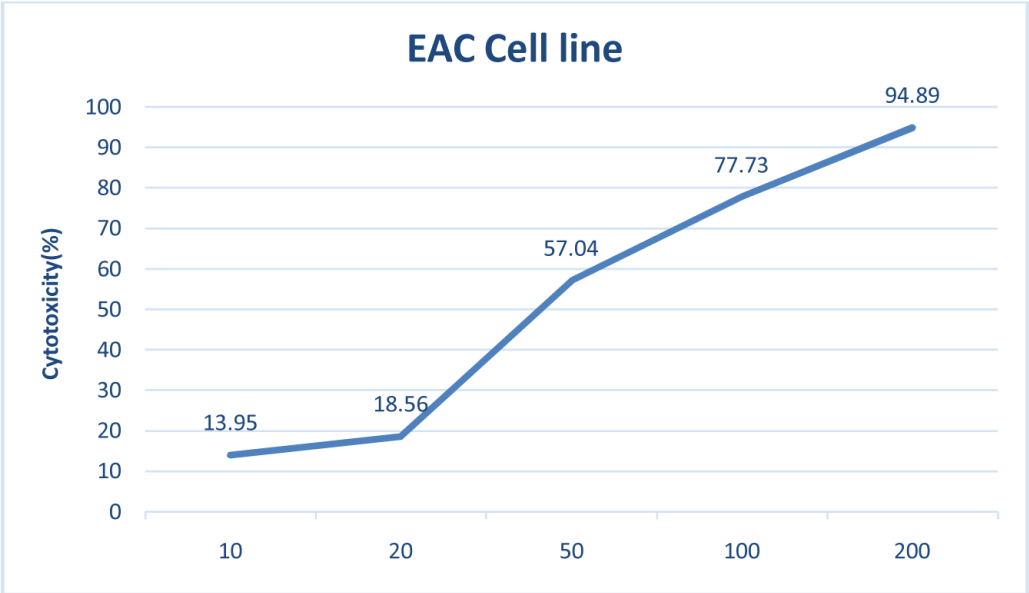

Fig. 3. Graphical representation of the cytotoxicity effect of *Pleurotus florida* mushroom against EAC cell line

g/ml of the sample showed the highest percentage of 94.89 ± 1.7 cytotoxicities in the EAC cell line. On analysis, the dose with a 100 g/ml mushroom sample was observed to have 57.04 ± 0.8 % cytotoxicity in the EAC cell line. Wolff *et al.* (2008) reported that the polysaccharide extract from *Pleurotus ostreatus* exhibited inhibitory results to the development of Ehrlich ascitic tumor cells and reduced the neoplastic cells at the level of 76% in the female swiss albino mice. However, lower doses of 20 g/ml and 10 g/ml of the sample showed a lower percentage of 18.56% and 13.95% of cytotoxicity in cell lines. The antitumor activity was found to be due to the bioactive compound, ergosterol isolated from the *Pleurotus florida* mushroom sample. The results corroborate with the findings of Takaku *et al.* (2001), who reported that the antitumor activity in *Agaricus blazie* was found to be due to the lipid fraction ergosterol. Facchini *et al.*(2014) proved that polysaccharides extracted from the *Pleurotus ostreatus* mycelium successfully inhibited the development of neoplastic cells of Ehrlich tumor and sarcoma 180.

CONCLUSION

Pleurotus florida mushrooms possess 14 identified bioactive substances and thesebioactive compounds showed profound anticancer activity against the DLA cell line and EAC cell line. The results revealed that mushroom samples were cytotoxic against Dalton's lymphoma Ascites cells and Ehrlich Ascites carcinoma. The anticancer activity was found to be due to the bioactive compounds, ergosterol isolated from the *Pleurotus florida* mushroom sample.The identification of the anticancer effect of these substances tested in tumor-bearing mice would give a possibility to take full advantage of the health-promoting and anticancer potential of the *Pleurotus florida* mushroom.

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YIELD CONTRIBUTING TRAITS OF QUINOA (*Chenopodium quinoa*) GENOTYPES USING MULTIVARIATE STATISTICS

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ABSTRACT

The study was carried out during the *rabi* seasons of 2019 and 2020 to evaluate promising genotypes of *Chenopodium quinoa* to compare the grain yield potential, variability and genetic relationship between different component traits. Genotypic coefficient of variation, the highest value was observed for seed yield (21.33) while lowest was observed for days to 50% flowering (1.45). Heritability was for plant height (95.49) and maximum genetic gain was observed for seed yield (32.85). High heritability coupled with high genetic advance was observed for seed yield, leaf width and seed weight (g/10ml). Days to 50% flowering had significant positive correlation with leaf length, plant height, days to maturity and seed weight (g/10ml) but a significant negative correlation with seed yield. Number of branches per planthad a significant positive correlation with inflorescence length. Step-wise regression indicated that days to 50% flowering, inflorescence length and seed weight (g/10ml) play significant role in deciding seedyield in quinoa as predictor variables. A set of eight qualitative traits could efficiently discriminate cultivars in PCA (explaining 70.90% of total variation), suggesting that it can serve as a valuable breeding tool for the characterization.

Keywords: *Chenopodium*, Correlation, Genetic Variability, Principal Component Analysis

INTRODUCTION

Chenopodium quinoa Willd. pertains to family Amaranthaceae with chromosome number 2n=4x=36, falls under the genus chenopodium, often known as goosefoot genus (Giusti.,1970). It is an essential pseudo cereal for worldwide food security and used as a staple food. Also plays an important role in the combate of hidden hunger. This halophytic crop is an annual broad leaved with deep penetrating roots and are adapted to different types of soil and climatic conditions. It manifests high level of resistance to multiple abiotic and biotic stresses (Hussain *et al*., 2020). Grain of quinoa being rich in antioxidants and wide range of minerals, vitamins, iron, calcium and dietary fibres and outstanding protein quality makes it highly nutritious (Miranda *et al.,* 2012). The grain

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protein is rich in amino acids such as lysine and methionine that are deficient in cereals (Bhargava *et al.,* 2003). Quinoa has high values of protein, lipids and minerals in comparison to important cereals *viz*., wheat, rice, corn, barley, oats, rye and sorghum which are used in the human diet worldwide (Koziol, 1992 and Dini *et al*., 1992). Average composition of the quinoa grains when compared with cereals (g 100g-dm) -lipids 7.0, protein 16.3, ashes 2.7, dietary fibers 7.0, carbohydrate 74.0.The grain is used to soup, make flour, cereal, alcohol and breakfast, while the flour is utilized in making processed food, biscuits and bread. It also has versatile industrial applications due to high viscous starch with small grains. It is autogamous with low out-crossing rate and small size flower provide obstacles for emasculation and hybridization. However, two behaviours *viz*., male sterility and gynomonoecious nature available in some cultivated varieties which help for making desirable crosses. Diversification of future agricultural systems, especially in Chhattisgarh, Madhya Pradesh, Rajasthan and North Indian Plains can be achieved by introducing nutri-reach potential crops such as quinoa.

Development of elite lines in any crop species requires selection from desirable germplasm and suitable parents for crossing. Recognizing its recent demand andimportance, there is a definite need for its genetic improvement. Hence, the investigation was carried out to evaluate thepromising genotypes of *C. quinoa* to ascertain its prospects of cultivation in the Chhattisgarh. Simultaneously, the studies of genetic parameters, correlation among the different traits have been done for the genetic gain of its yield through yield contributing traits.

MATERIALS AND METHODS

The field experiments were conducted in the experimental field of the Raj Mohini Devi CARS, Ambikapur (Chhattisgarh) during the *rabi* seasons of 2019 and 2020. Thirteen *Chenopodium* genotypes under All India Coordinated research network project on potential crops were used in the study (EC-507742, EC-507746, EC-507739, EC-507738, EC-507747, IC-411824, EC-507743, EC-507740, EC-507748, EC-507749, EC-507744, IC-411825, EC-507741). Randomized block design was replicated four times at the spacing of 30 cm X 15 cm were used for constitution of the experiment. All the recommended package of practices for the region was followed to raise a good crop (Yadav *et al*., 2017). Data on nine yield attributing characters namely, days to 50% flowering, number of branches per plant, inflorescence length(cm), leaf Length(cm), leaf width (cm), plant height (cm),days to maturity, seed weight (g/10ml), seed yield (q ha^{-1}). Data were analysed with the help of computer software STAR 2.0.1 for windows.

RESULTS AND DISCUSSION

The overall means for the nine traits across thirteen quinoa genotypes is presented in Table 1, which showed a good variation among the genotypes for each trait. Among the13 genotypes, days to 50% flowering (DF) varied from 73 to 84 with a mean of 78.17, Days to maturity (DM) varied from 118 to 133 with a mean of 125.94 and plant height (PH) varied from 50.60 cm to 107.60 cm with a mean of 75.04 cm. Inflorescence length (IL) varied from 17.00 cm to 27.60 cm with a mean of 21.41. Mean number of branches per plant (NBP) was1.60 and varied from 1 to 2.60. Seed weight (SW) per 10ml varied

from 3.00 g to 08.50 g with an overall mean of 06.54 g. Similarly, seed yield (q ha^{-1}) ranged from 5.56 to 21.11 with a mean of 14.76.

Phenotypic coefficient of variation was observed highest for seed yield (28.53), followed by number of branches per plant (21.26), seed weight (g/10ml) (15.25), plant height (12.97), whereas, it was found lowest for days to maturity (3.07). Highest value genotypic coefficient of variation was observed for seed yield (21.33), followed by seed weight (g/10ml) (10.83), leaf width (7.92), number of branches per plant (7.89), plant height (6.78), inflorescence length (6.53); While lowest was observed for days to 50% flowering (1.45). High heritability estimates were exhibited by plant height (95.49), followed by seed yield (57.88), seed weight (g/10ml) (55.70). Selection based on phenotypic performance was done by utilizing these characters would be reliable because it is least influenced by environmental changes.

Additive gene action with high heritability leads to guarantee large gain from selection unless high heritability alone does not provide sufficient genetic gain. Genetic advance in a trait is a product of heritability and selection differential and expressed in unit of standard deviation, has an added advantage over heritability as a guiding factor in selection programmes, where improvement of characters is desired. Maximum genetic gain was observed for seed yield (32.85), followed by seed weight (g/10ml) (15.86), while minimum gain was observed for days to 50% flowering (2.28). High heritability coupled with high genetic advance was observed for seed yield, leaf width and seed weight (g/10ml). It indicates that genotypic variance for these characters might be due to additive gene effects. Hence, the desired gain can be obtained by selection of characters based on phenotypic performance. Comparable results were observed by Bhargava *et al.* (2003) where high heritability was coupled with moderate genetic advance for inflorescence length, grain yield, stem diameter, primary branches per plant, and number of inflorescence per plant and dry weight of plant.

Estimation of correlation coefficients and regression analysis

Correlation coefficients were estimated amongnine traits (Table 2). Days to 50% flowering had significant positive correlation with leaf length, plant height, days to maturity and seed weight (g/10 ml) but a significant negative correlation with seed yield. Number of branches per planthad a significant positive correlation with inflorescence length.Leaf length was significantly associated with plant height, leaf width and days to maturity. Plant height had a significant correlation with days to maturity and significant negative correlation with seed yield. Inflorescence length had significant negative correlation with seed weight (g/10 ml). Bhargav *et al*. (2003) also reported that seed yield has negative correlation with inflorescence length. This study suggested that days to 50% flowering, leaf lengthand plant height had strong positive correlation with all the traits so simultaneous improvement of both the associated characters will be achieved, if used in the selection criterion.

Stepwise regression of seed yield (q ha^{-1}) with nine other quantitative characters contributing to yield was estimated in 13 chenopodium genotypes considering seed yield as dependent variable and other eight characters as estimator variables. This analysis

Table 1. Mean performance for seed yield and its components traits in Chenopodium

Characters	Unit	Abbre -viation	Min.	Max.	Mean	SE (±)	GCV	PCV	Heritabi- lity (h^2)	GA	GA(% mean)
Days to 50% flowering	Days	DF	73.00	84.00	78.17	3.09	1.45	1.91	57.88	1.84	2.28
Number of branches per plant	Nos.	NBP	1.00	2.60	1.60	0.30	7.89	21.26	13.77	0.09	6.03
Inflorescence length	Cm	IL	17.00	27.60	21.41	1.92	6.53	9.85	43.88	1.87	8.91
Leaf Length	Cm	LL	4.20	7.30	6.09	0.57	4.29	7.77	30.45	0.31	4.87
Leaf width	Cm	LW	3.18	5.40	4.26	0.53	7.93	11.17	50.32	0.49	11.58
Plant Height	Cm	PH	50.60	107.60	75.04	12.57	6.78	12.98	27.32	6.07	7.30
Days to maturity	Days	DM	118.00	133.00	125.94	4.01	3.00	3.07	95.49	7.69	6.04
Seed weight (g/10ml)	G	SW	3.00	8.50	6.54	1.35	10.83	15.25	50.48	1.11	15.86
Seed yield	q/ha	SY	5.56	21.11	14.76	3.66	21.33	28.54	55.70	0.16	32.85

Table 2. Correlation coefficient between seed yield and its components in Chenopodium

Character	Days to 50% flowering	Number of branches per plant	Inflorescence length	Leaf length	Leaf width	Plant height	Days to maturity	Seed weight (g/10ml)	Seed yield
Days to 50% flowering	1								
Number of branches per plant	-0.147	1							
Inflorescence length	-0.214	0.270*	1						
Leaf length	0.317**	-0.051	0.026	1					
Leaf width	0.096	-0.120	-0.157	0.259*	1				
Plant height	0.517**	0.139	0.215	0.361**	0.015	1			
Days to maturity	0.295**	0.107	-0.026	0.246*	-0.111	0.396**	1		
Seed weight (g/10ml)	0.336**	-0.006	-0.290**	0.140	0.030	0.197	0.066	1	
Seed yield	-0.276*	0.130	-0.041	-0.017	0.122	-0.331**	-0.184	0.027	1

* 5% level and ** 1% level of significance

Table 3. Principal components (PCs) for 12 quantitative traits in Chenopodium

	PC_1	PC_2	PC_3	PC_4	PC_5
Standard deviation	1.6412	1.3343	1.2280	1.0528	0.9094
Proportion of Variance	0.2693	0.1780	0.1508	0.1108	0.0827
Cumulative Proportion	0.2693	0.4474	0.5982	0.7090	0.7917
EigenValues	2.6935	1.7804	1.5079	1.1083	0.8271
Days to 50% flowering	-0.4288	-0.3079	-0.0539	-0.0936	-0.0419
Number of branches per plant	0.0618	0.1150	0.5775	-0.2617	-0.3210
Inflorescence length	0.0048	0.3689	0.4999	0.3120	-0.2316
Leaf length	-0.2443	-0.3707	0.2352	0.4002	0.1177
Leaf width	0.0234	-0.3952	-0.0993	0.5969	-0.2363
Plant height	-0.4444	-0.0915	0.3568	0.0401	-0.1509
Days to maturity	-0.3158	-0.0803	0.2910	-0.2051	0.6954
Seed weight (g/10ml)	-0.1621	-0.3968	-0.0781	-0.5036	-0.4865
Seed yield	0.4632	-0.3791	0.2537	-0.0849	0.1122

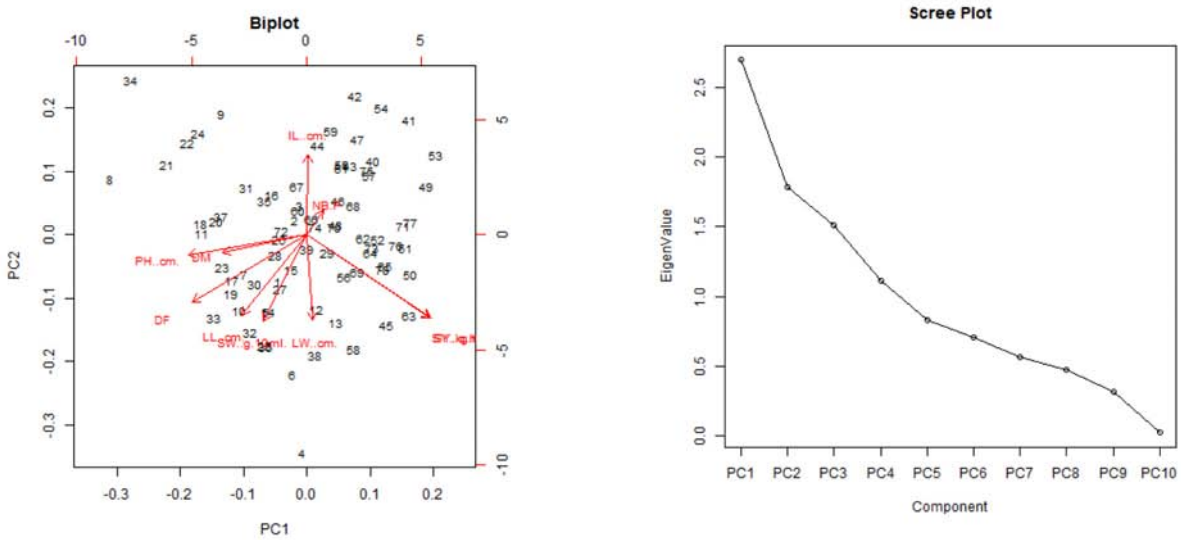

Fig. 1. Bioplot and scree plot constructed for 10 principle components in quinoa

indicated that days to 50% flowering, inflorescence length and seed weight (g/10 ml) play significant role in deciding seed yield in quinoa as predictor variables. The model fitted for seed yield (q ha^{-1}) in this study is as follows:

Seed yield (q ha^{-1})=-5.40+(0.06×DF)+ (0.12 IL) + (-0.02 PH) + (0.12 SW)

Principal component analysis

Principal component analysis is a widely-used statistical tool to analyse genetic variation among plant genotypes and determining the mostimportant variables contributing to variation (Price *et al*., 2006). In the study, first four principal components present in the data, first principal component considered as the most important component which explained 26.93% of the total variance (Table 3, Fig. 1). Important eigen vectors for PC1 were seed yield, number of branches per plant, inflorescence length and leaf width. The second principal component contributed 17.81% of the variation amonggenotypes. PC2 was positively defined by number of branches per plant and inflorescence length, while negative influence was noticed for rest of the traits. The third principal component accounted for 15.08% of the total variance, and was positively influenced by seed yield, number of branches per plant, inflorescence length, leaf length, plant height and days to maturity. Fourth component contributed 11.08% of variance, and was positively influenced by inflorescence length, leaf length, leaf width and plant height. Manjarres-Hernandez *et al*.(2021) reported that principal component analysis among the quantitative variables in the 30 quinoa accessions showed that 68.6% of the total variance was explained by the first two components in which PC1 included plant height, length, diameter, number of panicles, whereas, weight of 1000 seeds, stem, diameter and seed diameter in PC2.

CONCLUSION

Quinoa has huge variation for selected traits along with high heritability. Therefore, it is concluded that the characters which showed high genotypic value coupled with high heritability and genetic advance should be considered for direct selection. An ample scope for improvement of

yield and other associated characters especially, inflorescence length, plant height and seed weight. These traits should be used while selecting elite genotypes of quinoa.

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SEASONAL INCIDENCE OF PINK BOLLWORM *Pectinophora gossypiella* (Saunders) IN COTTON

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ABSTRACT

The field experiment was carried out during *Kharif* 2020-21 at Regional Agricultural Research Station, Lam, Guntur. The research revealed that the peak activity of moth was observed during the third week of December (51 SMW) with a trap catch of 441 moths/trap/week. The incidence of larvae in green bolls was noticed from first fortnight of November (46 SMW) and increased gradually during the first fortnight of December (51 SMW). The Green boll damage caused by pink bollworm ranged between 20 percent and 90 percent with a mean of 26.52 percent. The Green locule damage caused by pink bollworm ranged between 12.5 percent and 68.5 percent with a mean of 17.65 percent. The population of pink bollworm larvae per 10 Green bolls ranged between 2 to 14 with a mean of 3.13 Larvae per 10 green bolls. It first appeared during second week of November (46 SMW). The highest population of Larvae per 10 green bolls (14 Larvae per 10 green bolls) was observed at the time of third week of December (51 SMW). The Pink bollworm Larvae per 10 green bolls have showed significant negative correlation with minimum temperature (r= -0.661) and morning relative humidity (r= -0.524).

Key Words: Boll damage, Cotton, Pheromone trap catch, Pink bollworm

INTRODUCTION

Cotton is a fibre crop that produces natural fibre and is grown as an annual crop in both tropical and warm temperate regions (Rahman *et al.,* 2012). It has been commercially grown for domestic consumption and export purposes of 111 countries around the world (Srinivas *et al.*, 2018). It supplies seeds with a potential multi-product base such as hulls, oil, lint, and animal fodder, in addition to textile manufacture (Ozyigit *et al*., 2007).

Gossypium hirsutum, *G. herbaceum, G. arboreum*, *G. barbadense* are four spinnable fibre producing *Gossypium* species that are commercially grown. It provides up to 75 percent of the textile industry‘s entire raw material demands and employs around 60 million people (Sandhya rani *et al*., 2010). After China, India is

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the world's second-largest producer of cotton, accounting for 36 percent (118.72 lakh hectare) of total area and 25 percent (352 lakh bales) of seed cotton. Cotton productivity in India is 504 kg/ha, which is poor when compared to the global average of 786 kg $ha^{-1.}$

As per the USDA Foreign Agricultural Service in Mumbai cotton acreage of 12.35 million hectares and production of 28.35 million bales of 480 lbs of cotton for the marketing year 2018-19. Cotton is grown in India's nine major cotton growing states: Punjab, Haryana and Rajasthan in Northern zone, Gujarat, Maharashtra and Madhya Pradesh in Central zone and Andhra Pradesh, Karnataka, and Tamil Nadu in Southern zone. The different cotton growing districts in Andhra Pradesh are Guntur, Krishna, Chittoor, Nellore, Kadapa, Prakasam, Anantapur, Kurnool, with an area of 6.17 lakh ha and with production of 1.05 million bales and productivity of 1713 kg ha^{-1}. Cotton productivity in India was lower than the world average (786 kg $ha^{-1)}$ due to the variety of insect pests that attack cotton. Around 162 bug species infest crops at various phases of development, with 15 of them being major pests (Kannan *et al.,* 2004).

The bollworms (Dhruva and Gujar, 2011) namely Pink bollworm, *Pectinophora gossypiella (*Saunders), Cotton leaf worm, *Spodoptera litura* (Fabricius), Spiny bollworm, *Earias insulana* (Boiusduval), Spotted bollworm, *Earias vittella* (Fabricius) and American bollworm, *Helicoverpa armigera* (Hubner) normally referred as bollworm complex, pose greater threat to cotton production (Ghosh, 2001; Kranthi, 2015).

The use of synthetic insecticides to control insect pests in cotton has been used for many years and was hailed as a blessing during the green revolution. The sole dependence on synthetic insecticides, notably pyrethroids (Ramasubramanyam, 2004), created an imbalance in the agro-system, resulting in resistance and resurgence issues that necessitated the employment of other control methods. Insecticide application in cotton varies from 6-8 rounds in a rainfed scenario to 12-18 rounds in an irrigated situation on average (Kulkarni *et al.,* 2003). Bollworm control alone accounts for roughly 80% of the insecticide market, valued around 12 billion rupees, and about one-third of current pesticide sales (Gupta, 2001).

MATERIALS AND METHODS

The field experiments were conducted at Regional Agricultural Research Station, Acharya N.G. Ranga Agricultural University, Lam, Guntur (Andhra Pradesh), during *kharif 2020*-21.

Experimental details

The experiment was designed as observational trial with cotton hydrid DCH-32 was sown in *kharif* 2020 with a planting distance of 105 cm × 60 cm in a plot size of 378 m^2 with 40 plants per row and 600 plants per plot. The fertilizer dose of N:P:K 48 kg, 24 kg and 24 kg was given respectively during the cropping season.

Pheromone trap catch

At Regional Agricultural Research Station, Lam, Guntur, two pheromone baited sleeve traps were constructed at 1-2 m height in bulk plots depending on the crop stage to monitor the pink bollworm adult emergence from the first week of September 2020 to the end of March 2021. Pheromone lures were procured from Pheremone Chemicals Private Ltd., Hyd and

lures were changed every 15 days. Catches of adult moths were recoreded on a daily basis.

Field incidence

Cotton fruiting bodies were sampled at weekly intervals to investigate the association between pheromone trap catches and field incidence of pink bollworm. Ten green bolls were randomly selected from the experimental plot for this purpose. By destructive sampling of green bolls, boll damage % and larvae of PBW were recorded.

Percent Green Boll Damage

The number of healthy and damaged bolls by pink bollworm were counted on randomly selected five plants and the following formula was used to calculate the % green boll damage

$$\text{Green boll damage(\%)} = \frac{\text{No. of green bolls damaged}}{\text{Total no. of green bolls}} \times 100$$

Number of larvae / 10 green bolls

10 green bolls were chosen at random from the plot and dissected them and counted the number of larvae per 10 bolls

$$\text{Larval population (\%)} = \frac{\text{No. of larvae in green bolls}}{\text{Total no. of green bolls}} \times 100$$

Open boll damage

At the time of each picking, number of healthy and damaged bolls were recorded from five randomly selected plants from the plot. Percent open boll damage was worked out by the formula

$$\text{open boll damage (\%)} = \frac{\text{Total no. of good open bolls /plant}}{\text{Total no. of open bolls/plant}} \times 100$$

Open locule damage

At the time of each picking, number of healthy and damaged locules were counted from five randomly selected plants from the plot. Percent locule damage was worked out by the following formula

$$\text{Open Locule damage} = \frac{\text{Total no. of damaged locules}}{\text{Total no. of locules}} \times 100$$

Influence of weather factors on the buildup of pink bollworm

The data on percent green boll locule damage and larval occurrence were pooled by standard week wise and correlated with significant meteorological parameters for the corresponding standard week. Counts of male moths collected in the traps were pooled standard week wise and statistically correlated with weather parameters *viz*.,maximum temperature, minimum temperature, rainfall, number of rainy days, morning and evening relative humidity. Regression studies were also worked between trap catch Vs weather parameters, percent green boll locule damage vs weather parameters and larval incidence Vs weather parameters using OPSTAT statistical package.

RESULTS AND DISCUSSION

Larvae/ 10 green bolls

Pink bollworm larvae per ten green bolls ranged between 2 to 14 with a seasonal mean of 3.13 larvae per 10 green bolls (Fig.1). It first appeared during second week of November (46

SMW). The highest population of larvae per 10 green bolls (14 larvae per 10 green bolls) was observed at the time of third week of December (51 SMW).

The pink bollworm larvae per 10 green bolls showed substantial significant and negative correlation with minimum temperature (r=-0.661) and morning relative humidity (r= -0.524).

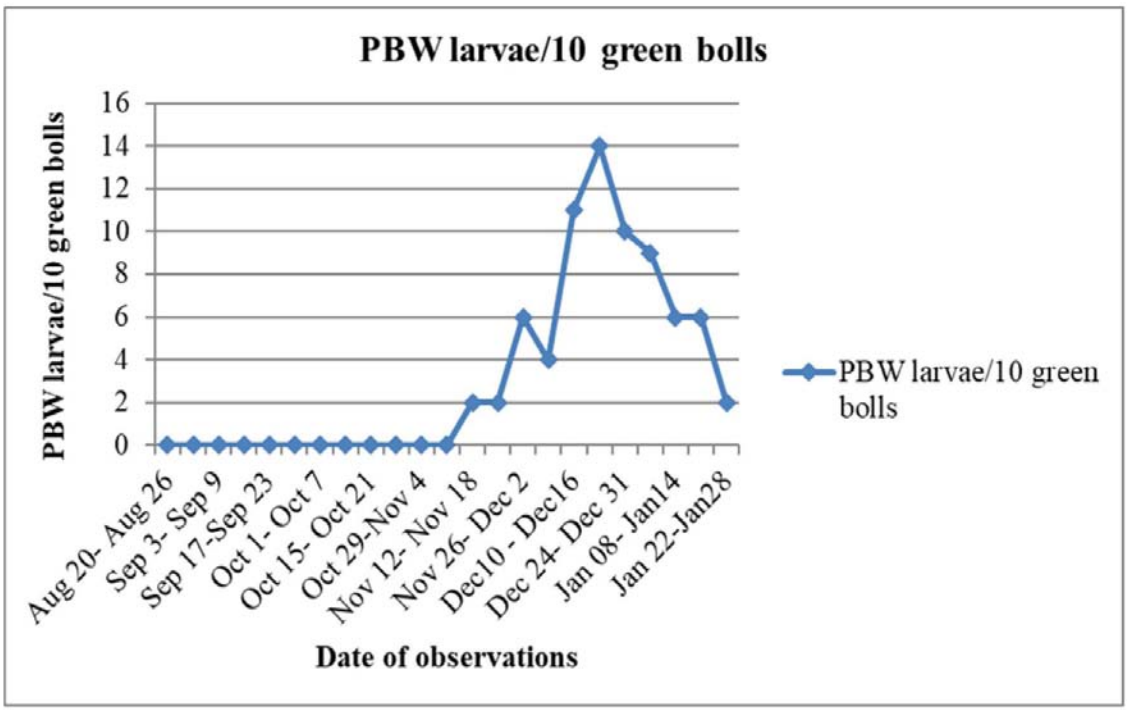
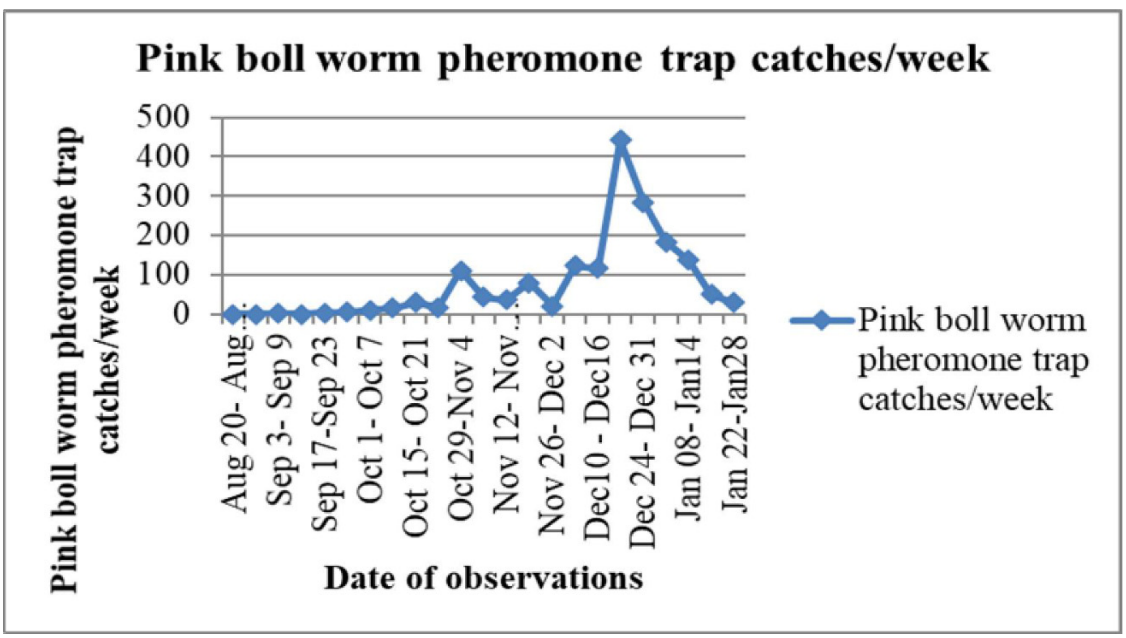


Fig.1. Mean population of Pink bollworm, *Pectinophora gossypiella* on cotton crop during *kharif* season of 2020



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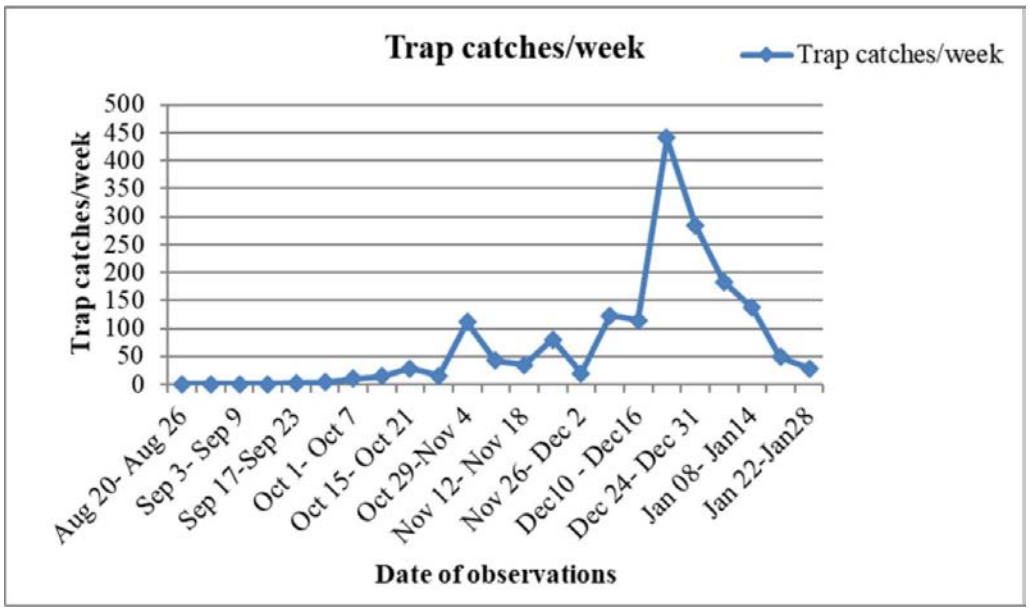

Fig. 2. Mean population of pheromone trap catches/week on cotton crop during *Kharif* season of 2020-21

Pink bollworm pheromone trap catches (moths/trap/week)

The pink bollworm moth catches ranged between 1 to 441 moths/trap/week with a seasonal mean of 75.17 moths/trap/week (Fig. 2). It was first appeared during first week of September (36 SMW). The highest moth catches (441 moths/trap/week) was observed at the time of third week of December (51 SMW).

The pink bollworm moth catches/week showed significant and negative correlation with minimum temperature (r= -0.454), morning

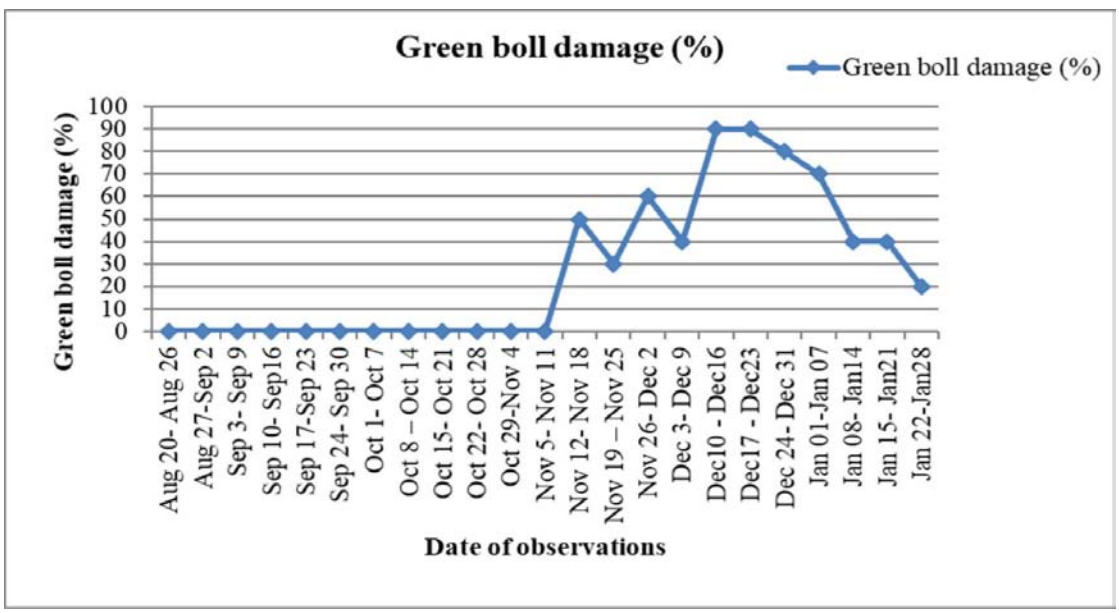

Fig. 3. Mean population of Green Boll damage (%) on cotton crop during *kharif* season of 2020-21

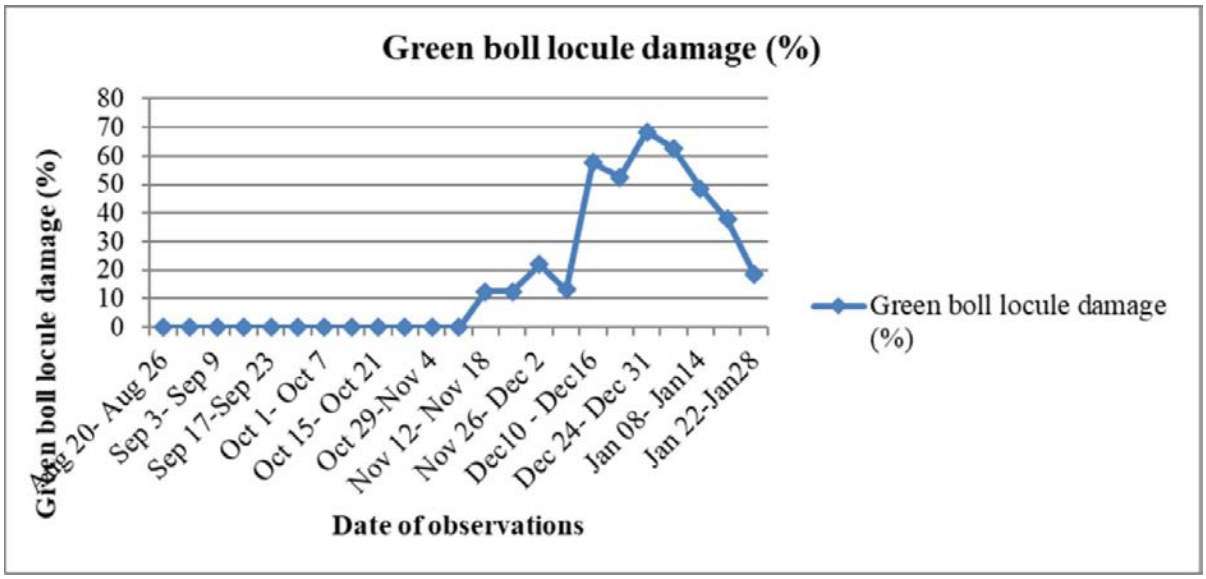

Fig. 4. Mean population of Green boll locule damage (%) on cotton crop during *kharif* season of 2020-21

relative humidity (r= -0.699) and rainfall (r= -0.459).

Green Boll damage (%)

The Green Boll damage caused by pink bollworm ranged between 20 % and 90 % with a seasonal mean of 26.52 percent (Fig. 3). It was first appeared during second week of November (46 SMW). The highest Green Boll damage (90 percent) was observed at the time of second week of December (50 SMW).

The Green boll damage showed significant and negative correlation with minimum temperature (r= -0.729) and morning relative humidity (r= -0.505).

Green boll locule damage (%)

Pink bollworm damage to Green boll locules ranged from 12 percent to 68.5 percent with a seasonal mean of 17.6 percent (Fig. 4). It was first surfaced in the second week of November (46 SMW). The highest green locule damage (68.5 percent) was recorded at the time of fourth week of December (52 SMW).

The percent Green boll locule damage caused by pink boll worm was significantly correlated with minimum temperature (r= -0.413) and morning relative humidity (r= -0.564).

The larval population of pink bollworm per 10 green bolls ranged between 2 to 14 with a seasonal mean of 3.13 larvae per 10 green bolls and showed showed significant and negative correlation with minimum temperature (r= -0.661) and morning relative humidity(r=-0.524). It was first surfaced in the second week of November (46 SMW). The highest population of Larvae per 10 green bolls (14 Larvae/10 green bolls) was observed at the time of third week of December (51 SMW).

The Green Boll damage caused by pink bollworm ranged between 20 to 90 percent with a seasonal mean of 26.52 percent. It was first surfaced in the second week of November (46

Table 1. Seasonal incidence of pink bollworm on cotton crop during *kharif* 2020-21 at RARS, Lam

SMW No.	Duration	PBW larvae/10 green bolls	PBW moth catches/ trap/week	Green boll damage (%)	Green locule damage (%)
34	Aug 20- Aug 26	0	0	0	0
35	Aug 27-Sep 2	0	0	0	0
36	Sep 3- Sep 9	0	1	0	0
37	Sep 10- Sep16	0	0	0	0
38	Sep 17-Sep 23	0	3	0	0
39	Sep 24- Sep 30	0	4	0	0
40	Oct 1- Oct 7	0	10	0	0
41	Oct 8 – Oct 14	0	15	0	0
42	Oct 15- Oct 21	0	29	0	0
43	Oct 22- Oct 28	0	16	0	0
44	Oct 29-Nov 4	0	111	0	0
45	Nov 5- Nov 11	0	43	0	0
46	Nov 12- Nov 18	2	35	50	12.5
47	Nov 19 – Nov 25	2	80	30	12.5
48	Nov 26- Dec 2	6	20	60	21.95
49	Dec 3- Dec 9	4	123	40	13.15
50	Dec10 - Dec16	11	115	90	57.57
51	Dec17 - Dec23	14	441	90	52.5
52	Dec 24- Dec 31	10	284	80	68.5
1	Jan 01-Jan 07	9	184	70	62.8
2	Jan 08- Jan14	6	137	40	48.6
3	Jan 15- Jan21	6	49	40	37.7
4	Jan 22-Jan28	2	29	20	18.35

Table 2. Correlation between pink bollworm (*Pectinophora gossypiella*) and weather parameters

Particulars	Weather parameters				
	Max Temp (°C)	Temp Min (°C)	Morning RH (%)	Evening RH (%)	Rainfall (mm)
Pink bollworm larvae/10 green bolls	-0.363	-0.661**	-0.524*	-0.408	-0.351
Green boll locule damage (%)	-0.407	-0.413*	-0.564**	-0.355	-0.403
Pink bollworm pheromone trap catches/week	-0.345	-0.454*	-0.699**	-0.338	-0.459*
Green Boll damage (%)	-0.379	-0.729**	-0.505*	-0.445	-0.349

SMW). The highest Green Boll damage (90 percent) was observed at the time of second week of December (50 SMW). The Green Boll damage showed significant and negative correlation with minimum temperature (r= -0.729) and morning relative humidity (r= -0.505).

The Green locule damage caused by pink bollworm ranged between 12.5 to 68.5 percentwith a seasonal mean of 17.65%. It was first surfaced in the second week of November (46 SMW). The highest Green locule damage (68.5 percent) was observed at the time of fourth week of December (52 SMW) and showed significant and negative correlation with minimum temperature (r= -0.413) and morning relative humidity (r= -0.564).

The Pink bollworm moth catches/week ranged between 1 to 441 moths/trap/week with a seasonal mean of 75.17 moths/trap/week. It first surfaced in the first week of September (36 SMW). The highest pink bollworm moth catches/ week (441 moths/trap/week) was observed at the time of third week of December (51 SMW).

CONCLUSION

The pink bollworm larvae per 10 green bolls, percent green boll damage with an average seasonal mean of 26.52, percent green boll locule damage with a mean of 17.65 and pheromone trap catches per week with a seasonal mean of 75.17 showed significant negative correlation with minimum temperature and morning relative humidity.

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EFFICACY OF DIFFERENT SEED TREATMENTS AGAINST *Aspergillus niger*

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ABSTRACT

Efficacy of various fungicides and bio-control agents against *Aspergillus niger* affecting groundnut was tested. Groundnut seed of 13 varieties *viz*., Abhaya, Amaravati, Chitravati, Dharani, Haritandhra, ICGV 00 350, Kadiri 6, Kadiri 9, Narayani TAG 24, TCGS 1073, TCGS 1616 and TCGS 1694 was artificially inoculated by soaking in conidial suspension of *A. niger* @ 10^6 conidia ml^{-1} for 20 min, dried at room temperature and then treated with fungicides *viz*., mancozeb @ 3 g kg^{-1}, carbendazim @ 2 g kg^{-1}, tebuconazole @ 1 g kg^{-1}, carboxin+thiram @ 2 g kg^{-1}; bio-control agents, *Trichoderma viride* @ 10 g kg^{-1} and *Pseudomonas fluorescens* @ 10 g kg^{-1}. The inoculated seed of different treatments were incubated in rolled paper towels for 10 days. Of all the fungicides and bio-control agents tested tebuconazole recorded highest germination (91.04%) and maximum disease control (90.29%), whereas, carbendazim recorded highest seedling length (18.44cm), seedling vigour index I (1660), seedling dry weight (0.22) and seedling vigour index II (19.48).

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an important oilseed crop in India grown as a rainfed crop and is often prone to significant yield losses annually due to deficit and uneven distribution of rainfall during the crop growth period, biotic and abiotic stresses. Post-harvest fungal pathogens are important constraints in the production of the crop, affecting not only the seed quality parameters but also the biochemical properties of seed during storage. *Aspergillus flavus, A. niger, Fusarium oxysporum, Macrophomina phaseolina* and *Penicillium* sp. were found to be predominant seed borne fungi in groundnut (Jogdand and Talekar, 2010). The germination decreased from 90% to 35% and 30% in groundnut, due to *A. niger* and *A. flavus,* respectively (Kakde and Chavan, 2010). Maximum percent reduction in germination (20%), plumule length (25.18%), radical length (23.9%), fresh weight (34.02%) and dry weight (37.93%) was observed by Rohtas *et al.* (2016) due to the infection of collar rot fungus *A. niger.* During the investigation efficacy of various fungicides and bio-control agents against *A. niger*

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infecting different cultivars of groundnut was studied during 2018-2019.

MATERIALS AND METHODS

Seed Inoculation

Apparently healthy seed of 13 groundnut cultivars were surface sterilized. The sterilized seed of each cultivar were soaked, individually, in conidial suspension of *A. niger* containing 10^6 conidia ml^{-1}, for 20 min and dried at room temperature overnight. The seed of control treatments were similarly treated except that they were soaked in sterile distilled water.

Assessment of the fungicides and biocontrol agents against *Aspergillus niger in vitro*

The inoculated seed was treated with various fungicides and biocontrol agents *viz*., mancozeb @ 3 g/kg, carbendazim @ 2 g/kg, tebuconazole @ 1 g/kg, carboxin+thiram @ 2 g/kg; bio-control agents *Trichoderma viride* @ 10 g/kg and *Pseudomonas fluorescens* @ 10 g/kg. The treated seed was dried under shade for 2 hours. This seed was kept for germination in moistened paper towels lined with blotter paper along with inoculated and uninoculated seeds as controls. Four replications of hundred seeds from each treated seed sample were placed on the germination paper at uniform spacing between the seed in rows. The paper towels were rolled, lined with blotter paper and placed in plastic tray in upright position under ambient conditions for 10 days. Observations were recorded on various seed quality parameters including germination (%), seedling length (cm), seedling dry weight (g) and seedling vigour indices.

Observations recorded

Germination (%): On the day of final count (10^{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 10^{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 were taken from each sample in each replication at random on the 10^{th} day and the seedling dry weight was measured after drying them in a hot air oven at 75±1 °C for 48 h and mean seedling dry weight was expressed in grams.

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)

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)

The data recorded was analyzed statistically by adopting Completely Randomized Design (CRD) for the experiment.

RESULTS AND DISCUSSION

Germination (%)

Significant increase in germination was observed due to seed treatment over the inoculated control, irrespective of the genotype. Thus, genotype has no interaction with the chemical or biocontrol agent used for seed treatment (Table 1, Fig. 1). The average germination percent of 91.25 in uninoculated control was reduced to 69.35 due to inoculation with *A. niger*. Tebuconazole @ 1 g kg^{-1} seed recorded highest germination (91.04%) followed by carbendazim @ 2 g kg^{-1} seed (89.65%), carboxin+thiram @ 2 g kg^{-1} seed (89.27%) and mancozeb @ 3 g kg^{-1} seed (88.56%). The germination in seed treated with *T. viride* @ 10 g kg^{-1} seed (72.02%) and *P. fluorescens* @ 10 g kg^{-1} seed (71.48%) was superior to inoculated control (69.35%).

Similar results of increase in germination of groundnut seed inoculated with *A. niger* after chemical seed treatment with carbendazim, carboxin+thiram and tebuconazole were observed by Kumari *et al.* (2016). Saranya *et al.* (2017) observed the efficacy of tebuconazole in improving germination of onion seed inoculated with *A. niger.* Adithya *et al.* (2017) obtained higher germination of *A. flavus* inoculated seed with *Trichoderma* spp and *P. fluorescens* followed by carbendazim and mancozeb, whereas, Kumari and Singh (2017) reported efficacy of individual and combinations of *Trichoderma* spp and *P. fluorescens* against collar rot (*A. niger*) of groundnut.

Seedling length (cm)

Irrespective of the genotype, significant increase in the seedling length of treated seed over the inoculated control was observed indicating no interaction between genotype and seed treatment (Table 2, Fig 2). The average seedling length in *A. niger* inoculated treatment was 16.07 cm as against 20.75 cm in uninoculated control. Carbendazim @ 2 g kg^{-1} seed recorded highest seedling length (18.44 cm) followed by carboxin+thiram @ 2 g kg^{-1} seed (18.26 cm) and mancozeb @ 3 g kg^{-1} seed (17.87 cm).*T. viride* @ 10 g kg^{-1} seed and *P. fluorescens* @10 g kg^{-1} seed showed 16.80 cm and (16.81 cm, respectively. Tebuconazole @ 1 g kg^{-1} seed recorded the lowest seedling length of 14.23 cm *i.e.* less than inoculated control (16.07 cm).

Increase in seedling length in inoculated seeds of groundnut due to seed treatment with carbendazim, mancozeb and carboxin+thiram was observed earlier by Adithya *et al.* (2017) and Ahmad and Zaidi (2018). Reduced seedling length in tebuconazole seed treatment was reported by Jaleel *et al.* (2007) in *Catharanthus roseus.*The reduction in seedling length in tebuconazole treated seed may be due to lower plant growth regulation activity of triazole fungicides which may be attributed to lower affinity of the different triazole- and imidazole-derivatives to the cytochrome P-450 dependent enzymes involved in gibberellin biosynthesis (Gortz *et al.,* 2008). Thus the growth retarding effect of triazoles is attributed to the inhibition of gibberillic acid biosynthesis that helps in shoot elongation.

Seedling vigour index I

Significant increase in seedling vigour index I was recorded in treated seed as against

inoculated control, irrespective of the genotype (Table 3, Fig. 3). The average seedling vigour index I of 1901 in uninoculated control was reduced to 1128 due to inoculation with *A. niger*. Carbendazim @ 2 g kg^{-1} seed recorded highest seedling vigour index (1660) followed by carboxin+thiram @ 2 g kg^{-1} seed (1639) and mancozeb @ 3 g kg^{-1} seed (1590), whereas, tebuconazole @ 1 g kg^{-1} seed recorded the lowest (1299). The seedling vigour index I in seed *T. viride* @ 10 g kg^{-1} seed and *P. fluorescens* @ 10 g kg^{-1} seed registered 1225 and 1215, respectively. Increase in seedling vigour index I of inoculated seed after seed treatment with carbebdazim and mancozeb was observed by Adithya *et al.* (2017). The reduction in seedling vigour index I in tebuconazole seed treatment was attributed to decrease in seedling length.

Seedling dry weight (g)

Significant increase in seedling dry weight over the inoculated control was observed due to seed treatment, irrespective of the genotype (Table 4, Fig 2). The average seedling dry weight of 0.24 g in uninoculated control decreased to 0.18 g as a result of inoculation with *A. niger*. Carbendazim @ 2 g kg^{-1} seed recorded highest seedling dry weight (0.22 g) followed by carboxin+thiram @ 2 g kg^{-1} seed (0.21 g) and mancozeb @ 3 g kg^{-1} seed (0.21 g), whereas, tebuconazole @ 1 g kg^{-1} seed recorded the lowest (0.18 g). *T. viride* @ 10 g kg^{-1} seed with 0.20 g and *P. fluorescens* @ 10 g kg^{-1} seed with 0.20 g were superior to inoculated control (0.18 g). Increase in dry weight of inoculated seed after seed treatment with carbendazim and mancozeb was observed by Ahmad and Zaidi (2018). The reduction in seedling dry weight in tebuconazole seed treatment may be attributed to inhibition of gibberellic acid biosynthesis which reduces seedling length there by reducing the translocation of food material into the seedling (Gortz *et al.,* 2008).

Seedling vigour index II

Seed treatment significantly increased seedling vigour index II as against inoculated control, irrespective of the genotype (Table 5, Fig. 3). The average seedling vigour index II of uninoculated control was 21.69, whereas, *A. niger* inoculated seed recorded 12.86. Among the four chemicals tested carbendazim @ 2 g kg^{-1} seed recorded highest seedling vigour index (19.48) followed by carboxin+thiram @ 2 g kg^{-1} seed (18.89) and mancozeb @ 3 g kg^{-1} seed (18.85). Tebuconazole @ 1 g kg^{-1} seed recorded the lowest seedling vigour index II of 16.76. *T. viride* @ 10 g kg^{-1} seed (14.49) and *P. fluorescens* @ 10 g kg^{-1} seed (14.15) were superior to inoculated control (12.86). The reduction in seedling vigour index II in tebuconazole seed treatment was attributed to decrease in seedling dry weight.

Percentage of infected seedlings

Significant decrease in percentage of infected seedlings over inoculated control was recorded due to seed treatment irrespective of the genotype (Table 6, Fig 4). The average per cent infection of 9.08 in uninoculated control increased to 42.35 due to inoculation with *A. niger*. Tebuconazole @ 1 g kg^{-1} seed recorded the lowest per cent infection (4.10) followed by carbendazim @2 g kg^{-1} seed (7.04%), carboxin+thiram @2 g kg^{-1} seed (7.38%) and mancozeb @ 3 g kg^{-1} seed (7.98%). *T. viride* @ 10 g kg^{-1} seed and *P. fluorescens* @ 10 g kg^{-1} seed resulted in 37.44% and 38.38%,

Table 1. Effect of seed treatment on germination (%) in groundnut genotypes inoculated with *Aspergillus niger*

S. No.	Genotypes	Germination (%)								
		Mancozeb	Carbendazim	Tebuconazole	Carboxin + thiram	*Trichoderma viride*	*Pseudumonas fluorescens*	Inoculated control	Uninoculated control	Mean
1	Abhaya	89.50 (71.07)	89.25 (70.86)	90.75 (72.30)	87.50 (69.29)	69.50 (56.46)	69.00 (56.15)	68.00 (55.53)	90.00 (71.58)	81.69 (65.41)^{bc}
2	Amaravati	88.75 (70.39)	89.25 (70.84)	90.50 (72.02)	89.25 (70.84)	71.00 (57.40)	71.25 (57.56)	64.00 (53.11)	90.75 (72.32)	81.84 (65.56)^{bc}
3	Chitravati	89.00 (70.63)	89.00 (70.61)	91.25 (72.80)	88.75 (70.39)	69.75 (56.61)	69.75 (56.61)	67.00 (54.92)	90.75 (72.29)	81.91 (65.61)^{bc}
4	Dharani	83.75 (66.21)	83.25 (65.82)	87.75 (69.50)	87.25 (69.05)	65.00 (53.71)	63.75 (52.96)	62.25 (52.07)	88.00 (69.71)	77.63 (62.38)^{a}
5	Haritandhra	88.25 (69.95)	90.00 (71.58)	90.00 (71.55)	89.00 (70.62)	69.50 (56.46)	69.25 (56.30)	67.75 (55.37)	90.75 (72.28)	81.81 (65.51)^{bc}
6	ICGV 00 350	86.00 (68.01)	88.25 (69.95)	89.25 (70.84)	88.75 (70.39)	70.25 (56.92)	70.00 (56.77)	67.75 (55.38)	91.00 (72.55)	81.41 (65.10)^{bc}
7	Kadiri 6	86.00 (68.01)	90.50 (72.02)	90.75 (72.28)	87.50 (69.27)	72.00 (58.04)	72.75 (58.52)	69.75 (56.63)	90.50 (72.05)	82.47 (65.85)^{c}
8	Kadiri 9	88.50 (70.17)	90.75 (72.27)	92.50 (74.15)	89.50 (71.07)	75.75 (60.48)	74.00 (59.33)	70.50 (57.08)	90.25 (71.82)	83.97 (67.05)^{d}
9	Narayani	89.75 (71.30)	92.25 (73.81)	93.75 (75.52)	91.00 (72.53)	72.75 (58.51)	71.75 (57.87)	69.75 (56.61)	92.75 (74.36)	84.22 (67.56)^{d}
10	TAG 24	94.75 (76.82)	95.50 (77.82)	99.00 (85.90)	98.00 (84.20)	86.75 (68.65)	84.50 (66.82)	84.00 (66.43)	98.25 (84.59)	92.59 (76.40)^{e}
11	TCGS 1073	91.75 (73.30)	90.00 (71.61)	90.75 (72.28)	90.00 (71.55)	72.25 (58.20)	71.75 (57.87)	71.00 (57.40)	91.50 (73.05)	83.63 (66.91)^{d}
12	TCGS 1616	87.00 (68.91)	87.75 (69.50)	87.25 (69.06)	86.75 (68.65)	70.50 (57.09)	70.75 (57.24)	70.00 (56.77)	90.50 (72.08)	81.31 (64.91)^{b}
13	TCGS 1694	88.25 (69.93)	89.75 (71.31)	90.00 (71.55)	87.25 (69.06)	71.25 (57.55)	70.75 (57.24)	69.75 (56.61)	91.25 (72.80)	82.28 (65.76)^{c}
	Mean	88.56 (70.36)^{C}	89.65 (71.39)^{D}	91.04 (73.06)^{E}	89.27 (71.30)^{D}	72.02 (58.16)^{B}	71.48 (57.79)^{B}	69.35 (56.46)^{A}	91.25 (73.19)^{E}	82.83 (66.46)

*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

	Genotype	Treatment	GxT
SEm	0.26	0.20	0.73
CD @5%	0.65	0.54	1.71
CV (%)	2.18		

Table 2. Effect of seed treatment on seedling length (cm) in groundnut genotypes inoculated with *Aspergillus niger*

S. No.	Genotypes	Seedling length (cm)								
		Mancozeb	Carbendazim	Tebuconazole	Carboxin+ thiram	*Trichoderma viride*	*Pseudumonas fluorescens*	Inoculated control	Uninoculated control	Mean
1	Abhaya	14.63	16.18	14.87	17.09	15.74	15.14	14.76	19.34	15.97[e]
2	Amaravati	15.74	16.02	13.11	15.34	13.78	13.96	14.30	18.91	15.15[c]
3	Chitravati	15.87	17.21	12.62	17.27	14.87	15.57	14.46	17.38	15.66[d]
4	Dharani	15.72	15.08	13.67	15.81	13.62	13.82	13.55	16.62	14.73[b]
5	Haritandhra	17.41	15.77	13.86	18.71	15.90	15.91	14.75	19.11	16.43[f]
6	ICGV 00 350	14.37	15.43	12.45	15.75	13.82	13.63	13.41	18.09	14.62[b]
7	Kadiri 6	17.06	19.12	12.97	17.60	16.29	15.67	14.88	20.88	16.81[g]
8	Kadiri 9	18.86	20.41	11.82	17.93	17.27	17.38	17.23	20.85	17.72[h]
9	Narayani	19.75	18.95	15.27	18.90	18.31	18.37	17.88	20.48	18.49[i]
10	TAG 24	27.00	26.66	18.61	27.78	26.32	27.25	24.84	31.18	26.20[k]
11	TCGS 1073	24.68	26.11	18.93	23.80	21.13	21.37	21.67	27.95	23.20[j]
12	TCGS 1616	13.70	14.22	12.87	13.34	15.27	14.72	12.22	19.43	14.47[a]
13	TCGS 1694	17.49	18.63	13.90	18.09	16.15	15.81	15.01	19.57	16.83[g]
	Mean	17.87[D]	18.44[F]	14.23[A]	18.26[E]	16.80[C]	16.81[C]	16.07[B]	20.75[G]	17.41

*Values followed by same alphabet do not differ significantly at 5% level of significance

	Genotype	Treatment	GxT
SEm	0.05	0.04	0.13
CD @ 5%	0.11	0.09	0.30
CV (%)	1.57		

Table 3. Effect of seed treatment on seedling vigour index I in groundnut genotypes inoculated with *Aspergillus niger*

S. No.	Genotypes	Seedling Vigour Index I								
		Mancozeb	Carbendazim	Tebuconazole	Carboxin+ thiram	*Trichoderma viride*	*Pseudumonas fluorescens*	Inoculated control	Uninoculated control	Mean
1	Abhaya	1309	1444	1350	1496	1094	1045	1003	1741	1310[f]
2	Amaravati	1397	1430	1187	1369	978	995	915	1716	1248[d]
3	Chitravati	1412	1532	1152	1532	1037	1086	969	1577	1287[e]
4	Dharani	1316	1255	1199	1379	885	881	843	1462	1153[a]
5	Haritandhra	1537	1419	1247	1665	1105	1101	999	1734	1351[g]
6	ICGV 00 350	1235	1361	1111	1398	971	954	908	1646	1198[c]
7	Kadiri 6	1467	1730	1177	1540	1173	1140	1038	1890	1394[h]
8	Kadiri 9	1669	1852	1093	1605	1308	1286	1215	1881	1489[i]
9	Narayani	1773	1748	1431	1720	1332	1318	1247	1899	1559[j]
10	TAG 24	2558	2546	1842	2721	2283	2303	2085	3063	2425[l]
11	TCGS 1073	2264	2350	1718	2142	1527	1533	1538	2557	1954[k]
12	TCGS 1616	1191	1248	1123	1158	1075	1041	855	1758	1181[b]
13	TCGS 1694	1544	1672	1251	1579	1151	1118	1047	1785	1393[n]
	Mean	1590[D]	1660[F]	1299[C]	1639[E]	1225[B]	1215[B]	1128[A]	1901[G]	1457

*Values followed by same alphabet do not differ significantly at 5% level of significance

	Genotype	Treatment	GxT
SEm	4.79	3.76	13.55
CD @ 5%	12.08	10.07	31.88
CV (%)	1.86		

Table 4. Effect of seed treatment on seedling dry weight (g) of groundnut genotypes inoculated with *Aspergillus niger*

S. No.	Genotypes	Seedling dry weight (g)								
		Mancozeb	Carbendazim	Tebuconazole	Carboxin+ thiram	*Trichoderma viride*	*Pseudumonas fluorescens*	Inoculated control	Uninoculated control	Mean
1	Abhaya	0.19	0.19	0.19	0.18	0.19	0.17	0.16	0.21	0.19[a]
2	Amaravati	0.20	0.21	0.18	0.21	0.21	0.20	0.16	0.25	0.20[e]
3	Chitravati	0.19	0.20	0.16	0.19	0.17	0.17	0.17	0.21	0.18[c]
4	Dharani	0.18	0.16	0.16	0.18	0.16	0.17	0.17	0.18	0.17[b]
5	Haritandhra	0.20	0.21	0.19	0.20	0.20	0.20	0.17	0.23	0.20[e]
6	ICGV 00 350	0.16	0.18	0.17	0.16	0.16	0.15	0.14	0.21	0.16[a]
7	Kadiri 6	0.21	0.23	0.18	0.19	0.20	0.19	0.19	0.24	0.21[f]
8	Kadiri 9	0.21	0.23	0.17	0.25	0.20	0.20	0.20	0.26	0.22[h]
9	Narayani	0.25	0.26	0.23	0.25	0.23	0.23	0.23	0.27	0.24[i]
10	TAG 24	0.26	0.25	0.19	0.26	0.26	0.24	0.22	0.26	0.24[i]
11	TCGS 1073	0.26	0.27	0.23	0.26	0.25	0.27	0.25	0.31	0.26[j]
12	TCGS 1616	0.18	0.20	0.17	0.18	0.17	0.17	0.16	0.22	0.18[c]
13	TCGS 1694	0.25	0.23	0.18	0.20	0.20	0.19	0.18	0.24	0.21[g]
	Mean	0.21[E]	0.22[F]	0.18[A]	0.21[E]	0.20[D]	0.20[C]	0.18[B]	0.24[G]	0.21

*Values followed by same alphabet do not differ significantly at 5% level of significance

	Genotype	Treatment	GxT
SEm	0.000674	0.000529	0.00191
CD @ 5%	0.0017	0.0014	0.0045
CV (%)	1.86		

Table 5. Effect of seed treatment on seedling vigour index II of groundnut genotypes inoculated with *Aspergillus niger*

S. No.	Genotype	Seedling Vigour Index II								
		Mancozeb	Carbendazim	Tebuconazole	Carboxin+ thiram	*Trichoderma viride*	*Pseudumonas fluorescens*	Inoculated control	Uninoculated control	Mean
1	Abhaya	17.41	17.09	16.79	16.06	12.93	11.94	11.02	19.31	15.32^{d}
2	Amaravati	18.11	18.68	15.88	19.17	14.62	14.55	9.93	22.53	16.68^{e}
3	Chitravati	17.13	17.71	14.96	17.22	12.07	11.86	11.34	18.87	15.14^{cd}
4	Dharani	14.85	13.61	13.60	15.70	10.63	10.60	10.33	15.40	13.09^{a}
5	Haritandhra	17.29	18.87	17.48	17.80	13.93	14.11	11.82	20.96	16.53^{e}
6	ICGV 00 350	14.08	15.55	14.86	14.38	11.19	10.27	9.42	18.72	13.56^{b}
7	Kadiri 6	18.30	20.91	16.43	16.95	14.17	13.95	13.41	21.81	16.99^{f}
8	Kadiri 9	18.90	20.74	16.12	22.58	15.11	14.54	13.94	23.51	18.18^{h}
9	Narayani	22.57	23.55	21.23	22.93	17.02	16.84	15.69	24.65	20.56^{i}
10	TAG 24	24.63	24.21	18.64	25.80	22.45	20.11	18.63	26.02	22.56^{k}
11	TCGS 1073	24.13	24.45	20.87	23.40	17.77	19.47	17.47	27.91	21.93^{j}
12	TCGS 1616	15.92	17.15	15.14	15.96	12.16	12.04	11.48	19.98	14.98^{c}
13	TCGS 1694	21.71	20.73	15.88	17.62	14.37	13.66	12.69	22.26	17.37^{g}
	Mean	18.85^{E}	19.48^{F}	16.76^{D}	18.89^{E}	14.49^{C}	14.15^{B}	12.86^{A}	21.69^{G}	17.15

*Values followed by same alphabet do not differ significantly at 5% level of significance

	Genotype	Treatment	GxT
SEm	0.06	0.05	0.18
CD @ 5%	0.16	0.14	0.43
CV (%)	2.12		

Table 6. Effect of seed treatment on per cent infection of groundnut genotypes inoculated with *Aspergillus niger*

S. No.	Genotypes	Per cent infection								
		Mancozeb	Carbendazim	Tebuconazole	Carboxin+ thiram	*Trichoderma viride*	*Pseudumonas fluorescens*	Inoculated control	Uninoculated control	Mean
1	Abhaya	9.00(17.32)	7.00(15.21)	6.00(13.98)	7.50(15.78)	37.25(37.59)	39.25(38.77)	40.00(39.22)	7.50(15.50)	19.19(24.17)^{bc}
2	Amaravati	7.75(15.87)	7.00(15.14)	3.00(9.69)	7.50(15.70)	36.00(36.84)	38.00(38.04)	42.75(40.81)	9.00(17.41)	18.88 (23.69)^{b}
3	Chitravati	6.50(14.58)	6.75(14.93)	3.75(11.03)	7.25(15.43)	37.75(37.89)	38.75(38.45)	42.50(40.67)	8.25(16.39)	18.94(23.67)^{b}
4	Dharani	10.25(18.62)	8.25(16.65)	4.75(12.54)	8.25(15.93)	38.25(38.18)	40.00(39.21)	43.50(41.24)	8.75(17.01)	20.25(24.92)^{c}
5	Haritandhra	8.00(16.10)	8.00(16.16)	6.00(13.98)	9.00(17.32)	38.25(38.18)	35.25(36.39)	42.75(40.81)	10.25(18.57)	19.69(24.69)^{bc}
6	ICGV 00 350	10.50(19.08)	8.75(17.15)	5.00(12.71)	10.00(18.37)	50.50(45.27)	54.00(47.28)	57.25(49.15)	9.00(17.41)	25.63(28.30)^{e}
7	Kadiri 6	7.25(15.53)	6.75(14.98)	2.25(8.24)	5.50(13.42)	36.00(36.85)	39.50(38.92)	42.00(40.38)	10.25(18.62)	18.69(23.37)^{b}
8	Kadiri 9	9.25(17.54)	7.25(15.28)	5.00(12.76)	7.50(15.66)	35.50(36.55)	32.75(34.87)	40.25(39.36)	9.50(17.54)	18.38(23.70)^{b}
9	Narayani	3.50(10.64)	5.00(12.71)	2.75(9.23)	4.25(11.83)	32.50(34.73)	34.50(35.95)	37.50(37.74)	8.50(16.92)	16.06(21.22)^{a}
10	TAG 24	6.25(14.09)	4.25(11.51)	3.00(9.69)	5.75(13.71)	32.25(34.58)	33.00(35.04)	33.50(35.34)	10.00(18.37)	16.00(21.54)^{a}
11	TCGS 1073	8.25(16.54)	7.25(15.59)	3.00(9.69)	7.25(15.53)	29.25(32.67)	30.00(33.16)	35.75(36.70)	9.50(17.87)	16.28(22.22)^{a}
12	TCGS 1616	8.25(16.65)	8.00(16.41)	4.25(11.80)	8.00(16.41)	48.00(43.83)	49.00(44.41)	51.75(45.99)	8.25(16.67)	23.19(26.52)^{d}
13	TCGS 1694	9.00(17.41)	7.25(15.53)	4.50(12.15)	8.25(16.64)	35.25(36.40)	35.00(36.25)	41.00(39.80)	9.25(17.50)	18.69(23.96)^{b}
	Mean	7.98(16.15)^{B}	7.04(11.35)^{B}	4.10(11.35)^{A}	7.38(15.52)^{B}	37.44(37.66)^{D}	38.38(38.21)^{D}	42.35(40.55)^{E}	9.08(17.37)^{C}	19.22(24.00)

*Values in the parenthesis indicate angular transformed values

*Values followed by same alphabet do not differ significantly at 5% level of significance

	Genotype	Treatment	GxT
SEm	0.41	0.32	1.15
CD @ 5%	1.03	0.86	2.71
CV (%)		9.59	

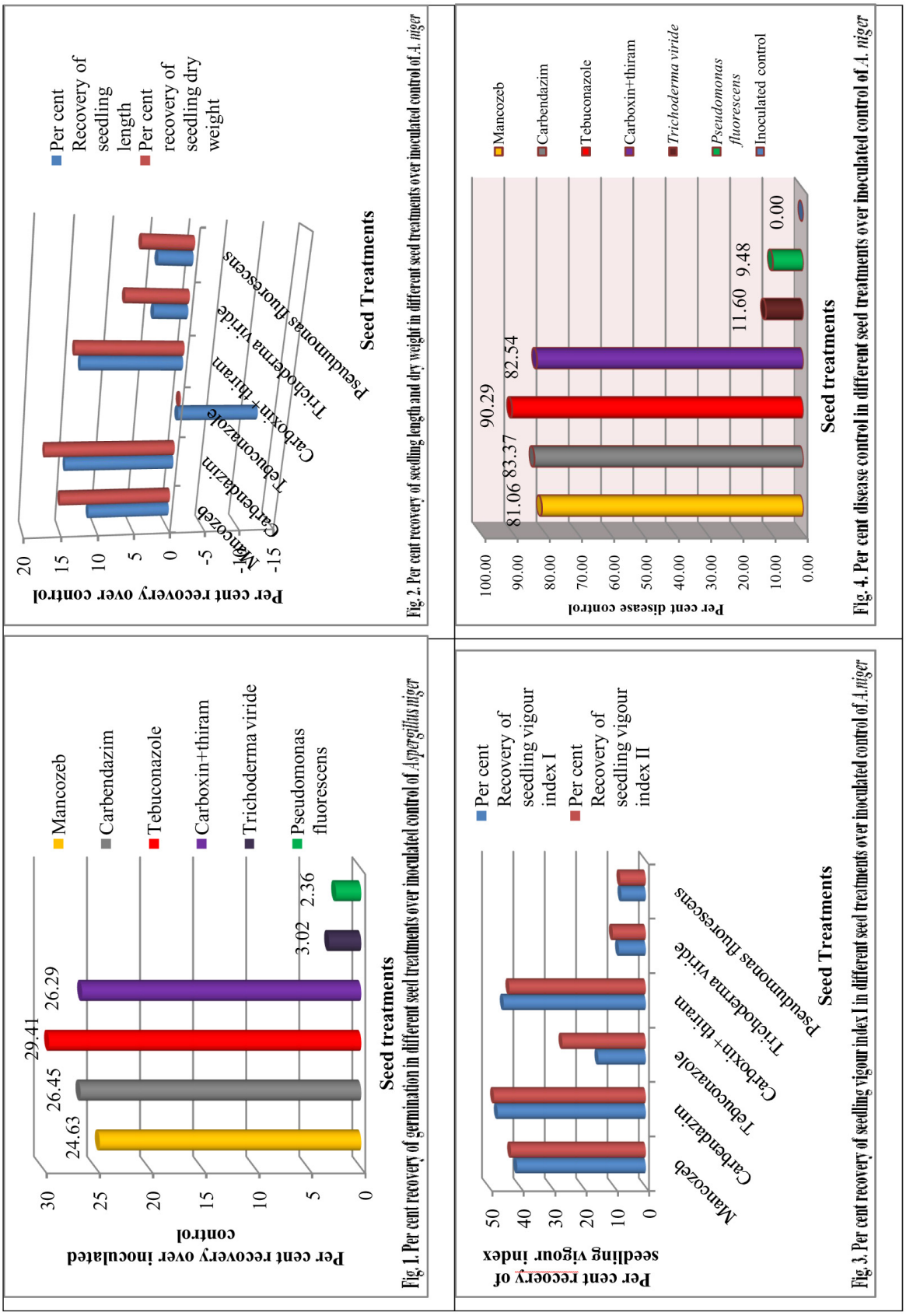

Fig. 1. Per cent recovery of germination in different seed treatments over inoculated control of *Aspergillus niger*

Fig. 2. Per cent recovery of seedling length and dry weight in different seed treatments over inoculated control of *A. niger*

Fig. 3. Per cent recovery of seedling vigour index I in different seed treatments over inoculated control of *A.niger*

Fig. 4. Per cent disease control in different seed treatments over inoculated control of *A. niger*

respectively, as against inoculated control (42.35). Similar results of decrease in per cent infection after seed treatment with carbendazim, tebuconazole, carboxin+thiram was observed by Islam *et al.* (2015). Kumari *et al.* (2016) also reported the reduction in percent infection after seed treatment with carbendazim, carboxin+thiram and tebuconazole. Seed treatment with propiconazole and carbendazim (Rohtas *et al.*, 2016) and seed treatment with carbendazim (Dolas *et al.*, 2018) also recorded decrease in percent disease incidence.

CONCLUSION

Seed treatment with tebuconazole or carbendazim efficiently controls the seed borne infection of *A. niger* in groundnut. Tebuconazole recorded highest germination and maximum per cent disease control where as carbendazim recorded highest seedling length, seedling vigour index I, seedling dry weight and seedling vigour index II.

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EFFECT OF SPACING AND SOURCE OF NITROGEN FERTILIZERS ON GROWTH AND YIELD OF AFRICAN MARIGOLD DURING SUMMER IN ANDHRA PRADESH

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ABSTRACT

The two-year research conducted on effect of spacing and source of nitrogen fertilizers on plant growth and flower yield of African marigold cv. Bidhan Marigold-2 by inducing heat stress tolerance during summer revealed that closer spacing of 45 cm x 30 cm, application of nitrogen in the form of calcium nitrate and their interaction effect were found to be superior in terms of flower yield ha^{-1} (165.959, 156.334, 183.511, respectively), whereas, for rest of the vegetative, flower and yield parameters, maximum values were recorded at wider spacing of 60 cm x 30 cm, nitrogen in the form of calcium nitrate and interaction effect of 60 cm x 30 cm + calcium nitrate followed by ammonium sulphate and urea, whereas, in terms of Benefit- Cost Ratio, application of ammonium sulphate was found to be superior followed by urea and calcium nitrate. The higher cost of calcium nitrate was non compensative compared to ammonium sulphate pushing down the treatment combinations with calcium nitrate.

Key words : Ammonium sulphate; Calcium nitrate; Marigold summer cultivation; Spacing and Urea

INTRODUCTION

African marigold (*Tagetes erecta* L.) belongs to the family Asteraceae and is native to Mexico. It represents the top most passion and creativity among various loose flowers grown in urban and rural areas of India. Marigold plants are used as bedding material in herbaceous borders of the landscape gardens apart from growing in pots. It is also grown commercially for the extraction of pigments (carotenoids and xanthophylls) and essential oils.

Eventhough marigold is a hardy crop growing throughout the year the flower yield drastically reduces during summer months due to heat stress. Due to its high shelf life even during summer months it fetches premium price in the market during summer as it coincides with various religious, social and customary occasions. Increasing marigold flower yield during summer months by adopting certain special horticultural practices such as change in plant geometry and using fertilizers that impart abiotic stress resistance was found to increase

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plant heat stress tolerance and increasing yield especially during summer months. Spacing influences the creation of micro climate in the canopy.The form of nitrogen applied to plant affects its tolerance to damage caused by the stress created through high temperatures. Addition of appropriate fertilizers in proper doses at right time drastically improves in both quantity and quality of plant growth. The most predominant nitrogen forms available in commercial fertilizers are nitrate (NO_3), ammonical (NH_4) and amide (NH_2).

Hence, the study was taken up to find the impact of plant geometry and nitrogen form in inducing heat stress tolerance and improving marigold yield during summer.

MATERIALS AND METHODS

The research site located at Horticultural Research Station, Venkataramannagudem, West Godavari, Andhra Pradesh was geographically situated at 16°83'N latitude and 81°5'E longitude with an altitude of 34 m (112 feet) above the mean sea level. This zone experiencehot and humid summer with mild winter and average annual rainfall of 900 mm. The experiment was carried out during 2017 and 2018. The marigold variety selected is Orange coloured Bidhan Marigold-2 and experiment was laid out in a Randomized Block Design with factorial concept replicated twice. The experiment consists of fifteen treatment combinations comprising of three spacings (45 cmx 30 cm, 45 cm x 40 cm, and 60 cm x 30 cm) and three forms of nitrogen (nitrate form as calcium nitrate, amide form as urea and ammonical form as ammonium sulphate). Fertilizers were applied as per the recommended dose (90-90-75 kg NPK ha^{-1}) in which the nitrogen was substituted with various forms of nitrogenous fertilizers as mentioned above.

Observations on vegetative growth, flowering and yield parameters were recorded at 150 DAT for ten plants randomly tagged with a label in each treatment and replication. Ten plants were pulled-off carefully from the ground and washed thoroughly with clean water to remove the soil particles adhered and dried in shade for recording the observations on different growth parameters in destructive method of sampling.

RESULTS AND DISCUSSION

Effect of spacing on vegetative parameters

Data from Table 1 reveals that wider spacing of 60 cm x 30 cm recorded significantly highest number of primary (12.28) and secondary branches (40.77), plant spread (27.17 cm in E-W and 45.45 cm in N-S directions), leaf area (49.10 dm^2), stem diameter at base (1.01 cm), specific leaf weight (11.99 mg cm^{-2}), total fresh biomass $plant^{-1}$ (1668.08 g) and total dry matter $plant^{-1}$ (314.85 g), whereas, the highest plant height of 88.24 cm and internodal length (44.7 mm) was recorded with closer spacing of 45 cm×30cm.

The increased growth rate in plants at wider spacing might be attributed to the less competition among plants for moisture, nutrients and sunlight. Plants at closer spacing grow tall and lengthy in search of sunlight due to high competition. Higher number of primary branches at wider spacing favoured more lateral growth of plant in the form of secondary branches. The above results are in agreement with the findings of Sheena Nain *et al.* (2017) in marigold. The decrease in internodal length with increase in

spacing could be attributed to the lesser competition among plants for nutrients, water, and light at low plant densities and also due to production of more number of lateral branches. Similar results were earlier reported by Himabindu (2010) in marigold cv. Pusa Narangi Gaindain marigold.Wider spacing provided higher ground area, congenial growth conditions for root and shoot growth that resulted in optimum plant height and higher number of primary and secondary branches thereby increasing plant spread.Closer spacing created competition for light resulting in etiolation effect which might have increased plant height and internodal length.

Higher plant spread resulted in higher leaf area at wider spacing which was also reported by Chaturvedi *et al.* (2010) in marigold. The increased thickness of stem could be ascribed to a better availability of nutrients per unit area due to sufficient space resulting in less competition among the plants. The results are in accordance with the report of Meena *et al.* (2015) in marigold. Increase in specific leaf weight depending on the spacing might be attributed to production of more number of branches and leaf area that in turn produced more fresh and dry matter at wider spacing due to less competition for resources among plants. Similar results of increased drymatter by Rasha *et al.* (2013), fresh and dry weights by Sheena Nain *et al.* (2017) in marigold were also reported earlier.

Effect of source of nitrogen fertilizer on vegetative parameters

Application of calcium nitrate recorded significantly highest plant height (87.74 cm), number of primary (12.73) and secondary (41.47) branches, plant spread (27.82 cm) in E-W, and (42.91 cm) in N-S directions, leaf area (49.62 dm^2 / plant), stem diameter at base(0.99 cm), specific leaf weight(12.14 mg cm^{-2}), total fresh biomass $plant^{-1}$ (1794.39 g) and total dry matter $plant^{-1}$ (338.73 g), whereas, the highest internodal lengthof 41.6 mm was recorded with application ofurea.

Application of nitrate form of nitrogen in the form of calcium nitrate significantly induced heat stress tolerance in marigold during summer. The positive effects of calcium nitrate might be attributed to the fact that calcium plays a vital role in regulating a number of physiological processes in plants at tissue, cellular and molecular levels that influence both growth and responses to environmental stresses (Waraich *et al.,* 2011). Nitrate form had a higher tolerance to photo-damage than ammonium form with low levels of lipid peroxidation and antioxidative enzymes under very high light intensity. Calcium nitrate contains nitrogen in readily available nitrate form which translates into quicker spurts in growth in comparison to urea which contains nitrogen in amide form that undergo nitrification before it becomes available to the plants. Presence of calcium also improves the overall growth of the plants as it is essential for the physiological activity of meristematic zones of roots and shoots particularly when cell division is occurring. The combined effect of calcium and nitrate form of nitrogen might have attributed to the maximum plant growth. Similar results were reported by Muneeb *et al.* (2015) in lilium for plant height, leaf area, stem diameter and specific leaf weight,Ghaname *et al.* (2009) in hot pepper for primary and secondary branches, plant spread, total fresh and dry matter per plant.

The decrease in internodal length with calcium nitrate may be attributed to the fact that exogenous application of calcium and nitrate form of nitrogen played significant role in mitigating the heat stress effectively compared to ammonical and amide form of nitrogen in urea which did not have calcium also resulting in overall increase in growth and number of lateral branches of the plant at high temperature.

The increase in specific leaf weight with calcium nitratemay be attributed to the increase in leaf area and dry weight of leaves which in turn determine the specific leaf weight. Similar result was obtained by Wani *et al.* (2019) in lilium. Nitrate form is more efficient in utilising the excessive light available during heat stress compared to other forms for photosynthesis resulting in production of more growth in terms of lateral branches and leaf area which gives the maximum fresh weight of plant during heat stress. The maximum total fresh and dry matter plant^{-1}obtained withcalcium nitratemight be attributed to the combined beneficial effect of nitrate form and calcium in increasing photosynthetic rate during heat stress. Similar result with application of calcium nitrate was reported earlier by Ghaname *et al*. (2009) in hot pepper and Tian (2015) in wheat (Table 1).

Effect of spacing and source of nitrogen fertilizer interaction on vegetative parameters

Pooled mean on the interaction effect revealed that 60 cm x 30 cm spacing and calcium nitrate recorded maximum number of primary (13.29) and secondary (43.21) branches, plant spread in E-W (28.83 cm) and N-S (56.41 cm) directions, leaf area(51.57 dm^2 / plant), stem diameter at base(1.12 cm), specific leaf weight(13.36 mg cm^{-2}), total fresh biomass plant^{-1} (2011.17g) and total drymatter plant^{-1} (379.59 g), whereas, the highest plant height(93.29 cm) was recorded with 45 cm x 30 cm closer spacing with calcium nitrate and internodal length of 46.5 mm with 45 cm x 30 cm spacing and urea application.

The interaction effects revealed that plant height, internodal length and production of primary and secondary branches mainly depend on spacing which is the major limiting factor compared to nitrogen source which provide favourable conditions for growth by alleviating heat stress. The production of secondary branches mainly depends on the production of primary branches and in wider spacing, less competition for water, light and nutrients from neighbouring plants coupled with beneficial effects of nitrate form of nitrogen along with calcium might have increased the production of lateral branches which inturn determines growth in terms of plant spread, leaf area, specific leaf weighttotal fresh and dry bio mass production. The influence of spacing is more than nitrogen source on internodal length as space becomes limiting factor for lateral growth of the plant even though other factors like nutrients are favourable for better plant growth. The impact of source of nitrogen is more compared to spacing in increasing the stem diameter as the form of nitrogen is mainly responsible for growth of the plant under suitable spacing. Similar results were earlier reported by Tian (2015) in wheat under saline stress (Table 1).

Effect of spacing on flower parameters

Wider spacing of 60 cm × 30 cm had taken maximum number of days for first flower bud appearance (42.43), 50% flowering (55.63) and

duration of flowering (77.06 days). Regarding flower parameters, it also recorded maximum values for flower diameter (4.88 cm) and flower receptacle length (2.10 cm).Widely spaced plants are provided with a better explorable area in terms of rhizosphere as well as micro-climate thus showing a better productivity plant^{-1} but not unit^{-1} area. Increased flower receptacle length at closer spacing might be due to etiolation effect.

The reason for increased vegetative phase at wider spacing might be due to lesser competition from the adjacent plants for space and light, thus delaying floweringresulting in continuous growth and flowering. Similar results were earlier reported by Himabindu (2010) in marigold. At wider spacing due to presence of favourable conditions like availability of nutrients, sunlight and soil moisture to individual plants, the flower size and weight might have increased in marigold. Similar results were reported by Sheena Nain *et al.* (2017) in marigold (Table 2).

Effect of source of nitrogen fertilizer on flower parameters

Application of calcium nitrate had taken maximum number of days to first flower bud appearance (44.20), 50% flowering (58.46) and duration of flowering (79.82 days) apart from maximum flower diameter (4.88 cm) and length of flower receptacle (2.20 cm).Calcium nitrateapplicationmight have led to higher metabolic activity in leaves and synthesis of carbohydrates which in turn might have helped the plants to continue in the vegetative phase for longer time leading to the delayed flower bud initiation.Similar result was earlier reported by Saidulu (2013) in marigold. Readily available nitrate form along with calcium is reported to improve nitrogen uptake by plants that have a positive influence on flower diameter and yield. Similar results were earlier reported by Muneeb *et al.* (2015) in lilium bulbs. The increased length of flower receptacle with calcium nitrate might be attributed to the improved cell division, protein synthesis and carbohydrate metabolism with calcium and nitrate form of nitrogen compared to other forms of nitrogen (Table 2).

Effect of spacing and source of nitrogen fertilizer interaction on flower parameters

Pooled data revealed that the interaction effect of 60 cm x 30 cm + calcium nitrate had taken maximum number of days to first flower bud appearance (44.68), 50% flowering (59.11) and duration of flowering (80.58 days) along with maximum flower diameter (5.18 cm) and flower receptacle length (2.25 cm).The increased vegetative phase in wider spacing with calcium nitrate might be attributed to the availability of water and nutrients in abundance coupled with beneficial effects of nitrate form of nitrogen. The delay in 50% flowering in the interaction effect of wider spacing and calcium nitratefertilization could be attributed to the delay in first flowering in this combination. The increased duration in flowering period could be attributed delayed senescence due to the synergistic effect of wider spacing and calcium nitrate combination. Increased uptake of nutrients, water and sunlight resulted in improved production of photosynthates by plants at wider spacing apart from significant increase in rate of nitrogen absorption and photosynthesis (Table 2).

Effect of spacing on yield parameters

Wider spacing of 60 cm ×30 cm recorded maximum ten flower weight (53.22 g), number of flowers plant^{-1} (46.19) and flower yield plant^{-1} (0.251 kg), whereas,the flower yield ha^{-1}

(165.959 q) was maximum in closer spacing of 45 cm × 30 cm due to more plant population per unit area.Better yields under wider spacing might be due to more plant spread and secondary laterals which resulted in more flower bearing surface. Similar results were reported by Sheena Nain *et al.* (2017) in marigold. Widely spaced plants are provided with a better explorable area in terms of rhizosphere as well as micro-climate thus showing a better productivity plant^{-1} but not unit^{-1} area. These results are in conformity with Himabindu (2010)(Table 2).

Effect of source of nitrogen fertilizer on yield parameters

Application of nitrate form of nitrogen as calcium nitrate recorded maximum ten flower weight (54.58 g), number of flowers plant^{-1} (47.25), flower yield plant^{-1} (0.262 kg) and flower yield ha^{-1} (156.334 q). Readily available nitrate form along with calcium improves nitrogen uptake by plants which might have had a positive influence on plant growth and flower yield. The increase in flower weight was due to the activation of photosynthetic machinery as a result of stimulating effect of nitrate form of nitrogen on photosynthetic process as nitrogen is a constituent of chlorophyll molecules thereby increasing the carbohydrate content. Similarly, increase in weight was earlier reported in hot pepper fruits by Ghaname *et al.* (2009). The increased flower yield could be attributed to the better heat tolerance induced by calcium and nitrate form of nitrogen. Production of the maximum flower yield plant^{-1} with calcium nitrateapplication could be the reason for maximum flower yield ha^{-1} (Table 2).

Effect of spacing and source of nitrogen fertilizer interaction on yield parameters

The interaction effect of 60 cm x 30 cm spacing + calcium nitrate application recorded maximum ten flower weight (55.49 g), number of flowers plant^{-1} (48.30) and flower yield plant^{-1} (0.271 kg), whereas, flower yield ha^{-1} was maximum with closer spacing of 45 cm x 30 cm spacing +calcium nitrate application (183.511 q) which might be due to higher plant population per unit area combined with the beneficial effects of calcium nitrate (Table 2).

Benefit-cost ratio

The data recorded on benefit cost ratio among spacing, nitrogen source and their interaction from Table 2 revealed that variation in cost of planting material depending upon spacing and cost of different nitrogen source of fertilizers resulted in varied cost of cultivation. As per the variation in flower diameter, flower weight and flower yield as influenced by different spacing's, nitrogen sources and their interactions gross returns also varied. Hence benefit – cost ratio exhibited a wide variation among the treatments. Even though the highest yield and gross returns were obtained by closer spacing of 45 cm x 30 cm and applying nitrate form of nitrogen as calcium nitrate, due to high cost of calcium nitrate fertilizer the net returns decreased incurring losses. The higher net returns with the highest benefit – cost ratio was recorded in 45 cm x 30 cm (1.65) applying ammonical form of nitrogen source as ammonium sulphate (2.48) and their interaction (2.76)

Table 1.Effect of spacing, source of nitrogen fertilizer and their interaction on vegetative parameters of African marigold cv. Bidhan Marigold-2

S. No	Treatments	Plant height (cm)	Number of branches plant^{-1}		Internodal Length (mm)	Plant Spread (cm)		Leaf area plant^{-1} (dm^2)	Stem diameter at base (cm)	Specific leaf weight (mg cm^{-2})	Total fresh biomass plant^{-1} (g)	Total dry matter plant^{-1} (g)
			Primary	Secondary		E-W	N-S					
1	**Spacing (cm)**											
	T_1 : 45 x 30	88.24	11.21	37.03	44.7	24.83	30.50	45.30	0.78	9.81	1306.50	246.74
	T_2 : 45 x 40	77.20	11.73	39.21	40.7	25.77	34.98	46.99	0.89	10.81	1491.31	281.53
	T_3 : 60 x 30	82.95	12.28	40.77	36.0	27.17	45.45	49.10	1.01	11.99	1668.08	314.85
	S Em±	0.08	0.01	0.02	0.02	0.05	0.04	0.02	0.001	0.005	7.98	1.51
	CD@ 5%	**0.24**	**0.01**	**0.07**	**0.06**	**0.14**	**0.11**	**0.05**	**0.002**	**0.015**	**23.20**	**4.39**
2	**Source of nitrogen fertilizer**											
	T_4 : Urea	77.77	10.96	36.85	41.6	24.10	32.60	45.12	0.80	9.57	1236.08	233.30
	T_5 : $Ca(NO_3)_2$	87.74	12.73	41.47	39.4	27.82	42.91	49.62	0.99	12.14	1794.39	338.73
	T_6 : $(NH_4)_2SO_4$	82.87	11.54	38.70	40.5	25.85	35.43	46.65	0.90	10.89	1435.42	271.10
	S Em±	0.08	0.01	0.02	0.02	0.05	0.04	0.02	0.001	0.005	7.98	1.51
	CD@5%	**0.24**	**0.01**	**0.07**	**0.06**	**0.14**	**0.11**	**0.05**	**0.002**	**0.015**	**23.20**	**4.39**
3	**Interaction effect of spacing (cm) x Source of nitrogen fertilizer**											
	T_7 : 45 x 30 + Urea	83.66	10.38	34.92	46.5	22.61	28.24	42.77	0.70	8.62	1054.83	199.19
	T_8 : 45 x 30 + $Ca(NO_3)_2$	93.29	12.17	39.56	43.6	27.28	33.41	47.87	0.87	11.01	1555.42	293.74
	T_9 : 45 x 30 + $(NH_4)_2SO_4$	87.78	11.08	36.60	44.0	24.61	29.86	45.25	0.78	9.79	1309.25	247.30
	T_{10} : 45 x 40 + Urea	72.23	10.97	36.92	41.1	24.03	31.30	45.15	0.81	9.52	1219.92	230.25
	T_{11} : 45 x 40 + $Ca(NO_3)_2$	82.08	12.71	41.63	40.4	27.36	38.90	49.42	0.99	12.06	1816.58	342.85
	T_{12}: 45 x 40 + $(NH_4)_2SO_4$	77.31	11.50	39.09	40.7	25.92	34.75	46.40	0.89	10.84	1437.42	271.50
	T_{13} : 60 x 30 + Urea	77.48	11.52	38.70	37.2	25.66	38.27	47.44	0.90	10.55	1433.50	270.46
	T_{14} : 60 x 30 + $Ca(NO_3)_2$	87.85	13.29	43.21	34.3	28.83	56.41	51.57	1.12	13.36	2011.17	379.59
	T_{15} : 60 x 30 + $(NH_4)_2SO_4$	83.52	12.04	40.42	36.6	27.01	41.68	48.29	1.02	12.04	1559.58	294.51
	S Em±	0.14	0.01	0.04	0.04	0.08	0.06	0.03	0.001	0.009	13.82	2.62
	CD@5%	**0.42**	**0.02**	**0.12**	**0.11**	**0.24**	**0.18**	**0.08**	**0.004**	**0.027**	**40.18**	**7.61**

Table 2.Effect of spacing, source of nitrogen fertilizer and their interaction on flower and yield parameters of African marigold cv. Bidhan Marigold-2

S. No	Treatment	Days taken to first flower bud appearance	Days taken to 50% flowering	Duration of flowering (days)	Flower diameter (cm)	Length of flower receptacle (cm)	Ten flower weight (g)	Number of flowers plant^{-1}	Flower yield plant^{-1} (kg)	Flower yield ha^{-1} (q)	BCR
1	**Spacing (cm)**										
	T_1 : 45 x 30	41.51	54.46	75.78	4.26	2.01	50.32	44.00	0.228	165.959	1.65
	T_2 : 45 x 40	41.97	55.04	76.45	4.57	2.06	52.03	45.27	0.242	123.341	1.34
	T_3 : 60 x 30	42.43	55.63	77.06	4.88	2.10	53.22	46.19	0.251	137.075	1.52
	S Em±	0.01	0.01	0.01	0.003	0.001	0.02	0.02	0.0002	0.45	
	CD@5%	**0.03**	**0.02**	**0.04**	**0.008**	**0.003**	**0.06**	**0.05**	**0.0005**	**1.30**	
2	**Source of nitrogen fertilizer**										
	T_4 : Urea	40.13	51.41	73.19	4.28	1.95	49.09	42.76	0.217	126.351	1.77
	T_5 : $Ca(NO_3)_2$	44.20	58.46	79.82	4.88	2.20	54.58	47.25	0.262	156.334	0.26
	T_6 : $(NH_4)_2SO_4$	41.58	55.25	76.29	4.55	2.02	51.92	45.46	0.242	143.692	2.48
	S Em±	0.01	0.01	0.01	0.003	0.001	0.02	0.02	0.0002	0.45	
	CD@5%	**0.03**	**0.02**	**0.04**	**0.008**	**0.003**	**0.06**	**0.05**	**0.0005**	**1.30**	
3	**Interaction effect of Spacing (cm) x Source of nitrogen fertilizer**										
	T_7 : 45 x 30 + Urea	39.69	50.93	72.61	4.00	1.91	46.48	41.40	0.199	144.744	1.89
	T_8 : 45 x 30 + $Ca(NO_3)_2$	43.72	57.82	79.03	4.54	2.15	53.62	46.15	0.252	183.511	0.29
	T_9 : 45 x 30 + $(NH_4)_2SO_4$	41.12	54.62	75.72	4.23	1.98	50.88	44.45	0.233	169.622	2.76
	T_{10} : 45 x 40 + Urea	40.13	51.38	73.23	4.29	1.95	49.59	43.03	0.221	112.649	1.61
	T_{11} : 45 x 40 + $Ca(NO_3)_2$	44.21	58.46	79.86	4.89	2.20	54.62	47.28	0.263	134.154	0.22
	T_{12} 45 x 40 + $(NH_4)_2SO_4$	41.58	55.28	76.28	4.52	2.03	51.89	45.50	0.241	123.220	2.18
	T_{13} : 60 x 30 + Urea	40.56	51.92	73.73	4.55	1.98	51.20	43.84	0.231	121.658	1.80
	T_{14} : 60 x 30 + $Ca(NO_3)_2$	44.68	59.11	80.58	5.18	2.25	55.49	48.30	0.271	151.336	0.26
	T_{15} : 60 x 30 + $(NH_4)_2SO_4$	42.06	55.86	76.87	4.91	2.06	52.98	46.44	0.251	138.231	2.51
	S Em±	0.02	0.01	0.02	0.005	0.002	0.04	0.03	0.0003	0.78	
	CD@5%	**0.05**	**0.04**	**0.07**	**0.013**	**0.005**	**0.10**	**0.08**	**0.0009**	**2.26**	

followed by wider spacing of 60 cm x 30 cm + ammonium sulphate (2.51).

Delayed senescence and increased flowering duration especially during heat stress also helped in increasing the flower yield contributing to highest returns. The cost of calcium nitrate was 22.30 kg^{-1} as against 13.16 kg^{-1} in case of ammonium sulphate and 5.90 kg^{-1} in case of urea. The percentage of available nitrogen in calcium nitrate was only 17.07 requiring huge quantity to meet the recommended nitrogen dose as against ammonium sulphate which has 20.6 percentage and urea with 46% of available nitrogen which are required in small quantities. Such a huge difference was incurred as additional cost for calcium nitrate application. Even though calcium nitrate combinations yielded high with maximum value of gross returns, the additional returns with calcium nitrate application as compared to ammonium sulphate and urea application were found to be non-compensative to the additional cost incurred. Due to the higher cost of calcium nitrate fertilizer ammonium sulphate became more economical with higher benefit – cost ratio in African marigold cv. Bidhan Marigold – 2.

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LONG TERM TREND ANALYSIS OF RAINFALL, MAXIMUM AND MINIMUM TEMPERATURE IN KRISHNA UPPER BASIN REGION OF INDIA

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ABSTRACT

The study was conducted in Krishna Upper basin covering parts of Karnataka and Maharashtra States with an aim to study the spatial and temporal variability of rainfall and temperature trend on annual and seasonal basis. This study utilized the IMD grid rainfall, maximum and minimum temperature data for a period of 119 years (1901 to 2019) and 69-years (1951-2019), respectively. Mann-Kendall (MK) test and Sen's slope estimator test were used to detect the statistical significance trend and the magnitude trend of time series respectively. A positive trend in the annual rainfall data was also observed as 0.557 mm/ year for the study area. An increasing trend of rainfall in the months of June and August was found to be significant. Among all the seasons, it is witnessed that the monsoon rainfall increased BY 0.528 mm/year. The study concluded that there was lot of spatial variability in rainfall trend across the study area particularly in annual and monsoon seasons and less variability in pre-monsoon, post-monsoon season and winter seasons. The maximum temperature observed was statistically significant with increasing trend in all the months, seasons and annual maximum temperature. There was an increase in annual maximum temperature by 0.02 ^{o}C per year. It was recorded that the trend minimum temperatures in a month was not statistically significant.

INTRODUCTION

Study on spatial and temporal distribution of rainfall is important and gives the information of water availability which is very essential for crop production particularly in arid and semi-arid regions. Rainfall is significant factor that decide crops to be grown in that area. The Indian economy also depends on the agricultural production which is influenced by climate particularly rainfall. Rainfall distribution over time and space are also important for water resources management, modeling of hydrological processes, flood forecasting and early warning systems, climate change studies, water balance components and crop production and irrigation scheduling. The average precipitation is likely to increase at global scale even if it increases or decreases at regional scale (Dore, 2005). The uneven distribution of rainfall and intensities increased the extreme events and their intensities

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that often increased the flood and drought events. The Intergovernmental Panel on Climate Change (IPCC, 2007) reported the variability of rainfall trend in inter-seasonal, inter-annual and spatial distribution-wiseand suggested that the future climate is expectedto affect agriculture and its production and hence food security of the Nation. They also reported that the global mean surface temperature is projected to rise 0.74 ^{0}C from the year 1906 to 2005. Gosain *et al.*(2006) reported that the availability of freshwater in most of the river basins of India is likely to decrease due to climate change.

Long term rainfall and temperature analysis is also important to know the behaviour of climate parameters and water availability of a location. Changes in climate parameters pattern influence spatial and temporal distribution of runoff and further influence water availability in the reservoirs and storage structures. Any reduction in runoff/inflow to the reservoirs would mismatch the demand of water requirement in that specific region. Furthermore, operation and maintenance of reservoirs need to be revisited under this change in climate scenarios. Understanding the rainfall distribution and other characteristics are particularly important in a river basin or a catchment area of reservoirs for better water resources management (Rao *et al.*, 2020).

Trend analysis of historical rainfall pattern offers understanding of rainfall characteristics and helps decision makers to manage the water resource effectively to deal with mitigation of extreme events like drought and floods (Bisht *et al*., 2017). Several studies were focused on the trend analysis of rainfall and temperature at country level, basin levels and regional level. Very limited studies were conducted in sub-basin and station level. Temporal variability of rainfall and its characteristics with various time scales *(i.e.* annual, seasonal, and monthly) were widely investigated. Kumar *et al*. (2010) analyzed temporal trends of rainfall by using monthly data series of 135 years (1871–2005) for 30 sub-divisions (sub-regions) in India and reported that no significant trend was detected for entire India. Monsoon and annual rainfall decreased, while for remaining seasons (pre-monsoon, post-monsoon and winter) rainfall increased at the national scale. Deshpande *et al*. (2016) studied long term trend of rainfall of someriver basins in India using IMD rainfall data at 0.25° spatial resolution (1951–2014).They reported an increasing trend in Krishna and Peninsular rivers and decreasing trend in the southwest monsoon seasonal rainfall for Ganga, Narmada–Tapi, Godavari, west coast river basins. Bisht *et al*. (2017) conducted a study on trend analysis of all the river basins of India and they reported that the decreasing trend in monsoon and annual rainfall has become much intense in the post-urbanization period as compared to the pre-urbanization era. Abeysingha *et al*. (2014) assessed the trend analysis of rainfall and temperature in the districts of Gomti River basin. The districts in the upstream area showed significantly increasing trend in annual rainfall ($p < 0.05$), whereas, the districts in the downstream areas showed decreasing trend. Mudbhatkal and Amai (2017) studied trend analysis of temperature and rainfall of Western Ghats and reported that the annual and monsoon rainfall in the southern river decreased at 0.43 and 0.30% decade (1% significance level), respectively.

Pai *et al.*(2014) developed a new daily rainfall data set with grid interval of 0.25° × 0.25° covering a longer historical period of 110 years from the year 1901 to the year 2010 over the entire country and Srivastava *et al*. (2009) developed temperature data set with grid interval of 1° × 1°, latitude × longitude for entire India. Several researchers used the gridded rainfall and temperature data for the study of long term trend analysis (Kumar *et al*., 2010; Duhan and Pandey,2013; Deshpande *et al*., 2016; Mudbhatkal and Amai, 2017; Rao *et al*., 2020) and they also used Mann Kendall (MK) test and Sen's slope estimator to find the trend and slope magnitude. It is very essential to know the spatial and temporal variability in rainfall trend at higher spatial resolution particularly in arid and semi-arid regions. The study was carried out for analysing the long-term trend of rainfall and temperature with respect to space and time.

MATERIALS AND METHODS

Study area

The Krishna Upper basin is a part of the Krishna basin which is one of the major basins in India covering Upper Krishna, Ghataprabha, Malaprabha and Middle Krishna sub basins (Figure 1), situated between 15°3' 20" and 18°6' 20" North latitudes and 73° 39' 30" – 77° 23' 10" East longitudes, extended in the states of Maharashtra and Karnataka. The study area covers parts of Belgaum, Bagalkot, Bijapur, Dharwad, Gadag, Gulbarga, Haveri and Raichur of Karnataka state and Kolhapur, Satara and Sangli districts of Maharashtra. The total drainage area of the study area is about 52300 km^2. The elevation of study area ranges from 343 m to 1456 m with elevation difference of 1113 m. Geologically, the study area comprises of Deccan basaltic lava flows of upper cretaceous to lower eocene age. The high altitude regions of the Western Ghats towards the western part of the study area with more rainfall and the eastern part of the study area, which experiences semiarid to arid climate, has less forest cover.

Details of data sets and data preparation

The entire study area was equally divided into 0.25^o grids and arrived at 74 grid points for virtual rainfall stations. Daily rainfall data at grid interval of 0.25^o x0.25^o for 119 years (1901–2019) was downloaded from the Indian Meteorological Department (IMD) database (Pai *et al*.,2014). Maximum and minimum temperatures at grid interval of 1 ^{o}x1 ^{o} for 69 years (1951–2019) was also downloaded from the IMD website (Srivastava *et al*., 2009). The rainfall and temperature stations data required for the study area was then extracted from downloaded data sets. The daily rainfall, minimum and maximum temperatures data were used to calculate the monthly rainfall and average monthly maximum and minimum temperatures at grid stations. This monthly data was used to calculate the annual, seasonal, average rainfall of sub-basins. Season wise data*i.e*. Pre-monsoon rainfall (summation of monthly data of March, April, May), Monsoon (summation of monthly data of June, July, Aug, Sept.), Post-Monsoon (summation of monthly data of Oct., Nov.) and Winter (summation of monthly data of Dec., Jan., Feb.) were calculated. Sub-basin wise monthly, seasonal, annual average rainfall data were also calculated.

Statistical Analysis

Statistical analysis was carried out with Mann-Kendall test, Theil-Sen's slope estimator (Kumar *et al*., 2009) for monthly, seasonal, and

annual rainfall and temperature using EXCELSTAT plugin in Office 360 (MS Office 2016). This analysis was also carried out for average rainfall, temperature of Upper Krishna, Middle Krishna, Ghataprabha and Malaprabha sub-basins.

RESULTS AND DISCUSSION

Preliminary analysis of rainfall

Initially, rainfall data was examined with general statistics on the basis of total study area and sub-basin wise namely, Middle Krishna, Malaprabha, Ghatprabha and Upper Krishna sub-basins. The general statistics (Minimum, maximum, mean, standard deviation and coefficient of variation) were presented in Table 1. The minimum and maximum rainfall recorded in the study area was 436 mm and 1832 mm, respectively with an average annual rainfall of 750 mm. Among the four sub-basins in the study area, Middle Krishna sub basin recorded mean annual rainfall of 580 mm with minimum rainfall of 315 mm and maximum rainfall of 1055 mm. Upper Krishna basin received mean annual rainfall of 981 mm with minimum rainfall of 524 mm and maximum rainfall of 2350 mm. The mean annual rainfall of Ghatprabha and Malaprabha sub-basins were 778 and 660 mm, respectively. Monsoon season contributed 70% to 80% of the annual rainfall in all the sub basins. Ghatprabha and Upper Krishna recorded more rainfall as western ghats contributed more rainfall to the sub-basins.

The coefficient of variation in the total study area was 22%. The coefficient of variation in Ghatprabha, Middle Krishna, Malaprabha and Upper Krishna were estimated as 24%, 24%, 30% and 24% respectively. Long term annual rainfall of 119 years since 1901 to 2019 for all the river sub-basins and the total study area were also presented in the Fig.2.

Spatial distribution of rainfall

The spatial distribution maps of average annual rainfall and monsoon rainfall were prepared and illustrated in Fig.2. Long term average ranged from 530 mm to 2000 mm and average monsoon rainfall ranged from 300 mm to 1800 mm. Most of the rain gauge stations in the study area received average annual rainfall ranging from 530 mm to 700 mm and characterized as semi-arid area. Middle Krishna sub basin, most of the area in Malaprabha sub-basin and part of Ghatprabha and Upper Krishna sub-basins fall under the rainfall region of 530 mm to 700 mm which was characterized as semi-arid regions. The western part of the study area isinfluenced by Western Ghats and received average annual rainfall ranging from 950 mm to more than 2000 mm. Similarly, spatial distribution of rainfall was also observed in the monsoon season rainfall. Most of the rainfall stations in the semi-arid area received an average monsoon rainfall ranging from 300 mm to 490 mm and the stations located in and closed to Western ghats received 700 mm to >1800 mm.

Preliminary analysis of maximum and minimum temperatures

Maximum and minimum temperatures of IMD data at grid interval of 1R”x 1R”for 69 years (1951–2019) were used to study the temperature trend and its variability. Five temperature grid stations fall under the study area. Average monthly, seasonal and annual maximum and minimum temperatures were calculated for entire study area. The general statistics of maximum and minimum temperatures were also calculated to understand the data before going for trend

analysis. The general statistics were presented in Table 2.

The annual mean maximum temperature and minimum temperature were recorded as 31.39 ^{0}C and 20.89 ^{0}C, respectively. The highest average maximum temperatures were observed in the month of April and ranged from 33.2 ^{0}C to 38.9 ^{0}C. The lowest average minimum temperatures were observed in the months of December and January and ranged from 14.3 to 19.4 ^{0}C. Standard deviation and coefficient of variation of annual maximum temperatures and minimum temperatures were 0.51%, 1.61% and 0.33%, 1.57%, respectively. The monthly coefficient of variability for maximum temperature ranged from 2.04% (Jan) to 3.17% (June) and minimum temperatures ranged from 1.32% (Aug) to 6.56% (Nov).

Trend analysis of rainfall

Mann Kendall test was carried out for entire study area wise, four sub basins wise and also carried out for all the 74 grid rainfall stations at monthly, seasonal and annual rainfall basis for the period of 119 years since 1901 to 2019. The MK test used to check the null hypothesis of no trend versus the alternative hypothesis of the existence of increasing or decreasing trend. Since the sample size was large (n>50), no pre-whitening of the data series was carried out. Sen's slope estimator was used to detect the magnitude of the trend in the time series data.

MK test and Sen's slope estimator for the total study area

The results of MK test and Sen's slope for average rainfall data for entire study area were given in Table 3. The results revealed that there was no much change or little change in non-monsoon months of January, February, March, April, May, November and December. There was increasing trend observed in the months of June, August, September, and October with increase of 0.261, 0.309, 0.045 and 0.166 mm/year, respectively. The increasing trend of rainfall in the months of June and August were found to be significant. Interestingly, it was found that there was small decreasing trend in the rainfall with decrease of -0.032 and -0.068 mm/year in the month of Julyand August, respectively. Among all the seasons, it was witnessed that the monsoon rainfall increased by 0.528 mm/year. It was also observed that there was no considerable increasing or decreasing trend in the rainfall in other three seasons. A positive trend in the annual rainfall data was also observed with 0.557 mm/ year.

MK test and Sen's slope estimator for the sub-basins

Average seasonal and annual rainfall time series data for four sub-basins were developed from the rainfall grid. MK test and Sen's slope estimator were applied to the time series data and the results were depicted in the Table 4. It was observed that there was an increasing trend in Middle Krishna sub-basin and Upper Krishna sub-basin in annual rainfall with 0.414 and 0.894 mm/year and also observed that there was no much change in annual rainfall in Ghataprabha and Malaprabha sub-basins with negligible increase of 0.023 and 0.078 mm/year, respectively. Rainfall trend in the monsoon season among sub-basins were evaluated and observed that except for Malaprabha sub basin, all other sub-basins rainfall trend was increasing with 0.321mm/year, 0.228mm/year and 0.919 mm/year in Ghataprabha, Middle Krishna and Upper Krishna sub-basins, respectively.

The trend for the monsoon season in Upper Krishna basin was found to be significant. During the pre-monsoon season in the Ghataprabha, and Upper Krishna sub-basins, the rainfall trend was found negative with -0.101 and -0.183 mm/year. In Malaprabha sub-basin, it was observed that during pre and post monsoon season, the rainfall trend increased by 0.142 and 0.062 mm/year. Interestingly, Sen's slope was more in post-monsoon season (0.259 mm/year) than in monsoon season (0.228 mm/year) for Middle Krishna sub-basin. Monsoon months rainfall trend was also analysed and no significant trend was observed in Ghataprabha and in Middle Krishna sub-basins. There was significant trend observed in the month of June which was highest increase among the monsoon months in Malaprabha and Upper Krishna sub-basins with 0.179 and 0.547 mm/year, respectively. In Upper Krishna basin, the magnitude of rainfall increasing trend was 0.487/year in the month of August. Similar results were reported by several researchers for Krishna basin and parts of Krishna basin. Kumar *et al.* (2010) reported that no significant trend was observed in seasonal and annual rainfall North Interior Karnataka and South Interior Karnataka. Jain *et al.* (2012) also reported that the rainfall in Krishna basin did not show significant trend. Mudbhatkal and Amai (2017) also reported that no significant trend in annual and seasonal rainfall of Purna, Tunga, and Netravathi Rivers of Western Ghats regions of India.

MK test and Sen's slope estimator at rainfall grid level

Mann Kendell test and Sen's slope estimator were used to know the significance of rainfall trend and its magnitude for all 74 rainfall grid stations at monthly, seasonal and annual basis. The spatial distribution of magnitude of rainfall trends at seasonal level were given in Fig. 3. During pre-monsoon season, rainfall trend in western parts of MiddleKrishna Malaprabha Ghataprabhaand Upper Krishna showed negative trend upto -0.50 mm/year. The remaining part of the study area showed positive trend with magnitude upto 0.45 mm/year. It was also observed that no considerable trend was observed in winter season for all the sub-basins. The magnitude of annual rainfall trend for entire Middle Krishna sub-basin and middle and lower catchment areas of Malaprabha, Ghataprabha and Upper Krishna sub-basins were shown positive and increased upto 1.56 mm/year. The upper catchment area of Ghataprabha and some pockets of Malaprabha and Upper Krishna were shown decreasing trend for annual rainfall with magnitude up to -5.21 mm/year. Few stations in Upper Krishna sub basin which were influenced by Western Ghats were shown increasing trend with 1.67 to 7.76 mm/year. Similar trend in monsoon rainfall was also observed and the magnitude of increase in rainfall trend was observed up to 8.48 mm/year. For most of the rainfall grids in the study area, the magnitude of increase in rainfall was up to 1.86 mm/year. The magnitude of post-monsoon season in Middle Krishna sub-basin, middle and lower reaches of Malaprabha and Ghataprabha sub-basins and some pockets of Upper Krishna sub-basins were found to be positive and increased up to 0.36 mm/year.The rainfall grid points located in eastern part of the study area showed positive trend in post monsoon rainfall and the rainfall trend of western part of study area showed negative trend with a magnitude upto -0.50 mm/year.

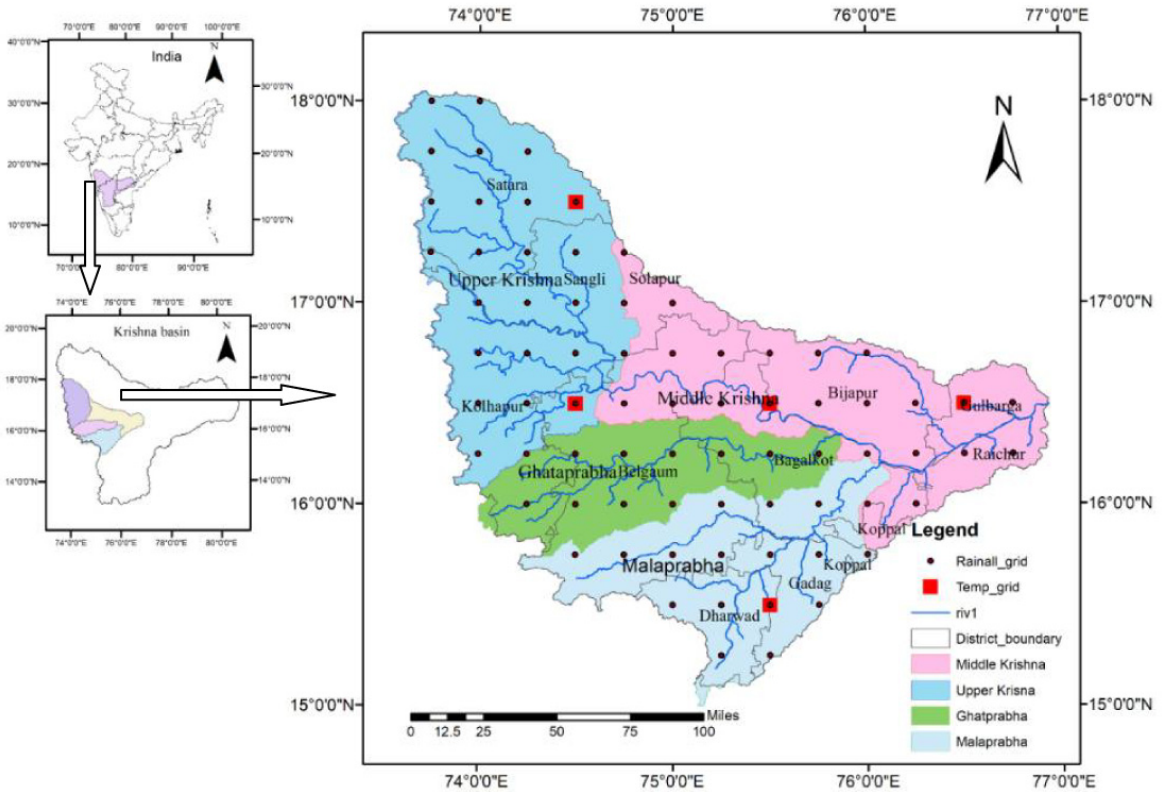
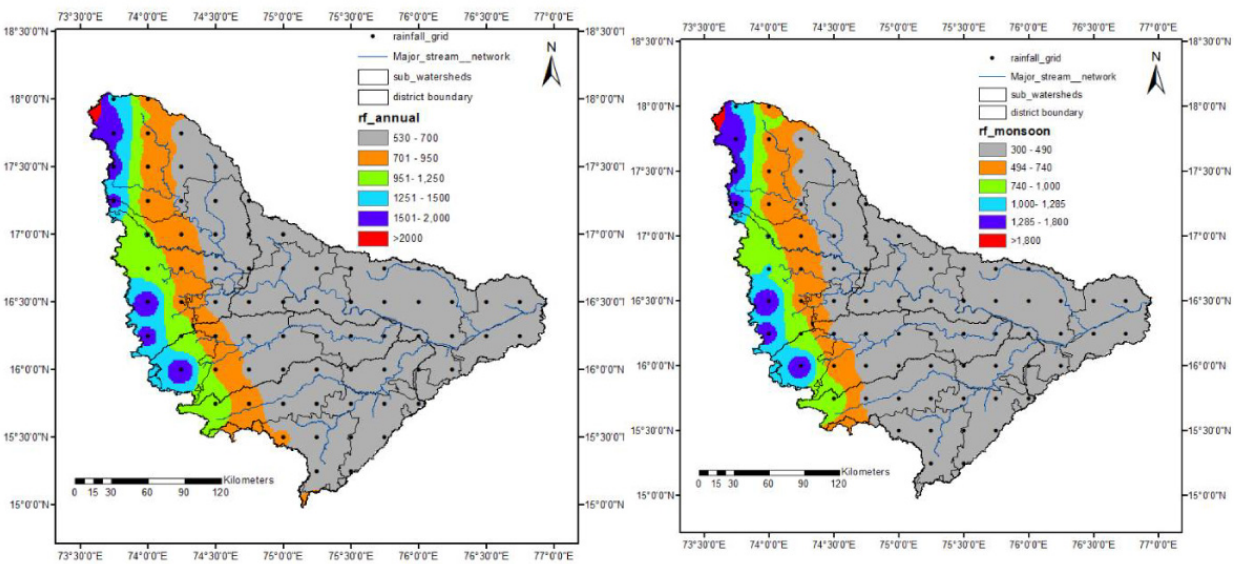


Fig. 1. Study area along with rainfall and temperature grid points, sub-basins and district boundaries



(a) (b)

Fig. 2. Spatial distribution of average rainfall in the study area (a) Annual rainfall, (b) Monsoon rainfall

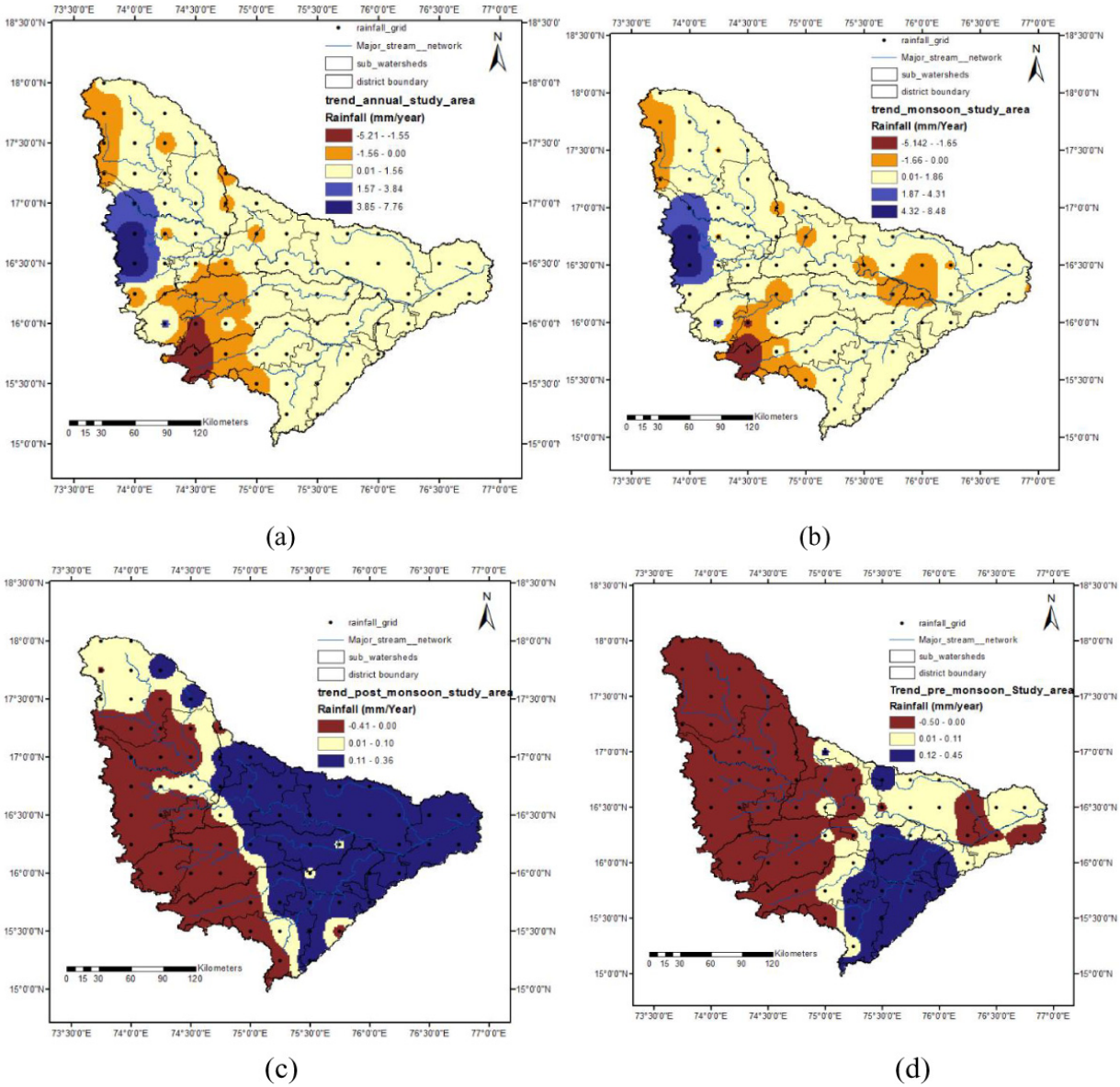


Fig. 3. Spatial distribution of magnitude of rainfall trend of (a) annual (b)monsoon (c) post monsoon and (d) Pre-monsoon seasons rainfall

Trend analysis of temperature

Maximum and minimum temperatures trend and its significance was identified by Mann Kendell test and Sen's slope estimator. This analysis was done for all five grid stations at monthly, seasonal and annual basis. The results of MK test and Sen's slope for annual average maximum temperature of the study area are presented in Table 5. The results revealed that there was statistically significant increasing trend in all the months, seasons and annual maximum temperatures. There was an increase in annual maximum temperature with 0.02^0 per year. The highest and lowest increase of maximum temperature was observed in the month of May with 0.026^0/year and in the month of June with 0.013 ^{0}C/year, respectively. The increase of maximum temperature in the seasons, pre-

Table 1. General statistics of rainfall data

S.No.	Sub-Basin	Season	Minimum rainfall (mm)	Maximum rainfall (mm)	Mean rainfall (mm)	SD	CV
1	Middle Krishna	Pre-monsoon	11.76	204.63	67.73	35.39	0.52
		Monsoon	155.56	687.31	378.33	103.24	0.27
		Post-monsoon	2.69	431.89	123.41	74.69	0.61
		Winter	0.00	98.44	11.03	16.47	1.49
		Annual	315.40	1055.06	580.16	140.67	0.24
2	Malaprabha	Pre-monsoon	35.00	222.46	98.12	40.95	0.42
		Monsoon	159.43	1904.45	411.88	168.88	0.41
		Post-monsoon	7.98	508.11	138.84	78.12	0.56
		Winter	0.00	130.89	11.38	19.32	1.70
		Annual	370.80	2201.44	660.24	196.04	0.30
3	Ghataprabha	Pre-monsoon	6.43	233.23	95.60	46.80	0.49
		Monsoon	295.72	1630.30	533.09	157.65	0.30
		Post-monsoon	61.22	455.00	171.29	72.72	0.42
		Winter	0.00	78.39	10.66	15.17	1.42
		Annual	479.10	1855.03	778.09	185.09	0.24
4	Upper Krishna	Pre-monsoon	7.38	216.65	67.21	40.45	0.60
		Monsoon	297.82	2089.22	795.34	207.13	0.26
		Post-monsoon	12.98	314.26	127.60	72.33	0.57
		Winter	0.00	92.35	9.36	17.24	1.84
		Annual	513.51	2349.28	981.13	231.73	0.24
5	Total study area	Pre-monsoon	19.92	184.73	82.17	36.51	0.44
		Monsoon	264.65	1577.82	529.66	140.50	0.27
		Post-monsoon	23.42	427.32	140.29	68.98	0.49
		Winter	0.00	100.02	10.61	16.13	1.52
		Annual	436.26	1832.84	749.90	167.69	0.22

monsoon, monsoon, post monsoon and winter were observed as 0.023, 0.17 ^{0}C, 0.18, 0.19 ^{0}C/ year respectively. The linear regression line between the annual average maximum temperature and years showed positive increasing trend with regression coefficient (R^2) of 0.67.

The results of MK test and Sen's slope for annual average minimum temperature of the study area are presented in Table 6. It was recorded that the trend for monthly minimum temperatures was not statistically significant. However, the trend in pre-monsoon and winter seasons was found to be significant. The trend

Table 2.General statistics of average monthly, seasonal and annual maximum and minimum temperature

S.No.	Month/ season	Tmax (℃)					Tmin (℃)				
		Max	Min	Mean	SD	CV (%)	Min	Max	Mean	SD	CV (%)
1	January	32.2	29.3	30.8	0.6	2.04	15	18.4	16.8	0.8	4.9
2	February	34.2	30.6	32.2	0.8	2.5	15.9	19.6	17.9	0.8	4.3
3	March	36.9	32.1	34.1	0.9	2.62	19.4	22.2	20.7	0.7	3.4
4	April	38.9	33.2	35.4	1.0	2.79	21.7	24.8	23.2	0.6	2.7
5	May	38.3	32	35.0	1.0	2.98	22.9	25.3	24.2	0.5	2.0
6	June	33.3	28.6	30.6	1.0	3.17	22.3	24	23.1	0.4	1.8
7	July	30.2	26.1	28.2	0.7	2.59	21.7	23.2	22.5	0.3	1.3
8	August	29.9	26.5	28.0	0.7	2.48	21.6	23	22.2	0.3	1.3
9	September	31.3	27.4	29.3	0.8	2.55	20.9	22.7	21.9	0.3	1.5
10	October	33.3	29.3	31.1	1.0	3.15	19.5	22.4	21.5	0.5	2.4
11	November	32.7	29.3	31.3	0.7	2.24	16.2	22	19.4	1.3	6.6
12	December	32.8	28.8	30.7	0.7	2.16	14.3	19.4	17.4	1.1	6.2
13	Pre-monsoon	37.8	33.5	34.8	0.8	2.4	21.8	23.7	22.7	0.5	2.0
14	Monsoon	30.5	27.5	29.0	0.6	2.07	21.8	23.1	22.4	0.3	1.2
15	Post-monsoon	33	29.3	31.2	0.8	2.43	17.9	22.2	20.4	0.8	3.9
16	Winter	32.4	30.2	31.3	0.5	1.65	16.1	18.5	17.4	0.6	3.3
17	Annual	32.7	30.1	31.4	0.5	1.61	20.1	21.5	20.9	0.3	1.6

for annual average minimum temperature was found to be decreasing trend with -0.004 ^{0}C / year. The trend for monthly average minimum temperature during the months of October, December to May was found be increasing trend ranged from -0.001 to -0.015 ^{0}C/year. A negligible increasing trend was observed in monthly average minimum temperatures during the months of June to September and November. The trend in average seasonal minimum temperature was found to be -0.006 ^{0}C, -0.001 ^{0}C, 0.001 ^{0}C and -0.01 ^{0}C/ year for the entire study area. The linear regression line between the annual average minimum temperature and years showed decreasing trend. Jain and Kumar (2012) reported that most of the stations in India, the mean maximum temperature was rising trend, mean and minimum temperature showed both rising and falling trend respectively. Mudbhatkal *et al.* (2017) reported that the temperature in Malaprabha catchment area showed increasing trend.

CONCLUSION

The study examined the trend analysis of rainfall, maximum and minimum temperature for long term. Mann Kendell test and Sen's slope estimator were used to detect significant trend and its magnitude. There was positive trend observed in the months of June, August, September and October with magnitude of 0.261 mm, 0.309 mm, 0.045 mm and 0.166 mm/year, respectively for the whole study area. The increasing trend of rainfall in the months of June and August was found to be significant. A positive trend in the annual rainfall data of whole study

Table 3. Results of MK test and Sen's slope estimator for the monthly, seasonal and annual precipitation during 1901-2019 for the entire study area

S.No.	Series\Test	Kendall's tau	p-value	Sen's slope
1	Jan	-0.058	0.375	0.000
2	Feb	-0.006	0.923	0.000
3	Mar	0.014	0.825	0.001
4	Apr	-0.036	0.563	-0.020
5	May	0.014	0.818	0.019
6	Jun	0.180	**0.004**	**0.264**
7	Jul	-0.015	0.811	-0.032
8	Aug	0.147	**0.018**	**0.309**
9	Sep	0.018	0.772	0.045
10	Oct	0.065	0.293	0.166
11	Nov	-0.087	0.159	-0.068
12	Dec	-0.026	0.688	0.000
13	Winter	-0.115	0.063	-0.019
14	Pre_monsoon	-0.005	0.934	-0.007
15	Monsoon	0.114	0.068	0.528
16	Post_monsoon	0.022	0.727	0.058
17	Annual	0.096	0.124	0.557

*bold values indicate statistical significance at 5% significant level as per the Mann-Kendall test (+ for increase and – for decreasing)

Table 4. Magnitude of rainfall trend (Sen's slope estimator) for monsoon months rainfall and seasonal & annual precipitation during 1901-2019 for sub-basins level

S. No.	Month/Season	Middle Krishna	Malaprabha	Ghataprabha	Upper Krishna
1	June	0.146	**0.179**	0.202	**0.574**
2	July	0.002	**-0.258**	-0.154	-0.064
3	August	0.177	0.167	0.188	**0.487**
4	September	-0.104	-0.089	0.034	0.294
5	October	0.301	0.085	0.034	0.062
6	Pre-monsoon	0.031	0.142	-0.109	-0.183
7	Monsoon	0.228	-0.065	0.321	**0.919**
8	Post- monsoon	0.259	0.062	0.005	-0.059
9	Winter	-0.015	-0.008	-0.016	-0.011
10	Annual	0.414	0.078	0.023	0.894

Note: *bold values indicate statistical significance at 5% significant level as per the Mann-Kendall test (+ for increase and – for decreasing)

Table 5. Results of MK test and Sen's slope estimator for the monthly, seasonal and annual Maximum temperature during 1951-2019 for the entire study area

S. No.	Series\Test	Kendall's tau	p-value	Sen's slope
1	January	0.411	**<0.0001**	0.018
2	February	0.357	**<0.0001**	0.022
3	March	0.379	**<0.0001**	0.024
4	April	0.402	**<0.0001**	0.023
5	May	0.386	**<0.0001**	0.026
6	June	0.194	**0.019**	0.013
7	July	0.375	**<0.0001**	0.017
8	August	0.469	**<0.0001**	0.021
9	September	0.317	**0.000**	0.016
10	October	0.259	**0.002**	0.019
11	November	0.373	**<0.0001**	0.019
12	December	0.342	**<0.0001**	0.016
13	Pre-monsoon	0.519	**<0.0001**	0.023
14	Monsoon	0.423	**<0.0001**	0.017
15	post-monsoon	0.344	**<0.0001**	0.018
16	winter	0.543	**<0.0001**	0.019
17	Annual	0.654	**<0.0001**	0.020

Note: *bold values indicate statistical significance at 5% significant level

area was observed with 0.557 mm/year and magnitude of monsoon rainfall trend was 0.528 mm/year and also showed no considerable trend in other three seasons. The results showed that there was increasing trend in Middle Krishna sub-basin and Upper Krishna sub-basin in annual rainfall with 0.414 mm/year and 0.894 mm/year and also observed that there was no much change in annual rainfall in Ghatprabha and Malaprabha sub-basins. The rainfall trend in monsoon season of Upper Krishna basin showed a significant positive trend with a magnitude of 0.919 mm/year.

The upper catchment area of Ghatprabha and some pockets of Malaprabha and Upper Krishna had shown decreasing trend of annual rainfall with magnitude up to -5.21 mm/year. Few stations in Upper Krishna basin which were influenced by western ghats were shown increasing trend with 1.67 to 7.76 mm/year. The results also showed that the maximum increase in monsoon season recorded as 8.48mm/year. The study concluded that there was lot of spatial variability in rainfall trend across the study area particularly in annual and monsoon season and less variability in pre-monsoon, post-monsoon season and winter seasons. It was also recorded that the rainfall in the Eastern part of all sub-basins except Upper Krishna during post and pre monsoon periods found to be increased.

The maximum temperature was found to be statistically significant increasing trend in all

Table 6. Result of MK test and Sen's slope estimator for the monthly, seasonal and annual minimum temperature during 1951-2019 for the entire study area

S.No.	Series\Test	Kendall's tau	p-value	Sen's slope
1	January	-0.153	0.064	-0.010
2	February	-0.152	0.065	-0.009
3	March	-0.123	0.137	-0.007
4	April	-0.140	0.090	-0.007
5	May	-0.133	0.107	-0.005
6	June	0.045	0.587	0.001
7	July	0.064	0.437	0.002
8	August	0.026	0.752	0.001
9	September	0.010	0.909	0.000
10	October	-0.052	0.531	-0.002
11	November	0.007	0.934	0.001
12	December	-0.171	**0.039**	-0.015
13	Pre-monsoon	-0.173	**0.036**	-0.006
14	Monsoon	0.057	0.494	0.001
15	Post-monsoon	-0.014	0.864	-0.001
16	Winter	-0.216	**0.009**	-0.010
17	Annual	-0.146	0.077	-0.004

Note: *bold values indicate statistical significance at 5% significant level

the months, seasons and annual maximum temperatures. There was an increase in annual maximum temperature by 0.02 ^{0}C per year. The highest and lowest increase of maximum temperature was observed in the month of May by 0.026 ^{0}C/year and in the month of June by 0.013 ^{0}C/year respectively. It was found that the trend for monthly minimum temperatures was not statistically significant. However, the trend in pre-monsoon and winter seasons was found to be significant. The trend for annual average minimum temperature was found to be decreasing trend by -0.004 ^{0}C/year. Furthermore, it is concluded that the increasing trend in minimum and maximum temperatures in the study area could lead to increase the evapotranspiration and irrigation water needs of crops in the study area in future as well.

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PREPARATION AND ANALYSIS OF NON-WOVEN FABRICS FROM UNDERUTILIZED PLANT STEMS

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ABSTRACT

Many plants have medicinal and therapeutic properties that will be and are of utmost importance in the various fields of technical textiles. Plants such as turmeric, neem, castor has numerous health promoting agents mainly used in the pharmaceutical's. Among the agricultural waste, the stems and twigs of the plants *i.e.*castor, turmeric, neem twigs are more promising as fibres extracted from them possess several useful properties. In the study conducted from the year 2019 to 2021 at Coimbatore, Tamil Nadu,the fibres were extracted from the castor, turmeric plant stem and neem twigs through the process of retting and non-woven fabrics were prepared using needle-punched method. The non-woven were blended with cotton fibre and then treated with its respective therapeutic oils to increase its properties. As the three selected fibres possessed healing and antimicrobial properties, it could be used as the potential source of raw materials in healthcare textiles. The non-woven fabrics were then evaluated, analysed and found that the prepared non-woven showed a good air-permeability, good water repellence, high thermal insulation property which could be used for the potential application for the development of technical textile materials.

Keywords: Agricultural waste, Biodegradable, Green environment, Non-woven fabrics

INTRODUCTION

There is an abundance of sources from which natural fibres can be extracted. Research efforts are refocusing on exploring alternative fibre crops, crop residues, and agricultural by-products, which are often underutilized. Presently there are some of the agricultural residues that have potential use in the area of textiles that is scarcely extracted and utilized.

The advantages of using agricultural residues are three-fold: economic, environmental, and technological. Traditionally farmers have harvested the produce and burnt or otherwise disposed of the other residues (stalks, stover, etc.). Utilizing agricultural wastes means that farmers can reap a "second harvest" from these wastes which are otherwise burnt. Burning yields smoke and other pollutants which adversely affect air quality, visibility, human and

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environmental health. This can be eliminated by utilizing them in a productive way. Technological interventions are required to use them productively without any environmental harm. New technologies are required to innovate and produce materials for a large variety of applications. Optimizing both the bulk and surface properties of various materials represents one of the promising approaches for meeting the technical and economical requirements for high-tech materials.

Konwar and Boruah (2018) stated that the textile fibres form an integral, fundamental and essential part of the life. They further opined about the natural fibres to be a sustainable textiles owing to its low cost, no health hazards anddegradability, etc.

The focus and trend on green environment has become the main goal for achieving a sustainable environment and the need of the hour in the present scenario of today. In this study, three therapeutic plants namely Castor, Neem and Turmeric were used. Castor plant has a great utilitarian value in making variousapplications in industry, agricultural sectors and pharmaceuticals uses (Salihu *et al.,* 2014).Turmeric plant and its extracts were being used in regulating and maintaining the biological activities andpharmacological products (Amalraj *et al.,* 2017). Furthermore, it is reported that the turmeric powder showed a healing power effect on aseptic and septic wounds in the animal studies. All the parts of the turmeric plants and many extracts were reported and found to be quite useful in many applications of our day to day life.

MATERIALS AND METHODS

Pilot study

The source of the study was selected based on the pilot study and literature survey. The pilot study was conducted by collecting various medicinal plants stems such as Castor plant, Sanseviera Cylindrica, Turmeric plant, Neem twigs,Water hyacinth,etc. A market and consumer survey was also conducted in the month of October, 2019 for two weeksto see the preference for the development of the new product for wound dressing material. The castor plant stalk, neem plant and turmeric plant stems wereselected andfurther identified at Botanical Survey of India (BSI), TNAU, Coimbatore,Tamil Nadu.

Market and consumer survey

The market survey was analysed and it was recorded that the medical and healthcare textile sector prefers natural medicinal plants to be the main source in the development of any kind of medical / healthcare textile market. The healthcare sector mainly concerns in the making of non-woven fabrics for the production of various products. The survey revealed that the eighty-five percent of the shops were satisfied with the existing textile market of the healthcare and medical products. They were satisfied with the performance of the existing fabric and fifteen percent were not satisfied with the existing product. Nearly fifty percent shops preferred a new product that will be more economical, possess its own medicinal properties as well as comfortable to the user. They are ready to accept new products.

The consumer survey was conducted randomly among the people from Coimbatore

district, respectively. The collected data were gathered and analysed. Half of the consumers nearly fifty percent were not satisfied with medical /healthcare textile products available in the market. They preferred a wound healing product which can heal faster and have healing properties. Hundred percent of the consumers wants a product to be made and developed from the medicinal plant. Around seventy percent were satisfied with the price of the existing product. The remaining thirty percent preferred a product which will be more economical and comfortable to use.

Fibre extraction-retting

The fibres were extracted with the help of pool retting process. The quality of the fibres has a major impact in the process of retting as studied by Ashish Hulle *et al*. (2015). Manimekalai and Kavitha (2017) had reviewed on the different types of Retting methods for bast fibres. Pool retting was carried out at the Production Laboratory, Avinashilingam University for 17 days in the month of January,2020. The Castor, Neem and Turmeric fibres were retted and extracted by proper washing and later on it was dried in the shade for one day. The process of retting is shown in Fig. 1.

Blend proportion and preparation of needle-punched non-woven

The extracted fibres were then blended with cotton fibres for the preparation of non-woven so that the cotton fibre can form as the base of the non-woven fabric. The ratio of blending of the non-wovenwascarried out for 50:50 proportion for three extracted fibres with cotton.The extracted bastfibres were not possible for 100% processing due to fibre breaking and less cohesiveness. The coding of the samples is given in the table 1. The Carding process and the Needle Punching were conducted in the Production Laboratory, UGC SAP project, Avinashilingam Institute, Coimbatore, Tamil Nadu. Figure 2 shows the images of the non-woven manufacturing of carding and needle-punching. Maity *et al*.(2012) opined that natural fibres which are used in the preparation of non-wovens are specifically for the application of technical textile in various sector.

Application of oil on the non-wovens

The non-woven was then treated with its respective turmeric therapeutic oils. Several

Step1 Collection of stems | Step 2 Pool retting | Step 3 Manual extraction | Step 4 Dried extracted fiber

Fig. 1. Retting Process

Table 1. Coding of the four samples

S.No.	Samples	Details of the sample
1.	C+C	Cotton with Castor (50:50)%
2.	C+N	Cotton with Neem (50:50)%
3.	C+T	Cotton with Turmeric (50:50)%
4.	C+C+N+T	Cotton with Castor,Neem, Turmeric. (40:20:20:20)

Fig.2a. Carding

Fig. 2b. Needle-punching process

studies have reported that the application of oil in fabrics have several advantages and enhances its properties depending on their products developed. Orafidya *et al.* (2003) studied that the application and treatment of herbal oil can enhance the rate of wound healing in a faster rate.The treatment of oil was applied with the help of the padding mangle machine. If the sample is too small then, the oils can also be applied manually with the help of the small brush. The oils were treated to impart significance and to enhance its therapeutic and medicinal properties to the non-wovens for various application depending on the end product.

After the oils were applied and treated to the non-woven samples, the samples were conditioned at standard atmospheric condition of RH 65± 2% and a temperature of ± 20 ^{0}C. Then, the samples were carried out and analysed for air permeability, thermal conductivity, spray test, sinking test.

Measurement of air permeability

The air permeability test of the prepared non-woven fabrics was conducted at the Department of Textiles and Apparel Design, Textile testing laboratory in Bharathiar University, Coimbatore, Tamil Nadu in February, 2021. Air permeability is the volume of air passed in second through the fabric of 100s mm^2. In this test, the nonwoven samples were clamped to the air inlet and the air passes through by means of a pump and measured with a flowmeter. The test was conducted for 10 readings for each sample and the average mean was calculated to see the accuracy and permeability of the samples.

Spray test- One of the methods to measure the fabric resistance to wetting of the surface which are usually applied for shower proof application for fabric finishes. Sometimes water proofcoatings are quite necessary as otherwise it will be waterlogged (Saville, 2008).

For this test, the non-woven samples were held in anembroidery hoop and mounted at an angle of 45 degree angle horizontally. As shown in the Fig. 3, a distilled water of 250 ml at 20^0 C was poured from the funnel which held upwards. The results were then observed by the standards photograph as given by the American Association of Textile Chemists and Colorists Scale (2013).

Thickness measurement

The thickness of the samples with and without the application of their respective oil was measured at the Testing laboratory, Department of Textiles and Clothing, Avinashilingam Institute, Coimbatore, Tamil Nadu. The reading of the dial gauge was noted to get the thickness of the specimen at normal load. Then, the weights were placed in the top of the tester in an increasing order and readings were noted as shown in Fig.4.

Fig. 3. Spray test

Fig. 4. Thickness

Fig. 5. Thermal conductivity

Thermal Conductivity: One of the intrinsic quality which determines the importance for maintaining proper insulation, water and wind proofing, etc. (Govindaraju and Jagannathan, 2018). The thermal conductivity test was conducted and carried out at Testing Laboratory, Department of Textiles and Clothing, Avinashilingam Institute, Coimbatore, Tamil Nadu. The values and results is expressed and given in Clo unit value which is an American unit (Saville, 2008). The picture is shown in Fig. 5.

Sinking Test:This test determines whether the fabric samples float or sink to check the absorbency of the materials. A piece of fabric of square shape of 25 mm x 25 mm was taken from all the blended non-woven samples. The ASTM D1117-80(section 5) was followed for the sinking test of non-woven fabrics. Then the samples were put in a beaker filled with distilled water. The length of the time taken to sink was observed and shown graphically for both the treated and untreated (Fig.10).

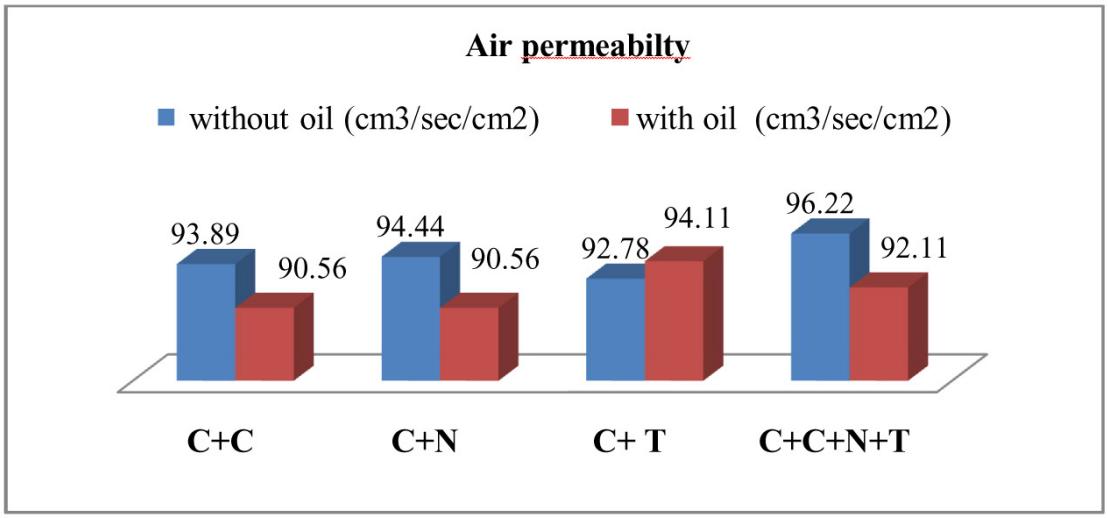

Fig. 6. Air permeabilityof the treated and untreated non-woven samples

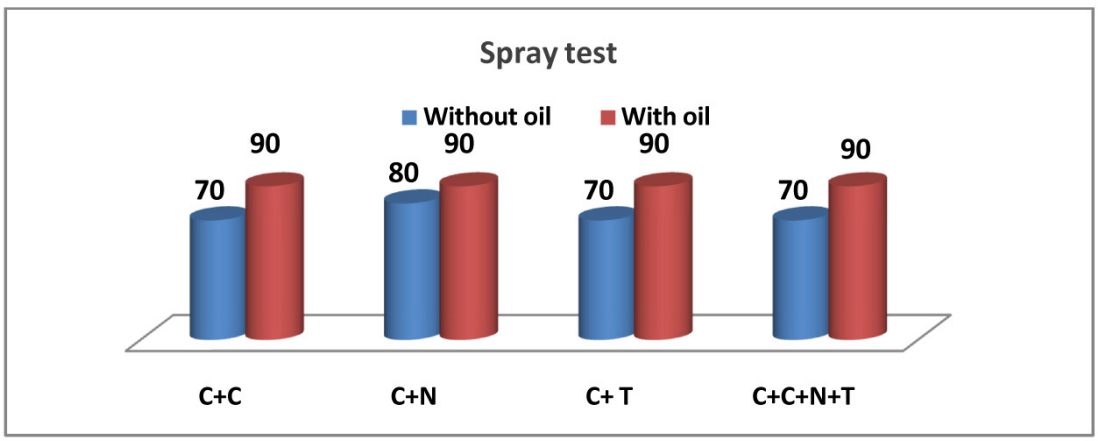

Fig. 7. Spray test of the treated and untreated samples

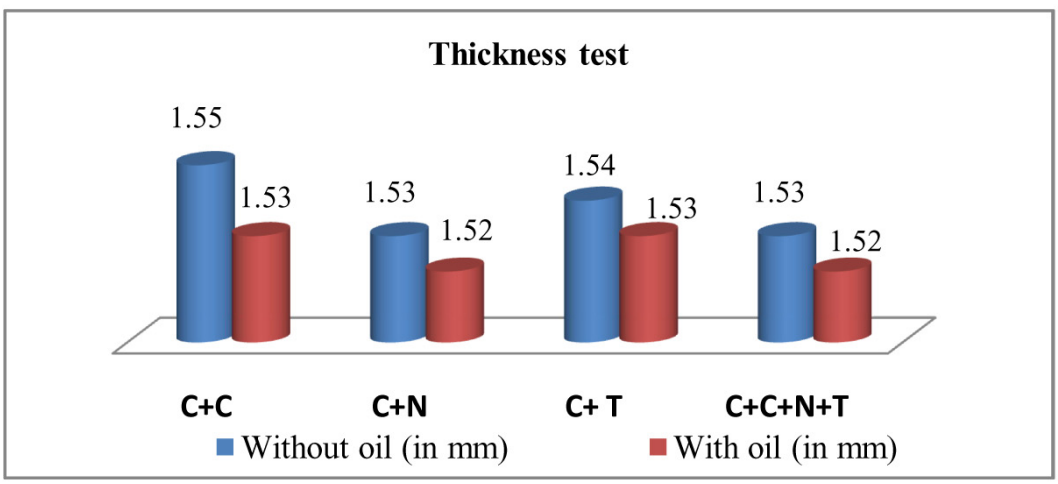

Fig. 8. Thickness of treated and untreated non-woven samples

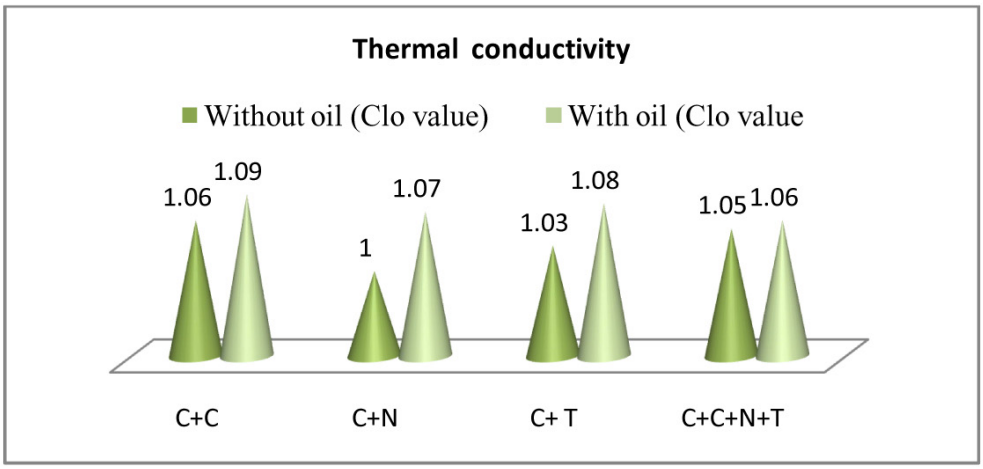

Fig.9. Thermal conductivity of treated and untreated non-woven samples

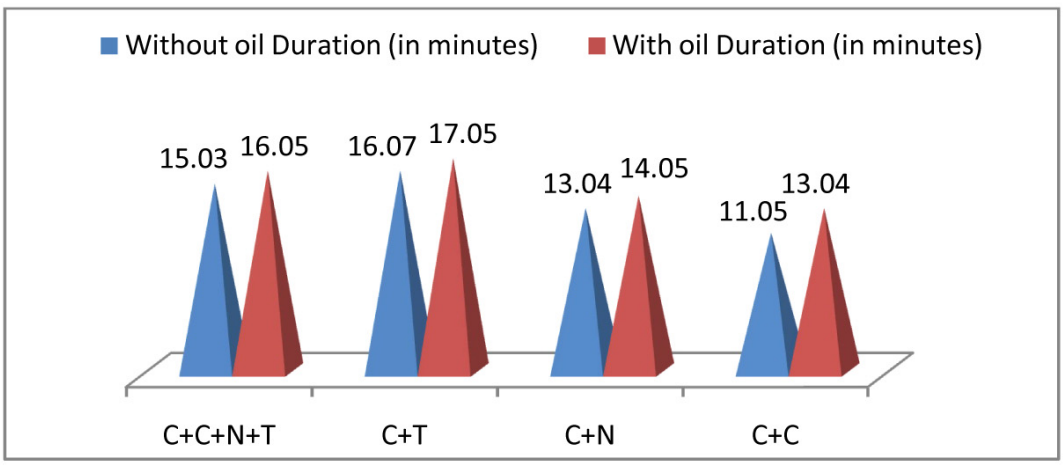

Fig.10. Sinking of the treated and untreated non-woven samples

RESULTS AND DISCUSSION

The result of the air permeability, thickness of the samples and thermal conductivity were recorded by following the standards of ASTM D737-96 for air permeability non-woven textiles, ASTM D5729-97 for the thickness and ASTM C177 for thermal conductivity of non-woven. It showed a good permeability which allows a proper passage of air through the samples. Saville (2008) in physical testing of textiles indicated the importance for passage of air in several applications in Technical Textiles such as filters, parachutes, airbags, etc. The fabric thickness also plays an important role in the comfort of the fabric.

Among the four samples, the combination of the three fibres with cotton (C+C+N+T) showed the best result of air permeability when compared with the remaining 3 samples. The untreated samples showed better results of air permeability than the treated samples. And it further showed that the treatment of oil slightly affects and influences to lower the passage of air flow for all the four samples for both air permeability and thickness of the samples. The thicker the fabric samples, lesser the permeability of the air to flow as well as the thermal conductivity

of the sample. Debnath (2011) also reported a similar study that the nonwovens prepared from jute and polypropylene blends showed an increased in thickness decreased the values of the air permeability and thermal conductivity.The graphical representation of the comparison of the air permeability, spray test, thickness, thermal conductivity and sinking test among the treated and untreated samples were showed in Figures 6,7, 8, 9 and Fig. 10. For the thermal conductivity test, the Clo value of the samples were observed and C+C sample showed the highest value for both the treated and untreated samples indicating a high thermal insulation property whereas the sample C+N showed the minimum value of Clo.

Regarding the spray test, four of the untreated samples *i.e*. (C+C, C+N, C+T, C+N+T) showed a rating of 70 indicating a partial wetting of whole of the upper surface where C+N showed 80 rating that indicate wetting of upper surface at spray points. Among the samples treated with oil, all the samples showed a result of 90 rating which indicated a slight random sticking or wetting of the upper surface. The result of spray test indicates that the non-woven fabric possess a water-proof property which will be useful in the preparation of water-proof textile materials and products.

Sinking test was performed to see the absorbability of the samples. It was observed that all the non-woven samples took more time to sink which takes an average of around 16 to 18 minutes, therefore all the samples were considered to be floated. All the five test values of the treated and untreated samples can be given in a single tablewhich can be referred at a glance mention below.

Non-woven have several applications in the field of textile industry as it has various functional properties like high durability, resistance to water and fire, strength and cost effective. The prepared blended non-wovens from the selected three plants (Castor, Neem and Turmeric)with and without the treatment of its respective oils to improve its therapeutic properties can be used for the development of healthcare textiles.The application of its respective oils will enhances the properties and recent studies have shown that moist wound dressing materials helps in healing faster (Nuutilla and Erikson, 2021). As the three selected possess healing and antimicrobial properties, it could be used for the wound dressing materials, underarm pads, heel pads, etc.

CONCLUSION

The fibers extracted from the three selected medicinal plants possess several medicinal properties of healing, antibacterial, anti-inflammatory which will be useful and beneficial for the development of Healthcare Textiles. In the study , it was found that the needle punched nonwoven fabricsshowed good air permeability, medium water repellence and a good thermal insulation. Among the untreated samples, the combination of three fibres with cotton (C+C+N+T) showed the highest air permeability.The untreated samplesshowed a better air permeability than the treated samples as the application of oil has slight effect on the passage of airflow and the thickness of the samples. For the thermal conductivity, both the treated and untreated has the Clovalue of above 1 indicating the slow transfer of heat flow of the materials, the treated sample C+C having the

highest Clo value. The treated samples showed a good property of water repellence and less absorbability which will be useful for developing water-proof technical textile materials. The time has come for the researchers to explore more about the underutilized plant fibres in order to have wider applications in technical textiles for various applications in day today life.

Table 2. Different test value of treated and untreated samples

S. No.	Samples	Air Permeability ($cm^3/sec/cm^2$)		Thermal Conductivity (Clo Value)		Thickness (mm)		Spray test		Sinking (Time taken in minutes)	
		with oil	without oil	with oil	without oil	with oil	without oil	with oil	without oil	with oil	without oil
1.	C+C	90.56	93.89	1.09	1.06	1.53	1.55	90	70	13.05	11.05
2.	C+N	90.56	94.44	1.07	1	1.52	1.53	90	80	14.05	13.04
3.	C+T	94.11	92.78	1.08	1.03	1.53	1.54	90	70	17.05	16.07
4.	C+C+N+T	92.11	96.22	1.05	1.06	1.52	1.53	90	70	16.05	15.03

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ENTREPRENEURIAL BEHAVIOUR OF RURAL WOMEN INVOLVED IN HANDLOOM INDUSTRY OF ASSAM

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ABSTRACT

This study was conducted in the Lakhimpur district of Assam in August, 2021 with an objective to analyse the entrepreneurial behaviour of rural women involved in handloom industry. The researcher selected 25 women from two villages using random sampling method, thus, making a total sample size of 50 respondents. The nine dimensions of entrepreneurial behaviour were studied to evaluate the level of entrepreneurial behaviour *i.e.* innovativeness, achievement motivation, decision-making ability, risk-orientation, information-seeking behaviour, cosmopoliteness, self-confidence, economic motivation and management orientation. The results revealed that more than half of the respondents (56%) had medium level of entrepreneurial behaviour, followed by respondents with low level of entrepreneurial behaviour comprising of 28%. Only 16% of the respondents were found to have high level of entrepreneurial behaviour.

Keywords: Dimensions, Entrepreneurial behaviour, Entrepreneurship, Handloom industry, Rural Women

INTRODUCTION

Entrepreneurship is becoming more widely acknowledged as a key driver of economic progress. Entrepreneurs add value by commercializing new products, creating new jobs, and forming new businesses by combining current resources with inventive ideas. Countries with higher levels of entrepreneurial activity see stronger economic growth. Level of entrepreneurial activity is thus an important indicator of the dynamism of an economy. It provides a benchmark for every economy, enabling comparison with others (Global Entrepreneurship Monitor Report, 2022). Entrepreneurship is the dynamic process of creating incremental wealth (Kuratko and Richard, 2001).

Women, on the other hand, make up half of humanity and 40% of the worldwide workforce (Women at Work, Trends, ILO, 2016). They actively contribute to social and economic development as employees, entrepreneurs, and service providers. In India, women make up roughly 10% of the overall number of

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entrepreneurs. They can play a significant role in boosting other women's confidence and raising awareness about the importance of self-reliance (Masood, 2011) as women entrepreneurship has been recognized during the last decade as an important untapped source of economic growth.

Women entrepreneurs have had a significant impact on almost every sector of the economy, accounting for more than 25% of all types of businesses. In addition, Micro, Small, and Medium Enterprises (MSME) sector, being the Indian economy's most active and vibrant sector, called as the "engine of growth," employs a large number of people in both rural and urban locations. The MSME sector accounts for 37.54 percent of national GDP, 45 percent of overall industrial production, and 40% of total exports, all of which are rapidly increasing. The manufacturing sector accounts for 7.09 percent of GDP in the MSME (MSME Report, 2012).

Assam is a land rich in natural and valuable mineral resources. Unfortunately, the state is currently one of the country's industrially undeveloped states. However, in terms of women entrepreneurs, the state does not lag behind the rest of the country.

Women entrepreneurship has attracted great amount of interest not only in the urban areas, but also amongst the rural women. The rural women of Assam have been always highly talented or skilled in numerous activities. This is demonstrated by the fact that Assam has 18 percent of the country's female entrepreneurs, compared to 10.11 percent in the rest of the country. Few women entrepreneurs operate large businesses in the state, and the majority of them work in the Small Scale Industries (SSI) sector. (Economic Survey of Assam, 2013-14). Women's engagement in trade, industry, and commerce that requires entrepreneurship remains low, owing to issues related to their gender roles. As a result, encouraging women to start businesses and gain economic empowerment is a problem for the Government, financing agencies, and Non-Governmental groups.

Women entrepreneurship in economic development of any nation has been recognized for its significant contribution. The women folk can easily be considered as backbone of any nation and better half of the men in almost all spheres of community development, of which India is not an exception. Rural women, who constitute about 50 percent of total rural population, play an active role in all spheres of economic life and contribute greatly towards national income. The concept of developing rural women entrepreneurship lays emphasis on the utilization of women labour force productively in generating income for their livelihoods, alleviating rural poverty, and in reducing negative social effects of unemployment and under employment. In Lakhimpur district of Assam, the rural women are actively involved in various enterprises through formation of Self Help Groups, among which handloom sector is predominantly found in the district, in both formal and informal microenterprises. Hence, the study was conducted to explore entrepreneurial behaviour of rural women in Lakhimpur district of Assam, with the following objectives:

To study the demographic profile of the women entrepreneurs, to assess the entrepreneurial background of the women entrepreneurs, and to explore the

entrepreneurial behaviour of the women entrepreneurs.

MATERIALS AND METHODS

The research period of the study was one month, which was conducted in the month of August, 2021. The state of Assam and district Lakhimpur was selected as the study area. North Lakhimpur sub-division was selected from Lakhimpur district, followed by the Boginadi block using purposive sampling method, since this study area consists significantly higher number of women entrepreneurs engaged in handloom enterprises. The investigator has randomly selected two villages from the Boginadi block *viz*., Sariani Gaon and Maaz Gaon and a sample of 25 entrepreneurs were selected from each village randomly. Thus, the total sample size for the study comes out to be 50.

The investigator has used methods such as face to face communication and observation and structured interview schedule as the tool for data collection. Analysis of data includes frequency, percentage analysis, mean, standard deviation and Pearson's Chi-Squared test.

Selection of independent variables and their measurement

Keeping the specific objectives of the study in view, different independent variables were selected such as age, religion, caste, marital status, type of family, size of family, educational qualification, main occupation and monthly income of the family. Age was assessed as per the chronological age of the respondents. The variables such as caste, marital status, type of the family and main occupation of the family were examined using Trivedi and Pareek scale (1963), and size of the family and educational qualification were examined using scales of NSSO (2007-2008) with slight modifications. The variables such as religion and monthly income of the family were assessed with the help of the structured interview schedule.

Measurement of entrepreneurial behaviour

Dependent variable i.e. entrepreneurial behaviour was measured in terms of nine dimensions *viz.,* innovativeness, achievement motivation, decision making ability, risk orientation, co-ordinating ability, planning ability, information seeking behaviour, cosmo politeness and self confidence using a standardized scale developed by Ranuji (2006) with scale values 9.82, 3.39, 6.60, 5.03, 6.91, 5.22, 1.65 and 3.69 respectively. Each dimension consisted of five statements and the responses were obtained on three-point continuum *viz*.., 'agree', 'undecided', and 'disagree'. A weightage of 2, 1 and 0, respectively were assigned to the response categories in case of positive statements and scoring was reversed for negative statements. Total score of the respondents was obtained by summing up the scores recorded. The respondents could obtain a minimum score of 0 and maximum score of 10 in each dimension, which implied that a respondent could obtain a total maximum score of 90 overall. Based on total score of the respondents in the nine components of entrepreneurial behaviour, the respondents were classified into three categories *viz*., high (>18.86), medium (12.27 to 18.86) and low (<12.27), where the mean score is 15.565 and standard deviation is 3.295.

RESULTS AND DISCUSSION

Table 1. Distribution of respondents based on their demographic profile (n=50)

S. No.	Variables	Frequency	Percentage (%)
1	**Age (in years)**		
	a) Below 20	2	4
	b) 21-30	28	56
	c) 31-40	12	24
	d) 41-50	8	16
2	**Religion**		
	a) Hindu	46	92
	b) Muslim	4	8
3	**Caste**		
	a) General	15	30
	b) OBC/MOBC	27	54
	c) ST	5	10
	d) SC	3	6
4	**Marital status**		
	a) Unmarried	5	10
	b) Married	42	84
	c) Widow	3	6
5	**Type of family**		
	a) Nuclear family	36	72
	b) Joint family	9	18
	c) Extended family	5	10
6	**Size of family**		
	a) Small (2-4)	30	60
	b) Medium (5-7)	13	26
	c) Large (8 and above)	2	4
7	**Education**		
	a) Primary school	3	6
	b) Middle school	7	14

Table.1 contd.

S. No.	Variables	Frequency	Percentage (%)
	c) High school	13	26
	d) Higher secondary	23	46
	e) Graduate	3	6
	f) Diploma	1	2
8	**Main occupation of the family**		
	a) Farming	44	88
	b) Service sector	3	6
	c) Business	2	4
9	**Monthly income of the family (in Rs.)**		
	a) 10,000-20,000	7	14
	b) 20,001-30,000	10	20
	c) 30,001-40,000	28	56
	d) 40,001-50,000	3	6
	e) >50,000	2	4

RESULTS AND DISCUSSION

Demographic profile of the women entrepreneurs

It was recorded from the study that more than half of the respondents (56%) included in the study were of 21-30 years. It was a good picture as the rural women had realized the importance of their self dependence and empowerment and hence, came forward to empower themselves financially as well to build a proper social identity at a younger age.

Table 1 shows that majority of the respondents belonged to OBC/MOBC caste (54%). Here the findings showed that the respondents of sample villages were from different castes of which OBC caste dominated the entire group.

Majority were from Hindu community (92%) and married (84%) because unlike urban areas, rural girls get married at young age, had nuclear families (72%) with small family sizes (60%). This finding was a clear indication of the touch of urbanization in the rural areas. Nuclear family prevails generally in the urban areas, which is gradually penetrating in the rural areas too. This condition might be linked to the fact that, as a result of the fragmentation of the rural family system, the majority of families were discovered to be nuclear. These findings are consistent with Chetia's findings (2002). Furthermore, the lower family size might be attributed to increased knowledge of family planning through communication media, as well as family planning practices taken by rural families, which aid to minimize family size. This conclusion was

consistent with the findings of Borkakoty (2013), who reported that the majority of rural women came from smaller families.

Majority of the respondents (46%) attained higher secondary level only which could not be assumed as a good picture for the respondents as higher secondary or high school education might not be considered sufficient enough in the today's world of high competition and smartness. Education of a person can greatly affect the level of intelligence of an individual. The study of Ritchie and Tucker-Drob (2018) indicates strong, consistent evidence for effects of education on intelligence. They expressed that although the impact of education for a year might be considered small in terms of IQ, at the societal level they are potentially of great consequence.

A large majority of the respondents' families (88%) had farming as their main occupation; since the study was in rural area, therefore it was an obvious picture that a large majority of people will have farming as an occupation.

More than half of the families of the respondents (56%) had monthly income of

Entrepreneurial background of the women entrepreneurs

Table 2. Distribution of respondents based on their entrepreneurial background (n=50)

S. No.	Variables	Frequency	Percentage (%)
1	**Mode of operation**		
	a) Sole proprietorship	38	76
	b) Partnership	12	24
2	**No. of years being involved**		
	a) 4-6 years	19	38
	b) 7-9 years	21	42
	c) 10 years and above	10	20
3	**Types of items produced***		
	a) Mekhela Chadar (Assamese traditional saree)	50	100
	b) Saree	50	100
	c) Gamusa (Traditional Hand Towel)	50	100
	d) Shirt	45	90
	e) Kurta	42	84
	f) Blouse	40	80
	g) Scarf	40	80
	h) Bedcover and pillow set	35	70
	i) Jacket/Shrugs	30	60

Table 2 contd....

S. No.	Variables	Frequency	Percentage (%)
4	**Frequency of production**		
	a) Daily	17	34
	b) Every two-three days	20	20
	c) Weekly	10	20
	d) Order based	3	6
5	**Product advertisement***		
	a) Word of Mouth	50	100
	b) Social media ads	50	100
	c) Exhibitions/trade fairs	45	90
	d) Local channels	40	80
	e) Distribution of samples to shops and supermarkets	32	64
	f) Print media	10	20
6	**Pattern of products sale***		
	a) Direct selling to customers from own stores	50	100
	b) Social media posts and live sessions	50	100
	c) Taking orders from stores in town	50	100
	d) Taking customized orders from customers	48	96
	e) Exhibition sale in and outside the state	45	90
	f) Exporting products outside the state	30	60
7	**Monthly profit status (in Rs.)**		
	a) Poor (<Rs.5000)	5	10
	b) Average (Rs.5000-Rs.10000)	18	36
	c) Moderate (Rs.10001- Rs.15000)	25	50
	d) High (>Rs.15000)	2	4

*Multiple responses

Rs.30,001-Rs.40,000, Here, it was reported that more than half of the respondents had moderate income considering the hike in prices of almost all good and commodities in the present days.

It was reported that majority 76% of the respondents were the sole proprietors and 42% of the respondents had been involved in their enterprises for 7-9 years. Although many of the respondents were in the young age group, they

were still involved in their enterprises either by supporting and helping their mothers or other family members since teenage.

Multiple responses were recorded when the respondents were asked about the types of items they produced. Cent percent of the respondents reported that they produced mekhela chadar, saree and gamusa with traditional motifs and age old designs. They produced these items both in cotton fabric as well as silk including Assam muga silk and mulberry silk. From these findings, it could be assumed that the respondents were competent enough and well- versed with the techniques and ideas of construction of all the garments for their enterprises even though many were from the young age group.

Regarding frequency of production, it was observed that 40% of the respondents used to work in production of their items every two or three days. Since, it had already been established that a large majority of the women were married, hence, it could be implied that the respondents were very hardworking because in spite of their household duties, they had the willingness to work and produce more items for their enterprises every two three days.

The responses for advertisement of products were enlisted and were reported that cent percent of the respondents advertised their products through word of mouth, social media such as Facebook, WhatsApp, Instagram and YouTube. About 90% advertised their products in exhibition and trade fair for sale. Hence, it could be inferred from the finding that the respondents were aware enough about different advertisement strategies since they had been involved in their enterprise for years. Moreover, the emerging drift of social media has greatly aided in increase in awareness level on latest trends of advertisements among the respondents.

Data on pattern of products sale by the respondents showed that cent percent of the respondents followed direct selling to customers from own stores, social media posts and live sessions from Facebook, WhatsApp, Instagram and YouTube, taking orders from stores and supermarkets. Hence, it could be inferred that the respondents had been greatly active and they followed numerous ways of products sale. Similar to advertisement strategies, respondents were quite up to date about different marketing strategies.

Regarding monthly profit status of the respondents, it was reported that half of the respondents *i.e.* 50% had a moderate profit status of Rs. 10001-Rs.15000 monthly. Here, considering the monthly income of the family along with family sizes, half of the respondents had been earning quite an acceptable amount of profit every month. Since, it was reported that 56% of the respondents had monthly family income of Rs. 30001- Rs.40000; therefore, it could be assumed that half of the family's incomes were earned by these respondents. Further, it had already been established that majority of the respondents had small family sizes of 2-4 members only; in that case, the respondents or their spouses would have lesser expenses eventually leading to more savings.

Entrepreneurial behaviour of the women entrepreneurs

Table 3. Distribution of respondents based on their levels of entrepreneurial behaviour **(n=50)**

S. No.	Level of Entrepreneurial Behaviour	Frequency	Percentage
1	High (>18.86)	8	16
2	Medium (12.27 to 18.86)	28	56
3	Low (<12.27)	14	28

Based on mean and standard deviation

Entrepreneurial behaviour of the respondents based on the nine dimensions

Table 4. Distribution of respondents based on the dimensions of entrepreneurial behaviour

(n=50)

S. No.	Variables	Category	Frequ -ency	Perce -ntage
1	Innovativeness	Low (<13.75)	10	20
		Medium (13.75-15.88)	35	70
		High(>15.88)	5	10
2	Achievement Motivation	Low (<10.69)	15	30
		Medium (10.69-12.43)	32	64
		High(>12.43)	3	6
3	Decision Making Ability	Low (<12.73)	7	14
		Medium (12.73-14.46)	30	60
		High (>14.46)	13	26
4	Risk Orientation	Low (<7.23)	20	40
		Medium (7.23-9.04)	26	52
		High (>9.04)	4	8
5	Information Seeking	Low (<8.93)	6	12
	Behaviour	Medium (8.93-9.87)	35	70
		High (>9.87)	15	30
6	Cosmopoliteness	Low (<12.26)	10	20
		Medium (12.26-14.02)	38	76
		High (>14.02)	2	4

Table. 4 contd...

S. No.	Variables	Category	Frequ -ency	Perce -ntage
7	Self Confidence	Low (<9.12)	11	22
		Medium (9.12-10.43)	28	56
		High (>10.43)	11	22
8	Planning Ability	Low (<11.21)	5	10
		Medium (11.21-13.02)	20	40
		High (>13.02)	25	50
9	Coordinating Ability	Low (<7.93)	28	56
		Medium (7.93-8.56)	17	34
		High (>8.56)	5	10

Table 3 shows that more than half of the respondents i.e. 56% had medium level of entrepreneurial behaviour, followed by 28% respondents with low level of entrepreneurial behaviour. Only 16% of the respondents had high entrepreneurial behaviour. Similar findings of Chandramouli *et al.* (2007), Subrahmanyeswari *et al.* (2007), Ram *et al.* (2014) and Sowmya (2009) reported that majority of the women respondents belonged to medium entrepreneurial behaviour category.

Nine dimensions of entrepreneurial behaviour of the women were measured and it was observed that majority (70%) of the respondents were in medium category. The results were in line with Pal (2006). The possible reasons could be attributed to the majority respondents' middle-level education and medium information-seeking behaviour.

Regarding achievement motivation, it was reported that 64% of the respondents had medium level. The results were in accordance to those of Nagesha (2005). The respondents' medium level of achievement motivation could be attributed to their desire to become financially secure.

It is evident from Table 4 that 60% of the respondents had medium level of decision making ability. The ability to make decisions is heavily reliant on a person's foresight. Because of their medium educational degree, the responders might have a medium level of this ability.

In terms of risk orientation, it was reported that more than half of the respondents *i.e.* 52% were in the medium category. It could be owing to the respondents' inability to accept risk, as they were not financially secure in comparison to financially secure respondents.

Data on information seeking behaviour of the respondents reported that majority 70% of the respondents were in the medium category.

Regarding cosmopoliteness, majority 76% of the respondents were in the medium category. As per the above results, considerable percentage of respondents had medium Cosmo politeness. This could be owing to their moderate

Table 5. Association of entrepreneurial behaviour with selected independent variables

S. No.	Independent Variables	Chi Square test value	'p' value
1	Age	25.686	0.00001*
2	Education	2.589	0.274^{NS}
3	Monthly profit Status	5.765	0.010**
4	No. of years being involved	122.000	0.000005*
5	Mode of operation	27.321	0.657^{NS}

** Significant at 1 percent level; **Significant at 5 percent level; NS: Not Significant*

economic circumstances, resulting in a lower level of active participation in extension activities such as field trips, as well as less extension contact with state government officials.

It is evident from Table 4 that more than half of the respondents *i.e*. 56% had medium level of self confidence. The respondents were not enough confident about their abilities to improve their enterprises although they had been engaged in it for years. They felt like they had been slightly lagging behind in terms of latest technologies and designs as one could see in social media. This may be the reason of medium self-confidence.

Regarding planning ability, half of the entire respondents *i.e.* 50% had high level of planning ability. Similar findings were reported by Khin Mar Oo (2005).

It was also reported that more than half of the respondents *i.e.* 56% had low level of coordinating ability. Low coordinating ability could be related to their varying levels of education and poor income from the firms.

Association of entrepreneurial behaviour of the respondents with selected independent variables

Association between entrepreneurial behaviour of the respondents was carried out with selected independent variables of the respondents using Pearson's Chi-squared test and the results are elaborated below:

The analysis showed that the independent variables such as age and no. of years being involved in enterprise had a significant association with entrepreneurial behaviour of the respondents at 1 percent level. The variables such as monthly profit status had a significant association with entrepreneurial behaviour at 5 percent level of significance. Whereas, there was not exist any significant association between variables such as education and mode of operation with entrepreneurial behaviour of the respondents.

CONCLUSION

This study examined the level of entrepreneurial behaviour among rural women working in the handloom sector in Assam's Lakhimpur district. It was reported that majority of the women were young, belonged to OBC caste, Hindu, married and from small family size with 2-4 members only. They had been in this sector for nearly ten years and produced different types of items. Regarding

entrepreneurial behaviour, majority of the women in the study exhibited a medium level of entrepreneurial behaviour as found in the study. There was found to exist a significant association between independent variables such as age, number of years involved and monthly profit status and entrepreneurial behaviour; whereas, there was no association found between education and mode of operation of the women.

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DECISION MAKING ABILITIES AMONG THE NSS VOLUNTEERS AT HIGHER EDUCATION INSTITUTIONS

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ABSTRACT

The study was conducted in the month of March, 2020 with the purpose of assessing the decision making abilities among the selected NSS volunteers before and after joining in the NSS (National Service Scheme). A total of 300 NSS volunteers were drawn from Avinashilingam Institute for Home Science and Higher Education for Women and Tamil Nadu Agricultural University (TNAU) using proportional random sampling method. A well-structured questionnaire was developed to collect data from the volunteers. The major findings of the study revealed that 85% of the volunteers were female. 80% of the volunteers joined in the NSS because they were interested in community service, and the selected NSS volunteers from both universities learned how to make sound decisions after joining the NSS. Out of the 14 statements of decision making abilities, eight statements were found significant at 1% level, one statement was found significant at 5% level (before and after joining in the NSS), and lastly, five statements showed no significant difference in decision making potential before and after joining in the NSS.

Key words: Decision making, Motivating factors, National Service Scheme, Volunteers

INTRODUCTION

Youth are the most vibrant part of the nation. Young people have an upbeat, energetic, inventive, and dynamic personality. Youth are the most valuable human resources for fostering the nation's cultural, political, and economic development because they have strong enthusiasm, willpower, and motivation. The ability and potential for growth of a country are determined by its youth, only when their energy is effectively channeled a nationcan progress well and bring about significant positive changes in society.

The National Service Scheme is a nationalized programme that teaches students good values. It is a group of activities that teach cooperation, tolerance, teamwork, imagination, creativity, adjustment, responsibility, and leadership to young volunteers. The NSS volunteers are always willing to take on new challenges in order to help the community solve its problems. It organizes the volunteers to

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provide all available assistance and support to the general public in a community. NSS is an excellent way for college students to develop their personalities. Youth in the NSS gain hands-on training through a variety of exercises and are exposed to combat in varying situations.

The goal of the NSS Regular and Special Camping Programmes is to introduce volunteers to the community and motivate them to make positive changes.Students participate in various NSS Regular Activity programmes in the adopted villages, college/school campuses, and urban slums during weekends or after college hours to complete 120 hours during an academic year.Twenty hours of the total 120 hours are spent on NSS volunteer orientation, which includes lectures, discussions, field excursions and audio-visuals, and another 30 hours are spent on campus labour projects that benefit the institution and college.(https://nss.gov.in/)

Education is an important component of methods for improving individual and societal economic and social development. The National Social Service Scheme (NSS) is a tool for providing the greatest possible social services. India's government has launched a number of initiatives to help the rural or backward area .NSS provides the undergraduate students with volunteer opportunities they devote their free time to a variety of social services and actions that promote development As a consequence, both the student and the teacher are pleased. The community and society as a whole are extremely important and benefited(Diganta Kumar,2020).

Decision-making is a complex process in an individual's life, and some of these choices will have a significant impact on their lives. An individual makes decisions about himself/herself and their affairs, but the choices affect others as well. When anyone needs to make a decision, they frequently seek assistance from friends, psychiatrists, lawyers, logistics specialists, etc. (Bouyssou *et al.,* 2013).

Individual decision-making abilities refer to a person's ability to select the best course of action after carefully evaluating and analysing the available options and circumstances. In NSS, volunteers become independent through various activities. In a special camp, volunteers learn to take decisions on their own while participating in different activities and tasks.

In the sphere of youth development, NSS has successfully completed a half-century. Thousands of volunteers shaped their lives throughout this time. Day after day, there are a growing number of NSS units and NSS volunteers because of the advantages of NSS. Private institutions are also introducing NSS programmes. As a result, it is possible. It has been suggested that students must join NSS in order to help establish the new world. India's citizens will be physically and mentally fit, strong and agreeable through this programme. (Roy,2021).

The objectives of the study are to study the demographic profile of the volunteers, to assess the factors motivating the volunteers to join in NSS, and to assess the decision-making abilities acquired by the volunteers before and after joining in NSS.

MATERIALS AND METHODS

The total sample for the study was 300 NSS volunteers from two universities, namely Tamil Nadu Agricultural University and the

Table 1. Demographic Profile of the NSS Volunteers

n=300

S. No.	Variables	details	Frequency	Percentage (%)
1	Age (years)	18-19	105	35
		20-21	108	36
		21 above	87	29
2	Gender	Male	45	15
		Female	255	85
3	Religion	Hindu	150	50
		Muslim	66	22
		Christian	84	28
4	Social category	OBC	192	64
		ST	6	2
		SC	24	8
		OC	78	26
5	Type of Family	Nuclear	201	67
		Joint	99	33
6	Family Size	Up to 2 (Small)	210	70
		3 to 4 (Medium)	60	20
		Above 4 (Large)	30	10
7	Area of residence	Rural	60	20
		Urban	189	63
		Semi urban	51	17
8	Source of Income	Agriculture	54	18
	(Head of the Family)	Business	81	27
		Private Sector	66	22
		Government Sector	99	33
9	Annual income of the	Low income		
	Head of the family (Rs)	(Rs.50,000 and below)	60	20
		Middle income (Rs 50,001 to 1,00,000)	129	43
		High income (Rs 100,001 and above)	111	37

Avinashilingam Institute for Home Science and Higher Education for Women in Coimbatore, Tamil Nadu. The study was conducted in the months of March and April, 2020. A total of 230 volunteers from Avinashilingam University and 70 volunteers from Tamil Nadu Agricultural University (TNAU) were chosen as the sample for the study.

A descriptive survey method was used for the conduct of the study. A proportionate random sampling method was used. A self-formulated Likert type five rating scale (strongly agreed, agreed, neutral, strongly disagreed, and disagreed) is used to assess the decision-making abilities of NSS volunteers. The procedure for scoring was 5,4,3,2,1. In order to examine the factors motivating the volunteers to join NSS, a dichotomous questionnaire was prepared (Yes/ No). The information was gathered using a well-structured questionnaire tool by the researcher.

The data was coded, categorised, and tabulated as per the objectives of the study. The data was then tallied. It was subjected to statistical analysis and percentage analysis was used to evaluate the factors that inspired the volunteers to jointhe NSS. Paired sample t-tests were used to measure the significant level before and after joining NSS among the volunteers.

RESULTS AND DISCUSSION

Table 1 depicts the demographic profile of the NSS volunteers selected for the study. According to the data, 35% of the volunteers were found to be between the ages of 18 years and 19 years old (they were undergraduate 1st year students who were NSS volunteers), and 29% were over the age of 21 (studying in undergraduate 2nd year). In terms of gender, the female population comprised up to 85% of the volunteers, while the males comprised only 15%, because majority of the respondents were from Avinashilingam Institute for Home Science and Higher Education for Women. A total of 64% were from the OBC category, while only 2% were from the ST category.

Regarding the family background of the volunteers, 67% of the volunteers belonged to nuclear families. Therefore, volunteers were always reliant on their parents, but in the NSS they had the opportunity to mingle with other people and face a wide variety of situations dealing with different kinds of people. A total of 70% of the volunteers were from small families, and 10% were from large families. It was recorded that the volunteers who belonged to large families have enhanced their social skill compared to those who belonged to small families. Regarding area of residence, it is reported that 63% of the volunteers were from urban areas, while 17% came from semi-urban areas. According to the source of income of the head of the family, data showed that 33% of the volunteers came from the government sector and that their highest annualincome was 43%, coming from the middle income group.

Table 2 shows that 81% of the volunteers joined in NSS because they want to do community service andNSS is a platform for students to engage in community service within their curriculum. The 72% of the volunteers were inspired by their teachers; volunteers were also motivated by an orientation programme regarding NSS's goals and objectives while 67 %of the volunteers joined to learn about their strengths and weaknesses because NSS volunteers may be assigned to a special camp

Table 2. Factors motivated to join in NSS

n=300

S. No.	Factors motivated	Frequency	Percentage (%)
1	Interest towards community services	243	81
2	Inspired by NSS teacher	216	72
3	Obtain NSS certificate	210	70
4	To realize one's own strength and weakness	201	67
5	To take part in extra-curricular activity	186	62
6	Develop self-confidence	165	55
7	Improving communication skill	156	52
8	To know the social problems faced by the society	147	49
9	Support to nation building	144	48
10	Expressing talent and skill	120	40
11	Develop self-determination	120	40
12	Develop courage to manage problems and situations	108	36
13	Develop leadership quality	96	32
14	To overcome stage fear	96	32
15	Practicing social and civic responsibility	93	31
16	To mingle with others	90	30
17	Acquire problem solving skill	84	28
18	Influence by the college senior	57	19

Multiple responses*

where they will be separated from their families and will have time to evaluate their skill. At home, they never have that opportunity because their parents monitor andhaveholdall of their activities, but in thecamp, they were expected to handle everything on their own. A total of 62% volunteers also stated that they have joined NSS to take part in the extra-curricular activities because it was mandatory in undergraduate level.

Fifty-five percent of the of the volunteers joined in the NSS to improve their confidence through NSS activities such as organizing a programme or taking care of the mess during a special camp, whereas 52% of the volunteers expressed that they wanted to improve their communication skill through NSS. In the case of NSS, volunteers work in teams; help them learn good manners and good communication skill. Respectively forty-nine percent of volunteers

Table3. Decision-making abilities acquired by the volunteers before and after joining NSS

n=300

S. No	Statements	Mean		SD		SE		t-value	Significance
		B	A	B	A	B	A		
1	Learn to take own decision	2.25	1.51	0.49	0.50	0.02	0.02	66.407	.000*
2	Always remain calm while making any group decision	1.60	1.63	0.49	0.51	0.02	0.02	-.821	.412^{NS}
3	Consult others when I have any doubt	2.52	1.53	0.50	0.50	0.02	0.02	74.000	.000*
4	Always stick with my own decision	1.62	1.61	0.48	0.49	0.02	0.02	.831	.406^{NS}
5	Before taking any decision always looking into alternative options	1.58	1.98	0.49	0.45	0.02	0.02	2.451	.029**
6	I can make any decision without considering others' suggestion	1.98	1.52	0.61	0.50	0.02	0.02	12.477	.000*
7	Never blame my friends if I took any wrong decision in group activity	1.92	1.90	0.79	0.81	0.03	0.03	3.978	.000*
8	I plan ahead before taking a decision	2.21	1.96	0.94	1.84	0.04	0.03	5.684	.000*
9	Once I took any decision never regretfor it later	1.78	1.73	0.76	0.74	0.03	0.03	1.360	.174^{NS}
10	I can ask question without feeling silly	2.31	1.97	1.08	0.86	0.04	0.04	6.728	.000*
11	Always I work out all the pros and cons before making decision	1.90	1.99	0.73	0.87	0.03	0.04	1.870	.062^{NS}
12	I understand the information enough to make a choice	2.01	1.95	0.82	0.73	0.03	0.03	-1.292	.197^{NS}
13	My decision making follows a logical process	1.59	2.53	0.49	0.52	0.02	0.02	-32.445	000*
14	I am confident enough to take my own decision	1.23	2.12	0.78	0.98	0.03	0.03	13.264	000*

***= Significant at 1% level, **= Significant at 5% level, NS = Not Significant,B= before,A=after**

indicated that they wanted to know about the social problems faced by society, NSS worked only for the benefit of society and NSS volunteers would work for the root problems of society and their basic needs, such as cleaning the villages, parks, community halls, providing various awareness programmes on water, sanitation, and health, etc. The data also states that 48% of the volunteers joined NSS to support national building. A nation will grow from the community; hence the goal of NSS is to develop the community as the fundamental unit. Forty percent of the volunteers joined to develop their self-determination and wanted to express their talent and skillthrough the NSS programme. NSS provides such an opportunity through conducting skill development training programmes where volunteers train other people in basic computer knowledge, knitting, pickle making, embroidery, etc.

Thirty-two percent of the volunteers joined NSS to overcome their stage fright because as NSS volunteers they can get a chance to explore their inner talent in public through socio-cultural activities and also develop their leadership qualities while participating in and managing any programme. Twenty-eight percent of the volunteers were involved in NSS with the goal of problem solving. While carrying out NSS activities, volunteers should learn to solve their issues while doing activities in groups. Nineteen percent of volunteers joined NSS after being encouraged by their college seniors. Volunteers noticed an improvement in their seniors' personalities after joining the NSS, so they too were interested in joining the NSS.

Alok Chantia(2008) reported that the majority of students are aware of the NSS's goals and objectives and are interested in joining. Because this is the only schemewhere they can assist society through the curriculum, the majority of respondents joined NSS with the intention of performing country service. It has enlightened in his study that NSS only focusing is on more environmental protection and he has recommended to the policy makers to adjoin other developmental activities in NSS where volunteers able to build up their skills.

Table 3 indicates the decision-making abilities acquired by the volunteers before and after joining the NSS. It can be seen that out of the total of 14 statements, namely "learn to take their own decision," t value showed (66.407); NSS provides an opportunity to the volunteers where they acquire the ability to make decisions on their own without depending upon their parents or anyone, The statement "consult with others when they have any doubt" affirmed that volunteers increase their social skill by consulting with peers for their opinion (it has been confirmed that the highest "t" value was at 74.000). If volunteers can make any decision without considering others' suggestions (t value was 12.477), volunteers emphasize in the study that if they are unsure about others' opinions, they can make their own judgment. Another statement showed a significant difference. They never blame their friends if they make any wrong decisions in a group activity. It can be assumed that in NSS, volunteers learn to accept themselves while participating in any programme. NSS encourages volunteers to accept their mistakes and not criticize their group members, which is another trait of a competent decision maker. The statement "I plan ahead before taking a decision" means that volunteers must be very

clear about their needs and goals in order to plan any program. In the statement "I can ask questions without feeling silly," volunteers expressed that after joining NSS, they were bold enough to clear their doubts with other people or with their teachers. In another statement, "my decision-making follows a logical process." In this phase, volunteers agreed that each volunteer became independent in the NSS camp because they were removed from the classroom setting and placed in an environment where they had to lead and direct a program. All of these eight statements showed a significant difference at the 1% level (before and after joining NSS). The data showed that the NSS plays a significant role in the development of decision-making skill among volunteers. The NSS volunteers got different atmosphere when they learnt about adjustments and compromising with the situation. They were able to conduct programmes and take leadership roles while organizing any activity.

Table 3 highlights that the statement "before taking any decision, look into the other alternative options" showed a significant difference among the volunteers at a 5% level. The five statements, namely "always remain calm while making any group decision", "always stick with their own decision", "always work out all the pros and cons before making a decision", "once they make any decision, never regret it", "understand the information enough to make a choice," showed no significant difference among the volunteers before and after joining in the NSS. Developing decision-making talents can give a person more control over their lives and allow them to be content with their own choices. Because a skilled decision maker develops more options from which to choose and a better chance of achieving the alternative chosen, NSS provides opportunities for volunteers to improve their decision-making abilities. However, based on the above statements, it can be assumed that the programmes and activities carried out under the NSS were not adequate for a volunteer to enrich all of their decision-making abilities. The lowest t-value found among five non-significant statements was 0.821, and the statement was "always remain calm while making any group decision." It might be the reason that, at the undergraduate level, they are not mature enough to properly catch all the consequences.

Suresh (2002) stated that the National Service Scheme makes a commendable effort to bridge the gap between theory and practice. NSS provides a number of training opportunities through regular programmes and special events, and these volunteers have improved and acquired many skill such as leadership, decision-making, and creative ability, as well as improved their everyday routines. Young volunteers' abundant energy, persistent dedication to goals and beliefs, and tenacious youthful spirit hold immense potential for the future.

Out of the 14 statements expressing decision-making abilities, nine statements (S. No 1, 3, 5, 6, 7, 8, 10, 13, and 14) have been found to indicate a significant difference in acquiring the decision-making skill before and after joining the NSS, and five statements showed no significant difference. Hence, there is a significant difference in decision-making abilities before and after joining NSS.

CONCLUSION

The study recorded that thirty-six percent were between the ages of 20 and 21 years.

Women volunteers from the NSS made upto 85 percent of the sample. Half of the respondents (50 percent) belonged to Hindu religion. Sixty-four percent of the volunteers belonged to OBC social category. Sixty-seven percent of the volunteers belonged to nuclear families. Seventy percent of the volunteers belonged to the small family category. It is interesting to note that 81 percent of the volunteers joined NSS because they are passionate about community service. Teachers inspired 72 percent of the volunteers to participate in the NSS, while college seniors inspired 19 percent of the volunteers. The t value was 74, and the highest range of the difference was revealed after joining NSS in the statement that "volunteers were counseled by others when they had any uncertainty". NSS played an important role in developing decision-making skill among volunteers, allowing them to understand real-life problems and identify solutions for both rural people and themselves.

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IMPACT OF PRIMARY PROCESSING TECHNIQUES ON THE NUTRITIONAL VALUES OF COMMONLY CONSUMED CEREALS, LEGUMES AND OILSEEDS

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ABSTRACT

The objective of this research was to study the impact of processing techniques on the nutrient composition of selected cereals, legumes and oilseeds.The experiment was carried out in the year from January to June, 2021 at Nutrition research laboratory, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore. The results revealed that the commonly consumed cereals and legumes after primary processing had significant improvement in terms of nutrients. Moisture content was found to be lowest in pumpkin seeds flour 0.31±0.10g/100g, available carbohydrate was found to be highest in finger millet flour 74.03±0.05g/100g, crude protein was found to be highest in soybean flour 34.06±0.10g/100g, crude fat was found to be highest in pumpkin seeds flour 49.50±0.15g/100g, crude fibre was found to be highest in mung bean flour 6.05±0.06g/100g.

Keywords: Cereals, Legumes, Nutritional values, Oilseeds and Processing techniques

INTRODUCTION

India is the largest producer of many kinds of cereals/millets and legumes which include rice, wheat, pearl millet, sorghum, oat, finger millet, foxtail millet, mung bean, rice bean, soyabean etc. Cereals and legumes are important staple foods, especially in the Indiandiet. They are rich source of nutrition, especially when used as whole grains. However, most grains are sorted, washed, dried, roasted, and ground to provide the final product useful to the processing industries. These pretreatment operations such as washing,roasting, grinding and refining change the nutritional composition of the end product. Cereals and legumes, such asrice, wheat, pearl millet, finger millet, mung bean, and soybeanareone of the significant partsof thehuman diet that provide energy and other major and minor nutrients like carbohydrates, proteins, B-complex vitamins andminerals. Studies have proven that including whole cereals and legumes in our daily diet protectsus from non-communicable diseases such as diabetes, cancer, obesity, and other, lifestyle disorders(Priebe*et al*., 2008).

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Millets are known as a powerhouse of nutrients in terms of vitamins, magnesium, iron, copper, calcium, phosphorous, and potassium. Millets such as sorghum, pearl millet, foxtail millet, finger millet, proso millet, barnyard millet and little millet helps to improve digestive health, prevent cancer and also control diabetes. Research showed that commonly consumed cereals and legumes grains are nutritionally comparable or even superior to major cereals owing to higher levels of protein with a more balanced amino acid profile, dietary energy, vitamins, several minerals such as iron and zinc, insoluble dietary fiber leading to the lower glycemic index (Krishnan and Meera, 2018).

WHO/FAO(2013) emphasized on development of low-costnutrient-dense food mixes prepared from locally available cereals and pulses to address the issue of hunger, food insecurity and Protein energy malnutrition (PEM) among the vulnerable segmentsof the population. It has been taken as an important tool to achieveUnited Nations Sustainable Development Goals (SDGs) and the World Food Summit (WFS) targets.

The inclusion of processed cereals and legumes for development of new products are a growing concept that is gaining wider recognition and acceptance amongst nutrition scientists as it is a simple and scientiûc approach to harnessing nutrient sources to meet human needs. In the recent years, there has been an increasing demand in developing countries like India forthe formulation of new food products todevelop novel fortified value-added food products from cereals and legumes which are economical and are locally available to improve the overall food and nutritional security hence bridging the gap of malnutrition (Pingali*et al*., 2017).Oilseeds are a significant part of the human diet. The functional ingredients present in the oilseeds help to prevent many noncommunicable and degenerative disorders. Oilseeds can be processed to prepare oils or snacks or can be incorporated into many recipes. Hence, an attempt was made to study the impact of processing techniques on the nutritional values of commonly consumed cereals, legumes and oilseeds.

MATERIALS AND METHODS

The raw materials such as rice, pearl millet, finger millet, wheat, mung bean, soyabean, sesame seeds, and pumpkin seeds were procured from the local market of

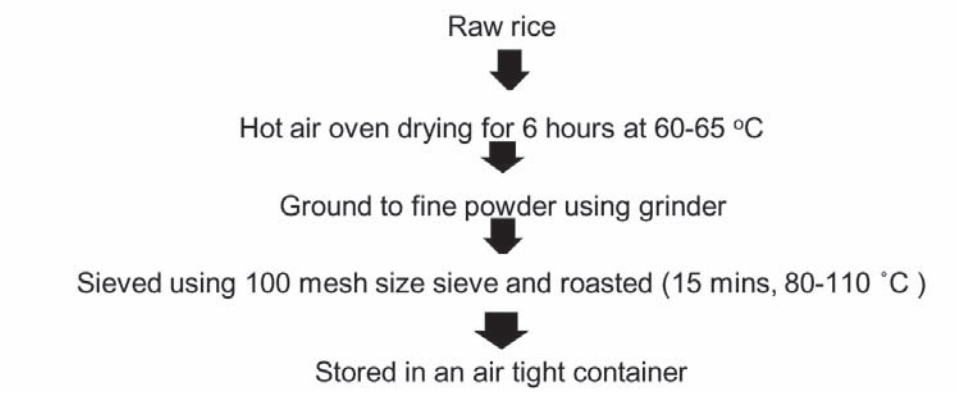

Fig. 1. Flow diagram of processing of rice into flour

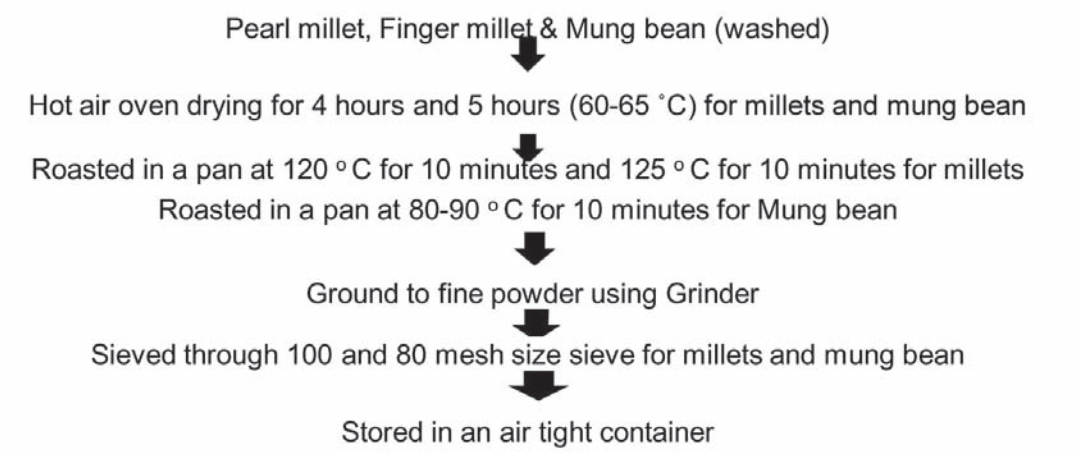

Fig. 2. Flow diagram of processing of pearl millet, finger millet and mung bean into flour

Coimbatore and Chennai, Tamil Nadu, India. These ingredients were selected for their easy accessibility, availability and high therapeutic and nutraceuticals properties. The samples were stored in high-density polyethylene virgin containers for future use.The raw ingredients used were analyzed for proximate analysis before and after they are subjected to primary processing techniques.The raw ingredients were directly grinded inan electric grinder for analysing the prior nutrient content. The proximate analyses for the raw ingredients post primary processing are mentioned in Fig. 1 to 5. The experiment was carried out in the year from January to June, 2021.

A. Processing of raw materials

1. Processing of rice into flour

The method used in this study was described by Southan(2006)with modifications

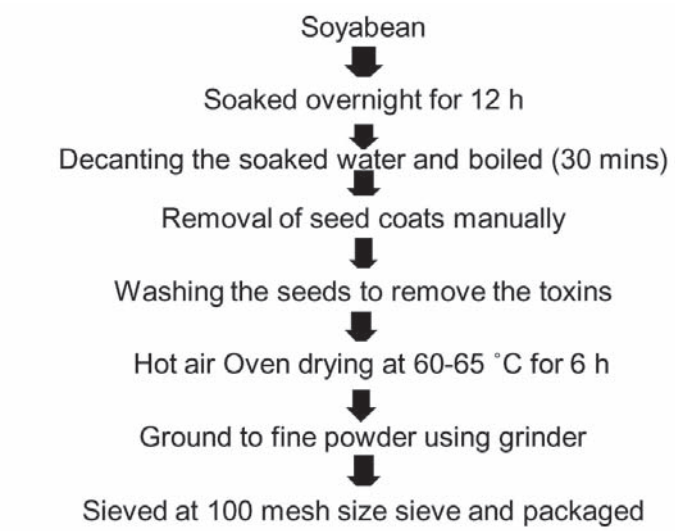

Fig. 3. Flow diagram of processing of soyabean into flour

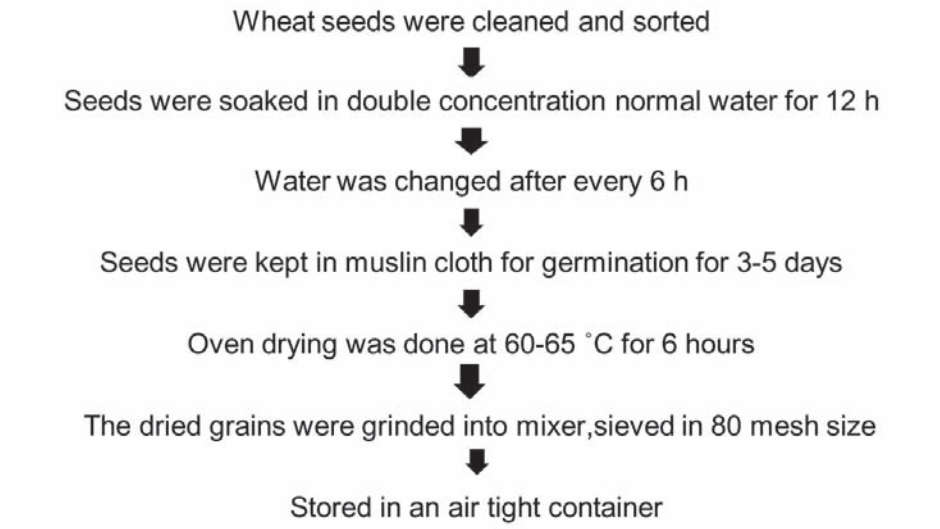

Fig. 4. Flow diagram of processing of amylase rich flour

2. Processing of pearl millet, finger millet and mung bean into flour

Pearl millet was processed by the method of Florence *et al*.(2014) with modifications and finger millet was processed by the method of Taynath *et al.*(2018) with modifications and mung bean was processed by the method of Patil *et al*. (2011) with modifications, respectively.

3. Processing of Soybean into flour

The method used in this study was described by Adelekan*et al. (*2013) with modifications.

4. Development of the amylase rich flour with wheat

The method used in this study was described by Zema *et al*.(2015) with modifications.

5. Processing of sesame seeds and pumpkin seeds into flour

The method used in this study was described by Animashaun *et al*.(2017) and Zema *et al.* (2015) with modifications.

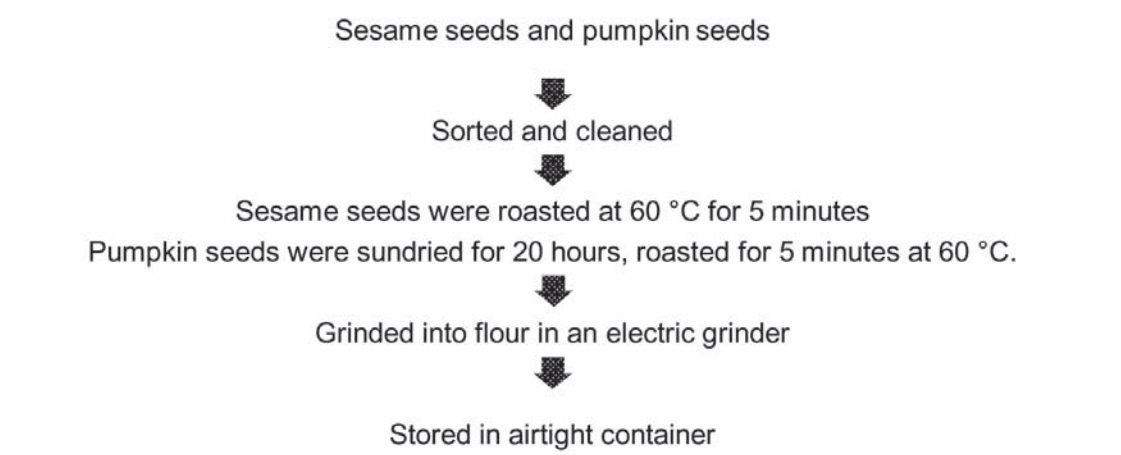

Fig. 5. Flow diagram of processing of sesame seeds and pumpkin seeds into flour

Proximate analysis of raw ingredients

Nutritional attributes such as protein, fat, available carbohydrate, and crude fibre of functional ingredients were determined by using standard procedures. Moisture content, protein, fat and crude fiber were determined by A.O.A.C. (2000) method.Available carbohydrate was determined by the method described by Hedge and Hofreiter (1962).

RESULTS AND DISCUSSION

Moisture

The moisture content of rice flour, pearl millet flour, finger millet flour, wheat flour, mung bean flour, soybean seeds flour, sesame seeds flour, and pumpkin seeds flour before primary processing were 11.20±0.01 g/100g, 11.20±0.05 g/100g, 5.58±0.20 g/100g, 11.01±0.15 g/100g, 10.00±0.05 g/100g, 7.05±0.10 g/100g, 11.20±0.10 g/100g, 10.31±0.15 g/100g, respectively (Table 1).

The moisture content of rice flour, pearl millet flour, finger millet flour, malted wheat flour, mung bean flour, soybean seeds flour, sesame seeds flour, and pumpkin seeds flour after primary processing were 3.46±0.06 g/100g, 3.90±0.10 g/100g, 3.50±0.10 g/100g/100g, 4.01±0.10 g/100g, 3.36±0.10 g/100g, 5.02±0.10 g/100g, 3.30± 0.10 g/100g and 0.31± 0.10g/ 100g, respectively (Table 2).

The significant decrease in moisture content before and after the processing techniques was due to the different drying and roasting temperature in which the raw ingredients were subjected. Reduced moisture levels was desirable as it aid in avoiding deterioration during storage, extending the product's shelf life, and increasing the concentration of nutrients, which may make some nutrients more accessible. The high moisture content in soyabean after processing among all the raw ingredients was due to the soaking ofwhole seeds that absorb moisture from the soaking medium *i.e.* water for physiological and biochemical changes. The imbibition of water by dry seed coat increases the moisture content of the seeds. Due to the imbibition of water, the seed coat becomes more permeable and moisture retention is more.

The total amount of moisture content present in raw ingredients before grinding is an important characteristic for determining the physical properties of the developed product. Studies have revealed that at different moisture content the properties of the raw ingredients and the structure of the raw ingredients may differ which may show different flour properties such as particle size distribution and flowability, which is the ability of flour (Jung *et al.,* 2018). The taste, texture, weight, appearance and shelf life of developed food products are all influenced by the moisture level of the raw ingredients. Even a minor variation from a stated standard might have a negative influence on a food material's physical qualities. Overly dry food samples may influence the final product's consistency. On the other hand, when samples have high moisture content, the rate of microbial development increases, potentially resulting in the damaged product as recorded by Nielsen (2010).

Available carbohydrate

The available carbohydrate content of rice flour, pearl millet flour, finger millet flour, wheat flour, mung bean flour, soyabean seeds flour, sesame seeds flour, and pumpkin seeds flour before processing were 72.04±0.05 g/100g, 70.00±0.07 g/100g, 74.03±0.05 g/100g,

Table 1.Nutritive values of raw ingredients before processing

S. No.	Functional ingredients	Nutrients (per 100 g of dry weight basis)				
		Moisture (g)	Available carbohydrate (g)	Protein (g)	Fat (g)	Crude fibre (g)
1.	Rice flour (*Oryza sativa*)	11.20±0.01	72.04±0.05	5.85±0.01	1.13±0.02	2.05±0.01
2.	Pearl millet flour (*Pennisetum glaucum*)	11.20± 0.05	70.00± 0.07	10.40±0.50	3.80± 0.14	1.88± 0.015
3.	Finger millet flour (*Eleusinecoracana*)	5.58± 0.20	74.03± 0.05	7.42± 0.05	6.20± 0.06	2.50± 0.06
4.	Wheat flour (*Triticumaestivum*)	11.01± 0.15	55.86± 0.01	10.50±0.03	11.05± 0.05	3.50± 0.05
5.	Mung bean flour (*Vignaradiata*)	10.00± 0.05	54.09± 0.05	20.02±0.05	1.05± 0.01	2.05± 0.06
6.	Soyabean flour (*Glycine max*)	7.05± 0.10	30.10±0.06	34.06±0.10	19.08± 0.01	4.00± 0.50
7.	Sesame seeds flour (*Sesamumindicum*)	11.20± 0.10	20.30± 0.15	18.12±0.10	36.50± 0.50	2.50±0.010
8.	Pumpkin seeds flour (*Cucurbita maxima*)	10.31± 0.15	9.90± 0.06	25.10±0.15	49.50± 0.15	4.50± 0.15

/alues are expressed in Mean ± SD (Standard deviation) **Each value is a mean of triplicate leterminations with a standard deviation

55.86±0.01 g/100g, 54.09±0.05 g/100g, 30.10±0.06 g/100g, 20.30±0.015 g/100g and 9.90± 0.06 g/100g, respectively (Table 1).

The available carbohydrate content of rice flour, pearl millet flour, finger millet flour, malted wheat flour, mung bean flour, soyabean seeds flour, sesame seeds flour, and pumpkin seeds flourafter processing were 82.94±0.005 g/100g, 75.00±0.010 g/100g, 88.50±0.015 g/100g, 63.86±0.005 g/100g, 73.00±0.005 g/100g, 19.08±0.005 g/100g, 25.40±0.005 g/100g and 11.90± 0.001 g/100g, respectively (Table 2).

The significant increase of the available carbohydrate content before and after the processing was due to standard protocol used for calculating the carbohydrate.Household methods such as washing, soaking, drying, roasting, removing the seed coat,and germinating help in the enhancement of the nutritional quality of cereals and legumes. The starch digestibility significantly increases from 36.3% to 39.2% when the cereals and legumes go through germination and dehulling (Ghavidel and Prakash, 2007). Egounlety and Aworh (2003) reported that soaking, roasting, and

removal of seed coats bring significant changes in the complex carbohydrates.

Roasting oilseeds are common processing techniques to deactivate the enzymes and improve the oil extraction. The temperature and time of heating subjected to oilseeds results in chemical changes along with the physical properties. Proteins and carbohydrates are the main composition of oilseeds besides lipids. Similar results were reported by Verma and Shukla (2011), where white riceflour when subjected to roasting gavehigh carbohydrate content*i.e*. 80.1 g/100 g. Mushtari *et al.* (2017) stated that finger millet flour contains 72g of carbohydrate in 100 g of sample. Kumar *et al*. (2011) found out that malted wheat flour contains 68.5 g of carbohydrates in 100 g of raw samples. Pathak *et al*.(2019) revealed the carbohydrate content in sesame seeds flour*i.e* 18.4 g in 100g of raw samples. Syed *et al*. (2019) stated that pumpkin seeds flour contain 10.71 g of carbohydrates in 100 g of raw samples.

Protein

The protein content rice flour, pearl millet flour, finger millet flour, wheat flour, mung bean flour, soyabean seeds flour, sesame seeds flour, and pumpkin seeds flour before processing were 5.85±0.01 g/100g, 10.40±0.50 g/100g, 7.42±0.05g/100g, 10.50±0.03 g/100g, 20.02±0.05 g/100g, 34.06±0.10 g/100g, 18.12±0.10 g/100g, and 25.10±0.15 g/100g, respectively (Table 1).

The protein content rice flour, pearl millet flour, finger millet flour, malted wheat flour, mung bean flour, soyabean seeds flour, sesame seeds flour, and pumpkin seeds flourafter processing were 6.00±0.005 g/100g, 11.40±0.005 g/100g, 7.80±0.001g/100g, 30.00±0.005 g/100g, 23.32±0.001 g/100g, 39.28±0.005 g/100g, 19.20±0.005 g/100g, and 30.10±0.001 g/100g, respectively (Table 2).

The significant increase of the protein content before and after the processing was observed.It was reported that soaking and fermenting some of the common cereals and legumes used for day-to-day life may help in increasing the protein content. From the processing techniques reported by Gupta*et al.* (2013), it is recorded that soaking and fermentation help in increasing the protein quality of commonly consumed cereals and legumes. Soaking and subsequent roasting, total protein content was increased by 23%. Chaudhary and Vyas (2014) also reported that during germination moisture was imbibed in seed and hormones were activated which also resulted in synthesis of new proteins. Increase in proteins and total sugars during soaking and roasting of cereals have been reported by Agume*et al*. (2017). It was also concluded by Agume*et al*. (2017) that soaking significantly influenced the protein content ($p < 0.04$), with soaked cereal flours generally that higher lower protein content than raw ones.

Verma and Shukla (2011) also reported similar results of high protein content in white rice flour*i.e*. 6.7 g/100 g. Malik (2015) revealed that pearl millet flour is a rich source of protein *i.e* 11g in 100g. Mushtari*et al.* (2017) stated that finger millet flour contains 7.23 g of protein in 100 g of sample. Kumar *et al.*(2011) recorded in his study that wheat flourcontains 9.7 g of protein in 100 g of raw samples. The study conducted by Gupta *et al.*(2013) revealed that 12 hours of soaked soybeanflour contains 41.8±0.80 g of protein in 100g of sample. Pathak

Table 2. Nutritive values of raw ingredients after processing

S. No	Functional ingredients	Nutrients (per 100 g of dry weight basis)				
		Moisture (g)	Available carbohydrate (g)	Protein (g)	Fat (g)	Crude fibre (g)
1.	Rice flour (*Oryza sativa*)	3.46± 0.06	82.94±0.005	6.00±0.005	3.14±0.38	3.05±0.001
2.	Pearl millet flour (*Pennisetum glaucum*)	3.90± 0.10	75.00± 0.010	11.40±0.005	4.08± 0.14	3.49± 0.001
3.	Finger millet flour (*Eleusinecoracana*)	3.50± 0.10	88.50± 0.015	7.80± 0.001	1.20± 0.05	3.65± 0.005
4.	Malted wheat flour (*Triticumaestivum*)	4.01± 0.10	63.86± 0.005	30.00±0.005	9.80± 0.002	3.12± 0.001
5.	Mung bean flour (*Vignaradiata*)	3.36± 0.10	73.00± 0.005	23.32±0.001	1.48± 0.25	3.91± 0.005
6.	Soyabean flour (*Glycine max*)	5.02± 0.10	19.08±0.005	39.28±0.005	10.48± 0.13	4.91± 0.001
7.	Sesame seeds flour (*Sesamumindicum*)	3.30± 0.10	25.40± 0.005	19.20±0.005	45.90± 0.10	3.01±0.005
8.	Pumpkin seeds flour (*Cucurbita maxima*)	0.31± 0.10	11.90± 0.001	30.10±0.001	51.90± 0.15	5.84± 0.001

*Values are expressed in Mean ± SD (Standard deviation)**Each value is a mean of triplicate determinations with a standard deviation

et al.(2019) revealed the protein content in sesame seeds flour is 19.2 g in 100g of raw samples. Syed *et al*. (2019) stated that pumpkin seeds flour contain 30.23 g of carbohydrates in 100 g of raw samples. The most common technique for pre-processing is soaking toremove of seed coat for cooking.

Fat

The fat content of rice flour, pearl millet flour, finger millet flour, wheat flour, mung bean flour, soyabean seeds flour, sesame seeds flour, and pumpkin seeds flour before processing were 1.13±0.02 g/100g, 3.80± 0.14 g/100g, 6.20± 0.06 g/100g, 11.05± 0.05 g/100g, 1.05± 0.001 g/100g, 19.08± 0.01 g/100g, 36.50± 0.50 g/100g, 49.50± 0.15 g/100g respectively (Table 1).

The fat content of rice flour, pearl millet flour, finger millet flour, malted wheat flour, mung bean flour, soyabean seeds flour, sesame seeds flour, and pumpkin seeds flour after processing were 3.14±0.38 g/100g, 4.08± 0.14 g/100g, 1.20± 0.05 g/100g, 9.80± 0.002 g/100g, 1.48±

0.25 g/100g, 10.48± 0.13 g/100g, 45.90± 0.10 g/100g, 51.90± 0.15 g/100g, respectively (Table 2).

Among all the functional ingredients, sesame seeds and pumpkin seeds had the highest amount of fat content. Roasting the seeds induced a non-significant increase in the lipid content of the soybean flour by 0%–11%. An increase in fat content after roasting has been reported for cereal seeds including millets and legumes. The increase in the fat content may result from the destruction of cell structure and the efficient release of oil reserve as reported by Agume*et al*. (2017). Thesoaked wheat and soyabeanseeds resulted in decreased amount of fat due to the increased activity of lipolytic enzymes germination, which hydrolyzes the fats into fatty acid and glycerol. Chaudhury and Vyas (2014) revealed that the process of soaking, germinating and malting grains was responsible for the decrease in crude fat content due to the loss of total solids during soaking and probably due to the utilization of fat as energy during the sprouting process.

Crude fibre

The crude fibre content of rice flour, pearl millet flour, finger millet flour, wheat flour, mung bean flour, soyabean seeds flour, sesame seeds flour, and pumpkin seeds flour before processing were 2.05±0.01 g/100g, 1.88±0.015 g/100g, 2.50±0.06 g/100g, 3.50±0.05 g/100g, 2.05±0.06 g/100g, 4.00±0.50 g/100g, 2.50±0.010 g/100g, and 4.50±0.15 g/100g respectively (Table 1).

The crudefibre content of rice flour, pearl millet flour, finger millet flour, malted wheat flour, mung bean flour, soyabean seeds flour, sesame seeds flour, and pumpkin seeds flour after processing were 3.05±0.001 g/100g, 3.49±0.001 g/100g, 3.65±0.005 g/100g, 3.12±0.001 g/100g, 3.91±0.005 g/100g, 4.91±0.001 g/100g, 3.01±0.005 g/100g, and 5.84±0.001 g/100g respectively (Table 2).

From the above study, significant decrease was reported in crude fibre content after sprouting of wheat because during germination, the activity of enzyme ß-galactosidase increases which leads to reduced levels of crude fibre.Similar results of fibre content in were reported by Mushtari *et al.* (2017) stated that finger millet flour when processed contained 3.6 g of fibre in 100 g of sample. Out of the pulses, processedsoyabeanflour contained the highest amount of fibre and similar findings were reported by Gupta*et al.*(2013)*i.e* 4.9±0.18 g/100g. Pumpkin seeds flour contained the highest amount of fibre among the oilseeds and the results were similar to the findings of Syed *et al*. (2019) who stated 6g of fibre is present in 100 g of pumpkin seeds flour. Hooda and Jood (2003) reported that during malting theactivity of enzyme ß-galactosidase increases which lead to reduced levels of crude fibre during germination. They also reported that the enzyme ß-galactosidase from germinated cereals acts upon galactomannan (present in the endosperm) leading to the complete degradation of alpha-1,6-galactosidic linkages which leads to the production of monosaccharide, thus resulting in the decrease of stored carbohydrates and an increase in total soluble and reducing sugars and fulfilling the energy needs of the growing embryo which was provided by monosaccharide.

CONCLUSION

The proximate analysis of some commonly consumed cereals/millets, legumes and oil seeds were carried out before subjecting to different

primary processing techniques and after subjecting to primary processing. Moisture contentwas found to besignificantly lower than the untreated ones due to different drying and roasting methods carried out for processing the raw ingredients. Available carbohydrate was significantly higher than the raw ingredients which were not subjected to any processing methods. The protein content was significantly higher in the malted wheat flour than compared to the untreated ones because of the malting process carried out. The fat contentwere found to be significant lower for soyabean flour and malted wheat flour than the untreated ones increased activity of lipolytic enzymes during soaking resulting in loss of crude fats. Crude fiber were significantly lower for malted wheat flour than the untreated ones, as the ingredients were subjected to high temperature due to drying and roasting processes. Considering the various processing methods it was apparent that simple household techniques may be employed to improve the nutritional quality of commonly used cereals, legumes and oilseeds for their further use.

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AN ECONOMIC ANALYSIS OF OILSEED SECTOR IN ANDHRA PRADESH

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ABSTRACT

The oilseed sector has an important place in Indian agriculture. India is importing 56 % of countries edible oil requirement. Therefore, the study is carried in focus with the growth of major oilseeds crops grown in Andhra Pradesh for the period of 1991-92 to 2020-21 using annual compound growth rates, Cuddy-Della Valle Instability Index, Decomposition analysis and Path analysis to provide policy options for betterment in oilseed sector. The results revealed that the compound growth rate of groundnut and niger showed a negative growth rate in all the growth parameters in the overall period (1991-92 to 2020-21), whereas, sunflower (1.41%) and sesamum (1.04%) showed positive growth rate in yield. The instability index in all the three growth parameters in palm oil and castor were found to fall in the category of high instability which showed that there is a larger fluctuation in the acreage and production during the overall period. The area effect contributed the highest to production compared to yield and interaction effect in all the oilseeds understudy during the overall period. The total oilseed under irrigated area is 7.43 percent to the total irrigated area which is the lowest compared to irrigated food grains and rice fallows in Andhra Pradesh. Hence, there is a need to intensify the area under oilseeds by promoting water-efficient technologies and assured irrigation facilities to augment productivity. The Government should take measures to achieve greater levels of independence in edible oils only by boosting production in various oilseeds including oil palm and other tree-borne oilseeds.

Key Words: Annual Compound Growth Rate, Decomposition, Instability, Oilseeds

INTRODUCTION

On the oilseeds map of the world, India occupies a prominent position, both in area and production. India is the 4th largest oilseed producing country in the world after the USA, China and Brazil, contributing 10% of the world oilseeds production, 6-7% of the global production of vegetable oil, and nearly 7% of protein meal. This is because of the low productivity of oilseed crops and year-to-year fluctuations in production (Indian Oilseed Market, 2018). This sector has an important place in the Indian agricultural sector covering an area of

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about 27.1 million hectares, with a total production of over 33 million tonnes in the year 2019-20 (Indiastat, 2020). For the development of the oilseed sector, the central government has launched many programmes such as Technology Mission on Oilseeds (TMO) in 1986 which was later restructured as Integrated Scheme of OilSeeds, Pulses,Oilpalm and Maize (ISOPOM) in 2004 (Reddy, 2009 and Reddy and Bantilan, 2012), National Mission on Oilseeds and Oil Palm (NMOOP) in 2014-15. But the performance of the oilseeds crops has not been as good as cereals and millets. Therefore,the oilseed sector has been a major concern for policymakers when India became one of the largest importers of edible oils in the world. Groundnut, mustard. rapeseed, sesame, safflower, linseed, niger, castor are the major traditionally cultivated oilseeds. Soybean and sunflower have also assumed importance in recent years. Coconut and oil palm are the most important of plantation crops. Among the non-conventional oils, rice bran oil and cottonseed oil are the most important. In addition, oilseeds of tree and forest origin, which grow mostly in tribal inhabited areas, are also a significant source of oils. Three main oilseeds namely, soybean, rapeseed-mustard and groundnut accounted for 91.87 percent of total oilseeds output during 2020-21.

Andhra Pradesh is one of the important states in the country that is growing oilseed crops like Groundnut, Sesamum, Sunflower and oil palm extensively. The area under oilseeds excluding Coconut during 2020-21 is 10.33 lakh hectares with a production of 29.93 lakh tonnes.

Table 1. Major Oilseed Producing States of India (2018-19)

S. No.	Crops	Major Producing States	Andhra Pradesh Rank
1	Groundnut	Gujarat (32 %), Rajasthan (20 %), Tamil Nadu (13 %)	4
2	Sunflower	Karnataka (55 %), Odisha (9 %), Haryana (9 %)	5
3	Safflower	Maharashtra (48 %), Karnataka (40 %), Telangana (7 %)	—
4	Soyabean	Madhya Pradesh (50 %), Maharashtra (35 %), Rajasthan (9 %)	16
5	Sesamum	West Bengal (33 %), Madhya Pradesh (20 %), Rajasthan (12 %)	8
6	Niger	Odisha (43 %), Chhattisgarh (23 %), Madhya Pradesh (12 %)	6
7	Rapeseed & Mustard	Rajasthan (44 %), Haryana (13 %), Uttar Pradesh (12 %)	25
8	Castor	Gujarat (82 %), Rajasthan (14 %), Andhra Pradesh (2 %)	3
9	Linseed	Madhya Pradesh (27 %), Jharkhand (20 %), Uttar Pradesh (18 %)	—

Source: Indiastat, 2020

The area under Groundnut alone accounted for 84.22 % of the total area under oilseeds during 2020-21 in Andhra Pradesh. Out of 29.93 lakh tonnes of production of total oilseeds, Palm oil and Groundnut accounted for production of 99.03% of the total oilseed production in the State (DES 2020-21, Andhra Pradesh).

In this pandemic situation, the state has faced a tremendous fluctuation in edible oil prices. The essential edible oils retail prices in 2020-21 have surged in groundnut by 22.29%, palm oil by 59.65 % and sunflower oil by 61.44% compared to 2019-20. This price volatility is because of dependence on the international market for edible oils affecting both domestic and international consumers and producers. In this context, with an objective to examine the present scenario and to provide suitable policy options in the oilseed sector the present study has been taken up.

Table 2. Area, yield and production of oilseed crops in Andhra Pradesh for 2020-21

S.No	Crops	Area (Lakh ha)	Production (Lakh tonnes)	Yield (kg ha^{-1})
1	Groundnut	870	778	894
2	Sesamum	36	9	250
3	Sunflower	12	8	667
4	Castor	16	6	407
5	Soyabean	2	3	1546
6	Niger	4	2	385
7	Palm oil	91	2186	24017
	Total oilseeds	**1033**	**2993**	**-**

Source: DES 2020-21, Andhra Pradesh, www.des.ap.gov.in

MATERIALS AND METHODS

For this study, secondary data (time series data) on area, production and yield of major oilseeds crops grown in Andhra Pradesh *i.e.* groundnut, niger, sesamum, sunflower, palm oil and castor for a period of 1991-92 to 2020-21 were studied. The entire study period was divided into three sub-periods, Period I (1991-92 to 2000-01), Period II (2001-02 to 2010-11), Period III (2011-12 to 2020-21) and the Overall period (1991-92 to 2020-21) to know the decadal performance of oilseeds in Andhra Pradesh. The requisite information was collected from the publications and the website of the Directorate of Economics and Statistics, Andhra Pradesh, Ministry of Agriculture, Government of India. The annual compound growth rates, Cuddy-Della Valle Instability Index, Decomposition analysis and Path analysis were employed for analysis.

In the case of palm oil, the data was available from 2005-06 to 2020-21 was taken for analysis.

Compound Growth Rate (CGR)

To estimate the CGR, the exponential time trend equation of the form:

$$Y=a\ bt$$

$$Ln\ Y=Ln\ a + t\ Ln\ b1$$

where Y: Variable whose growth rate is being computed t: Time trend (1, 2…n) a and b are regression coefficients to be estimated.

Cuddy-Della Valle Instability index

Cuddy-Della Valle Instability indexis a modification of the coefficient of variation to accommodate the trend present in the data, which is commonly present in economic time series data. This method is superior to the scale-dependent measures such as standard deviation(Cuddy and Della Valle 1978). The Cuddy Della Valle index (CDVI) is calculated as follows:

$$\text{Cuddy} - \text{Della Valle Index}\ (\%) = \text{CV}\sqrt{(1-\bar{\text{R}}^2)}$$

$$\text{CV}\ (\%) = \frac{Standard\ deviation}{Mean} \times 100$$

Where, C.V. = Coefficient of Variation

$\bar{R}^2$ = Coefficient of multiple determination

The ranges of CDVI (Sihmar, 2014) are given as follows:

Low instability = between 0 and 15

Medium instability = greater than 15 and lower than 30

High instability = greater than 30

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 (Singh and Sisodia,1989; 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.

Path analysis

In agriculture, the dependent variables were influenced by several other independent variables. The crop production may be determined by several variables like acreage, yield, rainfall, wholesale price, fertilizer consumption, etc. All these components influence production, and they are not only individually correlated with production but are also correlated among themselves. Hence, path analysis which explains direct and the indirect effects of the independent variables on the dependent variables were taken in the study.

Let a_i and b_j (i‘“ j = 1,2,3,….,k) be the direct effect and indirect effects of the i^{th} variable in a system of (k+1) variables then,

$$r_{x_iy} = a_i + \sum_{i\neq j=1}^{k} b_j \quad \text{... (1)}$$

Wherein:

r_{x_iy} denotes correlation coefficient between x_j and y;

a_i is the direct effect of the i^{th} causal variable on the response variable y; and

b_j is the indirect effect of the i^{th} causal variable on the response variable y *via* the

i^{th} causal variable (i.e. other than the i^{th} causal variable).

In this manner, each of the 'k' number of individual correlation coefficients of causal variables with the response variable will be partitioned into the additive effect of the direct effect of the respective variables and the sum of the indirect effects of the other variables.

$$r_{x_i y} = a_1 + b_2 + b_3 + b_4 + \cdots \ldots \ldots + b_k$$
$$r_{x_2 y} = b_1 + a_2 + b_3 + b_4 + \cdots \ldots \ldots + b_k$$
$$\ldots\ldots$$
$$r_{x_k y} = b_1 + b_2 + b_3 + b_4 + \cdots \ldots \ldots + a_k$$

Estimation of path coefficients

Generally, the path coefficients are denoted by p_{ij} (a, in equation 1), where i denotes for the dependent/response variable and j for the independent/causal variable. Thus, p_{ij} is the path coefficient of j^{th} independent variable on the i^{th} dependent variable. Path coefficients are defined as the ratio of the standard deviations due to a given cause to the total standard deviation of the response; in other words, $p_{ij} = \frac{\sigma_j}{\sigma_i}$. Path coefficient analysis is a special type of regression analysis that was worked out with the help of the ordinary least square technique. In fact, the β coefficients in regression analysis are the regression coefficients worked out from the standardized variables. As such the significance tests for β coefficients in regression analysis is equivalent to test the significance of path coefficients.

The main consideration in estimating the path coefficients is to fix the number of direct causal variables which are affecting the response of the dependent variable. A system of the simultaneous equation can be framed directly, and solutions of these equations will provide direct and indirect effects of the independent causal factors to the response variable.

Let y be the response variable and x_1 and x_2 be the causal variables then their relationship could be presented as, $y = x_1 + x_2$. Similarly, the variability in the response variable, measured in terms of variance, were written as: $\sigma_y^2, \sigma_1^2 and\ \sigma_2^2$ where $\sigma_y^2 = \sigma_1^2 + \sigma_2^2$, are the variances of y, x_1 and x_2, respectively,

$$\sigma_y^2 = \sigma_1^2 + \sigma_2^2$$
$$\frac{\sigma_y^2}{\sigma_y^2} = \frac{\sigma_1^2}{\sigma_y^2} + \frac{\sigma_2^2}{\sigma_y^2}$$
$$1 = p_{y_1}^2 + p_{y_2}^2$$

Wherein: $p_{y_1}^2 and\ p_{y_2}^2$ are the square of the path coefficients of x_1 and x_2 on the dependent variable y, respectively.

Calculation of direct and indirect effects:

In the present study, the direct and indirect effects of area (X_1); yield (X_2); rainfall (X_3) and minimum support price (X_4) were attempted on the production (Y) variable. The model was fitted for all the oilseeds understudy and given as follows:

$$\mathbf{Y = X_1 + X_2 + X_3 + X_4 + R}$$

Since, r_{ij} $(i \neq j)$ is the correlation coefficient between the i^{th} and j^{th}variables, the correlation coefficient of Y with that of X_1, X_2, X_3, and X_4 was given as:

Wherein, p_{y1}, p_{y2}, p_{y3} and p_{y4} are the path coefficients (i.e. direct effects) of X_1, X_2, X_3 and

$$r_{1y} = \text{Cov}(x_1, y)$$

$$r_{1y} = \frac{\text{Cov}(x_1, y)}{\sqrt{V(x_1)V(y)}} = \frac{\text{Cov}(x_1, x_1 + x_2 + x_3 + x_4 + R)}{\sqrt{V(x_1)V(y)}}$$

$$= \frac{\text{Cov}(x_1, x_1)}{\sqrt{V(x_1)V(y)}} + \frac{\text{Cov}(x_1, x_2)}{\sqrt{V(x_1)V(y)}} + \frac{\text{Cov}(x_1, x_3)}{\sqrt{V(x_1)V(y)}} + \frac{\text{Cov}(x_1, x_4)}{\sqrt{V(x_1)V(y)}} + \frac{\text{Cov}(x_1, R)}{\sqrt{V(x_1)V(y)}}$$

$$= \frac{V(x_1)}{\sqrt{V(x_1)V(y)}} + \frac{r_{12}\sqrt{V(x_1)V(x_2)}}{\sqrt{V(x_1)V(y)}} + \frac{r_{13}\sqrt{V(x_1)V(x_3)}}{\sqrt{V(x_1)V(y)}} + \frac{r_{14}\sqrt{V(x_1)V(x_4)}}{\sqrt{V(x_1)V(y)}} + 0$$

$$= \frac{\sigma_1}{\sigma_4} + \frac{r_{12}\sigma_2}{\sigma_4} + \frac{r_{13}\sigma_3}{\sigma_4} + \frac{r_{14}\sigma_4}{\sigma_4}$$

Thereby, $\mathbf{r_{1y} = p_{y1} + r_{12}\,p_{y2} + r_{13}\,p_{y3} + r_{14}\,p_{y4}}$ **... (2)**

X_4, respectively. Similarly, the path coefficients were obtained for r_{2y}, r_{3y} and r_{4y}.

Thus, the correlation coefficients of the independent variables can be stated as:

$r_{1y}\,p_{y1} + p_{y2}\,r_{12} + p_{y3}\,r_{13} + p_{y4}\,r_{14;}$

$r_{2y}\,p_{y1}\,r_{12} + p_{y2} + p_{y3}\,r_{23} + p_{y4}\,r_{24;}$

$r_{3y}\,p_{y1}\,r_{13} + p_{y2}\,r_{23} + p_{y3} + p_{y4}\,r_{34;}$ and

$r_{4y}\,p_{y1}\,r_{14} + p_{y2}\,r_{24} + p_{y3}\,r_{34} + p_{y4.}$

Wherein, p_{yi} refer to the direct effects and $p_{yi}r_{ij}$ refer to the indirect effects.

As the path coefficients are partial regression coefficients the estimate of total variation accounted by the variables in the analysis is obtained as R^2 and the unaccounted variation as (1- R^2) which is known as residual.

Calculation of residual

The residual value was calculated using the estimated path and correlation coefficients and it is given as follows:

It is to be noted that the values of the direct effects of different variables will be equal to their respective coefficients in the regression analysis. The residual in path analysis and the unexplained part in the regression analysis will be exactly equal.

RESULTS AND DISCUSSION

In Andhra Pradesh, the annual compound growth rate of groundnut and niger showed a negative growth rate in all the growth parameters in the overall period (1991-92 to 2020-21. Sunflower (1.41%) and sesamum (1.04%) showed a positive growth rate in yield though the area and production showed a negative growth rate in the overall period. Castorand oil palm showed positive growth in all the growth parameters. In Groundnut, the area showed negative growth rates in Periods I, II and III with -3.56%, -0.50% and -5.21% respectively. In the case of production and yield, the growth rate was seen to be negative in Period I by -4.43% and -0.91% respectively while it showed a positive growth rate in Period II and Period III. The results were similar to the Jha *et al.* (2012) where there was a decline in the compound growth rate in area production and productivity in oilseeds.

$$\mathbf{R^2 = 1 - [p_{y_1}^2 + p_{y_2}^2 + p_{y_3}^2 + p_{y_4}^2 + 2r_{12}p_{y_1}p_{y_2} + 2r_{13}p_{y_1}p_{y_3} + 2r_{14}p_{y_1}p_{y_4}}$$
$$\mathbf{+ 2r_{23}p_{y_2}p_{y_3} + 2r_{24}p_{y_2}p_{y_4} + 2r_{34}p_{y_3}p_{y_4}} \quad \text{..... (3)}$$

Table 3. Growth rate analysis of major oilseed crops of Andhra Pradesh (percent)

S. No.	Crops	Particulars	Period I (1991-92 to 2000-01)	Period II (2001-02 to 2010-11)	Period III (2011-12 to 2020-21)	Overall Period (1991-92 to 2020-21)
1	Groundnut	A	-3.56	-0.50	-5.21	-3.33
		P	-4.43	0.38	1.19	-3.64
		Y	-0.91	0.87	6.75	-0.33
2	Niger	A	-0.53	-6.70	-7.31	-5.15
		P	-3.73	-7.86	-9.20	-4.81
		Y	-3.35	-0.86	-4.64	-0.12
3	Sunflower	A	-0.71	-3.05	-27.87	-9.98
		P	2.60	-2.76	-27.06	-8.73
		Y	3.33	0.29	1.36	1.41
4	Sesamum	A	-0.73	-0.99	-4.50	-3.28
		P	-2.64	2.53	-5.15	-2.33
		Y	-1.91	3.17	-0.39	1.04
5	Palm Oil	A	-	-	9.34	13.87
		P	NA	NA	10.09	14.34
		Y	-	-	0.78	0.41
6	Castor	A	-4.24	7.16	-17.29	2.19
		P	-6.24	21.18	-10.59	5.21
		Y	-2.64	12.97	8.78	3.24

The niger showed a negative growth rate in all three growth parameters in Period I, II and III due to the decrease in the area (1.8 lakh ha in 1991-92 to 0.04 lakh ha in 2020-21) and production (0.08 lakh tonnes to 0.02 lakh tonnes) during the study period.In Sunflower, the area showed drastic negative growth rates from Period I to Period III (2.1 lakh ha to 0.12 lakh ha), whereas, yield showed a positive decreasing growth rate. In Sesamum and castor, all the three growth parameters showed negative growth rates in Periods I and III. Hence, there is a need to intensify the area by encouraging the farmers to cultivate oilseeds in assured irrigation conditions to increase productivity levels.

The Cuddy Della Vella instability index was carried out for the study period 1991-92 to 2020-21 for major oilseeds grown in Andhra Pradesh and the results are furnished in Table 4. In the overall period (1991-92 to 2020-21), the instability index of all the three growth parameters in palm oil and castorwere found to fall in the category of high instability which showed that

there is a larger fluctuation in the acreage and production. In Groundnut, production (38.21 %) and productivity (35.56 %) were found to have a high instability index and the area showed a low instability index of 12.19 percent. In the case of niger, production (16.67%) and productivity (18.36 %) were found to have a moderate instability index, whereas, the area showed a low instability index of 12.66 percent. Similarly, sunflower showed high instability in area and production with 51.24 percent and 56.03 percent, respectively. This high instability observed was due to a decrease in the area of the crop from 2.1 lakh hectares in 1991-92 to 0.12 lakh ha in 2020-21 as a result of the non-availability of remunerative pricethe farmers started to shift from sunflower to maize crop particularly in Rayalaseema region. Sesamum showed high instability in production with 34.32 percent as the production of the sesamum has abruptly decreased from 32000 tonnes to 9000 tonnes over the last three decades, whereas, areas and yield showed medium instability (APDES, 2021).

Table 4. Instability analysis of major oilseed crops of Andhra Pradesh (in percent)

S. No.	Crops	Particulars	Period I (1991-92 to 2000-01)	Period II (2001-02 to 2010-11)	Period III (2011-12 to 2020-21)	Overall Period (1991-92 to 2020-21)
1	Groundnut	A	5.65	15.41	13.95	12.19
		P	28.41	54.10	26.88	38.21
		Y	26.18	43.55	34.24	35.56
2	Nigerseed	A	5.28	10.97	13.31	12.66
		P	10.87	11.54	30.89	16.67
		Y	6.06	7.14	23.26	18.36
3	Sunflower	A	16.02	20.46	44.46	51.24
		P	20.76	21.92	36.55	56.03
		Y	23.98	16.38	23.58	20.58
4	Sesamum	A	16.69	38.43	26.47	26.04
		P	32.90	30.97	35.73	34.32
		Y	19.35	23.73	13.71	20.73
5	Palm Oil	A	-	43.23	9.68	47.98
		P	-	58.82	7.40	52.18
		Y	-	52.96	10.75	51.38
6	Castor seed	A	61.21	42.43	48.34	72.47
		P	76.13	62.88	47.01	74.09
		Y	29.95	19.97	32.00	36.47

Low instability = 0 - 15, Medium instability = 16 – 30 and High instability = > 30

In groundnut, although the area showed a low instability in periods I, II and III, production showed medium instability in the period I & III and high instability in period II and yield showed high instability in periods II & III and medium instability in the period I. The low instability was observed in niger during the period I and II, whereas, in period III the area showed a low instability with 13.31 percent, production showed a high instability of 30.89 percent and yield showed a medium instability of 23.26 percent. Similarly, in case of sunflower during the period I and II the medium instability was seen in all the growth parameters whereas, in period III, the area (44.46%) and production (36.55%) was showing high instability while yield showed medium instability of 23.26 percent. In sesamum, production showed high instability in periods I, II and III, whereas, the area showed medium instability in the period I & III and yield indicated medium instability in the period I & II. The high instability index was observed for palm oil during period II in the area (43.23 %), production (58.82 %) and yield (52.96 %) as the cultivation of palm

Table 5. Decomposition analysis of major oilseed crops of Andhra Pradesh (in percent)

S. No.	Crops	Particulars	Period I (1991-92 to 2000-01)	Period II (2001-02 to 2010-11)	Period III (2011-12 to 2020-21)	Overall Period (1991-92 to 2020-21)
1	Groundnut	Area Effect	100.03	100.45	100.21	100.00
		Yield Effect	-0.04	-0.45	-0.28	0.00
		Interaction Effect	0.01	0.01	0.07	0.00
2	Niger	Area Effect	0.00	99.41	100.58	99.73
		Yield Effect	100.00	1.06	-1.02	1.23
		Interaction Effect	0.00	-0.47	0.44	-0.96
3	Sunflower	Area Effect	102.24	99.58	99.99	100.02
		Yield Effect	-2.86	0.52	0.09	-0.38
		Interaction Effect	0.63	-0.09	-0.08	0.36
4	Sesamum	Area Effect	97.23	100.41	99.97	99.98
		Yield Effect	2.89	-0.31	0.05	0.08
		Interaction Effect	-0.12	-0.10	-0.02	-0.06
5	Palm Oil	Area Effect	NA	99.26	99.54	98.88
		Yield Effect	NA	0.26	0.23	0.20
		Interaction Effect	NA	0.48	0.23	0.92
6	Castor	Area Effect	101.83	91.43	100.20	99.97
		Yield Effect	-1.20	3.47	-1.98	0.09
		Interaction Effect	-0.64	5.10	1.79	-0.06

oil was encouraged by the provincial government's promotion and financial incentives during this period from 2006-07, before this there was no area under cultivation of this crop, later during period III the palm oil showed a low instability index in all the three growth parameters as the farmers started reaping the benefits of oil palm cultivation along with government incentives. In the case of castor, the area (61.21%, 42.43% & 48.34%) and production (76.13%, 62.88% & 47.01%) showed high instability due to a decrease in the area and production during the period I, II & III.

The contribution of area and yield along with interaction effect on production for major oilseeds of Andhra Pradesh from 1991-92 to 2020-21 (Table 5). The results revealed that in groundnut the area effect (100 percent) was found to be contributing highest to production compared to interaction and yield effect, while the yield effect was found to be negatively contributing in all the three periods. Similarly, in niger the yield effect (100 %) was contributing more compared to area and interaction effect in period I whereas in period II (99.41 percent) and III (100.58 percent) the area effect was the one that is contributing highest to production. The highest contribution in case of sunflower was found in area effect in period I, II & III while yield effect (-2.86%) was found to be negatively contributing in period II and interaction effect was seen to be negatively contributing to production in period II (-0.09%) & III (-0.08%). In sesamum and castor the area effect was found to be the highest contributing factor in period I, II, & III. In case of palm oil, the area effect in period II (99.26 %) and period III (99.54 %) contributed more to the production.

For the overall period in Andhra Pradesh, the area effect contributed highest to production compared to yield and interaction effect in all the oilseeds under study. In overall period, castor (-0.06 %), sesamum (-0.06 %) and niger (-0.96 %) showed negative interaction effect and in sunflower yield effect (-0.38 %) was found negative. Hence, it can be inferred that maximum contributing factor was area in all the oilseeds therefore it is necessary to bring the area along with productivity improvement by introducing high yielding oilseed varieties with biotic and abiotic resistant for enhancing the oilseeds production.

In agriculture, the production (dependent variable) is influenced by several other independent variables. Hence, path analysis was used to detect the direct and the indirect effects of the independent variables on the dependent variable in the study.

The direct and indirect effects between the area, productivity, rainfall and MSP and their correlation with the production of major oilseed crops are analysed for Andhra Pradesh from 1998-99 to 2020-21(Table 6). Among the oilseed crops, a significant correlation with production of area and productivity was noticed in all oilseed crops taken understudy and Sesamum was also found to havea significant correlation with production in MSP. Meanwhile, the Correlation coefficients of the area werehigher than the correlation coefficients of yield, rainfall, and MSP inniger (1.01), sunflower (1.02) and sesamum (0.91) while groundnut (0.77) and castor (0.65) productivity was found to be high correlation coefficients than the other factors. The direct effect of rainfall in groundnut (-0.0247) and niger (-0.0232) was found negative while in sunflower

Table 6. Direct and indirect influencing factors of the oilseeds production in Andhra Pradesh (1998-99 to 2020-21)

S. No	Crops	Para meter	A	Y	R	MSP	Corre -lation with output	R
1	Groundnut	A	**0.7047**	-0.0713	-0.0080	-0.0197	0.6058***	0.0505
		P	-0.0650	**0.7728**	-0.0083	0.0043	0.7038***	
		Y	0.2278	0.2590	**-0.0247**	-0.0024	0.4597	
		MSP	-0.6132	0.1462	0.0026	**0.0226**	-0.4418	
2	Niger	A	**1.0149**	-0.0403	-0.0027	-0.0505	0.9214***	0.0383
		P	-0.1193	**0.3430**	-0.0036	0.0035	0.2235***	
		Y	0.1163	0.0536	**-0.0232**	-0.0028	0.1440	
		MSP	-0.9147	0.0211	0.0012	**0.0560**	-0.8364	
3	Sunflower	A	**1.0282**	-0.0848	0.0039	0.0219	0.9693***	0.0386
		P	-0.5193	**0.1678**	-0.0075	-0.0090	-0.3679***	
		Y	0.0952	-0.0298	**0.0420**	0.0016	0.1090	
		MSP	-0.8817	0.0588	-0.0027	**-0.0256**	-0.8512	
4	Sesamum	A	**0.9178**	-0.3854	0.0003	0.1711	0.7037***	0.0725
		P	-0.4300	**0.8227**	0.0001	-0.1646	0.2281***	
		Y	-0.0254	-0.0058	**-0.0092**	0.0250	-0.0154	
		MSP	-0.5836	0.5034	0.0009	**-0.2691**	-0.3485***	
5	Castor	A	**0.6105**	-0.0909	0.0121	-	0.5317***	0.1944
		P	-0.0843	**0.6581**	0.0554		0.6291***	
		Y	0.0487	0.2401	**0.1519**		0.4407	

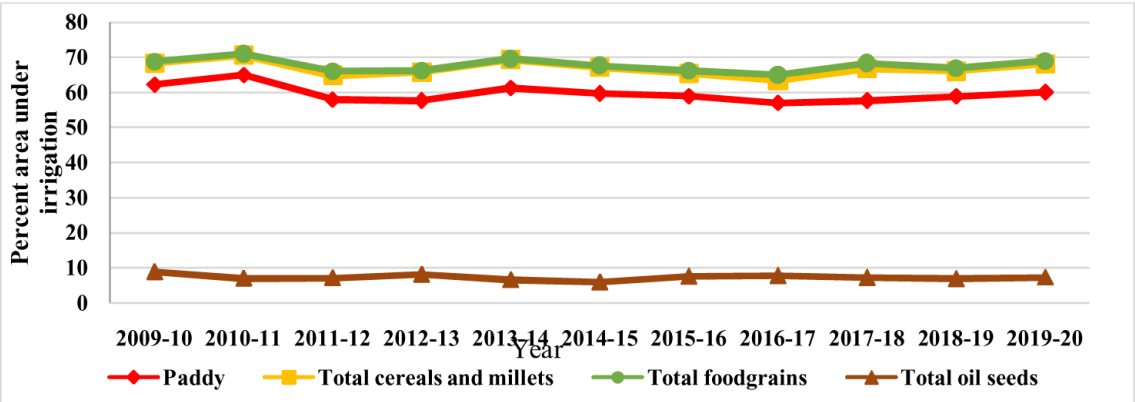
Note: 1. A – Area; Y – Yield; R – Rainfall; MSP – Minimum Support Price; & R - Residual

2. *** 1% level of significance

the direct effect of MSP (-0.0256) was negative and in sesamum, the direct of rainfall (-0.0092) and MSP (-0.2691) was found to contribute negatively to production. Hence, it is seen that in crops groundnut and castor the yield was the highest contributor while in niger, sunflower and sesamum the area was the highest contributor to the production than other factors. This indicates that government should focus on the needs of the farmers by providing a remunerative price for increasing oilseed cultivation.

The oilseed sector faces a host of challenges on technological, institutional and policy fronts. Oilseed cultivation in Andhra Pradesh is predominantly dependent on rainfall

and this leads to a higher magnitude of instability in the irrigated area of total oilseeds 10.72 percent, followed by 3.66 percent in rice and 2.71 percent in food grain during the period 2009-10 to 2019-20. In the irrigated area, the total oilseeds were recorded the lowest with 7.34 percent against 68.18 percent in total food grain, and the highest in paddy 60.05 percent during 2019-20. Often, the marginal lands are earmarked for the cultivation of oilseed crops. Such inherent disadvantages ensure that a levelled field is not provided to the oilseed crops even when they are being compared increasingly with their competing crops in terms of production,



Source: DES 2020-21, Andhra Pradesh, www.des.ap.gov.in

Fig.1. Percent area under irrigation under various crops in Andhra Pradesh

productivity and profitability were low (Figure 1). The results were similar to Prem (2016) who observed that the area under irrigation was the lowest with 28 percent in India.

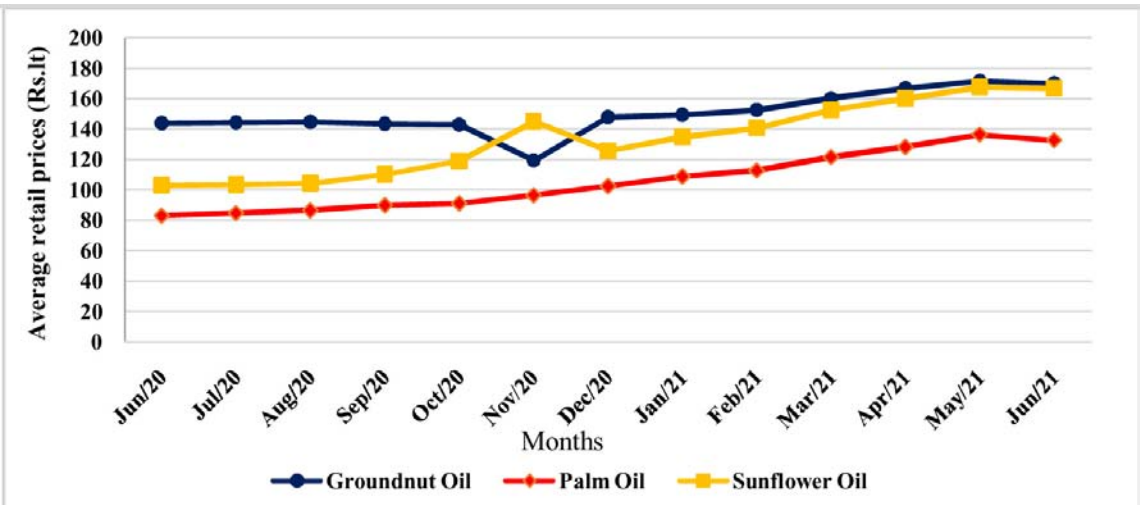
India is a net food exporting country but depends heavily on imports of edible oils (56 percent is imported to meet country's demand of 24 million tonnes) in which 52% of it consists of palm oil. Currently, the country has only about 3.4 lakh ha under oil palm, while the potential identified states for its cultivation are Andhra Pradesh, Arunachal Pradesh, Assam, Chhattisgarh, Karnataka, Kerala, Mizoram, Odisha, Tamil Nadu, and the other North-eastern states. Andhra Pradesh stands first in area and production of oil palm in the country with an area of 0.91 lakh ha and 21.86 lakh tonnes of fresh fruit bunches with average productivity of 24.01 tons per ha and West Godavari district is a major contributor of oil palm in 2020-21. Among the vegetable oil yielding crops, palm oil is the highest oil yielding plant in the world and has a critical role to play in meeting the vegetable oil requirements. Hence, the government has appealed to farmers to take up oil palm cultivation in a big way. It is a step to support the "*Atmanirbhar Bharat"* initiative and will reduce the imports of palm oil and make India self-sufficient in edible oils too. The Centre is also offering a seed subsidy of 85 % to oil palm cultivation to reduce edible oil imports. Hence, palm oil cultivation is a ray of hope for farmers as it is sustainable and needs only low maintenance but gives high returns.

The demand for edible oil has increased in Andhra Pradesh coupled with reducing imports

Table 7. Oil palm area, production and yield of Andhra Pradesh

S. No	Years	Area (Lakh ha)	Production (Lakh tonnes)	Yield (kg ha$^{-1)}$
1	**2012-13**	0.5	10.61	21097
2	**2013-14**	0.55	12.34	22319
3	**2014-15**	0.61	13.07	21482
4	**2015-16**	0.83	13.08	15867
5	**2016-17**	0.86	18.29	21279
6	**2017-18**	0.9	17.81	19784
7	**2018-19**	0.94	19.65	20906
8	**2019-20**	0.98	22.63	23155
9	**2020-21**	0.91	21.86	24017

Source: DES 2020-21, Andhra Pradesh, www.des.ap.gov.in

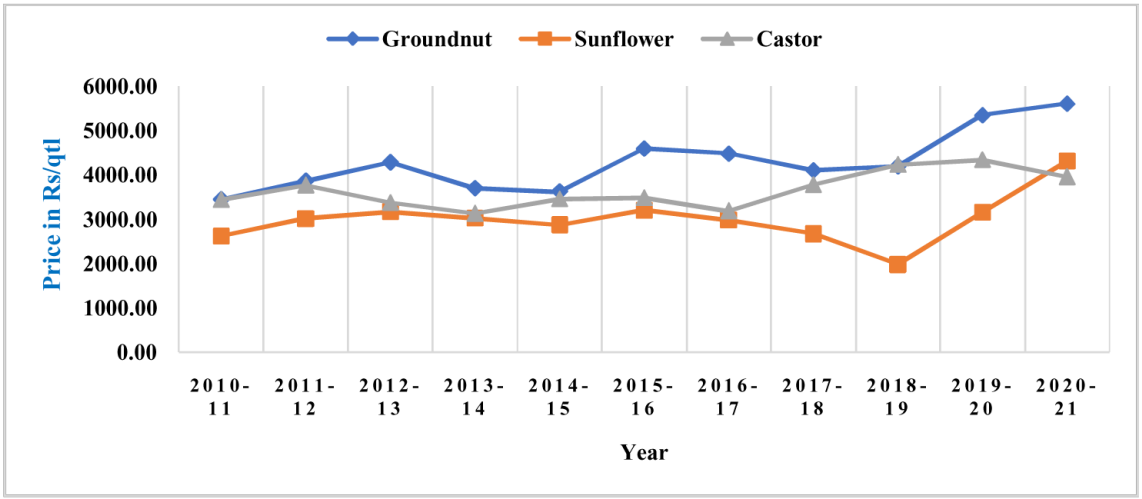


Source: DES 2020-21, Andhra Pradesh, www.des.ap.gov.in

Fig. 2. Average retail prices(Rs./l) of edible oils of groundnut, sunflower and palm oil in Andhra Pradesh

due to disruption in the supply chain network with the effect of COVID-19 has led to a steep rise in the prices of edible oils. Edible oil prices in Andhra Pradesh have risen sharply in sunflower oil (61.80%), palm oil (59.74%) and groundnut oil (18.51%) between June 2020 to June 2021 (Fig. 2). The prices have increased due to slowdown of import of palm and sunflower oiltherefore, the thrust should focus on growing these oilseeds that have the relative advantage to low yielding cereals crops and increase the cultivation of the oilseed crops in Andhra Pradesh.

Fig.3 explains the price behaviour of major oilseed crops namely groundnut, sunflower and castor in Andhra Pradesh from 2010-11 to 2020-21. The price of the product depends on the



Source: Data obtained from Adoni, Kurnool and Yemminganur AMC's.

Fig. 3. Price behaviour of groundnut, sunflower and castor oilseeds in Andhra Pradesh from 2010-11 to 2020-21

arrival of the particular crop to the market. The sunflower prices increased in the years 2019 to 2021 due to a decrease in the crop acreage and led to low arrivals to the market. In groundnut and castor, consistency in prices was observed from 2010-11 and 2020-21.

CONCLUSION

In the agricultural economy of India, the oilseeds sector plays an important role next only to food grains. The gap between demand and supply of oilseeds in India is about 56% which is met through imports leading to a hike in the oilseed prices. Andhra Pradesh is one of the important States in the country that is growing oilseed crops like groundnut, sesamum, sunflower and oil palm extensively. In Andhra Pradesh, the annual compound growth rate of groundnut and niger showed a negative growth rate in all the growth parameters in the overall period (1991-92 to 2020-21) while castor and oil palm showed positive growth in all the growth parameters and sunflower (1.41%) and sesamum (1.04%) showed positive growth rate only in yield. The instability index of all the three growth parameters in palm oil and castor were found to have a high instability which showed that there is a larger fluctuation in the acreage and production during 1991-92 to 2020-21. The decomposition analysis showed that the area effect contributed highest to production compared to yield and interaction effect in all the oilseeds understudy during the period 1991-92 to 2020-21. The maximum contributing factor was only area in all the oilseeds therefore it is necessary to bring the area along with productivity improvement by introducing high yielding oilseed varieties with biotic and abiotic resistance for enhancing productivity. The total oilseeds were recorded the lowest with 7.34 percent to total irrigated area followed by 68.18 percent in total food grain, and the highest in paddy 60.05 percent during 2019-20. Hence, there is a need to intensify the area under oilseeds by promoting efficiency in water use through protective irrigation and increase the

area of oilseeds under irrigation. The government should take measures to achieve greater levels of independence in vegetable oils only by boosting production in various oilseeds, oil palm and mainly in tree-borne oilseeds. To achieve these the government should increase Seed Replacement Ratio (SRR) in oil crops with a focus on varietal replacement, increasing irrigation coverage under oilseeds, diversification of area from low yielding cereals crops to oilseeds crops, expansion of cultivation of oil palm and tree borne oilseeds in rainfed areas with effective drip irrigation technology or watersheds or in wastelands, increasing availability of quality planting material enhancing procurement of oilseeds and collection, and processing of tree-borne oilseeds. In view of this, the way forward includes:

1. The perils of monocropping (rice-wheat-rice cycle) are well known in India. To prevent an ecological disaster and encourage crop diversification, we need to incentivise oilseed cultivation with all possible government programmes.
2. Providing seed subsidies, improved production technologies with biotic and abiotic stress-resistant varieties, productivity augmenting technologies for the varied agroclimatic conditionto encourage specific oilseed crop cultivation and related extension service will help in oilseeds area expansion.
3. There is a need to promote efficiency in water use through protective irrigation and increase its area under irrigation of oilseeds grown in rainfed areas.
4. Effective market interventions through price support, price signalling, etc. have to be complemented and strengthened through the selective use of innovative market approaches like futures markets.
5. Encouragement for production of secondary source of oilseeds like Oil palm by providing subsidised water-saving technologies like drip irrigation, providing a fixedgrant of cultivation expenses during the first year of crop establishment followed by the maintenance cost till bunch bearing period (up to four years), encouraging the assured buyback written agreements between growers and processors, etc.

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MARKETING COST, CHANNELS AND CONSTRAINTS: A CASE STUDY OF VEGETABLES MARKETING IN TELANGANA STATE

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ABSTRACT

The purpose of this research is to determine the cost, channels, and constraints associated with vegetable marketing in Telangana State. The study conducted during 2016-17 analysed the primary data using a multistage random sampling technique. The results revealed that lowest, highest, and total average marketing expenses per acre were Rs.765, Rs.4275, and Rs.2190, respectively. Marginal farm size and green chilli producers paid the highest average marketing cost on vegetables per acre (Rs.2342) and (Rs.2862), respectively, which was more than the total average marketing cost (Rs.2190 per acre). The vast majority (95.8%) of vegetable producers transported their products through the PCRC channel (Producer-Commission Agent-Retailer-Customers). The primary constraint is scarcity of storage space in marketplaces, which ranks top with a Garrett mean score of 69.11. The study advised that, in light of the scarcity of information in their various market locations, the government should establish a dedicated television channel devoted entirely to market pricing, market data, and vegetable farming. With the welfare of farmers in mind, the government should organise market functionaries and encourage the development of market infrastructure (i.e., cold storage facilities), as well as enhance market led extension services.

Keywords: Garret Ranking Technique, Marketing Channels, Marketing Constraints, Marketing Cost, Telangana State, Vegetables

INTRODUCTION

India is the second-largest producer of fruits and vegetables in the world, after China (Kondal, 2016; Kondal, 2020, and Kondal, 2022). Among all the horticultural crops, vegetables contribute more to the production of India. It has produced 185.88 MT in 2018-2019 (NHB-National Horticulture Board, 2018-2019). Vegetable production depends on various factors, such as systematic cultivation, cost of production & marketing and an efficient marketing system in the state. These are playing a vital role in the production process or cultivation. Within the stipulated time, vegetables must reach the market and consumer after the harvesting. In the state, certain infrastructure facilities are available for marketing procedures, so that the goods may reach in time. However, marketing encompasses

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the services necessary to get vegetable goods from fields to markets or customers. Throughout the process of vegetable marketing, several activities such as planning vegetable production, grading, packaging, shipping, and storage facilities have been involved, as well as the final sale in the market. Generally, the marketing cost includes mainly loading, packing, transport and market fee etc. While the goods are transporting, many constraints have to be faced by the producers/farmers. In general, producers/ farmers may come across many constraints in the cultivation of vegetables due to natural and climatic conditions. If the market functionaries perform well, they may be few problems that have to be faced by the producers/farmers. Constraints are mostly determined by the effectiveness of the agricultural marketing system/function. A successful marketing system is critical to progress/development (Dukpa and Ezung, 2020). Horticulture plays a crucial part in agriculture. Among the horticultural sectors, the vegetable sector contributes significantly to food security, nutrition, and poverty reduction through creating jobs for rural and semi-urban residents. Vegetables contributes for 58% and 44% to total horticultural output in India and Telangana State, respectively (GoI, 2014; Govt. of Telangana, 2014; and Kondal, 2018).

There has been a noticeable transition away from traditional agricultural crops into cash and commercial commodities including cotton, fruits, and vegetables. The cropping patterns of fruits and vegetables have evolved throughout time, and the area under cultivation of horticulture crops has risen dramatically as a result of agriculture's diversification. Simultaneously, this industry created a significant revenue for producers while maintaining a low cost of cultivation and offering appropriate job possibilities for rural and urban residents. Fruits and vegetable crops contribute significantly to nutritional security, population health, and poverty reduction. Horticulture output expanded as a result of new technology and the introduction of hybrid cultivars. Demand for vegetables, in particular, is expanding at a quicker pace than average due to population growth. Vegetables are short-season crops that are mostly grown on tiny farms around the nation. These crops, which are mostly labour demanding, provide jobs for both skilled and unskilled labourers. Horticultural crops, on the other hand, are distinct from agricultural crops. Because horticulture crops are perishable, producers must be prepared to preserve them even when commodity prices are unclear. To prevent these situations, farmers will sell their products via a variety of venues. Previously, a few research (Manivel, 2014; Mashapa *et al.*, 2014; Prakash *et al.,* 2014; Singh and Meetei, 2014; Kondal, 2016) concentrated on marketing cost, channels and constraints of vegetables in the different states in India. Despite the enormous importance accorded to the vegetable sector in India and Telangana State. The horticulture sector is an uncertain activity and so many things must be in favour to secure production, marketing and get profits. There are very few studies on marketing cost, channel and constraints of vegetable producers/farmers. To the best of the researchers' knowledge, there are no empirical studies in Telangana State concerning vegetable's marketing cost, channels and constraints. Therefore, there is a need to focus on the above issues. The study aim is to

examine the marketing cost, channels and constraints of vegetable producers/farmers in Telangana State, India.

MATERIAL AND METHODS

For this study in Telangana, Ranga Reddy and Medak (old) districts have been selected based on the volume of highest production of vegetables (1142306 MT in 2013-14) (Govt. of Telangana, 2014). Primary data was obtained using a multi-stage random sampling procedure during the months of January and February in 2016. At the first stage, two districts *i.e*., Ranga Reddy and Medak; at the second stage two Mandals (Shamshabad & Shameerpet from Rangareddy; Gajwel & Mulugu from Medak) from each district; at the third stage two villages from each Mandal (Narkuda & Malkaram villages from Shamshabad; Thumkunta & Turkaplly villages from Shameerpet; Mutrajpally & Ahmadipur villages from Gajwel; Siggannaguda & Tuniki Bollaram villages from Mulugu), and at the fourth stage 30 vegetable producers/farmers from each village have been selected randomly. The total sample size is 240. Simple statistical tools and the Garrett Ranking technique have been employed.

Garret Ranking Percentage Score=

100(Rij-0.5)/Nj

Whereas,

Rij is rank given for ith item by jth individual

Nj is the number of items ranked by jth individual

Operational Definition for farm size

S. No.	Farm Size	Definition
1	Marginal Farm	Less than one acre land under the cultivation of vegetables
2	Small Farm	one acre to two acres of land under the cultivation of vegetables
3	Medium Farm	Two acres to three acres of land under the cultivation of vegetables
4	Large Farm	More than three acres of land under the cultivation of vegetables

RESULTS AND DISCUSSION

Table 1. Farm size-wise marketing cost of vegetables per acre (Values in Rs.) (n=240)

		Average of value of different farms' marketing cost					
S.No.	Variables	Marginal (n=170)	Small (n=53)	Medium (n=114)	Large (n=3)	Overall Marketing Cost	S. D
1	Cost of Loading	261.5	362.5	331	240	287.6	137.06
2	Cost of Packing	779.2	474.6	498.2	750	695.2	399.06
3	Cost of Transport	1293.3	950.0	1044.6	900	1198.1	528.07
4	Cost of Market fee	7.4	4.2	48.2	0	9	54.79

Source: Primary data

Marketing costs are significant in expanding the area planted with vegetables. The whole marketing cost of loading was, on an average, 287.6 rupees per acre (Table 1). The cost of loading for small farm size producers was the highest (Rs.362), followed by medium (Rs.331), marginal (Rs.261), and large farm size producers/farmers (Rs.240). The cost of loading was low for large farm size farmers and high for small farm size producers/farmers, respectively. This occurred as a result of the frequent selling of goods. When selling, several types of loading costs apply until the product reaches the market. The average marketing cost per acre for packing was 695 rupees. The packing cost of marginal farm size producers was the highest (Rs.779), followed by large (Rs.750), medium (Rs.498), and small farm size producers/farmers (Rs.475). In this study, after transport cost, packing cost was high. This result is close to the Singh and Meetei (2014) findings. This occurred as a result of their commodities' frequent sales, and some farmers obtained free packaging material from commission brokers and wholesalers. The average marketing cost per acre for transportation was 1198 rupees. Transport costs were highest for marginal farm size producers (Rs.1293), followed by medium (Rs.1045), small (Rs.950), and large farm size producers/farmers (Rs.900). This occurred as a result of the frequent sale of a little quantity of product by marginal farm size producers, and as a result, transportation costs were very high owing to swings in fuel and petrol prices. The whole marketing cost of a market charge was, on average, 9 rupees per acre. The cost of market entry fee for medium farm size producers was very high (Rs.48), followed by marginal (Rs.7) and small farm size producers/farmers (Rs.4). Several farmers have been offering their crops for free at Rythu Bazaars and other marketplaces. However, transportation expenses were very expensive in comparison to other marketing expenditures in the research location. The average, lowest, and highest marketing expenses per acre were Rs.765, Rs.4275, and Rs.2190, respectively.

Table 2. Crop-wise and average marketing cost of vegetables per acre (Values in Rs.)

S. No.	Crops	<Rs.2000	>Rs.2000	Total	Average of Marketing cost
1	Brinjal	15 (15.4)	6 (4.1)	21	1911.42
2	Tomato	51 (52.5)	18 (12.5)	69	1607.60
3	Onion	3 (3)	10 (6.9)	13	2353.84
4	Okra (*Bhendi*)	16 (16.4)	17 (11.8)	33	2158.63
5	Ridge Gourd	3 (3)	22 (15.3)	25	2476.80
6	Green Chilli	3 (3)	51 (35.6)	54	2862.50
7	Beans	6 (6.1)	19 (13.2)	25	2248.20
	Total	97 (100)	143 (100)	240	
		97 (40.4)	143 (59.5)	240 (100)	2190.00

Source: Primary data; Note: *Figures in parentheses indicate percentages to the total*

Table 2 shows the crop-wise and average vegetables marketing cost per acre. Green chilli producers spent more on marketing costs per acre on average (Rs.2863), which was greater than the total average (Rs.2190 per acre), followed by ridge guord (Rs.2477), onion (Rs.2354), beans (Rs.2248), okra (Rs.2159), brinjal (Rs.1911), and tomato producers/farmers (Rs.1608). Baloch *et al.* (2014) also stated that high cost of cultivation was observed in onion cultivation). In this study, brinjal marketing cost is higher than tomato. In the study of Patel (2013), it was contrary findings (Marketing cost for tomato was higher than brinjal per quintal in North-Gujarat). Out of the 240 respondents, more than half (59.5%) of the farmers spent more than Rs.2000 per acre on marketing. Within this category, green chilli farmers accounted for the highest percentage (35.6%), followed by ridge guard (15.3%), green beans (13.2%), tomatoes (12.5%), okra (11.8%), onion (6.9%), and brinjal producers/farmers (4.1%). A total of 40 percent of the respondents' marketing costs were less than Rs.2000 per acre. Within this category, tomato producers accounted for the more than half number (52.5%), followed by okra (16.4%), brinjal (15.4%), green beans (6.1%), onion, ridge guard, and green chilli (3%) each. However, only one okra farmer in the study region paid more than Rs.4000 per acre on marketing cost.

Table 3 shows the farm size-wise and average marketing cost of vegetables per acre. Marginal farm size producers/farmers spent more on vegetables (Rs.2341.58), followed by medium (Rs.1922), large (Rs.1890), and small farm size producers/farmers (Rs.1791.5). On an average, marketing costs for all farm sizes were Rs. 2190 per acre. Out of the 240 respondents, 59.5 percent of farmers' marketing costs exceeded 2000. It illustrates that their marketing costs were greater than the overall average. Marginal farmers account for 81.1 percent of this category, followed by small farmers (13.2 percent), medium farmers (4.8 percent), and large farmers (0.6 percent). One marginal producer paid more than 4000 rupees per acre,

Table 3. Farm size-wise and average marketing cost of vegetables per acre

S. No.	Farm Size	Less than Rs.2000	Above Rs.2000	Total	Average of Marketing cost (Values in Rs.)
1	Marginal Farmers	54 (55.6)	116 (81.1)	170	2341.58
2	Small Farmers	34 (35)	19 (13.2)	53	1791.50
3	Medium Farmers	7 (7.2)	7 (4.8)	14	1922.14
4	Large Farmers	2 (2)	1 (0.6)	3	1890.00
	Total	97 (100)	143 (100)	240	
		97 (40.4)	143 (59.5)	240 (100)	2190

Source: Primary data; Note: *Figures in parentheses indicate percentages to the total*

1. Producer ⟶ Commission agent ⟶ Retailer ⟶ Consumers (PCRC)
2. Producer ⟶ Procurement agencies ⟶ Retailer outlet ⟶ Consumers (PPRC)
3. Producer ⟶ Retailer ⟶ Consumers (PRC)
4. Producer ⟶ Consumers (PC)

while 40.4 percent of respondents' marketing costs were less than Rs. 2000. Marginal farmers account for 55.6 percent of this category, followed by small farmers (35%), medium farmers (7.2%), and large farmers (2%). Vegetable supply plays a significant impact in marketing. Frequently, the majority of vegetable producers sell their goods at marketplaces on a daily or alternate day basis. When it comes to disposing of vegetables, producers/farmers have alternatives to distribute them. In the study area, the following channels are active:

Nowadays, profits are a major element in any farm, whether it is in the industrial or service

Table 4. Details of Vegetable marketing of the respondents

S. No.	Particulars	Variable	Frequency	Percentage
1	Channels	PCRC	230	95.8
		PPRC	2	0.8
		PRC	2	0.8
		PC	6	2.5
2	Payment Mode	Immediate	232	96.7
		Day by day	2	0.8
		Weekly Once	6	2.5
3	Information	Yes	48	20
		No	192	80
4	Communication Needed	SMS Alert	100	41.7
		Special TV Channel	139	57.9
		Interpersonal from Govt. Officials	1	0.4
		Channels	**Production (In Quintal)**	**Percentage**
5	Total Production	PCRC	11138	90.86
		PPRC	50.5	0.41
		PRC	300	2.45
		PC	770	6.28

Source: Primary data

sectors or agriculture. Thus, numerous variables such as input pricing, weather conditions, demand and supply, subsidies, middlemen, marketing facilities, government incentives, and the socioeconomic conditions of vegetable producers/farmers in particular may all have an effect. Producers will determine which crop is the most efficient or profitable enterprise for their soil/land in the present and future based on the returns gained on vegetable crops. In general, returns are determined by the soil's composition and environmental factors. If these requirements are met, the producers may expand their vegetable cropping pattern.

Table 4 shows the vegetable marketing of sample respondents. The majority (95.8 percent) of vegetable producers/farmers transferred their commodities through the first channel (PCRC), which is producer to commission agency to retailer to consumer. This result is close to the Patel (2013) (More than 85 percent of tomato and 84 percent of brinjal moved through this route in North Gujarat). Next to PCRC, producers/ farmers using producer to consumer (PC) channel followed by other two channels (PRC and PPRC). Due to labour shortages and time constraints, farmers chose the first channel (PCRC). Generally, marketing channels vary from crop to crop. Payment mechanism is essential for farmers. It will go a long way toward covering labour and other input costs. The majority of farmers (96.7 percent) were paid immediately after sale, followed by weekly once-a-week payments (2.5 percent) and daily payments (0.8 percent). This kind of payment will assist farmers in transitioning away from non-institutional credit sources such as money lenders, family, and friends. However, farmers lost some money when they used the first channel (PCRC). With respect to the market information obtained, market information is critical in assisting producers in making crop harvesting decisions. Particularly, knowledge about prices has a significant impact on the supply of vegetables. 80% of vegetable producers received no prior pricing information from market authorities or officials. Concerning the communication that is required, communication is the most critical aspect that producers/farmers constantly want. In the market, there should be a positive relationship between vegetable producers and market authorities. Producers were unable to get price. As a result, the majority of farmers responded that they need a specialized television channel, followed by SMS alerts and interpersonal contact from government authorities to keep informed about market prices and how to utilize current inputs. This level of information availability enables farmers to anticipate market prices and other market information. The information flow helps farmers to have an understanding of current market pricing as well as the magnitude of price swings in various marketplaces. In terms of marketing channel, 90.86 percent of total vegetables output was transferred only via the first channel (PCRC). It is a predominant channel in the study area, followed by PC (6.28 percent), PRC (2.45 percent), and PPRC (0.41 percent). During the research period, all vegetable producers collectively transmitted 12259 quintals of vegetable output from their individual farm gates to markets via four available channels.

Table 5 shows the marketing channel-wise total and average profits of sample respondents per acre. Marketing channels have a

Table 5. Marketing channel wise total and average profits of sample respondents(per acre)

S. No	Channel	Total Profit (In Rs.)	Average Profit (In Rs.)
1	PCRC	7512500.15	32663.04
2	PPRC	115016.1	57508.05
3	PRC	85690	42845.00
4	PC	397364	66227.33

Source: Primary data. **Note:** Profits are calculated after reduction of production and marketing cost

considerable impact on the degree of profit earned by producers. Profitability is dependent upon the method through which they choose to sell their goods in the marketplaces. On an average, vegetable farmers profited more via the fourth channel, producers to consumers (PC), than from the second (PPRC), third (PRC), first (PCRC) channels. It seems as if people who transferred their vegetables through the fourth channel benefited more than those who used the other channels. Even though the majority of producers/farmers used the channel (PCRC) and earned less profit since farmers often pay commission brokers more than 10%. This result is close to the Kaul (1998) (In his study, 7 to 10 percent of commission, which was quite high). Vegetables have number of restrictions, including production and marketing boundaries. Restrictions in marketing extend beyond manufacturing constraints. The next section discusses the marketing restrictions experienced by farmers in the study area.

Table 6. Marketing constraints of the sample respondents

S. No.	Marketing Constraints	Yes/No	Frequency	Percentage
1	Boarding facilities	Yes	20	8.3
		No	220	91.7
2	Lodging facilities	Yes	3	1.2
		No	237	98.8
3	Parking facilities	Yes	220	91.7
		No	20	8.3
4	Water facilities	Yes	168	70
		No	72	30
5	Toilet's facilities	Yes	19	7.9
		No	221	92.1
6	Canteen facilities	Yes	4	1.7
		No	236	98.3

Table 6 Contd...

S. No.	Marketing Constraints	Yes/No	Frequency	Percentage
7	Defective Weight	Yes	115	47.9
	(Faulty weight machine)	No	125	52.1
8	Minimum Security in the	Yes	82	34.2
	market at night time	No	158	65.8
9	Fixing Price less than	Yes	215	89.6
	Actual Price in the market	No	25	10.4
10	Existence of Middlemen in the market	Yes	227	94.6
		No	13	5.4
11	Availability of Suitable Transport	Yes	227	94.6
	facilities in the market	No	13	5.4
12	Implementation of Market Regulations	Yes	41	17.1
		No	199	82.9
13	Supervision of Market Authorities	Yes	60	25
	or Officials in the market	No	180	75
S.No.	**Marketing Constraints**	**Response**	**Frequency**	**Percentage**
		Low	196	81.7
14	Stall Cost in the Market	Average	43	17.9
		High	1	0.4
		Low	166	69.2
15	Storage Facilities in the Market	Average	31	12.9
		High	43	17.9
16	Bargaining Power of	Low	21	8.8
	Consumers in the market	Average	185	77.1
		High	34	14.2
17	Nature of Competition	Low	4	1.7
	in the Market	Average	113	47.1
		High	123	51.3

Source: Primary data

Table 6 shows the marketing constraints of vegetable producers/farmers in the study area. Regarding the boarding and lodging facilities, 91.7% and 98.8% of the respondents respectively stated that the boarding and lodging facilities were not available in their respective markets producers/farmers were unable to transport their products during the evening hours. Generally, producers/farmers transport vegetable produces early morning (3 A.M. or 4 A.M.). Regarding water facilities, 70 percent of the respondents stated that water facilities (drinking and washable) were available; the remaining 30 percent of respondents stated that water facilities were not available in the market. producers/farmers may use the water to clean their vegetables at the market. If the vegetables are clean, wholesalers and customers will pay greater attention to them and will prefer to purchase them as well. Regarding toilet facilities, 92% of respondents said that toilets were unavailable. It demonstrates that farmers (particularly female producers) experienced more difficulties in their individual market places. When enquired about canteen facilities, 98% of respondents said that they were unavailable. In certain market places, canteens are operated by private persons. In marketplaces, private canteens charge extra for food items. Concerning about malfunctioning of weight machines, 47.9% of the respondents claimed that market weight machines are defective. Regarding night time security, 65.8% of the respondents stated that security guards were not present in their particular marketplaces at night. Concerning about price fixing, 89.6 percent of respondents reported that their product had typically low pricing established in collusion with brokers/commission agents. Due to the lack of market authorities, it is apparent that commission agents play a significant influence in determining vegetable pricing. Concerning the presence of intermediaries in market places, 94.6% of the respondents said that they exist. Concerning the availability of market transportation, 94.6% of the respondents replied that market transportation is available. In terms of market regulatory implementation, 82.9% of the respondents felt that market authorities failed to enforce market rules and regulations. It demonstrates unequivocally the absence of market authorities' interference. Regarding market authorities' monitoring, 75% of respondents stated that market officials never keep an eye on market activities. It reveals that farmers might just have suffered losses as a result of market regulators' lack of monitoring. Market authorities seem to be in favour of wholesalers and commission agents. producers/farmers conveyed their views as, there was mutual agreement between commission agents, market authorities, and committee members in their individual marketplaces. That is why commission agents are critical in determining vegetable market pricing. Concerning stall costs, the majority (81.7%) of respondents said that they were minimal, and for a few farmers, they were nil, since they sold their goods for free at Rythu bazaars and other locations. Given their key role in the marketing of vegetables, the majority (69.2 percent) of the respondents claimed that storage facilities were in poor condition. It demonstrates that this is the market's and farmers' primary vulnerability. Concerning negotiating power, the majority (77.1 percent) of respondents thought that wholesalers/consumers' bargaining power was average. In terms of the competition's nature, 51.3 percent of respondents felt that it

Table 7. Garrett's Ranking for marketing related constraints perceived by respondents

S. No.	Factor	Constraints	Mean Score	Garret Rank
1	F1	Stall Cost	65.65	**3**
2	F2	Lack of Storage Facilities	69.11	**1**
3	F3	Bargaining	56.38	**4**
4	F4	Nature of Competition	67.39	**2**

Source: Primary data

was very competitive. It demonstrates that when producers/farmers rivalry is strong, farmers benefit from cheap prices per quintal owing to surplus supply. Producers/farmers seem to have cultivated their crops in a systematic way in order to fulfil demand, supply, and maximize profits.

Table 7 shows the Garret's ranking for marketing related constraints perceived by sample respondents. The primary constraint is a lack of storage facilities in markets, which ranks first with a Garrett mean score of 69.11, followed by the nature of competition, stall costs, and market bargaining with Garrett mean scores of 67.39, 65.65, and 56.38, respectively. The consumer/negotiating wholesaler's power obtained the lowest Garrett score. The result is looking positive for vegetable producers/farmers. They may sell their goods at a good price if they do not need cash quickly. Vegetable farmers sold their goods at a discount owing to a shortage of storage space in their particular marketplaces and the highly perishable nature of vegetables.

CONCLUSION

Due to the perishability of vegetables, marketing costs play a significant role in vegetable cultivation. The research discovered that transportation expenses were extremely high in comparision to other marketing expenditures, particularly for marginal farm size farmers (Rs.1293). However, the average marketing costs per acre were Rs.765, Rs.4275, and Rs.2190, respectively. The majority (59.5%) of producers/farmers' marketing costs exceeded Rs.2000. It demonstrates that their marketing costs were greater than the overall average. Marginal farm size and green chilli producers paid the highest average marketing cost per acre (Rs.2342) and (Rs.2862), respectively, which was more than the total average marketing cost (Rs.2190 per acre). The vast majority (95.8%) of vegetable producers/farmers transferred their products through the first channel (PCRC), followed by other channels and 90.86 percent of production was transferred via this channel alone, although those who transferred through the fourth channel (*i.e.*, PC) obtained a higher profit margin than those who transferred through the other channels. Certain restrictions obstruct the maintenance of a stable equilibrium between demand and supply. The primary constraint is a shortage of storage space (Warehouses) in markets, which ranks top with a Garrett mean score of 69.11, followed by the competitive environment, stall costs, and market bargaining. The study recommends that the government should establish basic infrastructure facilities in the market, and that, in light of a lack of

information in their respective areas, the government should create a special television channel which can dedicate exclusively to market prices, market details, and vegetable cultivation. This kind of information flow will help the farmers by informing them about prices and other market information in advance, allowing them to maximize and minimize their profits and cost, respectively.

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ANALYSIS OF EMPLOYMENT AND INCOME GENERATION THROUGH DAIRY FARMING IN RURAL PUNJAB

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ABSTRACT

Analysis of employment and income generation from dairying in rural Punjab, the study revealed that dairy farming generated, on an average, employment of 193 person days per annum in the rural areas of Punjab. Out of this, male employees were higher than female employees. The average annual income of households involved in dairying was ¹ 494289 per household from all sources, from which, the income from dairying constituted around one-fifth of the total income of the dairy farmers. The value of the Gini Coefficient exclusive of dairy income was higher than the value of the Gini Coefficient when dairy income included in total family income, thereby implying that dairying improved the income distribution by reducing income inequalities. The results of the t-test revealed that dairy income helped in sustaining the livelihood of dairy farmers, improved their income distribution, and hence, helped in raising the standard of living of milk producers.

Keywords: Dairy Farming, Employment, Gini Coefficient, Income Generation, Inequalities

INTRODUCTION

Dairy farming has been considered as a crucial value-added farming system practiced in India. Dairy farming is a major source of employment and income generation in rural areas. Dairying has provided livelihood to millions of resource poor farmers. Dairying is considered an effective instrument in bringing socio-economic transformation. Operation flood is one of India's highly successful rural developmental programmes. It is a smallholder dairy production initiative that, further, has laid the foundation for the dairy cooperative movement in India (Toor and Kaur, 2021). The importance of dairying hardly needs accentuation. The dairy sector contributed around 4 percent of the total Gross Domestic Product (GDP) at constant prices and a large share of 26 percent of the agricultural GDP at constant prices in India in 2015-16 (Lal and Chandel, 2016). The livestock population in Punjab was 8117.10 thousand in 2012. Out of this, buffalo population was 5159.73 thousand and cattle population was 2427.71 thousand in 2012. The milk production was 13347 thousand tonnes in Punjab in 2019-2020 (GoP, 2020).

Quddus and Islam (2008) found that the exotic cows had shown higher gross income than the local cows. Khan and Parashari (2014) found

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that a major proportion of the population was engaged in different dairy activities in Moradabad district of Uttar Pradesh. Jaiswal *et al*. (2018) revealed that dairying had positively and significantly contributed to the income and employment of rural households. In this study, efforts were made to work out employment and income generation from dairying in rural Punjab and to test the hypothesis stating that dairying has helped in the upliftment of standards of living of the milk producers.

MATERIAL AND METHODS

The data collection for this study was done in 2019. The study was based on primary data, collected through a detailed schedule from 420 dairy farmers belonging to different farm size categories, viz. large farmers (who owns 15 acres land or more), medium farmers (who own land in the range of 5-15 acres), small farmers (who own land in the range of 2.5-5 acres), marginal farmers (who own land up to 2.5 acres) and landless households (who do not own any land), from 21 villages situated in three different agro-climatic zones (Shivalik-Foothills, Central Plains, and South-West Dry zones) of Punjab state. A multi-stage sampling technique was used to select the villages and dairy farmers in the study area.

DATA ANALYSIS

Descriptive statistical tools such as mean values and proportions were used while carrying out the tabular analysis. Gini Coefficient and t-tests were also used to support the findings. Gini coefficient is a measure of statistical dispersion intended to represent the income inequality within a nation or a social group. The value of Gini Coefficient lies between 0 and 1. A Gini Coefficient of zero represents the perfect equality and Gini Coefficient of 1 expresses the maximal inequality. If xi the income of person *i,* and there are *n* persons, then the Gini Coefficient is given by:

$$G = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} \left| x_i - x_j \right|}{2n \sum_{j=1}^{n} x_j}$$

RESULTS AND DISCUSSION

Number of labourers employed in dairying

In dairying, there is a need for three main resources, *i.e.* land, labour and capital. Labour cost is the major component of the variable cost involved in dairying. Labour requirement depends upon the herd size, feeding practices and also on the degree of mechanisation. The labour can be family labour or hired labour. It is noticed in the study area that hired labour is also engaged in agriculture along with dairying.

Table 1 showed the distribution of dairy farmers based on labour hired for dairying. Only 77 (18.33 percent) dairy farm households (out of 420) were hiring labour for dairying. Out of these, 23 (29.87 percent) were permanent, managing dairying as well as agriculture, and 54 (70.13 percent) were casual labour to do temporary chores involved in agriculture and dairying.

The highest number (21) of the permanent labourers were found in the large farm size category and none of the dairy farm households from the marginal and landless households made use of hired labour permanently. The maximum number (29, 58 percent) of the casual labourers was among the large farm size category and none of the same belonged to landless households.

There was no use of hired labour among the landless households as most of the dairying activities were performed by themselves.

Human labour employment generated (person days per milch animal per annum)

Dairy farming involved millions of resource-poor farmers, for whom animal ownership ensured critical livelihood and economic stability. However, the role of dairying in rural income and employment is generally overlooked. The total use of family and hired labour for performing different dairy activities were considered human labour employment in dairying. Table 2 provided information about human labour employment in dairying, calculated based on person days per milch animal per annum. The study of Chhabra *et al.* (2016) revealed that dairying generated employment of 101 days per milch animal per annum among the members of dairy cooperatives in South-Western Punjab. On average, dairying generated employment for 193 person days per annum. However, the study of Dhawan and Kashish (2016) revealed that dairying employed 257 person days during 2000-03. The share of family labour was 130 person days per annum and that of hired labour was 63 person days per annum. The male labour employment in dairying was 144 person days per annum and female participation was 49 person days per annum. Female employment was higher (43 person days per annum) for family labour than hired labour (6 person days per annum). The female labour employment was lower as compared to male labour employment as most of the females performed milking of dairy animals and cleaning shed. All other dairy activities such as a collection of fodder, chaffing of fodder and milk marketing were performed by males.

Among the categories, the highest (223 person days per annum) generated employment was for medium farm size category, followed by 195 person days per annum for the marginal farm size category, 188 person days per annum for small farm size category, 154 person days per annum for large farm size category and 150 person days for landless households.

Sources of annual income of dairy farm households

Income is an important factor in maintaining the survival of the family. Dairy farmers had different sources of income, *viz.,* farm income, income from dairying, wages, pension, remittances, etc. Table 3 provides information regarding different sources of annual income among dairy farmers. The annual income per household among sampled farmers was ₹ 494289. As far as sources of income were concerned, dairy farmers got major income (₹ 244247, 49.4 percent) from agriculture, followed by ₹89360 (18.08 percent) from dairying, ₹ 86195 (17.44 percent) from other sources (such as employment in the public sector and private sector jobs and family-run business), ₹ 31806 (6.43 percent) from remittances, ₹ 28701 (5.81 percent) from wages and ₹ 13981 (2.83 percent) from the pension. Similar findings were reported by Nedelea *et al*. (2009), in which dairy farming was the second major income-generating activity of poor people. The highest (₹ 147864) income from dairying was received by the large farm size category as they had higher and good quality herd size and the lowest (₹ 54822) of the same was found among landless households as they failed to feed their dairy animals according to their dry matter requirement, resulting in poor performance of their dairy animals.

Impact of dairying on income distribution

Income distribution is a crucial indicator of socio-economic development. The income disparities lead to socio-economic imbalances. The disparities in income are captured by Gini Coefficient. Gini coefficient is used to measure

the concentration of income among households. The value of the Gini coefficient lies between 0 and 1. The higher the value of the Gini Coefficient, the higher is the income inequality and vice-versa. Table 4 shows the results for the Gini Coefficient, inclusive and exclusive of dairy income. The value of the Gini Coefficient was 0.43 inclusive of dairy income and it rose to 0.48 when dairy income was excluded from family income in rural Punjab. This implied that dairying helped in improving income distribution by reducing income inequality. The results are in line with the findings of Kashish *et al.* (2017) who reported that dairying has improved the income distribution of the dairy farmers. Across the categories, the Gini Coefficient varied from 0.23 to 0.38 in case of inclusive of dairy income whereas it ranged from 0.25 to 0.45 in case of exclusive of dairy income. This meant that dairying helped in sustaining the livelihood of milk producers and reduced income inequality among them. The same was the case with other household categories as the value of the Gini Coefficient was lower when dairy income was included than exclusion of dairy income.

Testing of hypothesis

H0: Dairy farming has no impact upon the upliftment of standard of living of milk producers.

H1: Dairy farming has a positive impact upon the upliftment of standard of living of milk producers.

To prove this hypothesis, income was used as a proxy variable for the standard of living of milk producers. The t-test was used to compare the average family income of inclusive and exclusive of dairy income (Table 5). One tail t-test was used as an alternate hypothesis that aimed to test the only positive impact of dairying on the standard of living of milk producers. The calculated value of t (3.14) was greater than the critical value of t (1.65). This led to the rejection of the null hypothesis. It implied that there was a significant difference in family income, inclusive and exclusive of dairy income. This difference could not be attributed to the fluctuations in data. The analysis revealed that the dairy income helped in sustaining the livelihood of dairy

Table 1. Number of hired labourers employed in dairying (n=420)

S. No.	Category	No. of hired labourers employed in dairying				
		Permanent		Casual		Total
		No.	%	No.	%	
1.	Large farm Househ.	21	42.00	29	58.00	50
2.	Medium farm Househ.	1	8.33	11	91.67	12
3.	Small farm Househ.	1	9.09	10	90.91	11
4.	Marginal farm Househ.	0	0.00	4	100.00	4
5.	Landless Househ.	0	0.00	0	0.00	0
6.	Sampled	23	29.87	54	70.13	77

Source: Field Survey, 2019; **Note:** Househ. is abbreviation used for Households

Table 2. Human labour employment (person days per milch animal per annum) (n=420)

S. No.	H Category	uman Labour Employment (person days per milch animal per annum)								
		Family Labour			Hired Labour			Total Labour		
		Male	Female	Total	Male	Female	Total	Male	Female	Total
1.	Large farm Househ.	81	7	88	63	4	67	144	11	154
2.	Medium farm Househ.	103	30	133	82	8	90	185	38	223
3.	Small farm Househ.	95	42	138	37	14	51	133	56	188
4.	Marginal farm Househ.	91	76	167	29	0	29	119	76	195
5.	Landless Househ.	64	86	150	0	0	0	64	86	150
6.		87	43	130	57	6	63	144	49	193
	Sampled	(66.92)	(33.08)	(100)	(90.47)	(9.53)	(100)	(74.61)	(25.39)	(100)
		(44.98)	(55.02)	(100)	(76.82)	(23.18)	(100)	(53.96)	(46.04)	(100)

Source: Field Survey, 2019; Note: Figures in parentheses indicate percentage to the total sample

Table 3. Sources of annual income of dairy farm households (n=420)

S. No.	Category	Sources of Annual Income of Dairy Farm Households												
		Agriculture		Dairying		Labour		Pension		Remittances		Any other		
		Value	%	Value	%	Value	%	Value	%	Value	%	Value	%	Total
1.	Large farm Househ.	743719	71.54	147864	14.22	0	0.00	16714	1.61	19286	1.86	112000	10.77	1039583
2.	Medium farm Househ.	295986	52.16	89171	15.72	0	0.00	28679	5.06	41429	7.30	112142	19.76	567407
3.	Small farm Househ.	129364	34.26	85997	22.77	0	0.00	7571	2.00	45429	12.03	109286	28.94	377647
4.	Marginal farm Househ.	50307	19.81	68945	27.15	26329	10.37	8229	3.24	34314	13.50	65864	25.93	253988
5.	Landless Househ.	1857	0.80	54822	23.55	117174	50.33	8715	3.74	18571	7.98	31683	13.60	232822
6.	Sampled	244247	49.41	89360	18.08	28701	5.81	13980	2.83	31806	6.43	86195	17.44	494289

Source: Field Survey, 2019

Table 4. Impact of Dairying on Income Distribution

Sr. No.	Category	Impact of Dairying on Income Distribution			
		Average Annual Family income (in ₹)		Gini Coefficient	
		Inclusive of dairy income	Exclusive of dairy income	Inclusive of dairy income	Exclusive of dairy income
1.	Large farm Househ.	1039583	891719	0.23	0.25
2.	Medium farm Househ.	567407	478236	0.29	0.34
3.	Small farm Househ.	377647	291650	0.38	0.45
4.	Marginal farm Househ.	253988	185043	0.37	0.45
5.	Landless Househ.	232822	178000	0.32	0.37
6.	Sampled	494289	404929	0.43	0.48

Source: Field Survey, 2019

Table 5. Results of t-test of comparing difference between means

Sr. No.	Average Annual Income inclusive of Dairy Income (in ₹ per household)	Average Annual Income exclusive of Dairy Income (in ₹ per household)	Standard Error	t	p-value	Critical t
1.	494289	404929	2855.43	3.14	0.0001*	1.65

*Statistically significance at 5 percent level of significance

farmers, improved their income distribution, and hence, helped in raising the standard of living of milk producers. The results are in line with the findings of Selvakumar and Ramaraj (2017) who reported that dairying helped in improving the socio-economic conditions of the milk producers in Salem district.

CONCLUSION

The study revealed that around 70 percent of the labourers employed by the dairy farmers were casual ones in Punjab, while around 30 percent of total labourers only employed by the dairy farmers were permanent labourers. There was no use of hired labour among the landless households as most of the dairying activities were performed by family members. Dairy farming generated, on an average, employment of 193 person days per annum in rural areas of Punjab in contrast to the earlier studies that revealed lesser person days per annum. Out of this, male employment (144 person days per annum) was

quite higher than female employment (49 person days per annum). The share of family labour was 130 person days per annum and that of hired labour was 63 person days per annum. The findings, however, are in contrast with earlier studies [Chhabra, *et al*. (2016)], which shown that the share of hired labour was higher than family labour in dairying.

The average annual income of dairy farmers was ₹ 494289 per household. The income from dairying constituted around one-fifth of the total income of the dairy farmers. The value of the Gini Coefficient exclusive of dairy income was 0.48. However, it reduced to 0.43 when dairy income was included in total family income. Similar findings had been reported by earlier studies, implying that dairying improved income distribution by reducing income inequalities. The results of the t-test revealed that dairy income helped in sustaining the livelihood of dairy farmers, improved their income distribution and hence, helped in raising the standard of living of milk producers.

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