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EVALUATION OF RICE GENOTYPES AGAINST SHEATH BLIGHT USING BASIC RESISTANCE COMPONENTS FOR RESISTANCE IDENTIFICATION

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ABSTRACT

Under the current climate change scenario, sheath blight caused by *Rhizoctonia solani*, a necrotrophic pathogen, is becoming a serious threat, causing significant yield losses in paddy, especially in the coastal ecosystem of Andhra Pradesh state. Resistance evaluation in popular rice cultivars taken up during 2020-21 season at Regional Agricultural Research Station, Maruteru (field studies) and Division of Plant Pathology, ICAR-IARI, New Delhi (lab studies) for identification of resistance sources for further breeding programmes using resistance components revealed that using single phenotypic component based arbitrary scale may not reveal the true varietal nature with respect to disease resistance and needs to consider the host-pathogen population dynamics. Among the three basic resistance components studied, rate of infection (RRBR) and incubation period (RRIP) found to have greater bearing on sheath blight resistance, whereas, lesion length (RRLL) found to be a less potential indicator for quantifying the resistance levels in the rice cultivars for sheath blight.

Keywords: Epidemiological modeling, Partial resistance, *Rhizoctonia solani*, Resistance Components

INTRODUCTION

Several biotic stresses affect rice cultivation in India, of which diseases such as sheath blight, blast, stem rot and bacterial blight cause significant losses both in terms of quality and quantity. In Andhra Pradesh state, under north coastal intensive rice cultivation system, sheath blight caused by *Rhizoctonia solani* Kuhn anastomosis group 1 (Gangopadyay and Chakrabarti, 1982) has become one of the major production constraints causing severe yield reduction of up to 45%. For sheath blight, a soil borne disease, the most effective management till date is chemical based only as despite of the efforts by several researches in Asian rice growing regions, no rice variety with a high level of resistance to sheath blight is currently available (Srinivasachary *et al.,* 2011; Singh *et al.,* 2016). Quantitative measurement of

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sheath blight (*R. solani*) is difficult due to the rapid change in appearance of the symptoms, over time, and the rapid decay of heavily infected tissues, especially under tropical, humid conditions. The present disease screening based on arbitrary scales during the crop growth stages is failing to provide the accurate resistance picture of the variety as the population dynamics of the pathogen were not taken in account.

Resistance components assessment *i.e.* partial resistance based on epidemiological modelling, is of high importance for comprehensive understanding and to connect plant disease epidemiologists and Molecular breeders (*Savary et al.,* 2006). Partial resistance components quantification can be done by measuring elementary processes such as infection efficiency, latency period, infectious period, sporulation, and lesion size etc. on a set of host varieties or germplasm accessions along with susceptible and resistant/tolerant checks, which can then be converted in relative resistance coefficients, ranging between 0 (full susceptibility) to 1 (full resistance) (*Savary et al.,* 1988; Zadoks, 1972). In epidemiological principles, all the partial resistance components contribute to the reduction of the epidemic apparent infection rate (r) resulting in reduced disease progress (Parlevliet, 1979; Vanderplank, 1968).

Resistance components against sheath blight in terms of epidemiological modelling is essential for accurate assessment of resistance and rectify screening method. By incorporating the components of resistance in an epidemiological model, simulation of the effect of relative resistances on epidemic can be done (*Bove et al.,* 2021).

Objectives

In this context, the study is taken up based on the hypothesis that resistance components such as incubation period and basic reproduction number reflect sheath blight resistance, and, thus, effective identification of resistance genotypes can be ensured.

MATERIALS AND METHODS

The study was taken up as a part of ICAR-PDF programme during 2020-21 season. Incubator studies were taken up at Division of Plant Pathology, ICAR-IARI, New Delhi . A total of 15 entries, comprising 12 rice genotypes prominently cultivated throughout the coastal ecosystem, especially in Andhra Pradesh, along with two known tolerant entries (TETEP and MTU 1001) and one susceptible check (MTU 7029) were used in the study (Table 1).

Table 1. List of rice cultivars screened for sheath blight

S. No.	genotype	S. No.	genotype	S. No.	genotype
1	NLR 145	6	BPT 5204	11	MTU 1064
2	NLR 3041	7	MTU 4870	12	MTU 1153
3	NLR 34449	8	MTU 1061	13	TETEP (Tolerant check)
4	RGL 2624	9	PLA 1100	14	MTU 1001 (Tolerant check)
5	BPT 2270	10	NLR 3238	15	MTU 7029 (Susceptible check)

Estimation of incubation period (as IP50) under semi-controlled conditions

Estimation of incubation period (as IP50) under semi-controlled conditions was carried out (Fig. 1) through artificial inoculation of the 13 rice genotypes along with check varieties MTU 7029 (susceptible) and MTU 1001 (tolerant) under three temperatures *i.e.* 22 ^{0}C, 28 ^{0}C and 32 ^{0}C following micro chamber screening technique (Jia *et al.,* 2013). Data was recorded on total tillers, diseased tillers, tiller height, lesion length (cm) following standard procedures at optimum temperature (29.1 °C) - Days for 50% tillers/hill showing visible symptoms was recorded from the total of 50 hills for each genotype. Observations were taken at two days interval on number of hills got visible lesions and estimation of IP_{50} based on degree days was carried out. Disease score was recorded as per the standard 0-9 scale (IRRI, 2002) and disease incidence was calculated using the formula (Wheeler, 1969).

Resistance evaluation of rice genotype against sheath blight pathogen

Resistance evaluation for all the test genotypes along with susceptible and tolerant check genotypes was carried out in the experimental farm of Regional Agricultural Research Station (RARS), Maruteru, West Godavari district of Andhra Pradesh, which is the hot spot for sheath blight disease during *rabi* season of 2020-2021. To estimate the sheath blight progression, field experiments was laid out, each of 3 m x 3 m having 350hills/ plot approximately, with six treatments, with different inoculum levels with the 15 rice genotypes including the checks. Inoculation of each hill was done by inserting approximately 5 g of sheath blight infected rice leaf sheaths, collected in surrounding fields in the experimental station, at the base of the hill (Savary *et al.,* 1997). Inoculations were carried out at the maximum tillering stage, *i.e.* 30 days after transplanting. A one-hill border

$$PDI = \left\{ \frac{\text{Sum of individual rating}}{\text{No of leaves examined} \times \text{Maximum diseases scale}} \right\} \times 100$$

Fig. 1. Micro chamber screening for estimation of IP50

surrounding the main plot was maintained for all plots. Each, treatment was replicated four times arranged in a randomised complete block design. Healthy and diseased tillers counts were made at weekly intervals on 25 hills in each plot.

Data was recorded on different disease parameters *viz.,* total tillers/plot, infected tillers, lesion length (cm), diseased portion (cm) along with yield components from the field experiments at regular intervals. Disease score was estimated at weekly intervals and mean disease score was arrived.

Estimation of relative resistance components (Field data)

Three basic resistance components were estimated from the field data for all the 15 rice genotypes including susceptible and tolerant checks using the following equations:

1. Estimation of relative resistance for incubation period - IP_{50} (time for symptoms development in 50% of the inoculated tillers),

   where X-test entry; C- check entry

   $$RRIP(X) = 1-[IP(C)/IP(X)] \text{ ——— } (1)$$

2. Estimation of relative resistance for lesion length (mm) at least for 20 randomly selected lesions

   $$RRLL(X) = 1-[LL(X)/LL(C)] \text{ ——— } (2)$$

3. Estimation of basic infection rate reproduction numbers (Rc)

   $$dXt/dt = Rc.(Xt-p-Xt-i-p).(1-Xt),$$

   p = initial inoculum level; BR=Rc

   $$RRBR(X) = 1-[BR(X)/BR(C)] \text{ ———}(3)$$

Based on the above three calculated resistance components (RRIP, RRBR and RRLL), combined relative resistance/ Resistance index (RRc/RI) was calculated. This was used as resistance index, as shown herewith.

Resistance index = [(1-(1-RRIP) x

(1-RRBR) x (1-RRLL)]

Resistance index was used for estimation of field resistance of rice genotypes against sheath blight.

RESULTS AND DISCUSSION

Estimation of sheath blight developmental rate

Semi controlled experiments were conducted for estimating cardinal temperatures for sheath blight infection in terms of sclerotial germination. IP_{50} values for three temperatures *viz.,* 22 ^{0}C, 28 ^{0}C and 32 ^{0}C, have been estimated under semi controlled conditions and optimum temperature (T_{Opt}) was estimated for calculating sheath light developmental rate (data not presented). From this IP_{50} values were estimated for all the test entries (Table 3) and IP_{50} value estimation for the susceptible check MTU 7029 was presented (Fig. 2).

Rate of incubation period completion (1/ IP_{50}) estimated from the semi-controlled experiment at 22 °C, 28 °C and 32 °C (data not presented) and the rate of incubation period completion can be approximated as rate of sheath blight development /relative rate of IP50 (RRIP) based on the prevalent temperature of a specific region/area. Further, RRIP was used for the estimation of resistance index (Table 3).

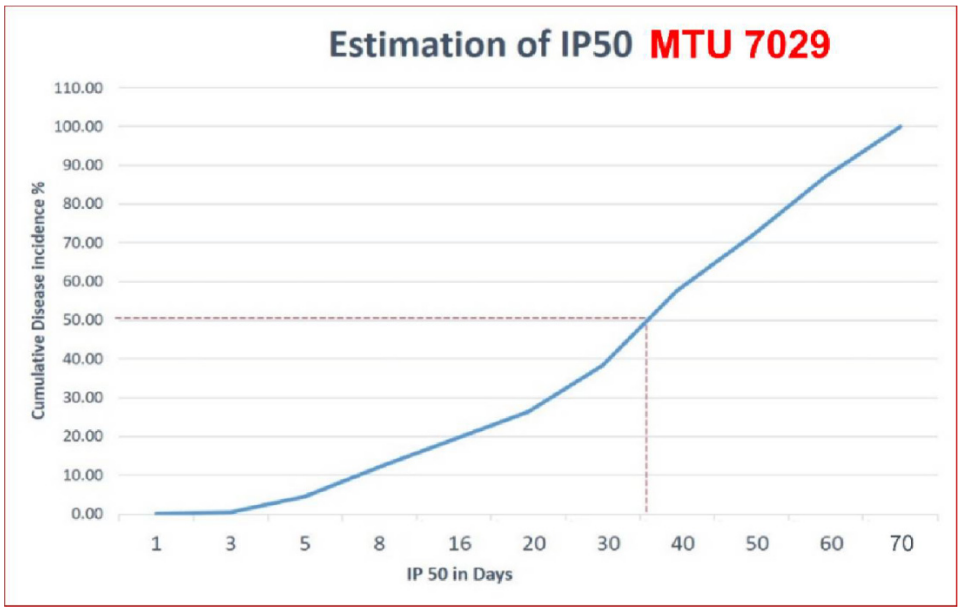

Fig. 2. IP_{50} estimation of rice genotypes under semi controlled conditions

Disease incidence under field conditions in test entries

Sheath blight disease incidence under field conditions in the test entries was presented (Table 2) From the data, it was observed that highest diseased area percent in relation to the total tiller height was observed in the susceptible check, MTU 7029 (97.24%) followed by RGL 2624 (81.34%) and NLR 34449 (80.46%). Least infected area was seen in MTU 1153 (31.34%) and NLR 145 (35.89%) in comparision with the tolerant check TETEP (45.84%) and MTU 1001 (50.80%). The observations clearly showed significant variation among the tolerant and susceptible cultivars among the all-tested entries in comparision with the checks. Similarly, the susceptible check recorded highest lesion length (9.49 cm) in comparison with the two standard tolerant checks, TETEP and MTU 1001 with lesion lengths of 3.6 cm and 3.65 cm, which are significantly different. The data also reflects that lesion lengths. among the tolerant cultivarsare more or less similar but significantly differing from the susceptible cultivars such as BPT 5204 (4.64 cm), NLR 34449 (3.84 cm) and RGL 2624 (4.72 cm). However, NLR 145 variety, which had lower disease area showed a lesion length of 5.44 cm.

Furthermore, the disease reaction based on diseased area %, done as per the 0-9 scale (IRRI,2002) is not fully explaining the disease resistance nature of the cultivar. It was observed that varieties which are showing comparatively lower lesion lengths and mean disease scores are grouped in either highly susceptible or susceptible groups *viz.,* MTU 1001, which is a known tolerant cultivar, was grouped into susceptible range based on the diseased area of 50.80%, even though showing lower lesion length of 3.65 cm and mean disease score of 5.90. Similar trend was observed in other varieties showing different disease reactions based on the percentage of diseased area.

Table 2. Sheath blight disease incidenceof rice in the test entries during *rabi* 2020-21

S.No.	Entry	Mean values					Disease reaction
		DTDH (cm)		Disease area %	lesion length (cm)	Mean Score	
1	NLR145	3.41	41.97	35.89	5.44	4.85	MS
2	NLR 3041	4.50	60.53	52.99	4.42	5.94	S
3	NLR 34449	8.11	74.14	80.46	3.84	6.94	HS
4	RGL 2624	4.83	72.21	81.32	4.72	6.83	HS
5	BPT 2270	4.94	65.38	56.76	4.54	6.41	S
6	BPT 5204	6.63	61.43	78.46	4.64	7.53	HS
7	MTU 4870	5.56	87.14	76.77	4.30	6.50	HS
8	MTU 1061	4.83	65.54	52.91	3.82	6.49	S
9	PLA 1100	5.61	69.25	61.71	4.42	6.61	S
10	NLR 3238	3.06	58.71	41.28	3.58	5.77	MS
11	MTU 1064	4.82	63.88	52.43	3.66	6.29	S
12	MTU 1153	2.56	36.75	31.34	3.24	4.00	MS
13	TETEP (T)	4.39	56.78	45.84	3.60	5.94	MS
14	MTU 1001(T)	5.94	54.57	50.80	3.65	5.90	S
15	MTU 7029 (S)	9.14	41.04	97.24	9.49	9.00	HS

DT– Diseased tillers/hill; DH -Diseased portion height in cm ; MS-Moderately Susceptible; S- Susceptible; HS - Highly Susceptible

Several workers (Eizenga *et al.,* 2002; Jia *et al.,* 2007; Prasad and Eizenga, 2008; Hossain *et al.,* 2014; Aggarwal and Sundar, 2013; Srinivasachary *et al.,* 2011 and Kumar *et al.,* 2009) grouped the rice genotypes/ germplasm across various rice growing regions following the standard scale and recorded the disease reactions, which were shown to have varied reactions under different regions and seasons. Bove *et al.* (2021) suggested that identification of components conferring partial resistance to grape wine downy mildew and implementation of these components in simulation models to predict the field resistance in the grape vine cultivars.

Thus, it is concluded that estimation of varietal disease reaction based on an arbitrary scale based on a single phenotypic component may not reflect the actual resistance nature of the cultivar and it should be supported by necessary other phenotypic which will take into account of the population dynamics for the host-pathogen system. Thus, there is a need for identifying the components contributing for

Table 3. Estimation of relative resistance components in test entries

S. No.	Entry	BR	RRBR	IP 50 (days)	RRIP (days)	LL (cm)	RRLL (cm)	RI	Disease Score
1	NLR 145	0.26	0.64	49.60	0.39	5.44	0.43	8.73	4.9
2	NLR 3041	0.45	0.39	42.00	0.28	4.42	0.53	7.94	5.9
3	NLR 34449	0.67	0.07	32.50	0.07	3.84	0.60	6.50	6.9
4	RGL 2624	0.68	0.07	32.40	0.06	4.72	0.50	5.64	6.8
5	BPT 2270	0.43	0.41	42.60	0.29	4.54	0.52	7.98	6.4
6	BPT 5204	0.61	0.16	35.10	0.14	4.64	0.51	6.46	7.5
7	MTU 4870	0.55	0.24	37.50	0.19	4.30	0.55	7.21	6.5
8	MTU 1061	0.40	0.45	44.10	0.31	3.82	0.60	8.48	6.5
9	PLA 1100	0.48	0.34	40.50	0.25	4.42	0.53	7.68	6.6
10	NLR 3238	0.33	0.55	47.00	0.36	3.58	0.62	8.91	5.8
11	MTU 1064	0.39	0.46	44.30	0.32	3.66	0.61	8.59	6.3
12	MTU 1153	0.25	0.65	50.00	0.39	3.24	0.62	9.19	4.0
13	TETEP (T)	0.39	0.46	44.30	0.32	3.60	0.66	8.75	5.9
14	MTU 1001 (T)	0.47	0.34	40.70	0.26	3.65	0.62	8.13	5.9
15	MTU 7029 (S)	0.72	0.00	30.30	0.00	9.49	0.00	0.00	9.0

BR- Basic rate of infection; RRBR – Relative rate of BRIP50 – Days for 50% infection; RRIP – relative rate of IP50LL -Lesion length (cm); RRLL- Relative rate of LL; RI – Resistance Index/ Combined relative resistance.

the disease suppression, thus conferring resistance in host plants against sheath blight. Further, there is a need for combination of phenotypic components for exact representation of the true resistance nature of the genotype.

Estimation of relative resistance components

The basic relative resistance components were estimated using the equations 1, 2 and 3 based on the data generated from field experiments for the 15 rice cultivars including check entries. The data was presented vide (Table 3).

From the data, it was observed that basic rate of reproduction *vis-a vis* basic infection rate (BR) ranged between 0.25 to 0.72. susceptible check MTU 7029 recorded highest BRR of 0.72, followed by 0.68 (RGL 2624) and 0.67 (NLR 34449), while the tolerant checks recorded lower BRR values of 0.39 and 0.47 in TETEP and MTU 1001, respectively.

Some entries recorded lower BRR values in comparison with the tolerant checks *viz.,* 0.25 (MTU 1153), 0.26 (NLR 145), 0.33 (NLR 3238) and 0.39 (MTU 1064), suggesting significant tolerance levels in these test entries. The corresponding relative rates of basic infection were calculated which ranged between 0.00 (susceptible check) to 0.65 (MTU 1153).

The cultivars with highest levels of basic infection rates showed lower IP_{50} values, thus, indicating lower incubation periods, suggesting lower for the pathogen multiplication. The data on RRIP values, ranged between 0.0 to 0.39 showed that susceptible cultivars had lower RRIP values in comparision with checks *viz.,* 0.06 for RGL 2624 and 0.07 for NLR 34449, which are in confidence with the RRBR values. Higher RRIP vales were recorded in genotypes MTU 1153 (0.39), NLR 145 (0.39) and NLR 3238 (0.36) which have higher RRBR values, suggesting higher levels of sheath blight tolerance. Relative lesion lengths estimated were in the range of 0.0 (MTU 7029) to 0.66 (TETEP), eventhough significant difference among the genotypes was not observed. This suggests that lesion length may not be a potential indicator for quantifying the resistance levels in the rice cultivars for sheath blight.

The combined relative resistance estimated in terms of Resistance Index using equation (3), ranged between 0.0 (MTU 7029) and 9.19 9 (MTU1153) with the tolerant checks showing 8.75 and 8.13 for TETEP and MTU 1001 respectively. Lowest RI values were observed in susceptible cultivars like RGL 2624 (5.64), BPT 5204 (6.46) and NLR 34449 (6.50) which are corresponding with the mean disease scores observed at field conditions. Thus, RI estimated based on the three resistant components is effective in expression of the resistance nature of rice cultivar against sheath blight and it can be used in population dynamics model for further use towards screening along with the visual scoring for effective identification of resistance sources for further utilization in breeding programmes for generation of sheath blight resistant material in rice. Bove *et al.* (2021) reported that the implementation of four resistance components for identification of partial resistance in grape vine against downy mildew was proved useful through simulation and modeling.

CONCLUSIONS

Estimation of sheath blight disease reaction of rice genotypes based on an arbitrary scale and based on a single phenotypic component is not sufficient for identification of the actual resistance nature of the cultivar, and needs to be supported by necessary other phenotypic data/components, duly taking into consideration of population dynamics for the specific host-pathogen system. From the data on three basic estimated relative resistance components estimated, it was observed that, the cultivars with highest levels of basic infection rates (RRBR) showed lower IP50 values (RRIP), thus, indicating lower incubation periods, suggesting lower time periods for the pathogen multiplication resulting in quick disease progression. It was also observed that susceptible genotypes had lower RRIP values in comparison with checks which are in confidence with the RRBR values. Higher RRIP vales recorded in some genotypes, which have

higher RRBR values, suggesting higher levels of sheath blight tolerance. Furthermore, lesion length may not be a potential indicator for quantifying the resistance levels in the rice cultivars for sheath blight. The combined relative resistance/ Resistance index (RI) estimated based on the three resistant components found to be very effective in expression of the resistance nature of rice cultivars tested against sheath blight and it can be used in population dynamics model for estimation of varietal resistance characters, especially under coastal rice eco systems.

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PHYSIOLOGICAL AND PHENOTYPIC CHARACTERIZATION OF COTTON IN HIGH PLANT DENSITIES UNDER WATER STRESS

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Date of Receipt : 04.11.2022 Date of Acceptance : 31.01.2023

ABSTRACT

The study was conducted to examine the effect of high density planting system (HDPS) and moisture regimes on certain varieties of cotton in tropical monsoon based Southern Telangana Agro-climatic Zone. This study was conducted with an objective to identify the suitable spacings and genotypes for cultivating under HDPS. In the experiment, growth attributes such as plant height, crop growth rate (CGR) and relative growth rate (RGR) were estimated at critical stages of growth and it was found that the plants under wider spacing of 75 x10 cm^2 spacing led to better plant height (48.1 cm) and CGR (0.58 g m^{-2} day^{-1}) at 60-90 DAS. Among the genotypes of cotton studied, WGCV-48 exhibited maximum plant height (52.8 cm), CGR (0.65 g m^{-2} day^{-1}) and RGR (0.034 g g^{-1} day^{-1}).

Keywords: Cotton, Crop growth rate, High density planting system, Moisture, Plant height

INTRODUCTION

Cotton is primarily cultivated for lint which is used for textile and other industrial purposes as well. The seed and its by - products play a significant role in economic development of various countries. India ranks first in area of cotton cultivation and second in production in the world after China as per the reports of Ministry of Textiles, GOI. India has a total area of 122.00 lakh ha under cotton cultivation, with a total production of 5.75 Million metric tonnes and productivity of 471 kg ha^{-1} in 2018-19. Telangana state has cotton cultivation in 17.94 lakh ha, with a total production potential of 53.00 Lakh bales and productivity of 502.23 kg ha^{-1} (The Cotton Advisory Board, 2019). Due to the difficulty in cultivation and marketing, the global area under cotton cultivation is stagnated at 34 million hectares (FICCI, 2012).

The productivity of cotton is adversely affected by various abiotic and biotic stresses, especially water deficit stress. Drought tolerance is a complex, multi-genic trait, which is governed by several genes. The most adopted system of planting consists of 120x60 cm^2 or 90x60 cm^2 spacing, results in 13888 to

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18518 plants per hectare. Ultra narrow system of planting has row spacing as low as 20 cm and could accommodate about 1.6 to 2.5 lakh plants ha^{-1}. Drought stress has been the major environmental factor that negatively impacts cotton yield throughout the world (Ramesh *et al.,* 2018). The CGR and RGR are the primary growth attributes of cotton affected by planting systems and moisture regimes.The experiment is intended to explore the basis of growth and physiology of cotton in high density planting system under different moisture regimes.

MATERIALS AND METHODS

Two field experiments were conducted during *Kharif,* 2015 and *Kharif,* 2016 at the Farm of College of Agriculture, Rajendranagar, Hyderabad. It falls under Southern Telangana Agro Climatic Zone. The climate of Hyderabad was classified as dry tropical and semi-arid. The experiment was laid out in a split plot design with six cotton genotypes as main treatments *viz.,* ADB- 39, H- 4492859, NDLH-1938, Anjali, Suraj and WGLV- 48 and three spacings as sub treatments viz., 75x10 cm^2, 60x10 cm^2 and 45 x10 cm^2 which accommodate 1.33, 1.66 and 2.22 lakh of plants, respectively and the experiment was replicated thrice.

The net plot size for each treatment was 9.0 × 2.0 m^2. A recommended dose of 90 N, 45 P_2O_5 and 45 K_2O kg ha^{-1} was applied in the form of Urea, SSP and MOP, respectively.

The plant height, CGR and RGR were measured at different stages of the crop. Plant height from the ground surface to the top most growing point of five tagged plants was measured at square formation, flowering and boll development stages of crop and expressed in centimeters. Crop growth rate was calculated to estimate the production efficiency of a crop (Watson, 1952) and RGR is the increase in dry matter per unit dry matter per unit time and is expressed as grams per gram per day. The CGR is measured by using the following formula.

$$CGR = \frac{(W_2 - W_1)}{(t_2 - t_1)} \times 1/P$$

$$RGR = \frac{(LogeW_2 - LogeW_1)}{(t_2 - t_1)}$$

in which, W_1 and W_2 are the dry weights of the plants at time t_1 and t_2, respectively and P is the ground area covered by each plant (m^2).

RESULTS AND DISCUSSION

Plant height

Among all the genotypes studied, WGCV-48 recorded maximum plant height of 25.3 cm. The percentage decrease of pooled plant height in 60 cm x 10 cm and 45 cm x 10 cm spacings as compared to 75 cm x 10 cm was 15.4% and 28.3%, respectively (Table 1). The grand mean values of height of cotton grown in *Kharif*, 2016 (24.6 cm) was found higher than in *Kharif*, 2015 (17.7 cm) which is attributed to the better day lengths in *Kharif*, 2016.

The Plant height at flowering stage found maximum and minimum in WGCV-48 and ADB-39 as 52.8 cm and 32.7 cm, respectively. The spacing of 75cm x 10cm resulted in maximum plant height than 60x10 cm and 45x10 cm spacings (48.1cm, 42.3 cm and 37.1 cm, respectively). Maximum plant height (72.7 cm) was recorded in interaction of WGCV-48 under 75cm x 10cm spacing in *Kharif*, 2016.

During boll development stage also, WGCV-48 dominated other genotypes with respect to plant height (69.1 cm). 75 cm x10 cm had maximum plant height than 60 cm x10 cm and 45 cm x10 cm spacings (65.3, 55.7 and 50.5 cm, respectively). The 75 cm x10 cm spacing treatment recorded 14.7% and 22.6% higher mean plant height values than 60 x10 cm and 45 cm x 10 cm spacings. Low light intensity which is a result of mutual shading in HDPS has negative effect to growth of cotton and lead to slow growing owing to lack of light (Santosh and Yohan, 2019).

Crop growth rate

Crop growth rate (Table 2) during 40-60 DAS was found rapid as the plant showing log phase of growth curve. WGCV-48 found to have significantly higher CGR (0.31 g m^{-2} day^{-1}) and minimum by Anjali (0.18 g m^{-2} day^{-1}). The percentage decrease of pooled CGR in 60 cm x 10 cm and 45 cm x10 cm spacings as compared to CGR in 75 cm x10 cm spacing are 7.7% and 19.3%, respectively. The results indicated that the crop grown at spacing below 75cm x 10 cm could lead to excessive intra specific competition and reduced growth rates. The grand mean values of CGR of cotton grown in *Kharif*, 2016 was found 4.3% higher than in *Kharif*, 2015.

During 60-90 DAS, WGCV-48 had maximum CGR (0.65 g m^{-2} day^{-1}), and ADB-39 (0.38) had minimum CGR. The crop under 75 cm x 10 cm spacing had shown maximum CGR (0.58 g m^{-2} day^{-1}) than 60 cm x10 cm and 45 cm x10 cm spacing (0.58,0.47 and 0.42 g m^{-2} day^{-1}). Grand mean values of CGR in *Kharif*, 2016 is higher than that of *Kharif*, 2015. The interaction effect as revealed by pooled values indicated that WGCV-48 grown under 75x10 cm spacing resulted in maximum CGR (0.72 g m^{-2} day^{-1}).

CGR between 90-120 DAS, the genotype WGCV-48 and ADB-39 recorded maximum and minimum CGR (1.17 and 0.69 g m^{-2} day^{-1}, respectively). The percentage decrease of pooled CGR in 60 cm x10 cm and 45 cm x 10 cm spacings over 75 cm x10 cm was 21% and 27.6%, respectively. The lowest CGR recorded in closer spacing might be due to maximum intra plant competition for acquisition of resources and ultimately decline in crop growth rate (Ashraf and Foolad, 2007). Plant growth and accumulation of dry matter is significantly affected by water deficit (Heuer and Nadler 1999). The grand mean values of CGR of cotton grown in *Kharif*, 2016 was found 4.3% higher than in *Kharif*, 2015. This could be attributed to higher CGR in second season and favorable effect of consistent weather and proper rainfall.

Relative growth rate

The relative growth rate (Table 3) indicates the efficiency index of the particular genotype. During 60-90 DAS, H- 4492859 had maximum (0.031 g g^{-1} day^{-1}) and ADB-39 had minimum (0.027 g g^{-1} day^{-1}) RGR in *Kharif*, 2015. Anjali on the other hand had shown maximum RGR (0.039 g g^{-1} day^{-1}) followed by WGCV-48 (0.037 g g^{-1} day^{-1}) in *Kharif*, 2016. The percentage decrease of pooled RGR in

Table 1. Plant height (cm) of cotton genotypes as influenced by different spacings in two seasons of crop growth and pooled

Stage of Crop	Square			Flowering			Boll development		
Season	*Kharif*, 2015	*Kharif*, 2016	Pooled	*Kharif*, 2015	*Kharif*, 2016	**Pooled**	***Kharif*, 2015**	***Kharif*, 2016**	**Pooled**
Genotypes									
1.WGCV-48	28.9	21.7	25.3	46.5	59.0	52.8	66.8	71.4	69.1
2.NDLH-1938	26.3	16.1	21.2	44.7	51.3	48.0	65.3	57.3	61.3
3.H-4492859	24.6	18.2	21.4	42.3	41.2	41.8	63.9	49.5	56.7
4.Suraj	23.1	18.9	21.0	39.2	46.1	42.7	60.3	51.2	55.8
5.ADB -39	22.6	15.2	18.9	36.6	32.7	34.7	56.4	47.3	51.9
6.Anjali	21.7	16.3	19.0	34.3	36.4	35.4	52.9	43.8	48.4
CD @ 5%	1.7	1.5	1.3	2.1	5.6	2.5	1.9	5.2	2.7
Spacings									
1.75 cm x 10 cm	27.0	22.5	24.7	45.3	51.0	48.1	69.6	61.1	65.3
2.60 cm x 10 cm	24.2	17.7	20.9	40.4	44.3	42.3	59.6	51.9	55.7
3.45 cm x 10 cm	22.4	13.1	17.7	36.1	38.1	37.1	53.6	47.4	50.5
CD @ 5%	1.1	0.9	0.8	1.4	2.4	1.3	1.6	2.9	1.5
Interactions									
***Kharif*, 2015**									
Spacing (cm)	75 x 10	60 x 10	45 x 10	75 x 10	60 x 10	45 x 10	75 x 10	60 x 10	45 x 10
1.WGCV-48	30.8	29.0	27.0	50.9	44.8	43.8	74.9	65.6	59.8
2.NDLH-1938	29.4	26.0	23.6	50.3	43.0	40.8	74.7	63.6	57.7
3.H-4492859	28.2	24.0	21.6	46.8	41.2	38.8	73.4	62.3	56.1
4.Suraj	25.4	22.6	21.3	43.6	39.1	34.8	68.3	59.8	52.7
5.ADB -39	24.2	22.4	21.3	41.1	37.8	30.8	65.0	54.7	49.4
6.Anjali	23.9	21.4	19.8	38.7	36.3	27.8	61.1	52.0	45.7
***Kharif*, 2016**									
1.WGCV-48	30.2	20.3	14.7	72.7	54.3	50.0	82.0	63.0	69.3
2.NDLH-1938	17.0	18.0	13.3	57.0	51.3	45.7	63.3	60.3	48.3
3.H-4492859	24.0	17.6	13.0	47.9	41.2	34.3	58.0	47.6	43.0
4.Suraj	25.3	17.3	14.0	50.0	45.7	42.7	53.0	51.3	49.3
5.ADB -39	17.7	15.4	12.5	39.7	36.3	22.0	54.7	49.3	38.0
6.Anjali	20.5	17.7	10.7	38.7	36.7	34.0	55.7	39.7	36.0

Table 1 Contd.,

Table 1 Contd...

Stage of Crop	Square			Flowering			Boll development		
Season	*Kharif*, 2015	*Kharif*, 2016	Pooled	*Kharif*, 2015	*Kharif*, 2016	Pooled	*Kharif*, 2015	*Kharif*, 2016	Pooled
				Pooled					
1.WGCV-48	30.5	24.7	20.9	61.8	49.6	46.9	78.5	64.3	64.6
2.NDLH-1938	23.2	22.0	18.5	53.7	47.2	43.3	69.0	62.0	53.0
3.H-4492859	26.1	20.8	17.3	47.4	41.2	36.6	65.7	55.0	49.6
4.Suraj	25.4	20.0	17.7	46.8	42.4	38.8	60.7	55.6	51.0
5.ADB -39	21.0	18.9	16.9	40.4	37.1	26.4	59.9	52.0	43.7
6.Anjali	22.2	19.6	15.3	38.7	36.5	30.9	58.4	45.9	40.9
CD @ 5%	2.8	2.3	2.0	3.5	7.4	3.6	3.8	7.8	4.0
CD @ 5%	2.8	2.1	1.9	3.4	5.9	3.2	4.0	7.1	3.6

Table 2. Crop growth rate (g m^{-2} day^{-1}) of cotton genotypes as influenced by different spacings in two seasons of crop growth and pooled

Stage of Crop	40-60 DAS			60- 90 DAS			90-120 DAS		
Season	*Kharif*, 2015	*Kharif*, 2016	Pooled	*Kharif*, 2015	*Kharif*, 2016	Pooled	*Kharif*, 2015	*Kharif*, 2016	Pooled
				Genotypes					
1.WGCV-48	0.32	0.29	0.31	0.61	0.694	0.65	1.00	1.33	1.17
2.NDLH-1938	0.24	0.25	0.24	0.44	0.589	0.51	1.03	0.82	0.92
3.H-4492859	0.27	0.24	0.25	0.56	0.531	0.54	0.91	1.19	1.05
4.Suraj	0.21	0.23	0.22	0.39	0.391	0.39	0.90	0.81	0.85
5.ADB -39	0.19	0.22	0.21	0.34	0.422	0.38	0.74	0.64	0.69
6.Anjali	0.17	0.18	0.18	0.35	0.56	0.46	0.64	0.53	0.58
CD @ 5%	0.01	0.03	0.02	0.07	0.10	0.07	0.11	0.18	0.10
				Spacings					
1.75 cm x 10 cm	0.26	0.26	0.26	0.54	0.63	0.58	1.08	1.02	1.05
2.60 cm x 10 cm	0.24	0.24	0.24	0.41	0.52	0.47	0.81	0.84	0.83
3.45 cm x 10 cm	0.20	0.21	0.21	0.40	0.45	0.42	0.71	0.79	0.76
CD @ 5%	0.01	0.02	0.01	0.05	0.06	0.04	0.06	0.09	0.05

Table 2 Contd.,

Table 2 Contd...

Stage of Crop	40-60 DAS			60- 90 DAS			90-120 DAS		
Season	*Kharif*, 2015	*Kharif*, 2016	Pooled	*Kharif*, 2015	*Kharif*, 2016	Pooled	*Kharif*, 2015	*Kharif*, 2016	Pooled
Interactions									
***Kharif*, 2015**									
Spacing (cm)	75 x 10	60 x 10	45 x 10	75 x 10	60 x 10	45 x 10	75 x 10	60 x 10	45 x 10
1.WGCV-48	0.36	0.31	0.30	0.71	0.63	0.48	1.15	0.97	0.87
2.NDLH-1938	0.26	0.24	0.21	0.51	0.37	0.43	1.31	0.89	0.88
3.H-4492859	0.31	0.26	0.23	0.64	0.58	0.44	1.24	0.65	0.82
4.Suraj	0.24	0.22	0.17	0.47	0.33	0.38	1.18	0.91	0.60
5.ADB -39	0.22	0.22	0.15	0.40	0.26	0.35	0.88	0.79	0.54
6.Anjali	0.17	0.19	0.15	0.48	0.30	0.28	0.69	0.67	0.55
***Kharif*, 2016**									
1.WGCV-48	0.33	0.28	0.26	0.73	0.68	0.67	1.55	1.36	1.09
2.NDLH-1938	0.26	0.26	0.24	0.73	0.54	0.50	0.92	0.70	0.83
3.H-4492859	0.26	0.23	0.22	0.56	0.57	0.46	1.42	1.20	0.96
4.Suraj	0.25	0.23	0.20	0.48	0.40	0.30	0.93	0.70	0.81
5.ADB -39	0.23	0.23	0.20	0.53	0.37	0.37	0.73	0.60	0.59
6.Anjali	0.21	0.19	0.16	0.72	0.57	0.38	0.60	0.49	0.51
Pooled									
1.WGCV-48	0.35	0.30	0.28	0.72	0.66	0.58	1.35	1.17	0.98
2.NDLH-1938	0.26	0.25	0.23	0.62	0.46	0.47	1.12	0.80	0.86
3.H-4492859	0.29	0.25	0.23	0.60	0.58	0.45	1.33	0.93	0.89
4.Suraj	0.25	0.23	0.19	0.48	0.37	0.34	1.06	0.81	0.71
5.ADB -39	0.23	0.23	0.18	0.47	0.32	0.36	0.81	0.70	0.57
6.Anjali	0.19	0.19	0.16	0.60	0.44	0.33	0.65	0.58	0.53
CD @ 5%	0.03	0.04	0.03	0.11	0.15	0.11	0.14	0.22	0.15
CD @ 5%	0.02	0.04	0.03	0.11	0.16	0.10	0.16	0.25	0.13

Table 3. Interaction of genotypes of cotton and Spacings with respect to CGR and plant height

	Genotype		Spacing		Interaction	
1. Plant Height (cm)	WGCV-48	52.8	75x10 cm^2	48.1	WGCV-48, 75x10 cm^2, *Kharif,* 2016	72.7
2. CGR (g m^{-2} day^{-1})	WGCV-48	0.65	75x10 cm^2	0.58	WGCV-48, 75x10 cm^2, *Kharif,* 2016	0.73

60x10 cm^2 and 45 x10 cm^2 spacings over 75x10 cm spacing was 12% and 8.8%, respectively.

During the period of 60 DAS to 90 DAS. the average RGR is 0.032 g g^{-1} day^{-1} and it was decreased to 0.027 g g^{-1} day^{-1} during 90 to 120 DAS period. The genotype NDLH-1938 (0.031 g g^{-1} day^{-1}), was on par with Suraj (0.030 g g^{-1} day^{-1}), had maximum RGR values in *Kharif*, 2015, whereas, WGCV- 48 (0.025 g g^{-1} day^{-1}) had minimum RGR. In *Kharif*, 2016, the cultivar H-4492829 had shown maximum RGR (0.032 g g^{-1} day^{-1}). The 75 cm x10 cm spacing had resulted in higher RGR values (0.029 and 0.028 g g^{-1} day^{-1}) than 60x10 cm^2 and 45 x10 cm^{-1} spacing (0.027 and 0.026 g g^{-1} day^{-1} in *Kharif*, 2015 (0.026 and 0.027 g g^{-1} day^{-1}) in *Kharif*, 2016, respectively. The increased RGR with wider spacing may be attributed to better assimilation efficiency facilitated by better LAI, leaf expansion and light capturing efficiency than in ultra high density planting. These reports are in accordance with Ashvathama, 2001.

CONCLUSIONS

The researcher critically evaluated the genotypes of cotton for their plant geometry and morphology to identify the suitable spacing and genotype specifically suited for HDPS. The results of the study indicated that growth attributes of cotton were significantly influenced

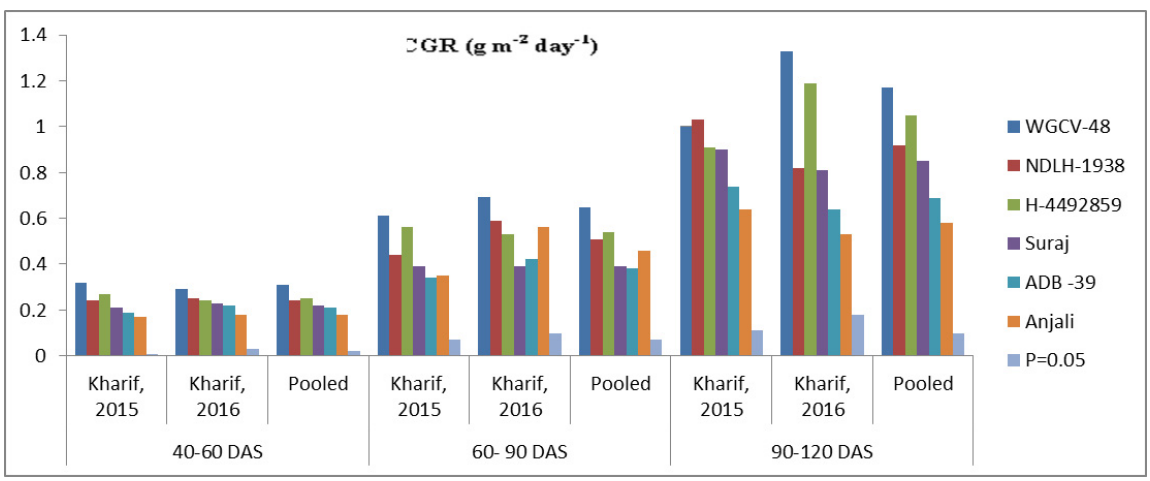

Fig 1. CGR (g m^{-2} day^{-1}) of cotton genotypes as influenced by different spacings

Table 4. Relative growth rate (RGR) (g g^{-1} day^{-1}) of cotton genotypes as influenced by different spacings in two seasons of crop growth and pooled

Stage of the crop	60- 90 DAS			90-120 DAS		
Season	***Kharif*, 2015**	***Kharif*, 2016**	**Pooled**	***Kharif*, 2015**	***Kharif*, 2016**	**Pooled**
			Genotypes			
1.WGCV-48	0.030	0.037	0.034	0.025	0.030	0.028
2.NDLH-1938	0.029	0.035	0.032	0.031	0.024	0.028
3.H-4492859	0.031	0.034	0.033	0.025	0.032	0.029
4.Suraj	0.029	0.028	0.029	0.030	0.028	0.029
5.ADB -39	0.027	0.030	0.029	0.028	0.023	0.026
6.Anjali	0.030	0.039	0.035	0.027	0.019	0.023
CD @ 5%	0.004	0.006	0.004	0.004	0.005	0.003
			Spacings			
1.75 cm x 10 cm	0.032	0.036	0.034	0.029	0.026	0.028
2.60 cm x 10 cm	0.027	0.033	0.030	0.027	0.025	0.026
3.45 cm x 10 cm	0.030	0.032	0.031	0.026	0.027	0.027
CD @ 5%	0.003	0.004	0.002	0.002	0.003	0.002
			Interactions			
			***Kharif*, 2015**			
Spacing (cm)	75 x 10	60 x 10	45 x 10	75 x 10	60 x 10	45 x 10
1.WGCV-48	0.032	0.032	0.027	0.025	0.024	0.025
2.NDLH-1938	0.031	0.025	0.032	0.034	0.030	0.029
3.H-4492859	0.032	0.033	0.030	0.028	0.019	0.026
4.Suraj	0.030	0.025	0.032	0.033	0.032	0.025
5.ADB -39	0.029	0.021	0.033	0.029	0.031	0.024
6.Anjali	0.038	0.024	0.028	0.025	0.028	0.028
			***Kharif*, 2016**			
1.WGCV-48	0.035	0.037	0.038	0.032	0.031	0.027
2.NDLH-1938	0.041	0.033	0.032	0.024	0.022	0.026
3.H-4492859	0.034	0.036	0.032	0.035	0.032	0.030
4.Suraj	0.031	0.028	0.024	0.028	0.025	0.031
5.ADB -39	0.034	0.027	0.028	0.023	0.022	0.023
6.Anjali	0.044	0.040	0.034	0.017	0.017	0.022

Table 4 Contd...

Table 4 Contd...

Stage of the Crop	60- 90 DAS			90-120 DAS		
Season	*Kharif,* 2015	*Kharif,* 2016	Pooled	*Kharif,* 2015	*Kharif,* 2016	Pooled
			Pooled			
1.WGCV-48	0.034	0.035	0.033	0.029	0.028	0.026
2.NDLH-1938	0.036	0.029	0.032	0.029	0.026	0.028
3.H-4492859	0.033	0.035	0.031	0.032	0.026	0.028
4.Suraj	0.031	0.027	0.028	0.031	0.029	0.028
5.ADB -39	0.032	0.024	0.031	0.026	0.027	0.024
6.Anjali	0.041	0.032	0.031	0.021	0.023	0.025
CD @ 5%	0.006	0.010	0.006	0.005	0.007	0.005
CD @ 5%	0.006	0.009	0.006	0.005	0.007	0.004

by high density planting among the genotypes and spacings as well. The maximum plant height of 82.0 cm was found in interaction of WGCV-48 under 75 cm x10 cm spacing in *Kharif,* 2016 at boll development stage of the crop. The maximum CGR (1.55 g m^{-2} day^{-1}) was recorded in interaction of WGCV-48 under 75 cm x10 cm spacing in *Kharif,* 2016 at 90-120 DAS stage of crop. The percentage decrease of pooled RGR in 60 cm x10 cm and 45 cm x10 cm spacings over 75cm x10 cm were 7.1% and 3.6%, respectively. The high density planting system reduced the weed problem by intensified competition faced by weeds from heavy crop population and shade effect. Identification of optimum leaf area index, maximum crop growth rate, suitable spacings and genotypes for high density planting can realize better yield potentials in cotton, with minimal seed rate acquisition. Developing a phenotype suitable for HDPS in shallow and medium deep soils, by carrying slight modifications in ideotype is essential.

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STUDY ON INHERITANCE OF BLAST RESISTANCE IN RICE (*Oryza sativa* L.)

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ABSTRACT

The study on generation mean analysis was conducted with six selected crosses of rice which were subjected to blast disease in uniform blast disease nursery. The material consisting of all the six generations (P_1, P_1, F_1, F_2, BC_1 and BC_2) revealed the role of digenic interactions in the inheritance of blast disease which was taken up at Agricultural Research Station, Nellore during 2017-18 *rabi* seson. In F_1 generation, all the hybrid combinations showed resistant reaction for blast. In case of F_2 generation, duplicate type of epistasis was observed in the cross combinations *viz.,* RNR 2465 x NLR 145, BPT 5204 x IR 64, BPT 5204 x NLR 34449 and RNR 2465 x IR 64 indicating that the involvement of digenic gene action and selection for this trait will be taken up in the later generations when desirable transgressive segregants are available. The crosses BPT 5204 x IR 36 and WGL 48684 x IR 36 exhibited 3:1 type of phenotypic ratio (R:S) indicating that single dominant gene governs the resistant reaction in these crosses.

Keywords: Blast disease, Chi-square, Inheritance, Resistance, Rice

INTRODUCTION

Rice blast disease, caused by the fungus *Magnaporthe oryzae/ Magnaporthe grisea* or *Pyricularia oryzae* (anamorph) is a leading constraint to rice production and a serious threat to food security worldwide. Blast is considered as a major limiting factor in the global rice production because of its wide distribution and destructiveness and under favourable conditions, even it causes 100% crop loss. Rainy periods or periods of high humidity also favour the disease. Certain cultural practices that encourage blast development include excessive use of nitrogen through chemical fertilizers and inadequate spacing often practiced under rice intensification (Piotti *et al.,* 2005).

Genetic resistance to rice blast has been extensively used by rice breeders and pathologists to combat the disease. Numerous races of this fungus are prevalent and blast resistant genes (Pi genes) providing a broad spectrum of resistance against the most prevalent races can be extremely valuable in rice breeding efforts. In many cultivars, blast resistance is quite short lived in field condition

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as the pathogen mutates very often favored by the environment to spread the disease. Hence, breeding for more durable resistant cultivars has become a priority in rice improvement programmes throughout the world provided having a very effective method of screening procedure for blast disease.

MATERIALS AND METHODS

In the study for blast inheritance, a total of nine parents were used. Among them, five parents were considered as lines (BPT 5204, MTU 1010, JGL 11118, WGL 48684 and RNR 2465) and these are high yielding and popular for their good cooking quality and with lack of resistance to blast disease, whereas, the testers (NLR 34449, NLR 145, IR 36 and IR 64) were of resistant in nature having high adaptability. The selected lines and testers were crossed in (5x4) line x tester fashion to generate 20 F_1 hybrids. Six hybrids out of 20 were selected based on yield performance in F_1 generation and back crosses were made by crossing with the corresponding parents. The F_1 plants were selfed to get F_2 seed. All the six generations were raised in the Uniform Blast Disease Nursery at Agricultural Research Station, Nellore during *rabi* 2017-18. The susceptible check used for this experiment was NLR 34242, which is a short duration (110-115 days) and medium bold grain culture.

The observation on disease reaction was recorded when the susceptible check was severely infected by blast. Individual plants in each generation *viz*., parents (P_1, P_2), F_1, F_2, BC_1 and BC_2 populations were scored based on leaf blast severity following Standard Evaluation System (SES, IRRI, 1996) on 0-9 scale. Similarly, the scoring was repeated 10-15 days after the first observation to avoid the escapes. Evaluation of blast resistance in all the generations was done for resistance and susceptible reactions based on the disease reaction scale where >3 was considered as susceptible. The maximum scores of each plant from two observations were considered for categorizing resistance and susceptible reaction. Chi-square test was employed to test goodness of fit of observed and expected frequencies in the segregating generations.

Screening of rice genotypes against blast disease resistance

Screening for resistance to leaf blast has to be usually done in Uniform Blast Disease nursery where natural blast infection is highly favourable. To create the blast congenial environment,the seed beds were raised upto 15 cm high above the ground level to avoid flooding. The fertilizers were applied at the rate of 150 kg urea per hectare. Two rows of the susceptible genotype (NLR 34242) were planted all around the experiment.

The spore suspension was sprayed on the test material during evening hours after 15 days of sowing. To create more disease, the pieces of freshly infected leaves collected from nearby rice fields were spread over the bed uniformly at 20 days after seeding in the evening time. The seed of each test entry (P_1, P_2, F_1, F_2, BC_1 and BC_2) was sown in a row of 0.5 m long. Disease evaluation was started 20-25 days after seeding. The sporulating lesions were counted in each leaf of the individual seedling. The number of lesions per seedling and the number of leaves at least with one sporulating lesion were calculated (Standard Evaluation System, IRRI, 1996).

The disease reaction of each line was scored according to the Standard Evaluation System given by IRRI, 1996. Based upon the blast score, the rice plants were divided into five categories; highly resistant (HR), resistant (R), moderately resistant (MR), susceptible (S) and highly susceptible (HS). The following categories were used in assessing the resistant reaction for rice blast disease.

Grade	Description
1	Small brown specks of pin point size
2	Small brownish to slightly elongated necrotic grey spots of about 1-2 mm diameter with distinct brown margin lesions mostly found in lower leaves.
3	Lesion type same as in case of 2 but more number of lesions present.
4	Typical susceptible blast lesions, 3 mm (or) longer, infecting less than 4% of the leaf area.
5	Typical susceptible blast lesions, 3 mm (or) longer, infecting less than 4-10% of the leaf area.
6	Typical susceptible blast lesions, 3 mm (or) longer, infecting less than 11-25% of the leaf area.
7	Typical susceptible blast lesions, 3 mm (or) longer, infecting less than 26-50% of the leaf area.
8	Typical susceptible blast lesions, 3 mm (or) longer, infecting less than 51-75% of the leaf area.
9	Typical susceptible blast lesions, 3 mm (or) longer, infecting more than 75% of the leaf area.

Rating	Reaction
1	Highly Resistant(HR)
3	Resistant (R)
5	Moderately Resistant(MR)
7	Susceptible (S)
9	Highly susceptible (HS)

RESULTS AND DISCUSSION

The six generations of the selected six crosses *viz.,* RNR 2465 x NLR 145, BPT 5204 x IR 64, BPT 5204 x IR 36, BPT 5204 x NLR 34449, WGL 48684 x IR 36 and RNR 2465x IR 64 were exposed to blast disease to study the inheritance pattern of the disease in uniform blast disease nursery at Agricultural Research Station, Nellore where the blast race was identified as ID 14.

Four out of six crosses *viz.,* RNR 2465 x NLR 145, BPT 5204 x IR 64, BPT 5204 x NLR 34449 and RNR 2465 x IR 64 showed resistant reaction (<3 score) in F_1 generation and segregated in the phenotypic ratio of 15:1 (R:S) in F_2 generation (X^2=11.94 at df=1, P value= >0.01 for RNR 2465 x NLR 145; X2=0.73, at df=1, P value= 0.5-0.25 for BPT 5204 x IR 64; X2= 3.94 at df=1, P value= 0.05-0.01 for BPT 5204 x NLR 34449; X^2= 0.71 at df=1, P value=0.5-0.25 for RNR 2465 x IR 64) indicating that two independent dominant genes were involved in the expression of resistance and both the genes are non- allelic showing duplicate dominant epistasis. Dwinitha *et al.,* (2008) reported duplicate epistasis for blast resistance in the cross IR 64 x *Oryza rufipogan.* In practice, it is difficult to differentiate the segregating ratio of 15:1, when a limited number of plants were utilized

for study. The use of large segregating population would permit a critical analysis (Tanaka, 1986).

The cross WGL 48684 x IR 36 and BPT 5204 x IR 36 exhibited resistant reaction (<3 score) to blast in all the plants studied in F_1 generation indicating dominant gene conferring blast resistance. In F_2 generation, the plants segregated in 3:1 ratio for resistance to susceptibility. The resistant trait in F_2 population was evaluated by testing the single gene model wherein it was observed that 25% of the F_2 population showed susceptibility while 75% as resistant. From data analysis of chi square to test goodness of fit, these two F_2 crosses segregated in a 3:1 ratio (X^2= 0.74, df:1, at P value: 0.50-0.25 for BPT 5204 x IR 36; X2= 2.02, df:1, at P value: 0.25-0.10 for WGL 48684 x IR 36) of resistant to susceptibility. This result suggests that there may be a single dominant gene governing the resistance in the parent IR 36. The complement of the resistant genes could be due to the donor genes from IR 36 that carried highly resistant genes. Studies from previous research also indicated that resistant gene expression is dependent on the donor cultivar genetic back ground, specificity of different isolates and effectiveness of specific host on specific strains that are governed by single gene (Sharma *et al.,* 2005).

Even earlier study done (Zhou *et al.,* 2007) at IRRI revealed that most of the traditional varieties generally have one or two dominant genes. In this study, particularly it was found that IR 36 was resistant to blast disease and resistant reaction was controlled by a single major gene. These results were in agreement with the earlier findings on the inheritance of the blast disease studied by crossing resistant variety 'Pongsu seribu 2' with susceptible variety 'Mahsuri' (Rahim *et al*., 2013). Filippi and Prabhu (1996), Yodkwanwat-im (2009) and Padmavathi *et al*. (2005) also reported that the resistance is governed by single dominant gene.

For the two crosses *viz.,* BPT 5204 x IR 36 and WGL 48684 x IR 36, the back cross progeny of BC_1 (F_1 x Susceptible parent) showed a phenotypic ratio of 1:1 (R:S), whereas, the ratio was 1:0 (R:S) when the F1 was crossed with resistant parent indicating that the resistance is governed by a single dominant gene in resistant parent. The back cross populations derived from crossing the F_1 with resistant parent (BC_2) for these two crosses stated that the resistant to susceptible plants segregated in a phenotypic ratio of 3:1 which affirms a digenic condition (Table 1).

On contrary to this, different types of gene actions were revealed for rice blast resistance *viz*., by three dominant genes, two resistant duplicate genes and monogenic dominant, inhibitory genes (Rath and Padmanabhan, 1972), monogenic recessive gene (Ramaiah and Rangaswamy, 1936), minor genes (Wang *et al.,* 1994) and recessive genes (Padmanabhan, 1973).

CONCLUSIONS

In general, blast resistance is governed by major genes which remains unaffected by environmental factors, but it is liable to break down when a more virulent or specialized pathotype appears. In contrast, the resistance governed by age of the crop, number of genes

Table 1. Mode of inheritance of rice blast resistance in various segregating generations in six selected crosses

S.No.	Generations	Total Plants	Observed frequencies		Expected frequencies		Ratio	Chi-square	P value
			R	S	R	S	R:S		
1	**RNR 2465 x NLR145**								
	P1	52	9	43	-	-	-	-	
	P2	48	41	7	-	-	-	-	
	F1	40	35	5	-	-	-	-	
	F2	232	206	26	218	14	15:1	11.94	>0.01
	BC1	48	26	22	24	24	1:1	0.32	0.75-0.5
	BC2	56	45	11	42	14	3:1	0.85	0.5-0.25
2	**BPT 5204 x IR 64**								
	P1	48	4	44	-	-	-	-	
	P2	44	39	5	-	-	-	-	
	F1	45	32	13	-	-	-	-	
	F2	142	129	13	137	15	15:1	0.73	0.5-0.25
	BC1	44	20	24	22	22	1:1	0.36	0.5-0.25
	BC2	52	41	11	39	13	3:1	0.40	0.50
3	**BPT 5204 x IR 36**								
	P1	48	4	44	-	-	-	-	
	P2	52	46	6	-	-	-	-	
	F1	43	32	11	-	-	-	-	
	F2	204	164	40	153	51	3:1	0.74	0.5-0.25
	BC1	49	28	21	25	24	1:1	0.73	0.5-0.25
	BC2	51	40	11	38	13	3:1	0.40	0.5
4	**WGL 48684 x IR 36**								
	P1	46	8	38	-	-	-	-	
	P2	52	46	6	—	—	-	-	
	F1	51	44	7	-	—	-	-	

Table 1 Contd...

S

Table1 Contd...

S.No	Generations	Total Plants	Observed frequencies		Expected frequencies		Ratio	Chi square	P value
			R	S	R	S	R:S		
	F2	197	156	41	144	48	3:1	2.02	0.25-0.1
	BC1	45	26	19	23	22	1:1	0.52	0.5-0.25
	BC2	63	49	14	45	15	3:1	0.41	0.50
5	**BPT 5204 x NLR 34449**								
	P1	48	4	44	-	-	-	-	
	P2	56	49	7	-	-	-	-	
	F1	41	29	12	-	-	-	-	
	F2	224	204	20	210	14	15:1	3.94	0.05-0.01
	BC1	56	4	52	-	-	-		
	BC2	48	32	16	36	12	3:1	1.77	0.25-0.1
6	**RNR 2465 x IR 64**								
	P1	52	9	43	-	-	-	-	
	P2	44	39	5	-	-	-	-	
	F1	42	34	8	-	-	-	-	
	F2	204	188	16	191	13	15:1	0.71	0.5-0.25
	BC1	58	22	26	24	25	1:1	0.20	0.75-0.5
	BC2	49	40	9	37	12	3:1	0.99	0.5-0.25

or by major genes imparts field resistance. From the foregoing discussion it was advocated that in order to get more desirable high yielding and good cooking quality genotypes with blast resistance, the selected progenies from the segregating populations may be back crossed with the resistant parent for some more generations followed by vigorous selection in each generation with large population.

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PERFORMANCE EVALUATION OF FOXTAIL MILLET VARIETIES IN RAINFED ALFISOLS

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ABSTRACT

The field experiment was conducted to study the suitability of foxtail millet varieties for Alfisols of scarce rainfall zone under rainfed conditions for two years during *Kharif* 2014-15 and 2015-16 at Agricultural Research Station, Ananthapuramu. The treatments consisted of six varieties *viz.,* Narasimharaya, Krishnadevaraya, Srilakshmi, SiA 3085, Prasad and Suryanandi. The results revealed that SiA 3085, Narasimharaya and Srilakshmi produced significantly higher grain yield when compared to the remaining tested varieties. Narasimharaya and Krishnadevaraya can be recommended for dual purpose (both for grain and straw) followed by Srilakshmi variety. SIA - 3085 variety has to be recommended for grain production on commercial basis as its potential for production of straw is low.

Keywords: Alfisols, Foxtail millet, Rainfed varieties

INTRODUCTION

Millets offer nutritional security and there is a need for promoting millets as they are highly nutritious. Millets are rich in protein, fibre, iron, minerals, B-complex vitamins and calcium. Consumption of millets reduces risk of heart disease, protects from diabetes, improves digestive system, lowers the risk of cancer and detoxifies the body (Nitya Sharma and Keshavan Niranjan, 2017). The most widely grown millets are finger millet, proso millet and foxtail millet especially wherever annual rainfall is below 350 mm, perhaps no other cereal crop can be grown under such moisture stress (Srikanya *et al.,* 2020). In India, in the four decades since 1961, the area under millets declined by nearly 50 percent from about 18 million hectares to about 9 million hectares. During this time, production of millets declined from about 8.8 million tons to about 7.2 million tons with a decline of 18 percent (Annual Progress Report: 2018-19, ICAR-AICRP on Small Millets, Bengaluru). Five-yearly analysis of data indicated a steady decline in the area of small millets from 7.56 m ha during 1951-55 to 0.5 m ha during 2017-18 (Annual Progress Report: 2018-19, ICAR-AICRP on Small Millets, Bengaluru).

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Foxtail millet is one of the oldest small millets cultivated for food and fodder. It is known for its drought tolerance and can withstand severe moisture stress and also suits to wide range of soil conditions. It is of shortest duration and low cost consumptive crop, nutritionally superior, providingprotein, minerals and vitamins and forms of staple food for the poorer sections of the society. In India, Andhra Pradesh (4,79,000 ha), Karnataka (2,32,000 ha) and Tamil Nadu (20,000 ha) are the major foxtail millet growing states contributing about 90 percent of the total area under cultivation (Agricultural Statistics, 2020). Andhra Pradesh is a major foxtail millet growing state with an area contributing about 79 per cent of the total area. However, the yield per unit area is less as the crop is mainly grown by small and marginal farmers on poor shallow and marginal soils under rainfed conditions besides lacking of high yielding varieties.

In Ananthapuramu district of Andhra Pradesh, except sorghum, pearlmillet and fingermillet, no other millet have showed any improvement in their cultivable area. Ananthapuramu district is the second most drought affected district of India. It receives 550 mm rainfall annually. The agriculture is predominantly dependent on rainfall which is very erratic and uncertain. Being located in the scarce rainfall zone of Andhra Pradesh it does not get the full benefit of either the south-west or north-east monsoon. In this region, local varieties of foxtail millet often cultivated under unmanured and unfertilized conditions has resulted in reduced returns.Hence, by keeping all the points in view, the study was carried out to study the performance of newly developed foxtail millet varieties in rainfed alfisols.

MATERIALS AND METHODS

The field experiment was conducted to study the suitability of foxtail millet varieties for alfisols of scarce rainfall zone under rainfed conditions fortwo years during *Kharif*, 2014-15 and 2015-16 at Agricultural Research Station, Ananthapuramu of Andhra Pradesh. The soil of the experimental site was red sandy loam with shallow depth, low in organic carbon (0.36%) and low in available nitrogen (143 kg ha^{-1}), medium in available phosphorus (28 kg ha^{-1}) and potassium (215 kg ha^{-1}). The experiment was laid out in randomized block design with three replications.The treatments consisted of six varieties *viz.,* T1: Narasimharaya, T2: Krishnadevaraya, T3: Srilakshmi, T4: SiA 3085, T5: Prasad and T6: Suryanandi. The experimental field was prepared by working with a tractor drawn disc plough and then tractor drawn cultivatorwas drawn along the field. The individual plots were laid out according to the layout plan. Sowing was taken up as per the treatments. The seeds were sown by dibbling in furrows at a depth of 3 cm. The furrows were covered immediately after sowing and compacted sufficiently for better germination. Thinning was done at 15 DAS retaining one healthy seedling $hill^{-1}$. The recommended dose of 40 and 20 kg ha^{-1} of N and P_2O_5 was applied at the time of sowing through urea and single super phosphate respectively. Thinning and gap filling was done wherever necessary, weeding and hoeing were taken up depending on the intensity of weeds at critical stages of crop weed competition. Two hand weedings were done with the help of star weeder in inter-rows and with hand hoes in the intra-rows all other cultural practices were kept

normal and uniform for all treatments. At harvest five plants were randomly selected from each treatment for recording growth parameters such as plant height, number of tillers and panicles per plant, panicle length,panicle weight per plant, threshing percent and test weight. At harvest in each treatment grain and straw yield from the net plot (5 m x 5 m) was recorded and expressed in kg $ha^{-1.}$

RESULTS AND DISCUSSION

Growth and yield attributes

During 2014, among the six varieties evaluated the taller plants were produced by the Narasimharaya followed by Prasad, without any significant difference between them. While,shorter plants were produced with Suryanandi. Srilakshmi and Narasimharaya varieties produced significantly taller plants compared to other tested varieties. The pooled data showed that Narasimharaya,Srilakshmi and Prasad varieties were significantly superior over other varieties with respect to plant height (Table 1). These results were contradictory to Karanam Navya Jyothi *et al*. (2016) who reported thatthe taller plants were produced by the variety SiA 3156 followed by SiA 3085, while, the shorter plants were produced with SiA 3088.Number of tillers per plant was also significantly influenced by the tested varieties during the year 2014. Suryanandi recorded significantly higher number of tillers per plant compared to other varieties. During 2015, higher number of tillers per plant (4.5) was produced by the variety Prasad followed by Suryanandi (4.3) without any significant difference between them. While, less number of tillers per plant was produced by SiA- 3085 (3.1).The pooled data revealed that variety Suryanandi recorded higher number of tillers per plant which in turn on par with Prasad and significantly superior to other varieties. These results were contradictory to KaranamNavya Jyothi *et al*. (2016) who reported that the total number of tillers m^{-2} was not significantly influenced by different varieties. The difference in the growth characters may be attributed to the genetic constitution of the varieties.During 2014, the variety Suryanandi produced higher number of panicles per plant which was at par with Prasad variety and significantly superior to other varieties. The variation in number of panicles per plant was not significant during the year 2015 and in pooled analysis.

SiA 3085 variety was outstanding as it recorded maximum panicle length (13.1 cm) but it was at par with Srilakshmi, Prasad and Narasimharaya varieties and significantly superior to Krishnadevaraya and Suryanandi varieties during 2014. Srilakshmi variety recorded higher panicle length (12.2 cm) which was significantly superior over other tested varieties during 2015. The pooled data showed that Srilakshmi and SiA 3085 were comparable to each other and significantly superior over other varieties with respect to panicle length.During 2014, SiA 3085 recorded significantly higher panicle weight per plant (15.3) compared to other varieties. Srilakshmi variety produced maximum panicle weight per plant which was at par with SiA 3085 and significantly superior to other tested varieties during 2015. Pooled data revealed that SiA 3085 produced significantly higher panicle weight compared to other varieties.

Variation in threshing percentage was inconsistent among the varieties during the period of investigation. Among the varieties during the year 2014, Suryanandi and Srilakshmi have recorded lower threshing percentage compared to other varieties. The threshing percentage was not significantly influenced by the tested varieties during the year 2015. Similar results were observed with pooled data also.The test weight was not influenced by the varieties during both the years of study. Similar results were observed with pooled data also. However,SiA 3085 produced higher test weight (2.91) and lesser test weight (2.28) was recorded with Prasad variety.

Grain and straw yield

Grain yield was remarkably influenced by the tested varieties during both the years of study. Prasad variety has recorded higher grain yield (529 kg ha^{-1}) during 2014 (Table 2). However, it was at par with Krishnadevaraya, SiA3085 and Suryanandi varieties and significantly superior over Narasimharaya and Srilakshmi varieties.The trend changed during the year 2015, Srilakshmi recorded maximum grain yield (814 kg ha^{-1}) though it was statistically on par with Narasimharaya(664 kg ha^{-1}) and SIA 3085(696 kg ha^{-1}) varieties and significantly superior to other varieties. The Pooled data showed that SiA 3085, Narasimharaya and Srilakshmi produced significantly higher grain yield as compared to the other tested varieties. Difference in yields among the varieties can be attributed to their genetic potentiality to utilize and translocate photosynthates from source to sink.The results were in conformity with the findings of Navyajyothi *et al*. (2015), Karanam Navya Jyothi *et al*. (2016), Sahaja Deva *et al*. (2019), Srikanya *et al*. (2020).

Krishnadevaraya had recorded significantly higher straw yield (2976 kg ha^{-1}) compared to other varieties during the year 2014. The difference in straw yield among the varieties was not significant during the year 2015. However,Narasimharaya produced higher straw yield (1805 kg ha^{-1}) and Suryanandi recorded lesser straw yield (1045 kg ha^{-1}).The pooled data showed that Narasimharaya and Krishnadevaraya have produced significantly higher straw yield compared to the other tested varieties.In 2014, among different varieties tested, significantly highest harvest index was produced by SiA 3085compared to other varieties. During 2015, highest harvest index (0.40) was produced by variety Srilakshmi without any significant difference between them. While,the lowest harvest index was produced by Prasad variety (0.22).The pooled data revealed that variety SiA 3085 recorded higher harvest index (0.32) which was at par with Suryanandi variety and significantly superior to other varieties. This investigation confirms the results reported by Brunda *et al*. (2015),Karanam Navya Jyothi *et al*. (2016), Ramachandrappa *et al*. (2016) and Himasree *et al*. (2017).

Correlation between yield components and yield of foxtail millet varieties

During 2014-15, number of panicles per plant was negatively correlated to number of tillers per plant. Panicle length was negatively correlated to number of tillers per plant but positively correlated with plant height (Table 3). Panicle weight has significant positive

Table 1. Growth and yield components of foxtail millet varieties in rainfed alfisols

S. No.	Treatments	Plant height (cm)			Number of tillers per plant			Number of panicles per Plant			Panicle length (cm)			Panicle weight per plant (g)		
		2014	2015	Mean	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean
1.	Narasimharaya	94.6	62.3	78.5	4.2	3.7	3.9	3.0	3.2	3.1	11.1	8.3	9.7	8.7	7.1	7.9
2.	Krishnadevaraya	81.4	59.7	70.6	4.4	4.1	4.3	3.6	3.6	3.6	9.9	9.8	9.9	7.2	8.2	7.7
3.	Srilakshmi	89.7	66.4	78.1	3.4	3.5	3.5	2.8	2.7	2.7	13.1	12.2	12.7	7.7	9.4	8.6
4.	SIA 3085	86.3	53.5	69.9	4.5	3.1	3.8	3.2	2.2	2.7	13.4	9.9	11.7	15.3	9.1	12.2
5.	Prasad	93.3	56.7	75.0	5.6	4.5	5.0	4.4	3.5	4.0	12.5	8.4	10.4	13.5	7.5	10.5
6.	Suryanandi	79.5	57.6	68.6	7.2	4.3	5.8	5.5	3.8	4.6	7.9	8.1	8.0	7.0	6.5	6.7
	SEm±	3.59	2.25	1.32	0.31	0.72	0.38	0.4	0.79	0.47	0.76	0.65	0.59	0.33	0.18	0.18
	CD at 5%	NS	7.18	4.21	0.99	NS	1.21	1.3	NS	NS	2.41	2.09	1.90	1.05	0.57	0.59

Table 2. Threshing %, test weight and yield of foxtail millet varieties in rainfed alfisols

S .No.	Treatments	Threshing %			Test weight (g)			Grain yield (kg ha-1)			Straw yield (kg ha-1)			Harvest Index		
		2014	2015	Mean	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean
1.	Narasimharaya	60.9	61.9	61.4	2.40	2.35	2.38	445	664	554	2455	1805	2130	0.15	0.27	0.21
2.	Krishnadevaraya	63.9	53.7	58.8	2.67	2.57	2.62	477	487	482	2976	1222	2099	0.14	0.28	0.21
3.	Srilakshmi	50.1	63.2	56.7	2.30	2.70	2.50	299	814	557	2234	1294	1764	0.12	0.40	0.26
4.	SIA 3085	68.8	59.0	63.9	2.97	2.86	2.91	486	696	591	1191	1367	1279	0.29	0.34	0.32
5.	Prasad	63.6	57.9	60.8	1.85	2.70	2.28	529	313	421	1637	1210	1423	0.24	0.22	0.23
6.	Suryanandi	57.4	56.3	56.8	2.54	2.40	2.47	477	547	512	1935	1045	1490	0.20	0.34	0.27
	S.Em±	2.61	3.7	2.6	0.30	0.23	0.25	22.7	62.6	31.5	83.0	150.0	75.0	0.01	0.04	0.02
	CD at 5%	8.33	NS	NS	NS	NS	NS	72.4	200	100	266.0	NS	241.0	0.04	NS	0.07

Table 3. Correlation coefficient between yield components and yield of foxtail millet varieties in rainfed alfisols during 2014-15

S.No.	Parameter	Plant height	Number of tillers / plant	Number of panicles /plant	Panicle length	Panicle weight /plant	Thresh-ing %	Test weight	Straw yield	Harvest Index	Grain yield
1.	Plant height	1									
2.	Number of tillers/plant	-0.461	1								
3.	Number of panicles/plant	-0.506	0.980**	1							
4.	Panicle length	0.649*	-0.681	-0.702	1						
5.	Panicle weight/plant	0.367	-0.034	-0.126	0.671*	1					
6.	Threshing %	-0.040	0.125	0.033	0.118	0.678*	1				
7.	Test weight	-0.587	-0.107	-0.192	-0.125	0.027	0.367	1			
8.	Straw yield	-0.144	-0.293	-0.190	-0.442	-0.816	-0.331	-0.046	1		
9.	Harvest Index	0.015	0.395	0.285	0.280	0.884**	0.713*	0.169	-0.885	1	
10.	Grain yield	-0.135	0.600*	0.542	-0.271	0.466	0.824**	0.017	-0.286	0.668*	1

**= Significant at 1 % level; * = Significant at 5 % level

Table 4. Correlation coefficient between yield components and yield of foxtail millet varieties in rainfed alfisols during 2015-16

S.No.	Parameter	Plant height	Number of tillers / plant	Number of panicles /plant	Panicle length	Panicle weight /plant	Thresh-ing %	Test weight	Straw yield	Harvest Index	Grain yield
1.	Plant height	1									
2.	Number of tillers/plant	-0.079	1								
3.	Number of panicles/plant	0.045	0.929**	1							
4.	Panicle length	0.527	-0.567	-0.593	1						
5.	Panicle weight/plant	0.186	-0.706	-0.799	0.900**	1					
6.	Threshing %	0.551*	-0.552	-0.582	0.407	0.336	1				
7.	Test weight	-0.334	-0.436	-0.694	0.548*	0.802**	0.081	1			
8.	Straw yield	0.291	-0.467	-0.343	-0.077	0.019	0.590*	-0.255	1		
9.	Harvest Index	0.318	-0.586	-0.449	0.648*	0.462	0.306	0.136	-0.190	1	
10.	Grain yield	0.487	-0.845	-0.686	0.648*	0.541	0.680*	0.089	0.383	0.825**	1

**= Significant at 1 % level; * = Significant at 5 % level

Table 5. Correlation coefficient between yield components and yield of foxtail millet varieties in rainfed alfisols (mean of 2 years data)

S.No.	Parameter	Plant height	Number of tillers / plant	Number of panicles /plant	Panicle length	Panicle weight /plant	Thresh-ing %	Test weight	Straw yield	Harvest Index	Grain yield
1.	Plant height	1.00									
2.	Number of tillers/plant	0.35	1.00								
3.	No. panicles/plant	0.23	0.96**	1.00							
4.	Panicle length	0.63*	-0.26	-0.38	1.00						
5.	Panicle weight/plant	0.45	0.09	-0.07	0.73**	1.00					
6.	Threshing %	0.25	0.11	-0.03	0.28	0.64*	1.00				
7.	Test weight	-0.40	-0.26	-0.37	-0.07	0.03	0.23	1.00			
8.	Straw yield	0.60	0.10	0.07	0.08	-0.27	0.02	-0.22	1.00		
9.	Grain yield	-0.38	-0.27	-0.27	-0.03	0.10	0.41	0.16	-0.29	1.00	
10.	Harvest Index	-0.62	-0.26	-0.23	-0.06	0.22	0.24	0.28	-0.80	0.79**	1.00

**= Significant at 1 % level; * =Significant at 5 % level

relation with panicle length and threshing percent.Straw yield was significantly and negatively correlated with panicle weight. Harvest index has significant and positive relation with panicle weight, threshing percentage and grain yield. Grain yield has significant positive correlation with number of tillers per plant and threshing percentage.

During 2015-16, number of panicles per plant has significant positive correlation with number of tillers per plant (Table 4). Panicle weight showed negative correlation with number of tillers per plant and number of panicles per plant but significant positive correlation with panicle length.Test weight was significantly and positively correlated with panicle length and panicle weight. However, it was negatively correlated to number of panicles per plant. Straw yield was positively correlated with threshing percentage. Grain yield has significant negative relation with number of tillers per plant and number of panicles per plant, but it had significant positive correlation with panicle length and threshing percentage. Harvest index revealed significant positive relation with panicle length and grain yield. It also expressed significant negative relationship with number of tillers per plant.

The pooled analysis showed that there was significant positive correlation between number of panicles per plant and number of tillers per plant (Table 5). Panicle weight per plant has significant positive correlation with panicle length. Panicle length was significantly and positively correlated to plant height. Threshing percent has positive relation with panicle weight per plant. Straw yield has significant positive correlation with plant height. Grain yield was not significantly influenced by any factor. Harvest index was significantly and negatively influenced by plant height and straw yield. However, it has significant positive correlation with grain yield.

CONCLUSIONS

Keeping in view the demand for fodder and grain, Narasimharaya and Krishnadevaraya can be recommended for dual purpose followed by Srilakshmi variety. SIA 3085 variety has to be recommended for grain production on commercial basis as its potential for production of straw is low.

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PERFORMANCE OF DIFFERENT GROUNDNUT (*Arachis hypogaea* L.) VARIETIES AND ECONOMICS UNDER DIFFERENT IRRIGATION SCHEDULES

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ABSTRACT

The field experiment was conducted during *rabi* season of 2021-22 at Agricultural College, Bapatla to evaluate the influence of irrigation schedules on yield and economics of different groundnut varieties. The experiment was laidout in split-plot design and replicated thrice. The experiment consisted of three irrigation schedules *viz*., IW/CPE ratio of 1.0 (M1), IW/CPE ratio of 0.8 (M2) and IW/CPE ratio of 0.6 (M3) as main plots and four groundnut varieties *i.e*., TAG-24 (V1), Dheeraj (V2), Kadiri Leapskhi (V3) and Kadiri Chitravati (V4) in sup plots. The results revealed that IW/CPE ratio of 1.0 produced significantly higher pod yield (3175 kg ha^{-1}) and haulm yield (4291 kg ha^{-1}) over IW/CPE ratio of 0.6 but it was at par with IW/CPE ratio of 0.8. Among the varieties tested, highest pod and haulm yield was recorded with Kadiri Lepakshi (3607 kg ha^{-1}) which was significantly superior over Kadiri Chitravati, Dheeraj and TAG-24. Highest gross returns, net returns and returns per rupee invested were obtained with IW/CPE ratio of 1.0 with Kadiri Lepakshi variety when compared to other treatments.

Keywords: Economics, Groundnut varieties, Irrigation schedules, IW/CPE, Pod Yield

INTRODUCTION

Oilseed crops contribute a considerable share to the Indian agricultural economy next to cereals, millets and pulses in terms of area and production. Oilseeds are the most important foods in international trade generating high foreign exchange, thus they can be considered as a backbone for Indian economy. The oilseed sector has tremendous potential for further growth. The predominant oilseed crops grown in India are soybean, groundnut, rapeseed, mustard, sunflower and castor.

Among the oilseed crops, groundnut is the 4th most predominant oilseed crop and 13th crucial food crop of the world. China and India are the huge producers of groundnut, accounting for over 41% and 18% of the total world's production, respectively (Mishra, 2020). It occupies an area of 27.96 m ha in

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the world with a production of 47.09 m t and productivity of 1680 kg ha^{-1} (FAOSTAT, 2020-21). Whereas, in India, it is cultivated to an extent of 4.88 m ha with a production of 9.25 m t and productivity of 1893 kg ha^{-1} (Source: www.indiastat.com) and it occupies a leading position among the oilseeds. Among the states in India, Gujarat accounts for 41% of the total production of groundnut and is the lead producer followed by Rajasthan (14 %), Andhra Pradesh (12 %), Tamil Nadu (11 %) and Karnataka (5%). In Andhra Pradesh, it is cultivated in an area of 0.84 m ha with a production of 1.05 m t and productivity of 1426 kg ha^{-1} (Source: www.indiastat.com). It consists of 50% oil, 21-36% high quality protein, 24% carbohydrates, minerals and vitamins.

Groundnut cultivation is associated with several constraints of which moisture stress and lack of suitable varieties for particular season are the main reasons for low productivity of groundnut. Irrigation scheduling is one of the important managerial activities and affects the efficient utilization of water by crops. It determine the process to decide when to irrigate the crops and how much water to apply. It optimizes agricultural production with minimizing yield loss due to water shortage and improving performance and sustainability of any irrigation system through conserving water. Scheduling irrigation on the basis of evaporative demand results not only in efficient utilization of water but also in considerable saving of water.

Among all the abiotic stresses the drought stress is the most important one, which limits production of groundnut. In groundnut, flowering and pod filling stages are critical for water stress and would results in drastic reduction in crop yield, and magnitude of reduction would depend on groundnut varieties. Under drought stress conditions, drought tolerant varieties will be able to give better yield considerably due to physiological and biochemical changes that were triggered by drought stress. It is necessary to screen the selection of tolerant groundnut varieties under moisture stress conditions (Sunitha *et al*., 2015). Hence, the investigation was carried out to study the influence of irrigation schedules on yield and economics of groundnut varieties.

MATERIALS AND METHODS

The field experiment was conducted at Agricultural College farm, Bapatla during the *rabi* season of 2021-22. The experiment site was a sandy loam soil (sand- 76.26%, silt-14.50% and clay-9.24%) with neutral in reaction (pH-6.91), low in available nitrogen (191 kg ha^{-1}) and organic carbon content (0.23 %), high in available phosphorous (38.4 kg ha^{-1}) and medium in available potassium (283 kg ha^{-1}). The total amount of rainfall received during the crop growth period was 374.7 mm in 21 rainy days. Bulk density of experimental soil at 0-15 cm and 15-30 cm depth was recorded as 1.51 g cc^{-1} and 1.55 g cc^{-1}, respectively. Field capacity of the soil was 21.9 cm per meter depth of soil. The experiment was laidout in split plot design and replicated thrice. The main plots consisting of three irrigation schedules *viz*., M1- IW/CPE ratio of 1.0, M2- IW/CPE ratio of 0.8 and M3-IW/CPE ratio of 0.6 and sub-plots consisting of four groundnut varieties *viz*., V1 - TAG-24, V2 - Dheeraj, V3 - Kadiri Lepakshi and V4-

Kadiri Chitravati. The crop was sown at a spacing of 22.5 cm × 10 cm. The crop was supplied with 30 kg N, 40 kg P_2O_5 and 50 kg K_2O ha^{-1} through urea (46 % N), single super phosphate (16 % P_2O_5) and muriate of potash (60 % K_2O), respectively to all the plots. Half of the recommended dose of nitrogen and potassium along with entire dose of phosphorus was applied as basal. Remaining half of the nitrogen and potassium was applied at 25 DAS. Gypsum was applied at the rate of 500 kg ha-1 at 30 DAS in pegging zone through band placement. Scheduling of irrigation was done on the basis of climatological approach (IW/CPE). Daily pan evaporation was recorded from the USWB open pan evaporimeter. Total amount of water applied to the crop was 410 mm, 340 mm and 300 mm, respectively, in case of M1, M2 and M3 irrigation schedules. Depth of irrigation was maintained 50 mm per irrigation in each treatment. Measured quantity of water was given to different treatments by using Parshall flume of 1 cusec capacity (Parshall, 1950). The volume of water to be given for each treatment is calculated from the formula

Volume = Area × Depth

The calculated volume of water from the formula *i.e.,* 900 L was applied for the depth *i.e.* 50 mm when cumulative evaporation reached 50 mm, 62.5 mm and 83 mm as per the treatments *i.e*. M1 (IW/CPE-1.0), M2 (IW/CPE-0.8) and M3 (IW/CPE-0.6), respectively based on time (minutes) that obtained from discharge rate of the flume. The time required to irrigate the plot was determined by using the following formula.

$$\text{Time required (min)} = \frac{\text{Plot size (m2)} \times \text{Depth of irrigation (m)} \times 60 \times 1000}{\text{Discharge from parshall flume (l sec}^{-1)}}$$

Pod yield (kg ha^{-1})

The data on pod yield was recorded after thorough drying and separating the pods from plant from each net plot area and expressed in kg ha^{-1}.

Haulm yield (kg ha^{-1})

The haulms obtained from each net plot area along with five sampled plants were thoroughly sun dried, weighed and expressed in kg ha^{-1}.

Economics

The gross returns from each treatment was worked out with the then prevailing market price of groundnut and the net returns from each treatment were arrived at by deducting the cost of cultivation worked out with the then prevailing cost of input and labour wages.

Net returns = Gross returns (Rs. ha^{-1}) – Total operational cost (Rs. ha^{-1})

$$\text{BiC Ratio} = \frac{\text{Net returns (Rs. ha}^{-1})}{\text{Cost of cultivation (Rs. ha}^{-1})}$$

RESULTS AND DISCUSSION

Yield of Groundnut Pod yield (kg ha^{-1})

Among the irrigation schedules, higher pod yield (3175 kg ha^{-1}) (Table 1) was obtained with IW/CPE ratio of 1.0 (M1) which was significantly superior to that of IW/CPE ratio of 0.6 (2579 kg ha^{-1}) and comparable with IW/CPE ratio of 0.8 (M2) (2916 kg ha^{-1}). Frequent

irrigation under M1 treatment might have created favourable moisture conditions for plant growth which might have increased yield attributes like number of pods plant^{-1}, number of filled pods plant^{-1} and number of kernels pod^{-1} ultimately increased the pod yield compared to other treatments. Similar findings were reported by Lokhande *et al*. (2018) who also noticed that the dry pod yield of summer groundnut was significantly higher when irrigation was scheduled at 1.0 IW/CPE and it was comparable with 0.8 IW/CPE. Ranjitha *et al.* (2018) also stated that higher pod yield (4005 kg ha^{-1}) was recorded by groundnut when drip irrigation was scheduled at 1.0 Epan and significantly superior over 0.4, 0.6 Epan and surface furrow irrigation at 1.0 IWCPE treatments but was on par with irrigation scheduled at 0.8, 1.2 Epan through drip. However, lowest pod yield was recorded with IW/CPE ratio of 0.6 (2579 kg ha^{-1}). The crop might have experienced stress at peg penetration stage when irrigations were given at IW/CPE of 0.6 and that lead to dehydration of protoplasm and causing reduction in photosynthetic rate resulted in lower pod yield. The findings are in agreement with Suresh *et al*. (2013) who stated that higher pod yield was obtained with irrigation scheduled at 1.0 IW/CPE (1511 kg ha^{-1}) which was significantly superior over 0.8 (I2) and (I1) IW/CPE 0.6 ratios.

Among the varieties, highest pod yield (3607 kg ha^{-1}) was recorded with Kadiri Lepakshi which was significantly superior over Kadiri Chitravati (3185 kg ha^{-1}), Dheeraj (2694 kg ha^{-1}) and TAG-24 (2074 kg ha^{-1}). These increased yield attributes might be due to increased growth parameters like number of branches and biomass production. Mouri *et al*. (2018) also noticed that BARI Cheenabadam-8 produced significantly the highest pod yield than BINA Cheenabadham-6.

Haulm yield (kg ha^{-1})

The data (Table 1) revealed that irrigation scheduled at IW/CPE ratio of 1.0 (4291 kg ha^{-1}) recorded higher value of haulm yield, which was significantly superior over IW/CPE ratio of 0.6 (M3) (3681 kg ha^{-1}) but found statistically on a par with IW/CPE ratio of 0.8 (M2) (4034 kg ha^{-1}). However, the lowest haulm yield was recorded with IW/CPE ratio of 0.6. Maintenance of adequate available soil moisture in the root zone coinciding with critical growth stages of crop that would have helped for proper uptake as well as utilization of nutrients and created a favourable impact on growth as well as yield components leading to better haulm yield of the crop with IW/CPE ratio of 1.0. Pawar *et al*. (2013) also revealed that highest values of haulm yield (21.91 q ha^{-1}) was obtained with application of irrigation at 1.05 IW/CPE ratio was obtained than rest of the treatments. However, it was at par with that of 0.9 IW/CPE ratio *i.e*., 21.56 q ha^{-1}. Rathod and Trivedi (2011) also reported that haulm yield increased with increasing rate from IW/CPE of 0.6 to 0.9 and highest haulm yield was recorded under IW/CPE of 0.9.

Among the varieties, Kadiri Lepakshi recorded significantly highest haulm yield (4647 kg ha^{-1}) over Kadiri Chitravati (4101 kg ha^{-1}), Dheeraj (3835 kg ha^{-1}) and TAG-24 (3424 kg ha^{-1}). Whereas, Dheeraj and Kadiri Chitravati were comparable with each other. The morphological differences among the

Table 1. Pod yield (kg ha^{-1}) and haulm yield (kg ha^{-1}) of groundnut varieties as influenced by irrigation schedules

S. No.	Treatments	Pod yield (kg ha^{-1})	Haulm yield (kg ha^{-1})
Irrigation schedules (M)			
1.	M1: IW/CPE ratio of 1.0	3175	4291
2.	M2: IW/CPE ratio of 0.8	2916	4034
3.	M3 : IW/CPE ratio of 0.6	2579	3681
4	SEm ±	84.8	74.5
5.	CD @ 5 %	333	293
6	CV (%)	10.2	6.5
Groundnut varieties (V)			
1.	V1 : TAG-24	2074	3424
2.	V2: Dheeraj	2694	3835
3.	V3: Kadiri Lepakshi	3607	4647
4.	V4: Kadiri Chitravati	3185	4101
5.	SEm±	110.3	122.2
6.	CD @ 5 %	328	363
7.	CV (%)	11.5	9.2
8.	Interaction (M × V)	NS	NS

varieties in their vegetative growth characterstics reflected in haulm yield. The highest haulm yield by Kadiri Lepakshi might be due to the genetic makeup of the genotype besides the environmental conditions. Nirmal *et al*. (2015) also reported that the highest pod yield was recorded with variety HNG 10 compared to TG 37A.

Economics of groundnut Varieties as Influenced by irrigation schedules

Gross returns, net returns and returns per rupee invested was calculated by considering the cost of inputs used and then prevailing market price of the product. The data (Table 2) indicated that the highest gross returns (Rs. 2,08,356 ha^{-1}) and net returns (Rs. 1,53,681 ha^{-1}) were obtained with IW/CPE ratio of 1.0 in Kadiri Lepakshi variety (M1V3) followed by M1V4 (IW/CPE ratio of 1.0 in Kadiri Chitravati). The lowest net returns and returns per rupee invested were obtained with M3V1 (IW/CPE ratio of 0.6 with TAG-24). That might be due to frequent and consistent applications of water in the vicinity of the plants which provided better soil moisture regime in the crop root zone and the better development of kernels which increases the yield which lead to highest net income.

Table 2. Economics of groundnut varieties as influenced by irrigation schedules

S. No.	Treatments	Pod yield (kg ha^{-1})	Cost of cultivation (₹ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ha^{-1})	Returns per rupee invested
1.	M1V1	2248.2	47800	124772	76972	1.61
2.	M1V2	3126.1	48425	173497	125072	2.58
3.	M1V3	3587.5	54675	208356	153681	2.81
4.	M1V4	3738.2	54675	198221	143546	2.63
5.	M2V1	2132.8	46600	118372	71772	1.54
6.	M2V2	2776.5	47225	154096	106871	2.26
7.	M2V3	3525.4	53475	195658	142183	2.66
8.	M2V4	3229.4	53475	179230	125755	2.35
9.	M3V1	1840.6	45400	102151	56751	1.25
10.	M3V2	2078.8	46025	115375	69350	1.51
11.	M3V3	3308.5	52275	183623	131348	2.51
12.	M3V4	2487.7	52275	138068	85793	1.64

Input cost:

Cost of Seed:

V1: TAG-24 : ₹ 100 kg^{-1}

V2: Dheeraj : ₹ 105 kg^{-1}

V3: Kadiri Lepakshi : ₹ 155 kg^{-1}

V4: Kadiri Chitravati : ₹ 155 kg^{-1}

Fertilizer cost:

Urea : ₹ 5.91 kg^{-1}

SSP : ₹ 10.50 kg^{-1}

Mop : ₹ 21.00 kg^{-1}`

Output cost:

groundnut: ₹ 55.5 kg^{-1}

Cost included per one irrigation: ₹ 1200 **ha^{-1}**

M1: ₹ 4800 ha^{-1}

M2: ₹ 3600 ha^{-1}

M3: ₹ 2400 ha^{-1}

The highest returns per rupee invested (2.81) was obtained with M1V3 which was due to highest yield obtained with Kadiri Lepakshi variety which recorded highest net returns. The lowest returns per rupee invested were obtained with IW/CPE ratio of 0.6 with TAG-24 variety (M3V1). Moisture stress conditions in M3 (IW/CPE ratio of 0.6) resulted in lower yields and net returns. Kotadiya *et al*. (2021) also reported that irrigating the groundnut crop at an IW/CPE ratio of 1.0 recorded highest gross and net returns as well as B:C ratio followed by 0.8 IW/CPE ratio. Groundnut irrigated at 0.6 IW/CPE ratio recorded lowest gross and net returns and B:C ratio. Kamble *et al.* (2018) also stated that highest gross monetary returns was recorded by the treatment irrigation at 1.0 PE which was (Rs. 1,87,532 ha^{-1}) while the lowest gross income (Rs.1,55,173 ha^{-1}) was in the irrigation treatment 0.6 PE.

CONCLUSIONS

Significantly higher pod and haulm yields of groundnut was recorded with IW/CPE ratio of 1.0 (M1) but was on par with IW/CPE ratio of 0.8. The lowest yield was recorded with IW/CPE ratio of 0.6. Among the varieties, Kadiri Lepakshi recorded significantly higher pod and haulm yield compared to Kadiri Chitravati, Dheeraj and TAG-24. The highest net returns and returns per rupee invested was obtained with IW/CPE ratio of 1.0 along with the Kadiri Lepakshi variety. Scheduling of irrigation at IW/CPE ratio of 0.8 along with Kadiri Lepakshi variety on sandy loamy soils under moisture stress conditions to achieve optimum yields as well as net returns with less number of irrigations compared to that of IW/CPE ratio of 1.0.

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FIELD EVALUATION OF FUNGICIDES FOR THE MANAGEMENT OF RICE BLAST CAUSED BY *Magnaporthe oryzae*

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ABSTRACT

Rice blast caused by *Magnaporthe oryzae* is the major threat to rice production worldwide. Prochloraz 23.5% + tricyclazole 20% SE, prochloraze 45% EC, tricyclazole 75% WP, azoxystrobin 18.2% w/w + difenconazole 11.4% SC, difenconazole 25% EC, hexaconazole 5% EC and propiconazole 25% EC were evaluated at different concentrations against the rice blast disease under field conditions during 2019-20 at Agricultural Research Station, Nellore. Results revealed that out of seven fungicides prochloraz 23.5 % + tricyclazole 20 % SE @ 2 ml/l was found effective with 64.78 % reduction of the disease and highest grain yield of 6026 kg ha^{-1} which was at par with prochloraze 45% EC @ 2ml/l with recorded 59.40 % reduction of the disease and 5512 kg ha^{-1} of grain yield of rice. Remaining test fungicides: tricyclazole 75% wp @ 0.6 g/l, azoxystrobin 18.2% w/w + difenconazole 11.4 % SC @ 1ml/l, difenconazole 25% EC @ 1 ml/l, hexaconazole 5% EC @ 2ml/l and propiconazole 25% EC@1 ml/l managed the disease with 52.35 %, 44.25, 23.89, 24.85 and 20.03% reduction, respectively.

Keywords: Fungicides, Management, Rice blast, *Magnaporthe oryzae*

INTRODUCTION

Rice (*Oryzae sativa* L.) is predominant food source for more than 60% of the world's population. With 20% of the planetary rice production, India is one of the leading producers of the grain. During the period of 1961–2018, rice area and production have increased from 115 M / ha^{-1} to167 M/ha and 215/ / MT to 782 / MT, respectively.

In Asia, it is cultivated in an area of 146 M.ha area with production of 705 MT *i.e.* 91 per cent of world rice production (FAO, 2019). India has the largest area of 43.19 M.ha and second rank in production (110.15MT) next to China with a productivity of 2550 kg $ha^{-1.}$ In Andhra Pradesh, it is cultivated in an area of 2.16 M.ha with a production of 7.49 MT and mean yield of 3466 kg ha^{-1} (Directorate of Economics and Statistics, 2016).

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The crop is known to be attacked by various diseases caused by nematodes, bacteria, viruses, fungus, and other organisms, which results in annual losses of 12–25% of the entire output (Strange, 2005). Among diseases, rice blast, caused by *Magnaporthe oryzae* B.C. Couch), is one of the most important fungal diseases. It can infect different parts of rice plant: leaf, collar, node, neck, parts of panicle and occasionally on leaf sheath. The disease results in yield loss as high as 70-80 percent (Ou,1985) when predisposition factors (high mean temperature values, degree of relative humidity higher than 85-89 percent, presence of dew and excessive nitrogen fertilization) favours epidemic development (Piotti *et al.,* 2005).The yield loss of 10 percent is significant as it is sufficient to feed 60 million people for one year. Realizing the importance, natural resource institute of London gave first rank to rice blast disease in its study of pre harvest disease occurring in South Asia (Gurinder *et al*., 2006).

Different approaches have been developed to overcome the challenges of rice blast disease and to increase the productivity. The chemical management is a key approach to harvest economic yield. even though, resistant variety is the best choice to cut down the cost of production, but cultivation of resistant varieties with one or two fungicidal spray will minimize the threat of development of matching virulence by preventing the population growth. Thus, good agronomic practices integrated with foliar spray of fungicide at the initiation of disease is the most appropriate and suggested practice to manage the disease in integrated pest management system which will be useful to *curtail* the pollution and balancing the ecosystem. Hence in this study, in order to identify new effective fungicide for the management of rice blast, seven different fungicides were evaluated.

MATERIALS AND METHODS

The experiment was conducted at Agricultural Research station, Nellore, Andhra Pradesh during *rabi* season, 2019-20 in randomised block design to evaluate different fungicides;prochloraz 23.5%+ tricyclazole 20% SE@ 2ml/l, prochloraze 45% EC @ 2 ml/l, tricyclazole 75% wp @ 0.6 g/l, azoxystrobin18.2 % w/w+difenconazole 11.4 % SC @ 1ml/l, difenconazole 25 % EC @1ml/l, hexaconazole 5 % EC @ 2 ml/l and propiconazole 25% EC @ 1ml/l against blast under field conditions.25 days old seedlings of susceptible cultivar (BPT5204) were transplanted. Fertilizers were applied @ 120:60:40 NPK kg ha^{-1}. Two sprays of treatments were given with 15 days interval with the initiation of the disease. Leaf blast severity were recorded from randomly selected 25 plants from each plot by using 0–9 disease rating scale given by International Rice Research Institute (SES,IRRI, 2013).The percent disease index (PDI) of leaf blast was calculated by applying the formula (Wheeler,1969). The grain yield recorded in each plot and expressed in kg ha^{-1}.

$$PDI = \frac{\text{Sum of all disease ratings}}{\text{Total number of ratings x Maximum disease grade}} \times 100$$

0-9 disease rating scale used for rating leaf blast of rice (IRRI, 2013)

Scale	Disease severity
0	No lesion observed
1	Small brown specks of pin point size without sporulating centre
2	Small roundish to slightly elongated, necrotic gray spots, about 1-2 mm in diameter, with a distinct brown margin. Lesions are mostly found on the lower leaves
3	Lesion type same as in 2, but significant number of lesions on the upper leaves
4	Typical susceptible blast lesions, 3 mm or longer infecting less than 4 % of leaf area
5	Typical susceptible blast lesions of 3mm or longer infecting 4-10 % of the leaf area
6	Typical susceptible blast lesions of 3 mm or longer infecting 11-25 % of the leaf area
7	Typical susceptible blast lesions of 3 mm or longer infecting 26-50 % of the leaf area
8	Typical susceptible blast lesions of 3 mm or longer infecting 51-75 % of the leaf area many leaves are dead
9	Typical susceptible blast lesions of 3 mm or longer infecting more than 75 % leaf area affected

RESULTS AND DISCUSSION

The chemical management is a key approach for the farmers to harvest economic yield. Good agronomic practices integrated with foliar spray of fungicide at the initiation of disease is the most appropriate and suggested practice to manage the disease in integrated pest management system which will be useful to *curtail* the pollution and balancing the ecosystem. It was reported that the use of fungicides gives three times the returns by controlling crop diseases (Ordish and Dufour, 1969).The positive returns are noticed usually on the application of fungicides to susceptible varieties; however, the application of fungicides to the varieties with common genetic resistance against foliar diseases also shown positive economic returns in the high disease severity period (Edwards *et al*., 2012 and Ransom *et al*., 2008).

The knowledge of returns obtained from fungicidal application will help the farmers to make decisions in disease management (Wegulo *et al*., 2011). Therefore, in the investigation in order to identify the effective fungicide for the management of rice blast, Prochloraz 23.5%+ tricyclazole 20% SE, prochloraze 45% EC, tricyclazole75% wp,azoxystrobin 18.2 % w/w+difenconazole 11.4 % SC, difenconazole 25% EC, hexaconazole 5% EC and propiconazole 25% EC were evaluated at different concentrations against the rice blast under field conditions.

All the fungicides evaluated have significantly managed the blast disease over the untreated control. Out of the eight fungicides, prochloraz 23.5%+ tricyclazole 20% SE @ 2 ml/l was found effective with 64.78 % reduction of the disease which was at par prochloraze 45% EC @ 2 ml/l with 59.40 reduction of the disease. Rest of the test fungicides;tricyclazole 75% wp @ 0.6 g/l, azoxystrobin18.2% w/w+difenconazole11.4% SC @ 1ml/l, difenconazole 25% EC @ 1 ml/l, hexaconazole 5% EC @ 2 ml/l and

Table 1. Bio efficacy of fungicides against rice blast under field conditions during 2019-20

Treat - ment No.	Description	Percent disease index (PDI)	% Reduction of the disease over control	Grain yield (kg ha^{-1})	% Increase of grain yield over control
T1	Prochloraz 23.5% + tricyclazole 20% SE @ 2ml/l	26.22 (30.75)	64.78	6026	75.79
T2	Prochloraz 45 % EC @ 2 ml	30.22 (33.28)	59.40	5512	60.79
T3	Tricyclazole 75 % WP @ 0.6 g/l	35.47(36.53)	52.35	4849	41.45
T4	Azoxystrobin 18.2 % w/w + difenconazole 11.4 % SC @ 1ml/l	41.50 (40.08)	44.25	4952	44.46
T5	Difenconazole 25 % EC @ 1 ml/l	56.66 (48.81)	23.89	4467	30.31
T6	Hexaconazole 5 % EC @ 2 ml/l	55.94 (48.40)	24.85	4406	28.53
T7	Propiconazole 25% EC @1ml/l	59.53(50.48)	20.03	4634	35.18
T8	Untreated control	74.44 (59.71)		3428	
	SEM (±)	1.58		185	
	CD at 5 %	4.83		545	
	CV	6.28		7.7	

propiconazole 25% EC 1ml/l managed the disease with 52.35%, 44.25%, 23.89%, 24.85% and 20.03% reduction, respectively. In untreated the disease index was recorded as 74.44%. Grain yield was significantly increased in all the fungicidal treatments over the untreated control. Among all the fungicides, prochloraz 23.5%+ tricyclazole20 % SE @ 2ml/l recorded highest grain yield of 6026 kg ha-1 with 75.79% increase over control and which was on par with prochloraze 45% EC @ 2 ml/l(5512 kg ha$^{-1)}$. Grain yield increase over control in rest of the test fungicides; azoxystrobin18.2% w/w+ difenconazole 11.4% SC@ 1 ml/l, tricyclazole 75% wp @ 0.6 g/l, propiconazole 25% EC 1 ml/l,difenconazole 25% EC @ 1ml/l, hexaconazole 5% EC @ 1ml/l were 44.46% (4952 kg ha^{-1}), 41.45% (4849 kg ha^{-1}), 35.18% (4634 kg ha^{-1}) 30.31% (4467 kg ha^{-1}), 28.53% (4406 kg ha^{-1}) respectively (Table1). Antignac *et al*. (1990) reported that prochloraz is an imidazole fungicide that inhibits ergosterol biosynthesis *via* inhibition of the cytochrome P450-dependent 14á-demethylation of lanosterol, which results in disruption of the fungal cell membrane and cell death.

Dong Lei *et al.* (2019) reported that the resistance risk of *M. oryzae* to prochloraz was at low level. Pramesh *et al*. (2020) reported that prochloraz 27% + tricyclazole 23% SE @1000 ml/ha found effective and economical in managing the rice blast in field conditions.

CONCLUSIONS

Prochloraz 23.5%+ tricyclazole 20% SE @ 2 ml/l was identified as effective fungicide with 64.78 % reduction of the blast disease and recorded higher grain yield (6026 kg ha^{-1}) which is on par with prochloraze 45% EC @ 2 ml/l in rice.

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ORGANOLEPTIC CHARACTERISTICS AND NUTRITIONAL COMPOSITION OF WHEY-GRAPE JUICE BLENDED BEVERAGE

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ABSTRACT

The study was conducted to develop whey and grape juice blended beverage by using whey, grape juice and sugar in the year 2022. Three beverage compositions were prepared: WGB1 (90%Whey:10%GJ), WGB2 (80%Whey:20%GJ) and WGB3 (70%Whey:30%GJ). Five grams of sugar was added to every 100 ml of the beverage. Organoleptic evaluation of the beverages was carried out by 25 semi-trained panel members. A 9- point hedonic scale was used to assess the sensory attributes such as color, appearance, flavor, taste, consistency and overall acceptability. The one-way ANOVA was used to test for significant differences in the mean scores of sensory evaluation. Although all combinations of whey and grape juice were found acceptable, the treatment WGB2 which contained 70 ml whey, 30 ml grape juice and 5 g sugar, received significantly highest mean scores for color (8.19), appearance (7.80), flavor (7.80), taste (7.84), consistency (7.92) and overall acceptability (8.19), which was found superior amongst all the treatments. The results of the nutrient analysis showed that the highly accepted beverage, which is 70:30 whey-grape juice blend contained 90% moisture, 0.64 g ash, 0.81 g protein, 0.41 g fat, 3.28 g lactose and 101.8 mg calcium. These results showed a high potential to produce and develop a new functional whey product.

Keywords: Beverage, Grape, Organoleptic evaluation, Whey

INTRODUCTION

Whey is produced predominantly in the dairy sector as a by-product during the manufacturing of products such as paneer and cheese (Shankarlingayya and Puranik, 2018). This whey is thrown away in the industries which causes a crucial environmental pollution. The utilization of whey will not only be valuable for the environment but also be useful for an increase in the economy of the manufacturers (Mustafa *et al.,* 2021). Whey is said to cause serious environmental pollution as it possesses high biological oxygen demand (BOD) of 30,000 – 50,000 mg/l and chemical oxygen demand (COD) of 60,000 – 80,000 mg/l (Silviya *et al.,* 2016).

Whey is a nutritious dairy by-product that contains nutrients like proteins, lactose,

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minerals and vitamins, etc. which have an essential value as human food. Whey contains 45-55% of total milk solids, 70% of milk sugar (lactose), 20% of milk protein and 70-90% of milk minerals and nearly all the water-soluble vitamins originally present in milk (Naina and Neeraja, 2012). Water-soluble vitamins present in milk also pass into the whey but their amount is very variable and depends on the storage conditions of the whey. Whey contains significant amounts of riboflavin, folic acid and cobalamine. The majority of folic acid and cobalamine are bound to whey proteins and remain mostly in the whey after cheese manufacture (Irena *et al.,* 2008 and Rajka *et al.,* 2014).

Fruits are rich sources of functional components, such as vitamins, antioxidants and fiber and have good sensory properties (Marek *et al.,* 2017). Fruit juices are nutrient-rich beverages. Fruit juice boosts the immune system of the body and helps to maintain water balance in the body. Consumption of fruits prevents the attack of coronary heart disease. (Silva *et al.,* 2016).

Grapes are an excellent source of fiber, potassium, vitamins and other minerals. Additionally, the grape is providing us with conventional antioxidant nutrients like vitamin C, manganese and also filled with antioxidant phytonutrients that range from common carotenoids such as beta carotene to unusual stilbenes such as resveratol. Grape is also enriched with different antioxidant nutrients. The nutrients in grapes may help to protect against cancer, eye problems, cardiovascular disease and other health conditions (Jaya *et al.,* 2019).

Beverages made from milk and fruit products are now gaining substantial attention as their future market is growing. These beverages are not only delicious but also nutritive. Whey mixed fruit juices are more suitable for human consumption in terms of health when compared to other drinks (Naina and Neeraja, 2012). Keeping the above facts in view, the investigation was carried out to study the sensory acceptability of beverages and also enhance the nutritional qualities of whey grape beverage to increase the deliciousness of the product.

MATERIAL AND METHODS

Location of the study

Development of whey-grape juice blended beverage and sensory evaluation of the product was carried out in the Department of Food Science and Nutrition, College of Community Science, Acharya N.G. Ranga Agricultural University, Lam, Guntur in the year 2022.

Procurement of raw material

Pasteurized toned milk, grapes, citric acid and sugar were procured from the local markets of Guntur.

Procedure for preparation of whey

Whey was prepared as per the method suggested by Manasi *et al*. (2013) with slight modification. Pasteurized toned milk was heated to 95 °C for 8 to 10 minutes and then cooled to 70 °C in less than 30 minutes. One percent citric acid was added to the milk followed by continuous stirring which resulted in complete coagulation of the milk protein (casein). The liquid (whey) was filtered using

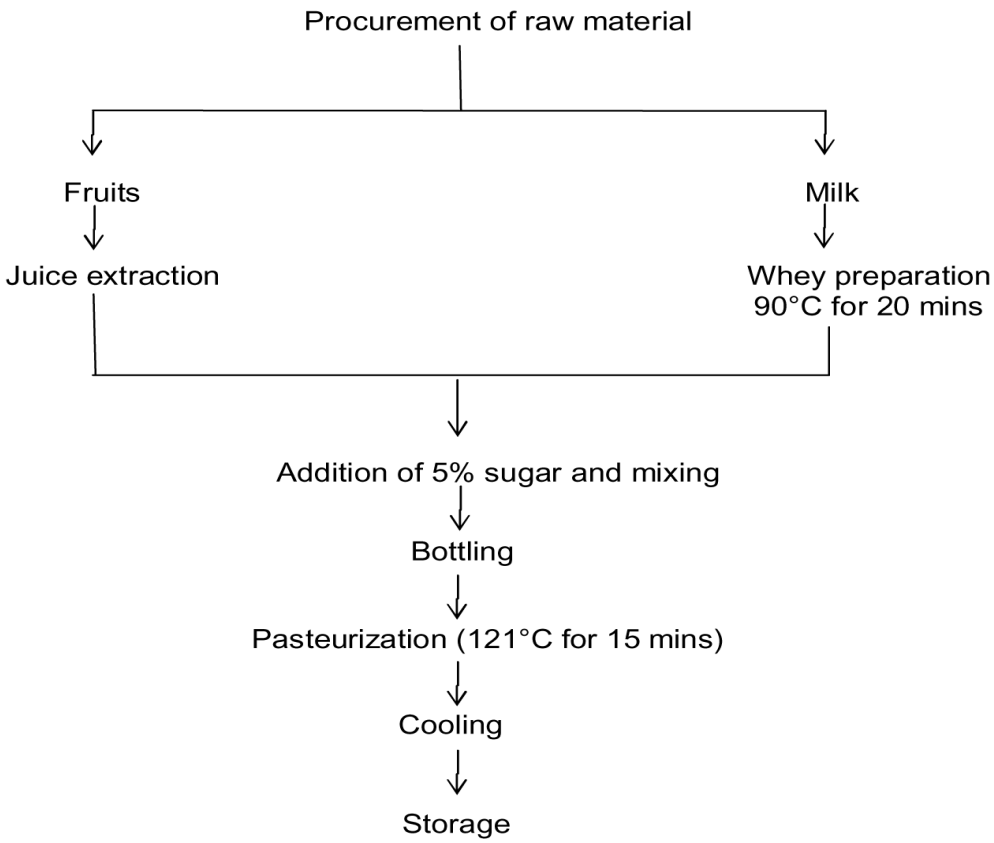

Figure 1. Flow chart for preparation of whey-grape juice blended beverage

a double-layer muslin cloth. The obtained whey was heated to 85 °C before blending with fruit juice.

Procedure for preparation of fruit juices

Fresh black grapes were collected from the local market. The grapes were washed with clean water to remove dirt and other undesirable materials before use. Then the grapes were blended with a juice blender without adding water. After that, the grape juice was filtered and kept in a labeled clean container.

Preparation of whey grape beverage

The whey-based grape beverages (WGB) were prepared by blending whey and grape juice in different proportions like 80:20 (WGB1); 70:30 (WGB2) and 60:40 (WGB3). In all treatments, 5% sugar was added and homogenized.

Organoleptic evaluation

Organoleptic evaluation for the developed whey-fruit juices blended beverages was completed by 25 members of teaching staff and students of the College of Community Science using a 9-point hedonic scale. Sensory evaluation was done at the Foods and Nutrition laboratory of the College of Community Science, Lam, Guntur.The Hedonic scale describes the degree of consumer satisfaction regarding product attributes like color, appearance, flavor, taste,

consistency and overall acceptability. It showed the overall acceptance of the product and the relative importance of each attribute. The maximum score is 9 - like extremely and the minimum score is 1 - dislike extremely.

Nutrient analysis

For nutrient analysis of the beverages, moisture, ash, protein, fat, lactose and calcium content of whey-grape juice blended beverage were determined by using AOAC (2000).

Statistical analysis

The data obtained in the study were statistically analysed using ANOVA (one-way analysis) technique.

Table 1. Quantity of ingredients for 100 ml whey-grape juice beverage

S.No.	Ingredients	WGB1	WGB2	WGB3
1.	Whey (ml)	80	70	60
2.	Grape juice (ml)	20	30	40
3.	Sugar (g)	5	5	5

RESULTS AND DISCUSSION

Beverages were prepared with varying proportions of whey and grape juice. The prepared beverages were subjected to sensory evaluation. The sensory evaluation results of the developed beverage with different proportions (whey: grape juice; WGB1-80:20, WGB2-70:30, and WGB3- 60:40) are given in Table 2.

The results obtained for the sensory attributes of whey-grape juice blended beverage had showed no significant difference ($p>0.05$) between the tested samples. The scores obtained for color attribute ranged from 6.85 to 8.19. The highest score for color was obtained for WGB2 (whey: grape juice – 70:30) with a score of 8.19 and the lowest score was observed for color is WGB1 (whey: grape juice – 80:20) with a score of 6.85, respectively.

The highest score for appearance was obtained for WGB2 (7.81) and the lowest score was observed for the WGB1 (6.96). The

Table 2. Effect of various levels of addition of grape juice on the sensory attributes of whey-grape juice blended beverage

S.No.	Sensory attribute	Mean scores of sensory evaluation			
		WGB1	WGB2	WGB3	Control
1.	Colour	6.85±0.78	8.19±0.80	7.73±1.00	7.46±0.02
2.	Appearance	6.96±1.03	7.81±0.84	7.65±0.84	6.23±0.82
3.	Flavor	6.81±1.47	7.81±1.32	7.73±1.18	6.17±0.6
4.	Taste	6.96±0.99	7.85±1.18	7.77±1.21	6.04±0.83
5.	Consistency	6.69±1.19	7.92±1.05	7.73±1.48	7.35±0.58
6.	Overall acceptability	7.27±1.21	8.19±0.84	7.96±0.91	6.39±1.14
	CV (@ 5%)	0.033	0.027	0.009	0.330
	SD	0.181	0.165	0.095	0.574

Table 3. Nutritional composition of whey-grape juice blended beverage (70:30)

S. No.	Parameter	Value per 100 ml of beverage	Value per 100 ml of whey water
1.	Moisture (%)	90	93
2.	Protein (g)	0.81	0.85
3.	Fat (g)	0.41	0.36
4.	Ash (g)	0.64	0.6
5.	Lactose (g)	3.28	4.5
6.	Calcium (mg)	101.8	47

highest score was obtained for flavor attribute WGB2 (7.81) and the lowest score for WGB1 (6.81).The highest score for taste attribute was obtained for WGB2 with a score of 7.85 and the lowest score for WGB1 with 6.96 score. The highest score for consistency attribute was obtained for WGB2 (7.92) followed by WGB3 (7.73) and WGB1 (6.69). Overall acceptability was again higher for WGB2 (8.19) followed by WGB3 (7.96) and WGB1 (7.27).

Nutritional composition of whey-grape juice blended beverage

The nutritional composition of whey-grape juice blended beverage, 70:30 which was highly accepted by the panel members is given in Table 3.

The results stated that the beverage has 90% of moisture, 0.64 g of ash, 0.81 g of protein, 0.4 g of fat, 3.28 g of lactose and 101.8 mg of calcium per 100 ml of whey-grape juice blended beverage. The incorporation of whey in grape juice enhanced the calcium content in the beverage.

CONCLUSIONS

The whey-grape juice blended beverage prepared by using 70% whey, 30% grape juice and 5% sugar had highest overall acceptability. Whey contains half of the milk solids and the addition of grape juice in the preparation of the beverage increased the nutritional value. The lactose and calcium present in whey aids in providing these nutrients to the body.

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DEVELOPMENT OF CALOTROPIS/COTTON BLENDED YARN AND ITS PROPERTIES

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ABSTRACT

Natural fibres, which are an important part of the human environment, and also valuable raw materials used for textile and non-textile production. The use of natural fibres instead of materials such as glass fibres, carbon, and talc provides several advantages including low density, low cost, good specific mechanical properties, and biodegradability. Blending is the mixing of two or more masses of fibres so that the resulting mixture has the characteristics of the average of the component items. The most important reason for blending is the creation of new and more desirable effects.This study was conducted in Assam in the year 2021. Four different methods were used for the extraction of fibre from the peeled bark of tender stems of *Calotropis gigantea* plants and among which chemical retting with alkali (NaOH) was selected for the study. The study was carried out by blending Calotropis and cotton in three proportions (25:75, 50:50, and 75:25 ratios) and the properties of blended yarns were investigated. It was observed that the Cotton yarn has given a higher amount of TPI and extension than the blended yarn. Fifty: fifty blended yarn have higher tensile stress, and higher lea strength than the other yarn, and were the finest among the blends.The cotton yarn had a finer count, high lea strength, and more count strength product compared to blended yarns. It was also noticed that 50:50 blended yarn had high count strength product than the other combination.

Keywords: Blending, Biodegradable, *Calotropis gigantea*, Fibre extraction, Properties, Yarn

INTRODUCTION

In recent years, the use of lignocellulosic fibre is increasing due to various factors such as environmental concerns, awareness among consumers, environmental and waste management legislations. Natural fibres, which are an important part of the human environment, are also valuable raw materials used for textile and non-textile production. The use of natural fibres instead of materials such as glass fibres, carbon, and talc provides several advantages including low density, low

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cost, good specific mechanical properties, and biodegradability (Bilal *et al.,* 2020 and Dhaliwal, 2019).

Calotropis gigantea is considered as common weed in some parts of the world. It is a genus of plants that produce milky sap hence also commonly called milkweed. This is also known as Mudar. Mudar is a medium-sized shrub, growing from 2 m to 3 m in height and with a stem diameter of 25 cm. *Calotropis gigantea* is a soft shrub that can be cultivated in dry habitats and in extremely drained soils. Stems of the Giant Milkweed plant can be used to obtain natural cellulosic fibres with good strength and elongation (Karthik and Ganesan, 2012). Milkweed stem fibres have strength higher than milkweed floss and alike cotton. However, the strength of the milkweed stem fibres is similar or higher than that of other common bast fibres such as jute and the fibres obtained from various agricultural by-products. Breaking elongation of the milkweed stem fibres is higher than that of milkweed floss and most other bast fibres but lower than the elongation of the cotton fibres. The high elongation of the milkweed stem fibres directs that the fibres may have a higher micro fibrillar angle than the common bast fibres (Karimah *et al*., 2021).

Blending is the mixing of two or more masses of fibres so that the resulting mixture has the characteristics of the average of the component items. The blending of cotton is done for at least three purposes. The first is to develop an inexpensive product. The second motive is the alteration of defects. The most important reason for blending is the creation of new and more desirable effects. The determination of blending is to develop yarn with such qualities that cannot be found by using one kind of fibre alone. Blending is similarly practiced for reasons of economic creation, scarcity of natural fibre, better performance in spinning, to improve the yarn strength, yarn evenness, defectiveness level, etc.Fibre blending is done to minimalize variations in length and quality (Sasikala and Thangamani, 2017). This study is selected to blend cotton fibre with Calotropis stem fibre and learn about the blended yarn's properties.

MATERIALS AND METHODS

a. Selection of *Calotropis gigantea* fibre

Selected C. *gigantea* is a widely growing plant in the waste land.It grows up to 3 m tall and has clusters of waxy flowers that are either white or lavender in colour. Fibres were extracted in four different methods from the peeled bark of tender stems of C. *gigantea* plants and studied for its properties. The fibres extracted using chemical Retting with alkali (NaOH) were selected for the study.

Figure 1.*Calotropis gigantea* fibre

b. Selection of cotton fibre

The cotton fibre was used for this study because the review of the literature suggested cotton blended fabrics combine the best properties of each of the components.Cotton has been the major substrate lending its quality to increase the value and use of alternative materials. Cotton is used for blending with various vegetable fibres. It is extensively used for blending in the textile industry because of its desirable characteristics.

c. Fibre extraction process

Retting is a method of extraction of fibres. It is a natural microbial process. Thisinvolves the degradation of non-fibrous matter which acts as glue between the fibres in woody plant parts and fibres without damaging the fibre cellulose. This process permits easy separation of individual fibre strands and the woody core.Both moisture and a warm temperature are required for microbial action, as retting is a biological process (Hulle *et al*., 2015). Water retting, chemical retting with urea and Sodium hydroxide, and enzyme retting were used to extract fibre from the C. *giantea* bark.

Water retting

Water retting is a wet process by which the bundles of cells in the outer layers of the stalk are separated from non fibrous matter by the removal of pectin and other gummy substances. Water retting requires a large amount of water, which is expensive but results in high-quality fibres (Mwaikambo, 2006). Water retting was carried out in trays. First trays were filled with clean tap water at room temperature and then the Calotropis peeled barks were steeped in water for six days.

Chemical retting

Chemical retting is the process where plants are immersed in a tank with a solution of a chemical such as sodium hydroxide, sodium carbonate, high pH agent, etc. The fibres loosen after few hours but close control is required to prevent deterioration and damage to the fibres.

Chemical retting with urea

Urea is an organic compound that is highly soluble in water, non-toxic, and makes the retting process quick also. It is a commonly used fertilizer for most of agricultural crops' science aids the growth of bacteria in soil and water. Urea upsurges the wetting action of water and boosts the growth of microbes in water (Dhanalaxmi and Vastrad, 2013).

The peeled bark was tied in small bundles and immersed in cold water with 1% urea. Chemical Retting with urea was done at room temperature. The weighed Calotropis barks were steeped in water for six days.

Chemical retting with alkali (NaOH)

The outer skin of the bark was peeled from the stems by hand and dipped in sodium hydroxide solution with a solution to bark ratio of 10:1 at room temperature overnight. The bundle of bark was soaked overnight in 1.0 N Sodium hydroxide solution (alkaline solution). The solution was then heated to 80 °C for 30 minutes. Fibres were extracted and thoroughly washed in warm water first and later in cold water. After washing, fibres were neutralized in a dilute acetic acid solution to remove any

remaining alkali, and air dried (Reddy *et al*., 2009).

Fibre extraction with enzyme treatment

A method given by Yang and Reddy (2006) was followed for fibre extraction with enzyme treatment. For fibre extraction with enzyme treatment first fibres were extracted in sodium hydroxide solution and then in the next step treated with enzyme solution. Steps were

1) Extraction with an alkali solution

The peeled bark of the Calotropis stem was treated with sodium hydroxide at a concentration of 1N for 40 minutes at 100 °C. The material to liquor ratio was 1:19 *i.e.* every 100 g bark were treated in 1900 ml solution for fibre extraction. The extracted fibres were then washed in water to remove the dissolved substances and neutralized with a 10% acetic acid solution. The material to liquor ratio was 1:10 MLR. Fibres were then rinsed in water and dried at room temperature.

2) Treatment with an enzyme solution

Fibres obtained after the alkali extraction was treated with 1.0% enzyme of each xylanase and cellulose. Extracted fibres were heated in enzyme solution at 55 °C for 40 minutes. The material to liquor ratio was 1:19 MLR *i.e*. 100 g fibre in 1900 ml solution at a pH of 6.0. Fibres obtained after the enzyme treatment werecarefully washed and dried at room temperature.

Spinnability studies

Spinning is the process of producing yarn from various raw fibre materials. Inspinning process,fibres are twisted together to bind them into a long, stronger yarn.Spinning is a part of the textile manufacturing process. It is the process of twisting together drawn-out strands of fibres to form yarn, though it is colloquially used to describe the process of drawing out, introducing the twist, and winding onto bobbins.Open-end spinning is an outstanding short-term blending process. The experiment was carried out to spin the Calotropis and cotton fibre blended yarns in diverse proportions (25:75, 50:50, 75:25) with a Z twist. Also, 100 percent Calotropis could not be spun into a yarn, hence, it was blended with cotton.

Fibre opening

Fibre opening and cleaning are to make the fibres free from foreign bodies and trash and also to make fibres ready for carding.

Cotton mixing

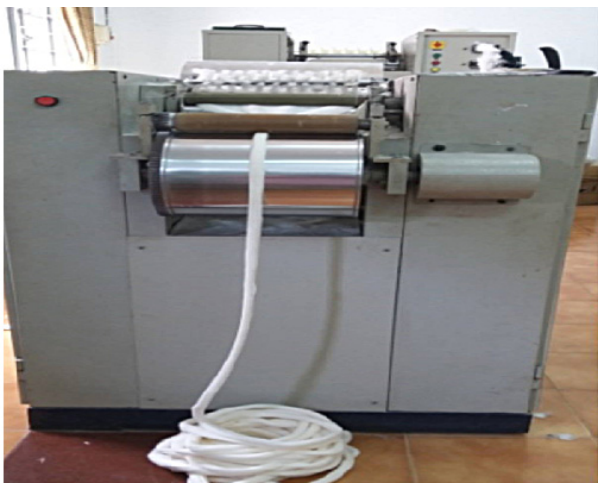
Cotton is a natural fibre and is procured from different stations. The properties of cotton such as strength, length, and colour get vary. Hence, in the cotton mixing process, 4 to 5 lots are mixed to get specified quality yarn. Fibre blending is done to minimize variations in length and quality.The blend proportions were done at 25:75, 50:50, and 75:25 of Calotropis and cotton fibres,respectively.

Carding

Carding is defined as the reduction of an entangled mass of fibres to a filmyweb by working between two closely spaced, relatively moving surfaces clothed withsharp wire points. Carding process includes an opening to individual fibres, elimination ofimpurities and dust, removal of neps, elimination of short fibres, fibre blending, fibreorientation, and sliver formation. The carding action is to make fibres parallel and straight. Carding process

A) Putting lap at the back

B) Sliver formation



C) Sliver winding

D) Sliver

E) Spinning

F) Yarn cone

Figure 2. Slivering and spinning process

is considered as the heart of spinning. Carding is a mechanical process that disentangles, cleans, and inter mixed fibres to produce a continuous web or sliver suitable for subsequent processing.

For carding process, a computerized miniature carding machine was used.The machine consists of a feed apron conveyor, feed roller, feed plate, licker-in,cylinder, doffer, stripping roller, crush roller, take-up drum, and flats. The sample required is 50 g of material. Before carding process, Calotropis and cotton fibre were blended manually according to the blending ratio. During this process,materials were converted into sliver form.

Computerized spinning

The machine can be run through the operator provided in front of the machine**.** Count and TPI (Twist per inch) can be adjusted by using the sliders provided in the Program mode. The rove was then converted to the yarn by passing through the speedframe and drafts were set to produce counts between 10 Ne to 20 Ne at KCT- TIFAC CORE,Coimbatore.

Winding

Winding is the process of making yarn into a suitable package ready for sale.Other than the above, the primary aim is to eliminate the faults in yarn. Neps, thick places, thin places, and count variations are some of the notable defects in the spinning yarn which have to be removed while winding into a suitable package known as a cone. The yarn was finally wound on packages at KCT- TIFAC CORE, Coimbatore.

RESULTS AND DISCUSSION

Physical properties of *Calotropis gigantea* fibre

Table 1 showed that water-retted fibrehas the highest length among all the four methods. It also showed that fibre taken out through chemical retting with urea had the highest elongation break which was 52.43%. Chemical retted fibre with sodium hydroxide was

Table 1. Fibre properties extracted by different retting methods

Method	Raw fibre length (cm)	Raw fibre fineness (micro-naire)	Raw fibre bundle strength (Mpa)	Elonga-tion at break (%)
1. Water retting	10.84	5.75	16.35	38.62
2. Chemical retting with urea	9.15	6.12	34.76	52.43
3. Chemical retting with sodium hydroxide	8.71	6.30	38.27	38.85
4. Fibre extraction with enzyme treatment	8.67	6.22	42.45	38.65
SEd	0.007	0.061	0.012	0.010
CD (5%)	0.016*	0.131	0.026	0.022

* Significant at 5% level

Table 2. Tensile properties of blended yarn

Proportions of blend (Calotropis: cotton)	Twist per inch(TPI)	Extension at Break (Standard) (mm)	Tensile stress at Maximum Load (MPa)
25:75	24.13	9.58	0.16
50:50	27.12	11.14	0.30
75:25	20.49	10.51	0.15
100 % cotton	32.66	22.74	0.23
SEd	0.004	0.005	0.009
CD (5%)	0.008*	0.012	0.020

* Significant at 5% level

finer than other fibre. Fibre extracted by the enzyme retting method has the highest bundle strength which is 42.45 Mpa. Similar result was reported by Bora and Padmini (2019). On the basis of one-factor analysis, it was found that there was a significant difference between all the fibres extracted using four methods at 5% level.

Physical properties of Calotropis blended yarns

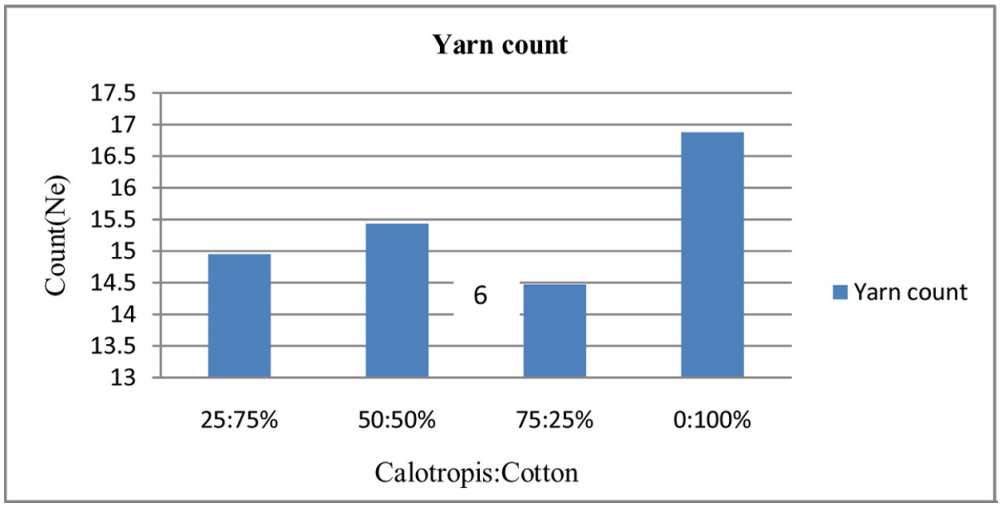
The physical characteristics of yarn blends include tensile properties, twist per inch, yarn count, count strength product (CSP), yarn elongation, and lea strength.

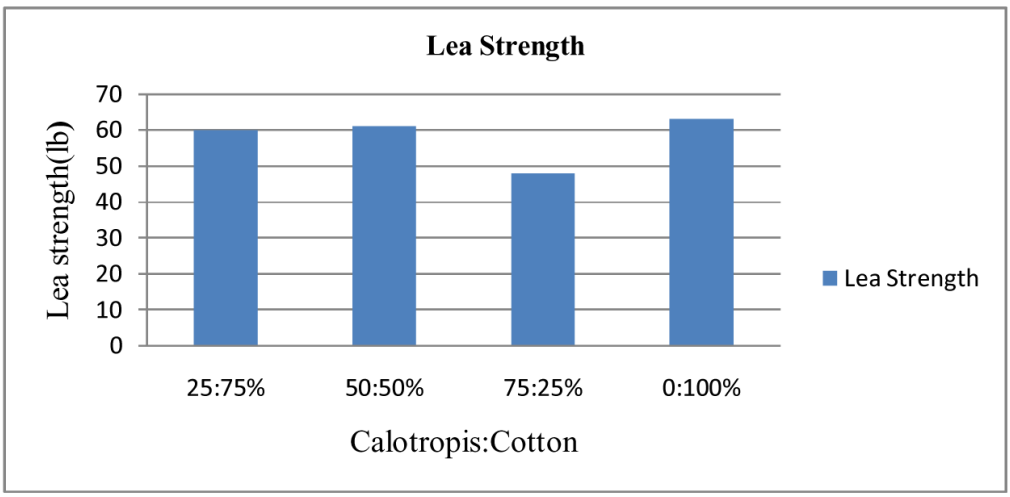
Table 2 showed that cotton yarn gave a high amount of TPI and high extension than blended yarn. Fifty:fifty blends have higher

Table 3. Effects of blending on yarn count, lea strength, and CSP of calotropis and cotton blended yarn

Proportions (Calotropis: cotton) Parameters	Yarn count (Ne)	Lea strength (lbs)	CSP
25:75	14.95	59.84	856.10
50:50	15.43	61.00	961.77
75:25	14.47	47.94	719.11
100% cotton	16.87	63.06	1064.98
SEd	0.502	1.921	39.154
CD (5%)	1.159 *	4.431	90.292

* Significant at 5% level





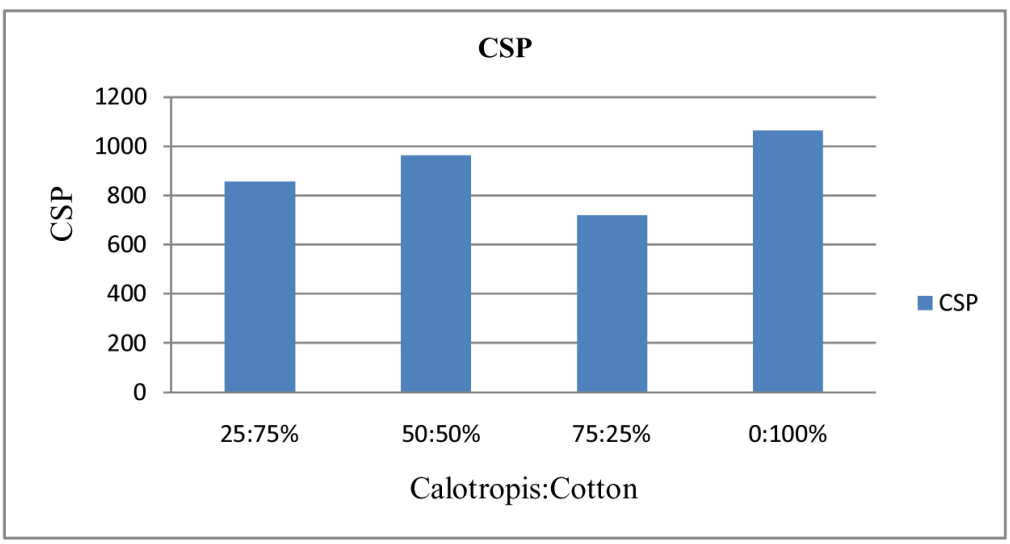


Figure 3. Effects of blending on yarn count, lea strength, and count strength product of Calotropis and cotton blended yarn

tensile stress than the other yarn. In general, yarn strength is influenced by fibre type, yarn count, and yarn twist. If a yarn has a higher twist per inch, the greater the yarn strength (Booth, 1996).

Debnath and Sengupta (2009) studied the effect of blend proportion on extension at the break. They have reported that breaking extension decreases in the case of jute yarn compared to blended yarn. As the number of fibres increases, the fibre cohesiveness also increases ultimately reducing the fibre-to-fibre slippage during tensile loading, resulting in lower breaking extension. Also mentioned that breaking extension increases with the increase in twist. From the statistical analysis of the data, it can be observed that there was a significant difference among all the test samples at a 5% level of significance.

Table 3 (Figure 3) showed that cotton yarn had a finer count, high lea strength, and higher count strength product compared to blended yarns. The 50:50 blended yarns were finer than other blends. The lea strength of 50:50 blended yarns was also higher than that of other blends. It was also found that the 50:50 combination has a high-count strength product than the other combination, though less than cotton alone.

According to Lakhsmi (2014), the cotton yarn had a finer count (7.98 Ne), high lea strength (143.01 lb), and more count strength (1383) product compared to blended yarns.The 30:70 blend had a count of 5.83 Ne, lea strength 67.03, and count strength product 387.3.The 50:50 blended yarns were finer 7.73 Ne than other blends. The lea strength of 50:50 blended yarns was also higher (96.03lb) than that of other blends; the count strength product was 741.66. The 70:30 blends have a count of 7.37Ne, a lea strength of 94.84 lb, and a count strength product 697.33.

Devi (2012) reported that the yarn count of cotton/Mesta yarn in a blend ratio of 60:40 respectively was finer (13.52) than the 100 percent cotton yarn (8.90) followed by 80:20 cotton/mesta blend (8.32). It was also found that the lea strength of 80:20 cotton/mesta blended yarn was highest (214 lb) followed by 100 percent organic cotton yarn (155 lb) and 60:40 cotton/mesta yarn (82 lb). Similarly, the count strength product of the 80:20, cotton/mesta yarn was higher (1780.76) than the 100 percent cotton yarn (1383) followed by 60:40 cotton/mesta blended yarn (1108.64).The statistical analysis of variance and comparison of individual means on the count, strength, count strength product of test yarns was analysed and the results were found to be highly significant. Similarly, all their interactions were recorded at 5% level of significance.

CONCLUSIONS

Cotton yarn gives a high amount of TPI and high extension than blended yarn.Fifty: fifty blends have higher tensile stress, and higher lea strength than the other yarn, and are the finest among the blends.The cotton yarn had a finer count, high lea strength, and more count strength product compared to blended yarns. It was also found that 50:50 blends have high count strength products than the other combination.

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FORMULATION, PHYSICO-CHEMICAL AND SENSORY ASSESSMENT OF INSTANT DHOKLA MIXES PREPARED WITH RED AND WHITE KIDNEY BEAN FLOURS

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ABSTRACT

Value added instant dhokla mixes were prepared by partially replacing the basic dhokla recipe consisting of besan flour (BF) with red kidney bean flour (RKBF) and white kidney bean flour (WKBF) in the year 2021-2022. Four variations of dhoklas were prepared with RKBF and WKBF in the ratio 2:1, 1:2, 1:1 and 0:1 of BF and KBF, respectively and were organoleptically evaluated with 9-point hedonic ranking scale. The mean scores obtained from a panel of 25 judges indicated that the incorporation of KBF in the ratio 2:1 was rendered most acceptable in terms of color (8.36, 8.1), appearance (8.4, 8.4), flavor (8.2, 8.2), taste (8.28, 8.3), texture (8.2, 8.1) and overall acceptability (8.48, 8.1) for dhoklas prepared from RKBF and WKBF, respectively. The nutritional composition of the most accepted formulations of instant dhokla mixes prepared from RKBF and WKBF were, moisture (5.24. 5.16%), protein (15.86, 17.91 g), fibre (1.96, 1.60 g), fat (3.42, 3.16 g), calcium (56.3, 54.39 mg) and iron (5.05, 5.1 mg), respectively.

Keywords: Dhokla, Kidney bean flour, Physico-chemical properties, Sensory assessment

INTRODUCTION

The red kidney bean is an herbaceous annual plant belonging to the family Leguminosae. It is an excellent source of protein (vegetable), fiber both soluble and insoluble, starch and vitamins (Audu *et al*., 2011). Kidney bean is a major source of vegetable protein and dietary fiber as well as other nutrients which are required for older adult or people who have over 65 years of age (Lichtenstein, 2017).

The kidney bean is an excellent source of nutrients which include mineral matter of about 3.5 percent, crude fiber of about 5.1 percent, protein about 22.7 percent, carbohydrates about 57.7 percent, fat about 1 percent. It is low in saturated fatty acids as well as sodium but it is rich in unsaturated fatty acids.

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The kidney beans can be processed into a number of value-added products and suitable for ready-to-use (RTU) products with ease of transportation and labelling and commercialisation. The products are prepared to increase the demand in the market level and they benefit the consumer in terms of health, nutrition and convenience.

Dhokla is a vegetarian food made with fermented batter consisting of rice/semolina and chickpea (Amrutha and Asha, 2014). Dhokla can be eaten for breakfast as the main item or as a snack which is tangy and sweet in taste, soft in texture, hence, liked by elderly people and children. The traditional dhokla is prepared by semolina and chickpea. It is essential to convert it into nutritious dhokla with increase in its nutrient content and physical properties by value addition, so that it can be able to add to a healthy diet. Traditional dhokla preparation requires longer time for fermentation to get the desired texture.

The research presented the formulation of instant dhokla mixes with incorporation of Kidney bean flours: Red Kidney Bean Flour (RKBF), White Kidney Bean Flour (WKBF) and evaluation of its physico-chemical parameters, sensory properties and acceptance.

MATERIALS AND METHODS

Location of the study

A study on formulation, physico-chemical and sensory assessment of instant dhokla mixes prepared with red and white kidney bean flours was conducted at the Department of Foods and Nutrition, College of Community Science, ANGRAU, Lam, Guntur in the year 2021-2022.

Procurement of raw materials

The red variety-Rajmash B3 1404 and white variety-Rajmash B3 1646 of Kidney beans were procured from Regional Agricultural Research Station (RARS), Chinthapalle of Andhra Pradesh state.

Preparation of kidney bean flour

The flow chart for preparation of kidney bean flour with two varieties of kidney beans (Red and White) is presented in Figure 1. The red and white varieties of kidney beans were cleaned thoroughly, blanched at 100 ^{o}C for 20 ^{o}C minutes and soaked over-night at room temperature. The soaked seeds were dehulled manually, dried at 60 ^{o}C for 10 h. The dried seeds were ground into fine powder.The obtained flours:RKBF and WKBF were kept in an air tight container until use.

Preparation of instant dhokla mix and dhokla with RKBF and WKBF

For preparation of ready-to-use Dhokla mix (100g), the prepared kidney bean flours (RKBF, WKBF) and besan flour (BF) in the proportions (ratio) 2:1, 1:2, 1:1, 0:1 respectively were mixed with other ingredients (Table 1and Figure 1), namely 20 g of semolina, 2 g of salt, 6 g of sugar powder, 1 g of turmeric, 0.5 g of baking soda and 0.5 g of citric acid.

Preparation of dhokla with ready-to- use dhokla mix

Hundred grams of ready-to-use dhokla mix was rehydrated with water (Table 1) to obtain thick batter. The batter was fermented up to 2 h at room temperature. The batter was poured into a greased bowl and steam cooked

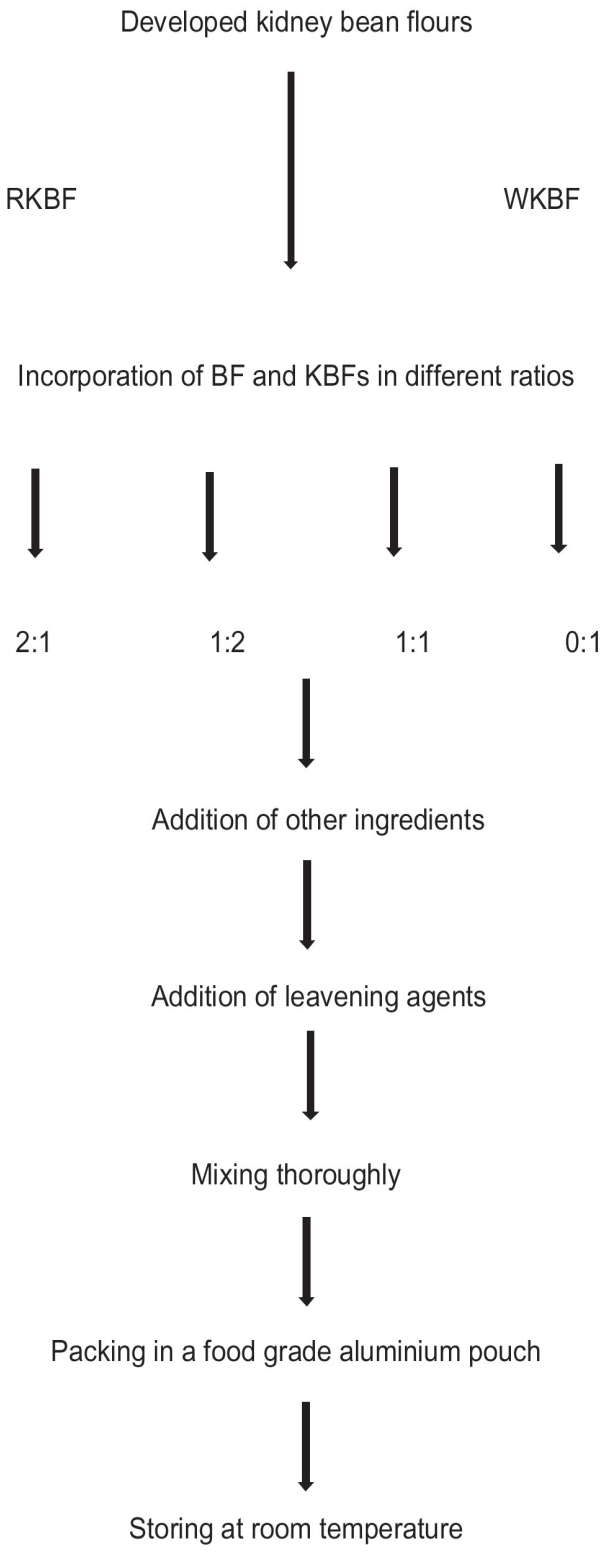

Figure 1. Flow chart for the preparation of instant dhokla mix

for 30 minutes. The obtained dhokla was cut into square pieces and seasoned with mustard, cumin, green chilli.

Physical analysis

Time required for cooking

Difference between the time at which cooker was set on burner and time at which the burner was switched off, was taken as the time required for cooking the dhokla.

Height

A clear transparent ruler (15 cm) was used to measure the height of the dhokla batter and cooked dhokla. The batter prepared was poured in a flat-bottomed utensil. The ruler was placed in the centre and four corners of the vessel until it touches the bottom of the vessel. This value was noted as the height before cooking. Similarly, after cooking, the ruler was placed vertically in the centre as well as the corners to measure the height after cooking.

Weight

The utensil used for cooking was weighed using a digital weighing balance. Then the vessel was weighed after pouring the dhokla batter. This was recorded as weight before cooking. After steaming, the vessel with product was weighed and the value was recorded as weight after cooking.

Porosity

Dhokla was cut into four equal parts and length and breadth were noted for each part. The number of pores on both the sides of four parts were noted and added. The average number of pores per cm^2 was calculated by dividing total number of pores by number of sides. This value was then divided by length

Table 1. Ingredient composition of value added instant dhokla mix with RKBF and WKBF (g)

S. No.	Ingredients	RIDM 1/ WIDM 1	RIDM 2/ WIDM 2	RIDM 3/ WIDM 3	RIDM 4/ WIDM 4
1	Bengal gram flour (g)	47	23	35	0
2	Semolina (g)	20	20	20	20
3	Red Kidney bean flour (g)	23	47	35	70
4	Salt (g)	2	2	2	2
5	Sugar powder (g)	6	6	6	6
6	Turmeric (g)	1	1	1	1
7	Leavening agent (g)	1	1	1	1

multiplied by breadth to obtain final porosity/ cm2 value of Dhokla (Usha *et al.,* 2010).

Sensory evaluation

The Kidney bean flour (RKBF, WKBF) incorporated dhoklas were evaluated by 25 semi-trained panellists. All the panellists tasted the four variations of instant dhoklas prepared with kidney bean flour (4 variations of RKBF and 4 variations of WKBF). For each sample, the panellists were asked to score colour, appearance, flavour, taste, texture and overall acceptability on 9-point hedonic ranking scale (1= dislike extremely, 5= neither like nor dislike, 9= like extremely). The dhoklas were labelled with a three-digit code, served at room temperature on plates and presented simultaneously to the panellists. Panellists did not receive any information about the nature or contents of the dhokla before evaluation.

Nutrient and mineral analysis

Nutrient analysis was carried out for Dhokla instant mixes incorporated with RKBF, WKBF for protein, fat, fibre and moisture by using AOAC (2000). Selected minerals such as calcium and iron were estimated using the Atomic Absorption Spectrophotometry.

Statistical analysis

A one-way analysis of variance (ANOVA) was used to evaluate the impact of incorporation of Kidney bean flour on sensory characteristics of Dhokla.

RESULTS AND DISCUSSION

Time required for cooking

The time required for cooking dhoklas is presented in the Table 2 and Table 3. An increase in time of cooking was observed between the samples in dhoklas made with both the varieties of KBF. The variations RIDM 1 and WIDM 2 took minimal time (20 and 18 minutes) to cook while the variations RIDM 4 and WIDM 4 took maximum time (28 and 26 minutes). Difference in time required for cooking increased by 2-3 minutes with increase in the ratio of KBF. This indicates that the time of cooking is directly proportional to increase in ratio of KBF. The dhoklas incorporated with RKBF took more cooking time (2 minutes) compared to the dhoklas incorporated with WKBF. As the ratio of KBF increased, there was a delay in the steaming

Table 2. Physical parameters of dhoklas incorporated with RKBF

Variations	Physical parameters					
	Height before cooking (cm)	Height after cooking (cm)	Weight before cooking (g)	Weight after cooking (g)	Cooking time (min)	Porosity/ cm^3
RIDM 1	1.3 ± 0.02	2.6 ± 0.34	130	153	20	2.75
RIDM 2	1.3 ± 0.03	2.3 ± 0.40	130	154	25	1.34
RIDM 3	1.3 ± 0.04	2.4 ± 0.06	130	153	22	1.65
RIDM 4	1.3 ± 0.05	2.1 ± 0.14	130	153	27	1.02

Table 3. Physical parameters of dhoklas incorporated with WKBF

Variations	Physical parameters					
	Height before cooking (cm)	Height after cooking (cm)	Weight before cooking (g)	Weight after cooking (g)	Cooking time (min)	Porosity/ cm^3
WIDM 1	1.3.5 ± 0.02	2.6 ± 0.34	130	152	18	2.67
WIDM 2	1.3.5 ± 0.03	2.35 ± 0.40	130	153	24	1.26
WIDM 3	1.3.5 ± 0.04	2.3 ± 0.06	130	153	22	1.79
WIDM 4	1.3.5 ± 0.05	2.2 ± 0.14	130	154	26	1.06

process which resulted in increase of cooking time (Pongjanta *et al.,* 2006).

Weight

The weights of dhoklas before and after cooking is presented in the Tables 2 and 3. Weights were same for all the samples upon rehydration (130 g) before cooking, but increased by 20 g after steaming. There was no significant difference ($p>0.05$) in the weights between samples, indicating that incorporation of KBF did not show any affect the weight of final product.

Height

The heights of dhoklas before and after cooking is presented in the tables 2 and 3. The height of all the samples were same before cooking, but increase in height after steaming was observed. The height of RIDM 1 and WIDM 1 were highest and height of RIDM 4 and WIDM 4 were lowest when compared to other variations. There was no significant difference in height ($p>0.05$) with increase of KBF among samples, but there was significant increase in height of cooked sample when compared to sample height before cooking.

Table 4. Mean scores of sensory parameters of dhoklas incorporated with RKBF

Mean scores							
		Quality parameters					
Product	Formul -ations	Appea -rance	Colour	Flavour	Texture	Taste	Overall Accep- tability
Instant Dhokla mix	RIDM 1	8.40±0.91	8.36±0.86	8.20±0.91	8.20±0.76	8.20±0.93	8.48±0.77
	RIDM 2	7.00±1.15	7.28±1.17	6.92±01.15	7.04±1.39	6.88±1.26	7.04±1.05
	RIDM 3	7.10±1.44	7.32±1.18	6.96±1.54	7.20±1.29	7.12±1.42	7.20±1.32
	RIDM 4	7.30±0.9	7.28±1.20	7.00±1.25	7.16±1.24	6.80±1.5	7.24±0.87
	F value	8.03	5.73	6.30	10.41	6.89	5.04
	CD@5%	0.83	0.82	0.78	0.81	0.78	0.84
	SEM	0.13	0.14	0.11	0.12	0.11	0.14

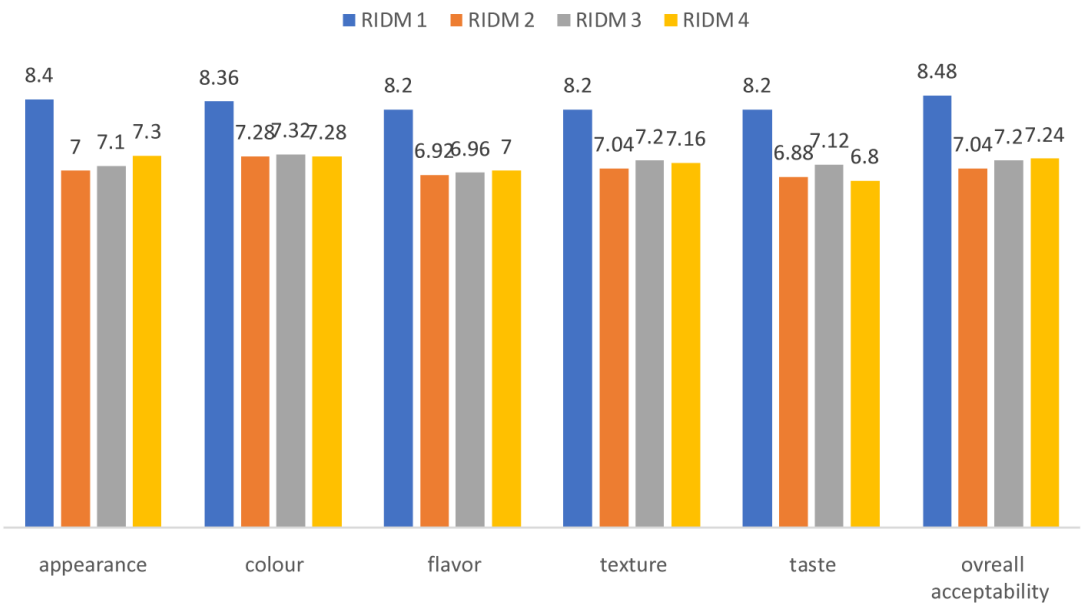

Figure 2. Sensory scores of Dhokla with RKBF

Porosity

The porosity of dhoklas after cooking is presented in the Tables 2 and 3. The porosity decreased with increase in the ratio of KBF. Dhokla with ratio 2:1 in both the varieties (RIDM 1 and WIDM 1) showed higher rate of porosity. And the dhoklas with ratio 0:1 (RIDM 4 and WIDM 4) showed lower rate of porosity. There was no significant difference ($p>0.05$) in porosity between dhoklas prepared with two

Table 5. Mean scores of sensory parameters of dhoklas incorporated with WKBF

Product	Formul-ations	Mean scores					
		Quality parameters					
		Appea rance	Colour	Flavour	Texture	Taste	Overall Accep-tability
Instant Dhokla mix	WIDM 1	8.44±0.76	8.15±0.88	8.23±0.90	8.19±0.84	8.30±0.88	8.19±0.84
	WIDM 2	7.04±1.01	6.92±1.14	7.03±1.22	7.07±1.14	7.00±1.17	7.11±1.05
	WIDM 3	7.12±1.36	6.88±1.39	6.96±1.48	6.85±1.26	6.77±1.31	6.70±1.23
	WIDM 4	7.04±1.24	6.80±1.13	6.88±1.24	6.65±1.09	6.80±1.13	6.61±1.13
	F value	6.75	5.43	7.24	9.76	6.57	5.61
	CD@5%	0.82	0.76	0.76	0.75	0.76	0.74
	SEM	0.13	0.12	0.12	0.11	0.11	0.11

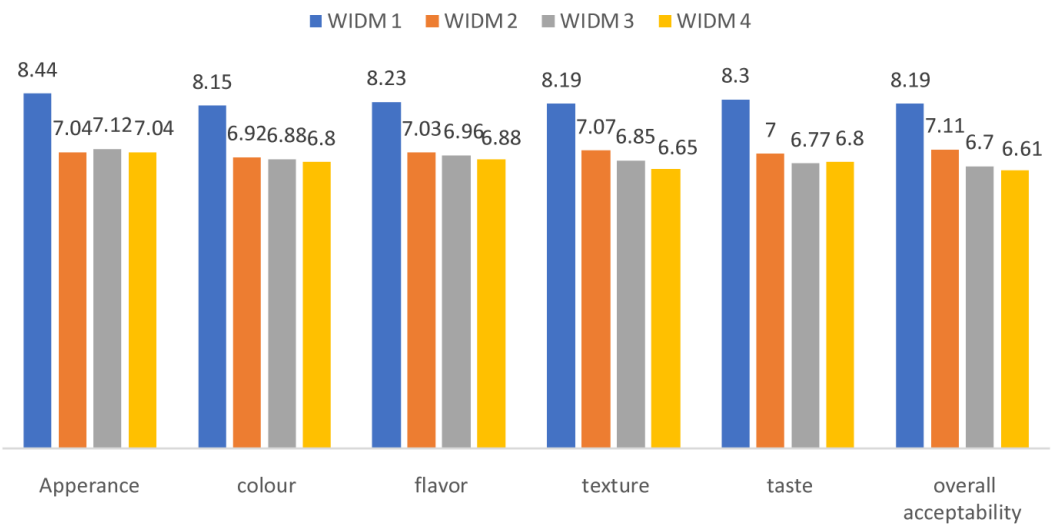

Figure 3. Sensory scores of dhokla with WKBF

varieties of KBF. The increase in the ratio of KBF resulted in more compact dhoklas, indicating that the increase in KBF is inversely proportional to porosity.

The results were on par with the study conducted by Usha *et al.* (2010). Cooking time increased with increase in percent of pumpkin flour in instant dhokla mix. Weight before and after cooking of dhokla was constant and 125g and 150g respectively for 4 formulations. The height decreased with increase in percent of PF from 0.98-0.78 inches. Porosity decreased significantly from 2.76-0.83 cm^3.

Sensory evaluation

Four variations of value-added instant dhokla mixes with incorporation of RKBF and WKBF were prepared. They were evaluated

Table 6. Nutrient and mineral composition of most accepted dhoklas with RKBF and WKBF

	Nutrients	Values per 100 g		
		RIDM 1	WIDM 1	Basic dhokla
1.	Moisture (%)	5.24	5.16	5.48
2.	Protein (g)	15.86	17.91	14.87
3.	Crude Fat (g)	3.42	3.61	2.95
4.	Crude Fiber (g)	1.96	1.60	0.63
5.	Minerals	RIDM 1	WIDM 1	Basic dhokla
6.	Calcium (mg)	56.3	54.39	40.89
7.	Iron (mg)	5.05	5.1	3.95

to obtain the best variation amongst the four. The mean scores and standard deviation for sensory attributes of dhoklas made with RKBF and WKBF are presented in the Tables 4 and 5 and Figures 2 and 3, respectively. The data revealed that mean scores of appearance, colour, flavor, texture, taste and overall acceptability in dhoklas with RKBF and WKBF ranged from 7 to 8.4 and 7.04 to 8.44, 7.28 to 8.36 and 6.8 to 8.15, 6.92 to 8.2 and 6.88 to 8.23, 7.04 to 8.2 and 6.65 to 8.19, 6.8 to 8.2 and 6.77 to 8.3, 7.04 to 8.48 and 6.61 to 8.19, respectively. Incorporation of KBF directly influences the parameter (Daniela *et al.,* 2019), thus, the mean scores for all the attributes decreased gradually with increase in the ratio of KBF in both the varieties. The mean scores were highest for variations RIDM 1 and WIDM 1 with ratio 2:1 and lowest for variations RIDM 4 and WIDM 4 with ratio 0:1 in terms of all the attributes in both the varieties. The data revealed that overall acceptability was highest for the dhoklas made in the ratio 2:1 of BF and KBF. The mean scores of acceptancy were highest for dhoklas incorporated with RKBF when compared to dhoklas incorporated with WKBF.

One way statistical ANOVA ($p<0.05$) indicated significant difference in terms of appearance, color, flavor, texture, taste and overall acceptability in KBF incorporated dhoklas in both the varieties.

The study by Amrutha and Asha (2014), reported the results for value added instant dhokla mix were, the variation D scored uppermost scores than other variations for all sensory characters such as colour (4.80), texture (4.80), taste (4.60), flavour (4.60) and over all acceptability (4.75) on 5-point hedonic scale. In the study conducted by Sweta and Jincy (2017) the data revealed that the mean scores of protein-rich dhokla instant mix for overallacceptability ranged from 6.2, 6.8, 8.1, 7.6 and 7.9.

Nutrient and mineral analysis

The nutritional and mineral composition of most accepted variations of instant dhokla mixes with incorporation of RKBF and WKBF is given (Table 6). Results evidenced that the

values of moisture, crude fat, crude fiber of both RIDM 1 and WIDM 1 were similar. Protein content was more in WIDM 1 (17.91 g) when compared to RIDM 1 (15.81 g). The nutritional and mineral content increased with increase in ratio of KBF in both the varieties of dhokla mixes when compared to basic dhokla mix.

CONCLUSIONS

Incorporation of KBF in different ratios had a significant impact on physical characteristics, sensory parameters and nutritional composition of dhoklas prepared from instant mixes of both varieties. Incorporation of KBF had impact on the physical parameters except the weight of cooked product. Cooking time, height was reduced with increase in the ratio of KBF in both the varieties. The sensory analysis revealed that amount of KBF was inversely proportional to overall acceptability of the products. The variations with ratio 2:1 of BF and KBF in both the varieties (RIDM 1 and WIDM 1) was found to be ideal in terms of physical and sensory parameters. The nutritional and mineral composition of dhoklas incorporated with RKBF and WKBF was increased with increase in the ratio of KBF.

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PREVALENCE OF HIDDEN HUNGER (MICRONUTRIENT DEFICIENCY) AMONG THE HANDLOOM WEAVERS IN WESTERN ODISHA

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ABSTRACT

The objective of the research was to assess the prevalence of hidden hunger (micronutrient deficiency) among the handloom weavers of western Odisha. A sample size of 320 comprising of 170 male and 150 female respondents were selected randomly from four villages of Ulunda and Birmaharajpur blocks of Odisha in the year 2019-2020. The results indicated that the majority of male (58.23%) and female (50%) weavers had normal Body Mass index. Both male and female respondents had low vitamin A, vitamin C, calcium, and iron intake in comparison to RDA(Recommended Dietary Allowances) irrespective of all BMI categories. It was interesting to note that the thiamine, riboflavin, and sodium intake of both male and female weavers were found to be excess in comparision to RDA. Niacin intake of both male and female weavers was found to be excess in comparision to RDA for Obese-II respondents *i.e.* 8.55% and 7.57%, respectively. No significant mean difference between actual zinc and potassium intake of the respondents in comparision to RDA, ICMR Gopalan *et al.* (2016) was found in this study.

Keywords: Micro Nutrient Deficiency (MND), Minerals, Nutrients, Vitamins, Weavers

INTRODUCTION

The prevalence of hidden hunger or micronutrient deficiency is a global challenge. It is not only a problem for children or mothers but also a problem for people of all age groups. As per FAO (2017), Worldwide, about 800 million people are chronically hungry, which means they are undernourished in terms of calories and more than two billion people are affected by hidden hunger, meaning that they suffer from micronutrient deficiencies.

Although progress was made in reducing these problems, ending hunger in all its forms – as stated in the Sustainable Development Goals (SDGs) remains a global challenge (FAO *et al.,* 2017; Barrett, 2010; Stokstad, 2015; Obersteiner *et al*.(2016); Allen and Brauw, (2018). The 2019 EAT-Lancet Commission report showed except for 5% of rich Indians, the average daily intake of calories of Indians was below the recommended *i.e*.(2503 kcal/capita/day). The consumption of

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fruits, vegetable legumes, meat, fish and eggs was significantly lower. The share of calories from protein sources was only 6–8%, compared to 29% in the reference diet. These findings were akin to those of the National Nutrition Monitoring Bureau (NNMB) surveys in India, which showed that cereal-based Indian diets had resulted in rampant qualitative deficiency of micronutrients particularly, vitamins A, B2, B6, B12, folic acid, and Vitamin C, and minerals such as iron, zinc, and calcium Bamji *et al.* (2021).

Studies conducted by the National Institute of Nutrition, Hyderabad, India (2019) also showed a high prevalence of vitamin deficiencies, particularly, vitamins A, B2, B6, B12, folic acid, and vitamin D even in the well-fed Indians from middle-income group Siva Prasad *et al.*(2019).

Handloom weavers constitute a marginal community of western Odisha. Their contribution to the Indian economy is also next to agricultural farmers. While many development programs are floating for the betterment of agriculture farmers and to scale up their economic condition such programs for the weaving community are meagre. Low income perpetuates lower living conditions and deficient dietary intake followed by poor health conditions. Implementation of different food supplementation programs may fulfil the calorie need of the drown-trodden population to some extent but handling problems related to micronutrient deficiency in the general population is still an issue. Therefore, the researcher designed this study to examine the "Prevalence of Hidden hunger (Micro Nutrient Deficiency) among Handloom Weavers of Western Odisha''.

MATERIALS AND METHODS

The research was carried out in the Ulunda and Birmaharajpur blocks of the Sonepur district of western Odisha. Two villages were selected from each block having the highest number of handloom weavers for the study. An exploratory cum descriptive research was adopted for the study and the purposive sampling method was followed. The study was conducted from 2019-2020. Three hundred twenty (320) handloom weavers comprised of 170 male and 150 female respondents in the age group of 20-60 years were selected from the total population. All handloom weavers were interviewed on a pretested schedule and their dietary intake was assessed by using the 24-hour recall method. The use of everyday household utensils and models of portion sizes was used to estimate the quantity of food they had consumed. The average food intake was calculated for each respondent with special reference to micronutrients such as vitamins A and C, Thiamine, Riboflavin, Niacin, Folates /B9, Calcium, Iron, Phosphorous, Potassium, Sodium, Copper, and Zinc. The actual mean micronutrient intake of the respondents was calculated according to their nutritional status (BMI) and compared with the standard values of RDA of ICMR Gopalan *et al.* (2016) for moderate workers. BMI as per WHO classification (Asian) was used to assess the nutritional status of the respondents (2010). Since weaving work is done by sitting in loom

Table 1. Recommended Dietary Allowances (RDA) of micronutrients for moderate worker, as per ICMR

S. No	Nutrients	RDA	
		Male	Female
1	Vitamin A (mug/d)	4800	4800
2	Vitamin C(mg/d)	600	400
3	Thiamine(mg/d)	1.4	1.1
4	Riboflavin(mg/d)	1.6	1.3
5	Niacin(mg/d)	18	14
6	Folates /B9(ug/d)	200	200
7	Calcium(mg/d)	600	400
8	Iron(mg/d)	17	21
9	Phosphorous (mg/d)	600	600
10	Potassium(mg/d)	3750	3225
11	Sodium(mg/d)	2100	1900
12	Copper(mg/d)	1.7	1.7
13	Zinc(mg/d)	12	10

Gopalan *et al.* (2016)

RESULTS AND DISCUSSION

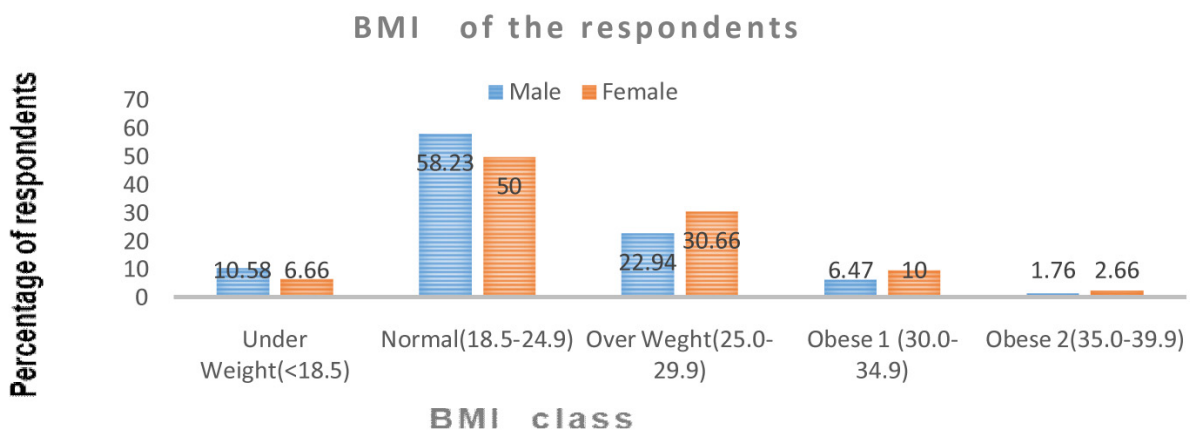

Fig 1. Distribution of the respondents based on their BMI

for longer periods of time and moving within a limited area of work place, so weavers were considered as moderate workers in this study

Figure 1 showed the information on the BMI of weavers which depicts that most of the male, as well as female weavers, had normal BMI *i.e.* 58.23 % and 50%, respectively. It was observed that the majority of male weavers were underweight whereas the maximum percentage of female weavers were overweight, obese-I, and obese-II in comparision to their counterparts. Usharani (2014) found in their study that more male weavers were underweight or normal whereas more percentage of female weavers were overweight, obese-I, and obese-II which is at par with the findings of the study.

Vitamin intake of male weavers

The data in Table 2 delineates the vitamin intake of respondents according to their BMI class. It was observed that vitamin A intake was 1967 IU, 2571.04IU, 2799.81 IU, 3168.37 IU, and 3449.66 IU for underweight, normal, overweight, obese-I, and obese-II category male weavers, respectively, which was found to be deficient in comparision to RDA irrespectively. There was no significant association found between vitamin A intake and the BMI category of the respondents. Similarly, Thiamine intake was found to be deficient for underweight, normal, and overweight respondents in comparision to RDA that is 0.87%,1.04%, and 1.42% respectively whereas it was found to be excess in comparison to RDA for obese-I and obese-II respondents *i.e.* 20% and 54.28%, respectively. However, consumption of riboflavin intake was found to be excess in comparision to RDA for all BMI category respondents. There was significant relation found between riboflavin intake and normal, overweight, obese-I, and obese-II male respondents respectively except for underweight respondents. Niacin intake was found to be deficient for underweight, normal, and overweight respondents in comparison to RDA that is 38.27%, 37.83%, and 11.11% respectively. which was found to be excess in comparison to RDA for obese-I and Obese-II respondents *i.e.* 3.33% and 8.55%, respectively. Folate (Vitamin-B9) and vitamin C intake of all respondents were found to be deficient in comparision to RDA which varied from 18.61% to 38.90% and 2% to 65.35%, respectively. However, no statistically significant difference was found in the intake of niacin, folate and vitamin C among the male respondents according to their BMI. Similar, findings were also observed by Chitrotpala (2016) that folic acid intake was deficient among farmers varied from 15.5% to 24.84%.

Shalini *et al.* (2018) found in their study that the dietary inadequacy of riboflavin, niacin, calcium, vitamin A, vitamin C and thiamine was about 63%, 60%, 57%, 48%, and 42%, respectively which are similar to the findings of the present data except for riboflavin.

Mineral intake of male weavers

The data in Table 3 showed an association between the mineral intake of male respondents with their BMI status. It was interesting to note that the percentage of deficiency for calcium intake of respondents was found to be very less intake in comparision to RDA irrespective of their BMI which varied from 48.38% to 77.74%. Shalini *et al*. (2018) found in their study that the dietary inadequacy of calcium was 58%, which was similar to the findings of this data. Similarly, Iron intake was

also found to be deficient for all respondents in comparision to RDA which varied from 27.94% to 54.64 %. It is interesting to observe that phosphorous intake was found to be excess in comparison to RDA in all respondents which varied from 3.89% to 146.61%. Statistically, a significant association was also observed between their phosphorous intake and BMI. Similarly, sodium intake was found to be excess in comparision to RDA in all respondents which varied from 45.28% to 47.15%.However, potassium intake was found to be deficient in comparision to RDA in all respondents which varied from 8.74% to 60.32%, whose association was also found to be insignificant. Zinc intake was found to be deficient for underweight, normal, and overweight respondents in comparision to RDA that is 44.33%, 38.58%, and 3.83%, respectively, whereas, it was found to be excess in comparision to RDA for obese I and obese II respondents *i.e.* 0.08% and 19.41%, respectively. No significant association between actual zinc intake and RDA was found in the study. Interestingly, Copper intake was also found to be excess in comparision to RDA in all the respondents which varied from 58.23% to 77.88% but no statistically significant association was found between copper intakes to RDA. A similar observation was also found by Prasetyo *et al*. (2018) that the prevalence of micronutrient deficiencies in Indonesian adults was 54.2%, 36.4%, and 74.3%, for calcium, iron, and zinc, respectively.

Vitamin intake of female weavers

Table 4 depicts the vitamin intake of female weavers to their BMI status. It was found that vitamin A intake was a deficit in all respondents which varied from 38.45% to 76.04%. There was no significant relationship found between vitamin A intakes of female respondents according to their BMI category. Similarly, thiamine intake was also found to be a deficit for underweight, normal respondents in comparison to RDA, 15.45% and 4.15% respectively, however, it was found to be excess for overweight, obese I, and obese II respondents in comparison to RDA that is 7.24%, 11.54% and 54.54%. It was interesting to note that riboflavin intake was found to be excess in comparision to RDA in all the respondents 85.38% to 127.69%. However mean intake of niacin was found to be a deficit for underweight, normal, weight, and obese -I female respondents in comparision to RDA is 23.14%, 13.64%, 3.07% and 0.007%, whereas, it was found to be excess for obese II respondents in comparision to RDA that is 15.06%. Folate (B9) intake was also found to be a deficit in comparision to RDA for all respondents which varied from 35.44% to 15.64%.Similarly, ascorbic acid intake was found to be a deficit in underweight, normal, and overweight respondents in comparision to RDA which is 32.75%, 13.25%, and 9.6%, whereas, it was found to be excess for obese I and obese II respondents in comparision to RDA that is 1.6% and 6.72%. Usharani (2014) found in their study inadequate intake of â carotene by 86 percent of respondents which was almost at par with the Vitamin-A deficiency of respondents. Similar findings were also observed by Prasetyo *et al*. (2018) that the prevalence of micronutrient deficiencies in Indonesian adults was 44.8% and 71.4% for vitamins A and C, respectively. Similarly, Chitrotpala (2016) in her study also found that the adequacy of all nutrients namely beta-carotene, folic acid, and vitamin C, were lower than Recommended Dietary Allowances (RDA)

for women marginal farmers and small farmers in Odisha.

Mineral intake of female weavers

Table 5 showed the mineral intake of female weavers concerning their BMI. It was interesting to note that the mean intake of calcium was found to be deficient at 50.79 % to 70.7% in comparision to RDA irrespective of their BMI category and it was observed that the percentage of deficiency decreased with the betterment of their nutritional status. The mean intake of iron was found to be deficient in comparison to RDA for all female weavers which varied from 14.57% to 67.38%. The percentage of deficiency was more for overweight respondents *i.e.* 67.38% and less for the obese I category. Chitrotpala (2016) found in their study that iron intake was lowest for small farmers (10.75 mg/day) followed by landless laborers (11.98 g/day) and for marginal farmers (14.94 g/day).However, phosphorus intake was found to be excess in comparision to the RDA of all respondents which varied from 62.37% to 88.23%, and a statistically significant difference between actual intake and RDA was found among underweight, obese-I, and obese-II respondents. The potassium means intake was found to be deficient in comparision to RDA for all respondents, which varied from 24.36% to 47.48%. Similarly, the Zinc intake was found to be a deficit in comparision to the RDA of all female respondents which varied from 4.2% to 28.6%. Zinc deficiency was found among all respondents which was more for underweight and less for obese-II category female respondents. Sodium mean intake was found to be excess in comparision to RDA for female respondents which varied from 86.05% to 89.42% and excess intake was more for obese-II followed by overweight respondents. However, the mean intake of copper was found to be excess in comparision to the RDA of all female respondents which varied from 32.35% to 65.88% and excess intake was more for obese-II respondents. A statistically significant difference was also found between the actual mean intake of copper and RDA of all respondents. Similar findings were also observed by Chitrotpala (2016) in her study that the adequacy of all nutrients namely calcium, iron, and fibre was lower than Recommended Dietary Allowances (RDA) for female marginal farmers and small farmers in Odisha.

Comparision of vitamin intake of male and female respondents

The data of Table 6 delineates the percentage of deficit/excess vitamin intake of respondents to BMI. It was observed that the deficiency of vitamin A intake of male weavers is more in comparison to female weavers. The percentage of deficiency of thiamine intake for underweight male weavers was found to be more than for female weavers, whereas the percentage of deficiency of thiamine of female respondents was found to be more in the normal and overweight BMI categories. However, in the case of the obese-II BMI category thiamine intake of male respondents was excess in comparision to female respondents. However, no significant excess intake of thiamine in the obese-I category was found in this study. Riboflavin intake of female weavers was found to be excess in comparision to obese-I and obese-II male weavers irrespective of their BMI, whereas, niacin intake of underweight, normal, and overweight BMI category males was more as compared to female weavers of the same BMI categories.

Folate (vitamin B9) intake of male respondents was also more as compared to all BMI category female respondents. Similarly, ascorbic acid intake of underweight, normal, overweight, obese-I, and obese-II BMI categories male weavers was more deficient as compared to female weavers of the same BMI categories. However, in Obese-I and Obese-II BMI categories female weavers had an excess intake of vitamin C as compared to RDA but male respondents had deficiencies. Prasetyo *et al*. (2018) found in their study that the prevalence of vitamins A and C in women was lower than in men. Similarly, Shalini *et al*.(2018) also found in their study that the nutrient intakes of vitamin A, thiamine, riboflavin, niacin, B12, zinc, and folate intake were significantly lower in women than in men ($p < 0.05$).

Comparision of mineral intake of male and female respondents

Table 7 reveals the percentage of deficit/ excess mineral intake of respondents to BMI. It was observed that the calcium intake of male weavers belonging to the underweight, normal, overweight, and obese-I BMI categories was found to be less as compared to female weavers. But female weavers having Obese-II BMI category had more calcium deficits as compared to male weavers. The phosphorus intake of male respondents was found to be deficient in comparision to RDA but female respondents had excess phosphorus intake as compared to RDA of all BMI categories. Iron intake of male respondents was found to be excess in comparison to RDA, whereas, in the case of female respondents iron intake was found to be deficient as compared to RDA irrespective of BMI categories. Shalini *et al.* (2018) found in their study that the nutrient intakes of iron were significantly lower in women than men ($p < 0.05$), which was similar to the findings of the present data. Similarly, the potassium intake of male weavers for normal, underweight, and overweight BMI categories were found to be more deficient as compared to female weavers of the same BMI categories. But in the underweight, Obese-I, and Obese-II BMI categories percentage of potassium intake was found to be more deficient in female respondents. Copper intake was found to be more excessive among women respondents irrespective of their BMI. The percentage of deficiency of zinc intake was found to be more in underweight, normal, obese-I, and obese-II BMI male respondents whereas it was found to be more deficit in overweight respondents. Prasetyo *et al*. (2018) also found in their study that the prevalence of calcium and iron deficiencies in women was higher than in men, where as zinc, intake in women was lower than in men.

CONCLUSIONS

The results of the study revealed that both male and female respondents were deficient in vitamin A, vitamin C, calcium, and iron intake in comparison to RDA irrespective of all BMI categories, whereas, Thiamine (obese-I and II), riboflavin, niacin (obese-II) and sodium intake of both male and female weavers were found to be excess in comparision to RDA, respectively. No significant association for both male and female respondents for actual zinc and potassium intake and RDA was found in this study. Thus, extensive research needs to be carried out in this direction and necessary steps may be taken to handle the challenges related to hidden hunger at the grass root level.

Table 2. Actual mean vitamin intake of the male weavers in comparision to ICMR (RDA) (n=320)

S. No.	Vitamin intake / BMI Class		Vitamin A(mcg)	Thiamin(mg)	Riboflavin(mg)	Niacin(mg)	(Folates /B9(ug)	Ascorbic Acid /Vitamin C(mg)
		RDA per 100gm	4800	1.4	1.6	18	200	40
1	Under Weight	Actual mean intake	1967.07	0.87	2.11	11.11	120.19	14.26
		%Deficit/Excess	-59.01	-37.85	+31.87	-38.27	-39.90	-64.35
		z/t Test	-32.13^{NS}	-15.58^{NS}	-5.89^{NS}	7.7S	10.77^{S}	-13.32^{NS}
2	Normal	Actual mean intake	2571.04	0.97	2.35	11.19	139.02	23.03
		%Deficit/Excess	-46.43	-30.71	+46.87	-37.83	-30.49	-42.42
		z/t Test	-32.91 ^{NS}	-7.04 ^{NS}	2.37 ^{S}	-2.35 ^{NS}	-8.73 ^{NS}	-7.90 ^{NS}
3	Over Weight	Actual mean intake	2799.81	1.42	2.56	16.004	146.14	35.91
		%Deficit/Excess	-41.67	-1.42	+60	-11.11	-26.93	-10.25
		z/t Test	-10.42 ^{NS}	0.04 ^{NS}	2.77 ^{S}	-1.36 ^{NS}	-13.87 ^{NS}	-1.29 ^{NS}
4	Obese I	Actual mean intake	3168.37	1.68	2.68	18.60	152.59	37.08
		%Deficit/Excess	-33.99	+20	+67.5	+3.33	-23.70	-7.3
		z/t Test	-9.52 ^{NS}	0.91 ^{NS}	10.43 ^{S}	-1.82 ^{NS}	-7.30 ^{NS}	-3.07 ^{NS}
5	Obese II	Actual mean intake	3449.66	2.16	2.7	19.54	162.78	39.2
		%Deficit/Excess	-28.13	+54.28	+68.75	+8.55	-18.61	-2
		z/t Test	-11.53 ^{NS}	-11.36 ^{NS}	11.84 ^{S}	-14.56 ^{NS}	-78.79 ^{NS}	-0.31 ^{NS}

Source –Gopalan *et al.* (2016) S- Significance at 0.05 level, NS-Not significant

Table 3. Actual mean mineral intake of the male weavers in comparision to ICMR (RDA) (n=320)

S. No.	Mineral intake BMI Class		Calcium(mg)	Iron(mg)	Phosphorus(mg)	Potassium(mg)	Sodium(mg)	Zinc(mg)	Copper(mg)
	RDA per 100gm		600	17	600	3750	2100	12	1.7
1	Under Weight	Actual mean intake	133.53	7.71	623.38	1488.17	3051.40	6.18	2.004
		%Deficit/Excess	-77.74	-54.64	+3.89	-60.32	+45.28	-44.33	+17.88
		Z/t test	-55.93 NS	-32.40 NS	7.64 S	-35.03 NS	7.22 NS	-22.92 NS	2.76 S
2	Normal	Actual mean intake	160.53	8.80	982.82	1639	3053.30	7.37	2.38
		%Deficit/Excess	-73.24	-48.23	+63.80	-56.29	+45.33	-38.58	+40
		Z/t test	-7.90 NS	-33.43 NS	12.53 S	-5.81 NS	15.90 S	-38.80 NS	2.57 S
3	Over Weight	Actual mean intake	186.83	9.35	1152.002	2419.02	3069.86	11.54	2.64
		%Deficit/Excess	-68.86	-45	+92.0003	-35.49	+46.14	-3.83	+55.29
		Z/t test	67.59 S	-5.13 NS	11.17 S	-25.99 NS	13.57 S	6.97 S	3.84 S
4	Obese I	Actual mean intake	216.44	10.31	1237.72	2643.91	3076.66	12.01	2.56
		%Deficit/Excess	-63.92	-39.35	+106.28	-29.49	+46.50	+0.08	+50.58
		Z/t test	-40.75 NS	-13.34 NS	6.61 S	-8.11 NS	5.80 NS	0.008 NS	4.68 S
5	Obese II	Actual mean intake	307	11.31	1479.66	2919.02	3090.33	14.33	2.69
		%Deficit/Excess	-48.38	-33.47	+146.61	-6.14	+47.15	+19.41	+58.23
		Z/t test	-93.71 NS	-27.94 NS	4.87 S	-8.74 NS	24.46 S	-21.89 NS	1.01 NS

Source –Gopalan *et al.* (2016) S- Significance at 0.05 level, NS-Not significant.

Table 4. Actual mean vitamin intake of the female weavers in comparision to ICMR (RDA) (n=320)

S. No.	Vitamin intake / BMI Class		Vitamin A(mcg)	Thiamin(mg)	Riboflavin(mg)	Niacin(mg)	(Folates /B9(ug)	Ascorbic Acid /Vitamin C(mg)
	RDA per 100gm		4800	1.1	1.3	14	200	40
1	Under Weight	Actual mean intake	1149.93	0.93	2.41	10.76	129.12	26.90
		%Deficit/Excess	-76.04	-15.45	+85.38	-23.14	-35.44	-32.75
		z/t Test	-7.74 NS	-3.13 NS	7.86 S	-3.07 NS	-10.24 NS	-2.29 NS
2	Normal	Actual mean intake	1988.99	1.15	2.57	12.09	145.53	34.70
		%Deficit/Excess	-58.56	+4.15	+97.69	-13.64	-27.23	-13.25
		z/t Test	-8.04 NS	0.18 NS	5.94 S	-4.13 NS	-10.63 NS	-2.07 NS
3	Over Weight	Actual mean intake	2360.54	1.18	2.73	13.57	146.87	36.16
		%Deficit/Excess	-51.94	+7.27	+110	-3.07	-26.56	-9.6
		z/t Test	-10.66 NS	0.27 NS	7.84 S	-0.63 NS	-10.06 NS	-1.26 NS
4	Obese –I	Actual mean intake	2720.15	1.26	2.81	13.99	153.31	40.64
		%Deficit/Excess	-43.33	+14.54	+116.15	-0.07	-23.34	+1.6
		z/t Test	-4.95 NS	1.03 NS	13.32NS	-0.002 NS	-6.62 NS	0.25 NS
5	Obese- II	Actual mean intake	2954.25	1.7	2.96	15.06	168.72	42.69
		%Deficit/Excess	-38.45	+54.54	+127.69	+7.57	-15.64	+6.72
		z/t Test	-11.07 NS	1.50 NS	8.16 S	0.51 NS	-3.17 NS	1.53 NS

Source –Gopalan *et al.* (2016) S- Significance at 0.05 level, NS-Not significant

Table 5. Actual mean mineral intake of the female weavers in comparision to ICMR (RDA) (n=320)

S. No.	Mineral intake / BMI Class		Calcium(mg)	Iron(mg)	Phosphorus(mg)	Potassium(mg)	Sodium(mg)	Zinc(mg)	Copper(mg)
	RDA		600	21	600	3225	1900	10	1.7
1	Under Weight	Actual mean intake	117.18	8.67	974.25	1693.59	3535	7.14	2.25
		%Deficit/Excess	-80.47	-58.71	+62.37	-47.48	+86.05	-28.6	+32.35
		z/t Test	21.10 NS	-19.27 NS	6.70 S	-10.52 NS	15.19 NS	-6.39 NS	4.17 S
2	Normal	Actual mean intake	159.24	9.71	1020.24	1963.15	3552	7.16	2.63
		%Deficit/Excess	-73.45	-53.76	+70	-39.12	+78.66	-28.4	+54.7
		z/t Test	61.60 NS	11.61 S	-18.92 NS	-5.69 NS	43.97 S	-16.13 NS	3.47 S
3	Over Weight	Actual mean intake	173.28	9.85	1082.84	2013.79	3583.56	7.77	2.67
		%Deficit/Excess	71.12	-67.38	+80.47	-37.55	+88.60	-22.3	+57.05
		z/t Test	51.68 NS	10.08 S	-31.62 NS	-16.0 NS	31.80 S	-11.46 NS	3.84 S
4	Obese I	Actual mean intake	176.13	12.27	1109.60	2157.91	3561	8.48	2.75
		%Deficit/Excess	-70.64	-14.57	+84.93	-33.08	+87.42	-15.2	+61.76
		z/t Test	27.40 NS	-2.70 NS	8.30 S	-6.70 NS	21.30 S	-2.57 NS	2.26 S
5	Obese II	Actual mean intake	196.84	14.02	1129.40	2439.25	3599	9.58	2.82
		%Deficit/Excess	67.19	-33.23	+88.23	-24.36	+89.42	-4.2	+65.88
		z/t Test	2.69S	-5.72 NS	5.39S	-4.07 NS	10.97 S	-0.25 NS	2.69 S

Source –Gopalan *et al.* (2016) S- Significance at 0.05 level, NS-Not significant

Table 6. Percentage of deficit/excess vitamin intake of respondents in relation to BMI

(n=320)

S. No.	Vitamin intake BMI Class		Vitamin A(mcg)	Thiamin (mg)	Riboflavin(g)	Niacin(m)	(Folates /B9(ug)	Ascorbic Acid /Vitamin C(mg)
1	Under weight	Male	-59.01	-37.85	+31.87	-38.27	-39.90	-64.35
		Female	-76.04	-15.45	+85.38	-23.14	-35.44	-32.75
2	Normal	Male	-46.43	-25.71	+46.87	-37.83	-30.49	-42.42
		Female	-58.56	+4.15	+97.69	-13.64	-27.23	-13.25
3	Overwei ht	Male	-41.67	-1.42	+60	-11.11	-26.93	-10.25
		Female	-51.94	+7.27	+110	-3.07	-26.56	-9.6
4	Obese I	Male	-33.99	+20	+67.5	+3.33	-23.70	-7.3
		Female	-43.33	+14.54	+116.15	-0.07	-23.34	+1.6
5	Obese I	Male	-28.13	+54.28	+68.75	+8.55	-18.61	-2
		Female	-38.45	+54.54	+127.69	+7.57	-15.64	+6.72

Comparision of mineral intake of male and female respondents

Table 7. Percentage of deficit/excess mineral intake of respondents in relation to BMI

(n=320)

S No.	Mineral intake BMI Class		Calciur (mg)	Phospho us (mg)	Iron (mg)	Potassiu (mg)	Sodium (mg)	Zinc (mg)	Copper (mg)
1	Under Weight	Male	-77.74	-54.64	+3.89	-60.32	+45.28	-44.33	+17.88
		Female	-70.7	+62.37	-58.71	-47.48	+86.05	-28.6	+32.35
2	Normal	Male	-73.24	-48.23	+63.80	-56.29	+45.33	-38.58	+40
		Female	-60.19	+70	-53.76	-39.12	+78.66	-28.4	+54.7
3	Over Weight	Male	-68.86	-45	+92.0003	-35.49	+46.14	-3.83	+55.29
		Female	-58.68	+80.47	-67.38	-37.55	+88.6	-22.3	+57.05
4	Obese I	Male	-63.92	-39.35	+106.28	-29.49	+46.50	+0.08	+50.58
		Female	-55.96	+84.93	-14.57	-33.08	+87.4	-15.2	+61.76
5	Obese II	Male	-48.38	-33.47	+146.61	-6.14	+47.15	+19.41	+58.23
		Female	-50.79	+88.23	-33.23	-24.36	+89.42	-4.2	+65.88

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COMPARATIVE STUDY OF THE SOLID WASTE DISPOSAL PRACTICES OF HOUSEHOLDS IN SELECTED TOWN PANCHAYAT AND URBAN AREAS OF COIMBATORE

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ABSTRACT

The study was conducted in the year of 2022 to evaluate households' solid waste disposal practices in selected town panchayat and urban regions of Coimbatore and to determine the association between household solid waste disposal and selected socio-demographic variables.Town panchayat and urban areas of Coimbatore were examined for this research. Fifty samples of town panchayat and urban families were evaluated for the study. It was observed that urban households dispose of solid garbage more effectively than town panchayat families. It was revealed that some socio-demographic variables, such as place of residence, education level of homemakers, and household income were correlated with disposal techniques. Most town panchayat homes utilize door-to-door collection services to dispose of unsorted rubbish. As per this study, individuals primarily throw out non-segregated trash because they do not care, and sanitation staff does not encourage them to throw away only segregated waste. Therefore, public participation is crucial for solid waste management, as it minimizes both municipal labour and the costs associated with garbage separation. Municipalities can also develop public awareness about solid waste management and establish rigid rules on disposal of non-separated trash so as to increase the practice of waste segregation .

Keywords: Disposal of waste, Household practices, Segregation of waste, Solid waste Management.

INTRODUCTION

The amount and composition of municipal solid garbage have substantially expanded due to rising urbanization, changes in lifestyle and eating trends (Kiran *et al.,* 2015). Coimbatore, which has a population of over 1.8 million, is estimated to create approximately 1,300 metric tons of garbage daily. The per capita generation of solid waste in Coimbatore is roughly 800 g and consists primarily of rubbish from houses, hospitals, and industrial organizations, depending on the

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population's economic status (Thyagarajan *et al.,* 2021).

According to Noufal *et al.*(2020), households have a crucial part in the solid waste stream and waste management. According to Thyagarajan *et al.* (2021), most of the city's mixed garbage consists of moist market waste and dry non-biodegradable debris. This waste is placed in the Vellalore-Kurichi area of Coimbatore. Only 40 percent of the city's waste gets processed before being composted, while the other 60 percent is just deposited in an unplanned landfill area. From these dumped products, runoff spills into water bodies, generating a foul odour, drawing flies, polluting the soil, and reducing the rate of soil penetration, among other detrimental repercussions for the population (Ntagisanimana *et al.*, 2021).

Mixed garbage is ineffective as a resource unless source-separation practices are implemented. Society must devise means to limit and repurpose garbage (Pandey, 2014). Waste reduction and management depend on waste segregation, which is also necessary for efficient waste management. Due to insufficient source segregation measures, Indian towns can only compost 0.21 percent of their dumped wet waste (The Hindu, 2013). The increasing amount of municipal waste generation, the difficulty of allocating and managing higher municipal waste costs within local government budgets, and a lack of scientific understanding have all hampered solid waste management in the urban environment. This presents a significant challenge to local government in the developing countries. Technical interrelationship stages of municipal solid waste management and public support are required to create an appropriate environment for resolving municipal solid waste management issues (Saja *et al.,* 2021). Source separation of 100 percent of waste is only feasible with the cooperation of the people. The study was undertaken to analyze the solid waste disposal practices of households in selected town panchayat and urban regions of Coimbatore and to study the relationship between solid waste disposal practices and selected socio-demographic variables of families.

MATERIALS AND METHODS

Coimbatore is an industrial city in the Indian state of Tamil Nadu. The city has an area of 257.36 sq. km and a population of 1.8 million. It is organized into five zones, each of which contains 100 wards. According to the corporation's data, 5,06,009 households generate around 815 tons of solid waste daily, of which 50 percent are compostable, whereas, 40 percent of the city of Coimbatore's total waste is thrown in a mixed waste landfill in Vellalore.

Regarding garbage management, urban areas generate more waste than rural places. The population density in metropolitan settings will always result in substantial garbage output.Villages have less industries, urbanization, vehicles, etc. and more high-quality plantings than contemporary cities, which results in less pollution. Additionally, there were significant differences in the facilities offered for collecting residential waste. As a result, the researcher was interested in selecting one urban area and one town panchayat using the method of convenience

sampling in order to observe the disposal procedures used in these two distinct locations. Karamadai was identified for town panchayat, whereas, Saibaba colony was selected as the urban area. Karamadai is conveniently located near the Tamil Nadu neighbourhood of Mettupalayam in northern Coimbatore. The Saibaba colony is located west of the Sivananda colony and north of the Vadakovai. The respondents were selected using a purposive sample method to guarantee that the survey would represent homemakers.The study was carried out from April 2021 to June 2021.

One hundred residences were surveyed, fifty from a town panchayat (Karamadai) and fifty from an urban region (Saibaba Colony) of Coimbatore. An interview schedule was utilized to collect information from the families to determine the solid waste disposal behaviours in both locations. A total of eight statements were asked to elicit the information regarding solid waste disposal practices by the families except general information. Using Chi-square analysis, the relationship between solid waste disposal practices and the demographic and socioeconomic features of the samples was examined.

RESULTS AND DISCUSSION

Table 1 represents that about 81 percent of homes were nuclear, and 19 percent were joint families. Seventy-nine percent of families had less than five individuals, while 21 percent had five to seven persons. A maximum of 61

Table 1. Socio-demographic variables of the selected samples

S.No.	Variables	Category	Total n=100	Town panchayat (n=50) (%)	Urban (n=50) (%)
1	Family Structure	Nuclear	81	84	78
		Joint	19	16	22
2	Family size	Less than 5	79	84	74
		5-7	21	16	26
3	Education level	Illiterate	11	20	2
		High School	61	64	58
		Graduate	28	16	40
4	Age	21-40	27	18	36
		41-60	56	62	50
		61 & Above	17	20	14
5	Household income *	Up to Rs. 12,000/month	54	50	58
		Rs. 12,001 – Rs. 18,000/ month	34	36	32
		Rs. 18,001 – Above	12	14	10

Source: * Tamil Nadu Housing Board (TNHB) Scheme (2022)

percent of homemakers had a high school education, 28 percent had bachelors degree, and 11 percent were illiterate. Fifty-six percent of the homemakers were 41-60 years old, 17 percent were above 61 years and 27 percent were of 21-40 years. A maximum of 54 percent of families had a monthly income below Rs. 12000, 34 percent between Rs.12001 and Rs. 18000, and 12 percent over Rs.18001.

A maximum of 84 percent of town panchayat homes were nuclear, and 16 percent were joint families. Only 22 percent of joint families were identified inmetropolitan regions compared to 78 percent of nuclear families. This showed the breaking up of joint families even in town panchayat. Family size and standard of life may affect solid waste production. Subramani and Ponkumar (2012) found that living standards, business activities, housing conditions, and individual habits and preferences affect municipal solid waste production.

Eighty-four percent of town panchayat families and seventy-four percent of urban families had less than five individuals. Noufal *et al.* (2020) found that family size, monthly income, educational attainment, gender and age of the head of the household are relevant factors in predicting solid waste generation and composition.

A maximum of 64 percent of town panchayat homemakers had a high school education, 16 percent had bachelors, and 20 percent were illiterate. In comparision, 58 percent of urban homemakers had a high school education, 40 percent had a bachelor's, and only, two percent were illiterate. It demonstrates that urban household literacy is better when compared to town panchayat.It is disheartening to note that 20 percent of town panchayat households still have illiterates. Sixty-two percent of homemakers in the town panchayat were between 41-60 years old, 20 percent were older than 61 years and 18 percent were of 21-40 years. In urban households surveyed, 50 percent of homemakers were in the age group of 41-60 years old, 36 percent were 21-40 years, and 14 percent were 61 years or older.

Half of town panchayat families earned less than Rs.12000 per month; 36 percent earned between Rs.12001 and Rs.18000; 14 percent earned Rs.18001 or more. Among urban families, 58 percent had a monthly income below Rs.12000, 32 percent between Rs.12001 and Rs.18000, and 10 percent over Rs.18001.

Biodegradable and non-biodegradable solid waste exists in all households. Biodegradable garbage includes decomposing kitchen and yard waste. Landfills are filled with non-biodegradable trash. Dry landfill waste does not decompose. They harm the environment and the public. Solid waste disposal ensures a clean environment. It encourages recycling and sustainability (Jeremy, 2015). Table 2 showed garbage disposal habits of selected households.

Homemakers (100%) or domestic help (9%) only disposed off the solid garbage in all the surveyed households. According to Noufal *et al.* (2020), solid waste management activities are family jobs. Hence, the primary responsibility for solid waste management within the home falls on women since they are

Table 2. Solid waste disposal practices followed in the selected households

S.No	Variables	Category	Total n=100	Town panchayat (n=50) (%)	Urban (n=50) (%)
1	The person in charge of house hold waste disposal	Homemakers	100	100	100
2	Provision of a suitable bin	Yes	100	100	100
3	No. of waste bins used	One	37	54	20
		Two	46	36	56
		Three	12	6	18
		Four & above	5	4	6
4	Type of waste collected in bins	Collection of biodegradable waste and non-biodegradable waste	51	22	80
		Collection of combined waste	42	68	16
		Segregating only non-biodegradable waste	7	10	4
5	Disposal methods followed	Disposing on roads	9	18	-
		Putting trash in the street dumps	6	-	12
		Keeping a waste bin for door-to-door collection	70	62	78
		Dumping on the roadside when the door-to-door collection was unavailable	15	20	10
6	Frequency of waste disposal	Every day	81	64	98
		in two days once	4	8	-
		in three days once	4	8	-
		Once a week	2	2	2
		When sufficient garbage is collected	7	14	-
		Dispose of trash when the sanitary collector arrives	2	4	-
7	Segregation of waste	Yes	60	36	84
		No	40	64	16

expected to monitor household chores and deal with the household garbage.

Table 2 showed that 100 percent of families have a proper bin for disposing of domestic garbage, suggesting an awareness of safe waste collection at home. In urban areas, 56 percent of families had two trash bins because they segregated waste. However, in the town panchayat, only 36 percent of households used two bins for segregated waste, and 54 percent had only one bin for unsegregated waste. This highlights the public and employees' responsibilities to separate garbage has to be emphasized. Eighty percent of urban dwellings and 22 percent of town panchayat families utilized a suitable rubbish container. Four percent of urban families and 10 percent of town panchayat households collected only non-biodegradable trash such as plastic bottles and glass. It is because the families used biodegradable garbage (vegetable and fruit peels and leftover food waste) as natural garden fertilizer through composting and as fodder for cows and goats. Ninety-eight percent of urban and 64 percent of town panchayat residences disposed of trash daily. This illustrates that rubbish disposal depends on municipal employees' service.The methods followed in the disposal of solid waste by the selected households are signified in Figure 1.

Figure 1 showed that 62 percent of town panchayat households kept waste bins for door-to-door collection, 20 percent of households threw waste on roads when door-to-door collection was not provided, and 18 percent of households regularly disposed of garbage on roadsides since the municipality made no provision for disposal of wastes by the households. Seventy-eight percent of urban and 62 percent of town panchayat households used door-to-door rubbish collection. Due to administrative limits, door-to-door collecting services are restricted in the town panchayat. Despite the corporation's services in metropolitan areas, 12 percent of the households dumped trash on the street bins as a result of their desire to avoid paying the garbage collector. Ten percent of town panchayat homes dumped rubbish on highways without a door-to-door pick up. Urban areas have more door-to-door collecting than town panchayat areas. Food trash, which can be composted, and recyclable plastics, which

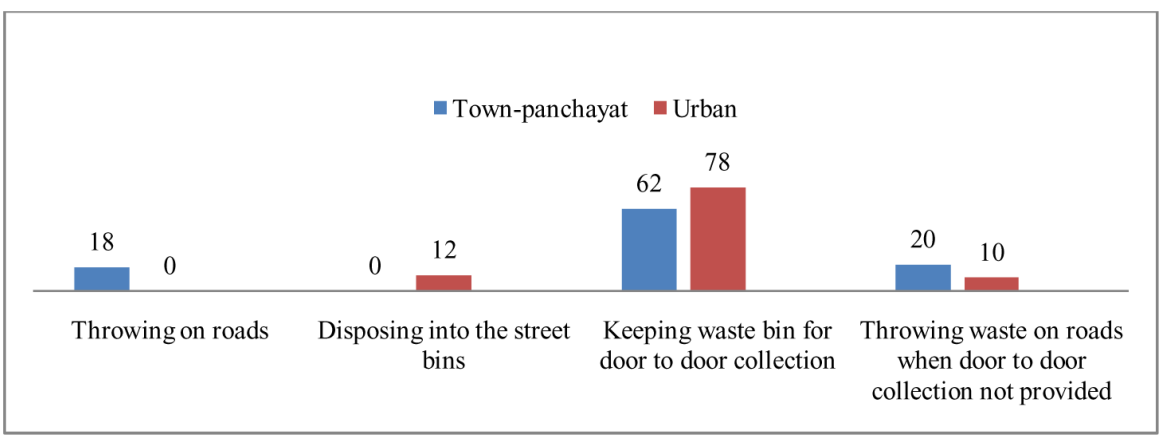

Fig.1. Methods of solid waste disposal practiced by the households (in percentage)

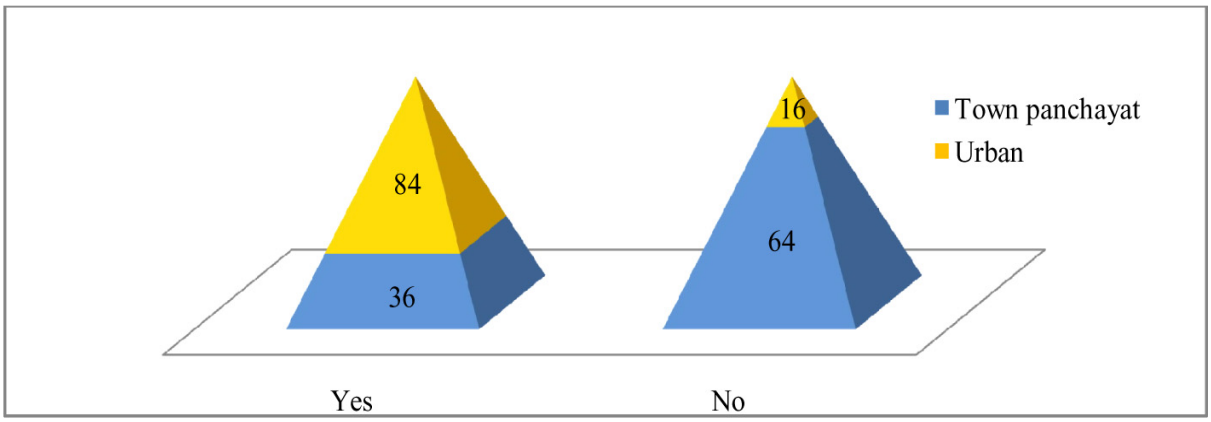

Figure 2. Segregation of domestic waste by selected households (in percentage)

are often thrown away without separation, make up the bulk of household solid waste, according to Fadhullah *et al.* (2022) Households and those responsible for garbage disposal must be taught the proper methods to dispose of solid waste to protect future generations.

Figure 2 showed the segregation of domestic waste followed by the surveyed households.

Figure 2 showed the details of the families who separate biodegradable and non-biodegradable trash before disposing it. Eighty-four percent of urban people obeyed sanitation authorities' instructions to separate their waste before disposal. In contrast, just 36 percent of town panchayat households did so.

Table 3. Solid waste disposal practices followed in the selected households (n=40)

S.No.	Variables	Category	Total no. of respondents who are not segregating the waste		
			Total n=40(%)	Town panchayat (n=32)(%)	Urban (n=8) (%)
1	Reason for not segregating the waste	1. Not concerned	16(40)	15(47)	1(12.5)
		2. Dumping the waste in open places due to irregular door to door collection and shortage of street bins	17(42.5)	14(44)	3(37.5)
		3. Sanitation workers did not insist on waste segregation	3(7.5)	3(9)	-
		4. No different street bins to dispose wet and dry waste	4(10)	-	4(50)

Table 4. Association between waste management procedures followed and location of the households

S. No.	Disposal practices		Area: Town panchayat n=50 (%)	Area: Urban =50 (%)	Total n=100(%)	p value
1	No. of waste bins used	One	27(54.0)	10(20.0)	37(37.0)	0.004**
		Two	18(36.0)	28(56.0)	46(46.0)	
		Three	3(6.0)	9(18.0)	12(12.0)	
		Four & above	2(4.0)	3(6.0)	5(5.0)	
		Total	50(100.0)	50(100.0)	100(100.0)	
2	Type of waste collected in bins	Collection of biodegradable waste and non-biodegradable waste	11(22.0)	40(80.0)	51(51.0)	0.000**
		Collection of combined waste	34(68.0)	8(16.0)	42(42.0)	
		Segregating only non-biodegradable waste	5(10.0)	2(4.0)	7(7.0)	
		Total	50(100.0)	50(100.0)	100(100.0)	
3	Disposal methods followed	Deposing on roads	9(18.0)	-	9(9.0)	0.001**
		Putting trash in the street bins		6(12.0)	6(6.0)	
		Keeping waste bin for door-to-door collection	31(62.0)	39(78.0)	70(70.0)	
		Dumping on the roadside when the door-to-door collection was unavailable	10(20.0)	5(10.0)	15(15.0)	
		Total	50(100.0)	50(100.0)	100(100.0)	
4	Segregation of waste	Yes	18(36.0)	42(84.0)	60(60.0)	0.000**
		No	32(64.0)	8(16.0)	40(40.0)	
		Total	50(100.0)	50(100.0)	100(100.0)	

Note: *Figures in parenthesis indicate the percentage; ** Significant at 1% level

Table 3 depicts that 40 percent of residences surveyed revealed that they did not care how garbage was disposed of, while 42.5 percent stated they dumped trash in places owing to a shortage of street bins and uneven door-to-door service rendered. Seven and half percent of households claimed that sanitation employees did not insist on waste segregation, and 10 percent of residences had no specific street receptacle for segregated garbage. These reasons were given for not sorting the waste.

Table 4 displays the chi-square test used to examine the link between the number of bins used by individual, the kind of garbage collected in bins, the disposal methods used, and the waste segregation by residential area.

Table 4 represents that the chi-square test used to investigate the correlation between the number of bins people use and the area of residence. It was determined to be statistically significant at the 1 percent level because the P value was less than 0.01 (P<0.01).Table 4 demonstrates that home solid waste disposal methods in town panchayats and urban areas vary considerably (P<0.01). The central system for collecting solid waste in town panchayats and urban zones consisted of door-to-door garbage collection. As a consequence of the inconsistent services offered by door-to-door collection providers, it is clear that households are dumping their garbage in open places. In support of this, Noufal *et al.* (2020) asserted that inadequate and unreliable trash collection services provided by local authorities and waste contractors led residents to use unlawful waste disposal techniques to clear their residential areas of waste. These techniques include burning, burying, and disposing waste in open fields. According to Akmal and Jamil (2021), door-to-door collecting is prevalent in the majority of developed countries. Due to budgetary and administrative constraints, however, municipalities in underdeveloped countries may only offer this service to a limited portion of the population.

The chi-square test found a statistically significant link between trash segregation and residential area (P<0.01), as shown in Table 4. Similar findings were reported by Boateng *et al*. (2016). They concluded that location significantly influences waste disposal and that there are geographical variances in the waste situation between urban and rural populations in Ghana.Homemakers' education levels can significantly impact household solid waste disposal habits, such as the number of bins individuals use, the kind of garbage collected in bins, the disposal methods used, and the segregation of waste by residential area.

The chi-square test revealed a significant relationship between trash disposal techniques and homemaker education level (P<0.01). Homemakers' education levels can significantly impact household solid waste disposal habits (Table 5).Tang *et al.*(2022) discovered that inhabitants with more excellent education are more inclined to assist in garbage sorting. Residents may gain crucial knowledge about garbage sorting via education. More extended schooling and higher education levels lead to a better awareness of the environment and make it simpler for citizens to engage in activities such as sorting domestic garbage. In their research, Eshwari *et al*. (2019) reported

Table 5. Association between disposal practices and homemaker's educational level

S.No.	Disposal practices		Homemaker's educational level				
			Illiterate n %	High School n %	Graduate n %	Total n%	p value
1	No: of waste bins used	One	7(63.6)	28(45.9)	2(7.1)	37(37.0)	0.001**
		Two	3(27.3)	23(37.7)	20(71.4)	46(46.0)	
		Three	-	6(9.8)	6(21.4)	12(12.0)	
		Four & above	1(9.1)	4(6.6)	-	5(5.0)	
		Total	11(100.0)	61(100.0)	28(100.0)	100(100.0)	
2	Type of waste collected in bins	Collection of biodegradable waste and non-biode gradable waste	-	29(47.5)	22(78.6)	51(51.0)	0.000**
		Collection of combined waste	9(81.8)	28(45.9)	5(17.9)	42(42.0)	
		Segregating only non-bio degradable waste	2(18.2)	4(6.6)	1(3.6)	7(7.0)	
		Total	11(100.0)	61(100.0)	28(100.0)	100(100.0)	
3	Dispos-al methods followed	Throwing on roads	2(18.2)	5(8.2)	2(7.1)	9(9.0)	0.004**
		Disposing into street bins	-	5(8.2)	1(3.6)	6(6.0)	
		Keeping waste bin for door-to-door collection	3(27.3)	44(72.1)	23(82.1)	70(70.0)	
		Throwing waste on roads when door-to-doorcollection is not provided	6(54.5)	7(11.5)	2(7.1)	15(15.0)	
		Total	11(100.0)	61(100.0)	28(100.0)	100(100.0)	
4	Segregation of waste	Yes	2(18.2)	35(57.4)	23(82.1)	60(60.0)	0.001**
		No	9(81.8)	26(42.6)	5(17.9)	40(40.0)	
		Total	11(100.0)	61(100.0)	28(100.0)	100(100.0)	

Note: *Figures in parenthesis indicate the percentage; ** significant at 1% level

Table 6. Association between disposal practices and household Income

S.No.	Disposal practices		Total household income on a monthly basis				
			Up to Rs.12000 n %	Rs.12001– Rs.18000 n %	Rs. 18001 & above n %	Total n%	p value
1	No of waste bins used	One	23(42.6)	11(32.4)	3(25.0)	37(37.0)	0.172
		Two	18(33.3)	20(58.8)	8(66.7)	46(46.0)	
		Three	9(16.7)	2(5.9)	1(8.3)	12(12.0)	
		Four & above	4(7.4)	1(2.9)	-	5(5.0)	
		Total	54(100.0)	34(100.0)	12(100.0)	100(100.0)	
2	Type of waste collected in bins	Collection of biodegradable waste and non-biodegradable waste	27(50.0)	18(52.9)	6(50.0)	51(51.0)	0.707
		Collection of combined waste	24(44.4)	14(41.2)	4(33.3)	42(42.0)	
		Segregating only non-biodegradable waste	3(5.6)	2(5.9)	2(16.7)	7(7.0)	
		Total	54(100.0)	34(100.0)	12(100.0)	100(100.0)	
3	Disposal methods followed	Throwing on roads	5(9.3)	4(11.8)	-	9(9.0)	0.495
		Disposing into the street bins	5(9.3)	-	1(8.3)	6(6.0)	
		Keeping waste bin for door-to-door collection	36(66.7)	24(70.6)	10(83.3)	70(70.0)	
		Throwing waste on roads when door-to-doorcollection is not provided	8(14.8)	6(17.6)	1(8.3)	15(15.0)	
		Total	54(100.0)	34(100.0)	12(100.0)	100(100.0)	
4	Segregation of waste	Yes	30(55.6)	21(61.8)	9(75.0)	60(60.0)	0.446
		No	24(44.4)	13(38.2)	3(25.0)	40(40.0)	
		Total	54(100.0)	34(100.0)	12(100.0)	100(100.0)	

Note: *Figures in parenthesis indicate the percentage

a greater level of education and employment as variables influencing waste management knowledge and behaviour. The relationship between family income and disposal behaviours is depicted (Table 6). It is evident that the chi-square test revealed no significant link between home solid waste disposal techniques and household income (Table 6). However, Sabarinath (2017) asserts that households with low incomes or limited financial resources are less likely to sort their rubbish due to a lack of home space and an inability to purchase dustbins.This may be due to the restricted financial resources of families.

CONCLUSIONS

Urban inhabitants dispose off their segregated household waste better than town panchayats. Chi-square analysis found a statistically significant link ($P<0.01$) between household location and solid waste disposal technique, as well as homemaker education level. People did not care about proper disposal of rubbish, sanitation staff do not insist on suitable method of disposing segregated waste, and there are no biodegradable dumpsters on the street. Cities may enhance garbage segregation by educating the citizens and enforcing littering regulations. Establishing a street bin and increasing door-to-door collection may assist communities in minimizing garbage in public places. Regional waste management office should educate and emphasize on composting. Small-scale community composting may assist to speed up these endeavors.

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PLAY BEHAVIOUR OF SELECTED PRIMARY SCHOOL CHILDREN OF ASSAM

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ABSTRACT

The study aimed to find out the type of play behaviour adopted by the children of primary school in Biswanath, Assam in the year 2022. The size of the sample was 600 primary school children in the age group of 6-8 years selected through random sampling technique. A self constructed questionnaire was used to identify social and non-social play behaviour among the children. The study revealed that children of 8 years had higher social play behaviour when compared to children between ages of 6 and 7 Years. Study also reported that children living in joint family had higher social play behaviour than those of nuclear family. No gender difference in children's play behaviour was found.

Keywords: Assam, Play behaviour, Primary School children

INTRODUCTION

Play is a normative child behavior with defining characteristics. Play has a significant contribution towards children's physical as well as psychological development. According to the Oxford English Dictionary (2021), play is an activity done for pleasure. Play develops relationship between a child and the environment, which happens naturally and is uninhibited by imagination. In addition, play is the basis for developmentally appropriate practice for children which ensures foundation for their learning (Frost and Sutterby, 2017). Children use their optimum maturity level in order to carry out play activities more enjoyable which may not be seen in other daily activities. Therefore, it is necessary to teach children in play way method, which will assure a pleasant learning experience for them, help in acquiring knowledge and skills and make them competent (Pasek *et al.,* 2008).

Play behaviour of children

Play is a regular and spontaneous activity where children engage in various play activities depending on their age and interest. Play behaviour of children differs from individual to individual. According to Parten (1932), children show six categories of play behaviour, the first four categories are classified under non-social or semi-social play

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activities which includes- 1) Unoccupied play behaviour where the child does not have any intentions or focus towards their activities; The child might stare blankly or roam without any aim; 2) Onlooker play behaviour involves observation of other children's activities without participating in peer activities; 3) Solitary play behaviour is where the child is playing separately from other children and paying little or no attention to other children; he is fully engage in his own activities; and 4) Parallel play behaviour is where the child plays near other children but not playing with them. Additionally, socially interactive play involves two categories which are- Associative and Co-operative play behaviour. Associative play behaviour involves interaction with other children where children might use similar materials for play but they rarely engage in communication. Whereas, Co-operative play involves group activity that is organized in order to carry out some activities to attain a particular goal. Peer interaction is important for the overall development of children. In particular, child's interactions among peers, in the form of co-operation, conflict, opposition, as well as friendly discussion, assists the child to increase an understanding of the self. Even children experience themselves indirectly through peer responses. Thus, relationship with peers is essential for developing the skills for co-operation, compromise, empathy and altruism (Rubin *et al.,* 2012). Friendship with peers involve dyadic relationships including *closeness and reciprocity* resulting in social play. In addition, lack of peer relations more often show non-social behaviour such as social reticence, decrease in prosocial behavior, academic difficulties and low self- esteem in children (Buhs *et al*., 2006; Coyne *et al*., 2011). Therefore, helping children in establishing good relation with peers through social play is of utmost important as play behaviours provide a significant clues about interaction and communication of children with their peers and also with their social competence behaviour (Magdalena, 2015; Uyanýk *et al.,* 2018). Identifying play behaviour of children helps parents and teachers to provide positive environment for the optimum development of children as well as to enhance better learning environment and help minimizing the negative consequences of future life.

MATERIALS AND METHODS

The study is a descriptive study conducted in Biswanath district of Assam in the year 2022. The purpose of the study was to identify play behaviour of children including social and non-social play behaviour in the primary school of Biswanath, Assam. A total of 600 primary school children in the age group of 6-8 years, covering the North, South, East and West zone of Biswanath district, Assam were selected as sample for the study. The sample were chosen through random sampling technique.

A self-constructed questionnaire on play behaviour was constructed to assess play behaviour of children. The questionnaire includes both i) socio-demographic profile and ii) play behaviour of the sample. The questionnaire included a total of 40 statements with both social and non-social play behaviour. A reliability and validity test were done for the self-constructed questionnaire with the help of Chronbach's alpha and the total value of overall variable was 0.975. The structure of the questionnaire was of 5-point Likert scale with options of 'Strongly Disagree', 'Disagree', 'Somewhat Agree', 'Agree' and 'Strongly

Agree'. The maximum score of the play behaviour scale was 200 and minimum score was 40. The higher score indicated better social play behaviour and lower score showed higher non- social play behaviour of children. The range was decided based on the acquired mean value for each dimensions and overall play behaviour score.

The questionnaires were distributed to the mothers of the selected sample for collecting the required data. An assurance was given by the researcher that the collected data will be used only for research and will remain confidential.

RESULTS AND DISCUSSION

The study aimed to identify play behaviour of primary school children in the age group of 6- 8 years in Biswanath, Assam based on age, gender and family type of primary school children. Results of the study obtained through the mothers of the children. Study analysed different social and non-social play behaviour including unoccupied, solitary, onlooker, anxious, associative, co-operative play behaviour and games with rules of the children. Data were analysed through appropriate statistical measures such as mean, SD, t-test, and ANOVA test. Data regarding Demographic characteristics of the respondents are shown in the Table 1.

Table 1 showed that majority (34.2%) of the respondents were in the age group of 8 years. Among the sample number of male children were more (51.5%) than female children and also most (58%) of the children were living in nuclear family.

Level of play behaviour of children

Data obtained from the respondents regarding Social and Non-social play behaviour is shown in the Figure 1 and Table 2.

From the Figure 1, it is observed that more than fifty percent of the children had average score followed by high and low level in play behaviour. This indicates that most of the primary school children showed average social play behaviour while some children showed high social play behaviour and some showed low level of social play behaviour.

From the Table 2, it is found that in case of non-social play behaviour 36.7% of the children scored high in unoccupied play behaviour, 47.7% scored high in solitary, 23.3%

Table 1. Distribution of respondents according to their demographic characteristics

S. No.	Demographic Characteristics(n=600)		n	%
1.	Age (years)	6	194	32.3
		7	201	33.5
		8	205	34.2
2.	Gender	Male	309	51.5
		Female	291	48.5
3.	Type of family	Nuclear	348	58
		Joint	252	42

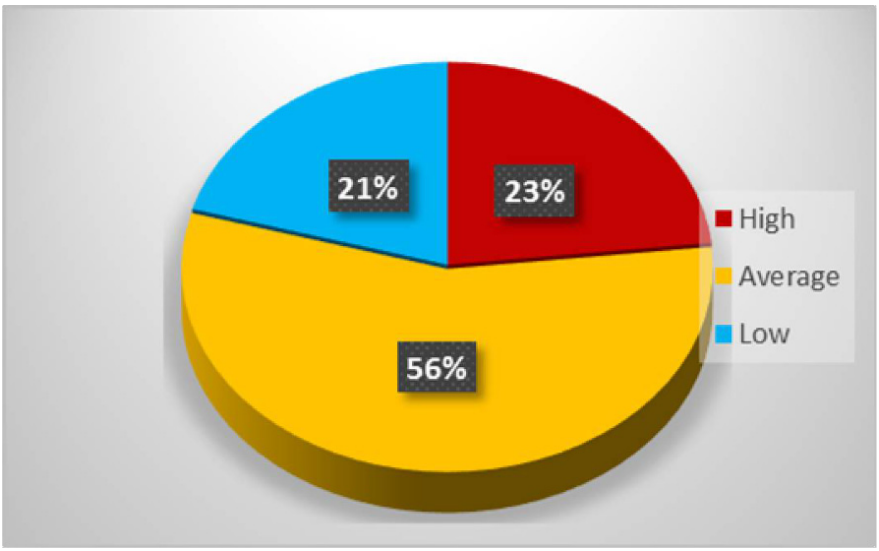

Figure 1. Distribution of level of play behaviour of respondents

had high score in onlooker and 32.05% had high score in anxious behaviour. On the other hand in social play behaviour, it is observed that majority (43.8%) of children had higher score in associative and 36.2% had higher score in cooperative play behaviour. In case of games with rules, it is observed that percentage of children scored in low category was more (28.7) than that of high category.

From the results, it can be stated that in non-social play including unoccupied, solitary, onlooker play behaviour and anxious behaviour children of primary school (6-8) years scored high which indicates they were engaged less in non-social behaviour. Usually, children come across peer influence when they enter school to a certain extent because they are surrounded by peers, but also because they're

Table 2. Distribution of level of play behaviour of respondents on different dimensions (based on multi-responses of the respondents)

S. No.	Play behaviour	High		Average		Low	
		N	%	N	%	N	%
1.	**Non-social**						
	Unoccupied	220	36.7	188	31.3	192	32
	Solitary	286	47.7	213	35.5	101	16.8
	Onlooker	134	22.3	374	62.3	92	15.3
	Anxious	192	32.0	264	44.0	143	23.8
2.	**Social**						
	Associative	263	43.8	208	38.0	109	18.2
	Cooperative	217	36.2	245	40.8	137	22.8
	Games with rules	164	27.3	263	43.8	172	28.7

developmentally proficient of caring what others think. Thus, children get exposure to interact with peers and learn to be independent in absence of parents. With the friendship with peers, children gratifies their need for belongingness through acceptance or attraction in the group, and also the need for relationship which is satisfied through friendly interactions with peers. By participating in the group coordinates their behaviours and attains the common goal (Cheah *et al*., 2001; Whitman, 2018). Play is the mediator through which children learn new skills and practice those learned skills while playing with the peers and thereby increases peer relations. During school years, social play becomes an integral part of the children. When a child grows, involving in social play rises as children become more aware with other children and become familiar with their environment and thus have a tendency to play with peers (Gray, 2017). In addition, the child's peer relationships allows the child to develop a sense of belonging within the group. Thus, children of primary school enjoys playing in a group rather than playing alone and hence they engage in more social play behaviour as compared to non-social play behaviour.

Level of play behaviour of primary school children based on age

From the Table 3, it is observed that majority of the children in the age group of 8 years had highest score in unoccupied, solitary, onlooker, anxious, associative, cooperative and games with rules than those of 6 years and 7 years children. Results also revealed that there is a significant difference among children in the age group of 6 years, 7 years and 8 years in the play behaviour with various dimensions namely- unoccupied, solitary, onlooker, anxious, associative, co-operative and games with rules.

From the results it is revealed that children of 8 years had higher score in social play as compared to children of 6 and 7 years. Right after entering school children gets new environment out of home where he starts interacting with peers in the absence of parents. During school period, children experience various environment of challenges which help them in shaping themselves in variety of ways, both playing in pairs, small and large groups and also during interaction with peers. (Sorlie *et al.,* 2021). As the children grow and progressively increase their shared environment, school becomes an essential ground where children both learn and practice their learned social behaviour. Children learns through interacting with peers and peer relation becomes a part of their life. After spending years at school, the amount of time the children of 8 years spend interacting with peers right after entering school rises from about 10% to more than 30% and the peer group becomes much larger as compared to peer groups of earlier years (Rubin *et al*., 2012). Thus, the extent to which children of 8 years feel socially integrated and recognized in the classroom determines their performance working in a group and results in involvement of more social play instead of non-social play (Ladd *et al.,* 2012). On the other hand children who are shy displays more non-social behaviors like onlooker, unoccupied, which in turn, associates with less social play (Stefania *et al*., 2022).

Play behaviour of primary school children based on gender

From the results of Table 4, it is revealed that majority of the female children scored high

Table 3. Distribution of level and differences in play behaviour of children based on age (in reference to multi-responses of the respondents)

S. No.	Play behaviour	Age	High		Average		Low		Mean	SD	F value
			N	%	N	%	N	%			
1.	**Non-Social**										
	Unoccupied	6 years	66	31.3	67	31.8	78	37.0	8.12	2.55	.029*
		7 years	68	34.9	68	34.9	59	30.3	8.32	2.47	
		8 years	86	44.3	53	27.3	55	28.4	8.80	2.78	
	Solitary	6 years	86	40.8	89	42.2	36	17.1	19.18	4.41	.043*
		7 years	96	49.2	70	35.9	29	14.9	19.61	4.51	
		8 years	104	53.6	54	27.8	36	18.6	20.36	5.24	
	Onlooker	6 years	36	17.1	144	68.2	31	14.7	11.31	2.73	.026*
		7 years	43	22.1	122	62.6	30	15.4	11.62	3.02	
		8 years	55	28.4	108	55.7	31	16.0	12.12	3.37	
	Anxious	6 years	65	30.8	92	43.6	54	25.6	14.06	3.30	.000**
		7 years	58	29.7	90	46.2	47	24.1	14.60	3.63	
		8 years	70	36.1	82	42.3	42	21.6	15.68	4.12	
2.	**Social**										
	Associative	6 years	83	39.3	89	42.2	39	18.5	17.06	4.59	.006*
		7 years	82	42.1	79	40.5	34	17.4	17.46	4.66	
		8 years	98	50.5	60	30.9	36	18.6	18.59	5.56	
	Cooperative	6 years	73	34.6	89	42.2	49	23.2	28.20	6.53	.000**
		7 years	86	44.1	73	37.4	36	18.5	29.70	7.26	
		8 years	99	51.0	50	25.8	45	23.2	31.51	9.06	
	Games with Rules	6 years	57	27.0	89	42.2	65	30.8	13.82	2.67	.000**
		7 years	50	25.6	95	48.7	50	25.6	14.13	2.90	
		8 years	61	31.4	80	41.2	53	27.3	15.10	3.92	
	Total	6 years	31	14.7	135	64.0	45	21.3	111.76	23.48	.000**
		7 years	41	21.0	117	60.0	37	190	115.44	25.60	
		8 years	68	35.1	84	43.3	42	21.6	122.16	30.91	

*Significant at 5% level; ** highly significant at 1% level

Table 4. Distribution of Level and differences in play behaviour of children based on gender (in reference to multi-responses of the respondents)

S. No.	Play Behaviour	Gender	High		Average		Low		Mean	SD	t-test
			n	%	n	%	n	%			
1.	**Non-social**										
	Unoccupied	Male	112	36.2	86	27.8	111	35.9	8.29	2.60	.246 NS
		Female	108	37.1	102	35.1	81	27.8	8.54	2.62	
	Solitary	Male	146	47.2	110	35.6	53	17.2	19.64	4.83	.733 NS
		Female	140	48.1	103	35.4	48	16.5	19.77	4.65	
	Onlooker	Male	70	22.7	190	61.5	49	15.9	11.61	3.07	.621 NS
		Female	64	22.0	184	63.2	43	14.8	11.74	3.04	
	Anxious	Male	100	32.4	129	41.7	80	25.9	14.74	3.69	.890 NS
		Female	93	32.0	135	46.4	63	21.6	14.78	3.80	
2.	**Social**										
	Associative	Male	138	44.7	118	38.2	53	17.2	17.57	5.00	.560 NS
		Female	125	43.0	110	37.8	56	19.2	17.80	4.97	
	Cooperative	Male	131	42.4	110	35.6	68	22.0	29.70	7.68	.847 NS
		Female	127	43.6	102	35.1	62	21.3	29.82	7.87	
	Games with Rules	Male	90	29.1	132	42.7	87	28.2	14.17	3.11	.182 NS
		Female	78	26.8	132	45.4	81	27.8	14.52	3.37	

NS= Non significant at 5% level

in unoccupied play, solitary and cooperative play behaviour as compared to male children. Regarding onlooker, co-operative, games with rules and anxious behaviour, male children scored high than those of female children. The results also indicates that there is no statistically significant difference in unoccupied, solitary, onlooker, anxious, associative, co-operative, and games with rules between male and female children.

Results also revealed that there is no significant difference in social and non- social behaviour among male and female children. School plays important role in socialization of gender attitude, behavior of children. Teachers as well as peers shape children's attitudes results in gender differences in behaviour of children. Teachers who believe in gender stereotypes and prejudices and receive less training in recognizing and combating those stereotypical behaviour, often expect and lay the foundation for gender differences among their children. Thus, most of the schools maintain the traditional gender stereotypical behaviour rather than neutralizing biases and behaviour (Bigler and Rebecca, 2013). In this study the association between gender-typed play behaviour was not moderated by sex, however, the researcher did not found any differences in their play behaviour as well.

Play behaviour of primary school children based on type of family

Data acquired from the study was also analysed based on family type of children for both social and non-social play behaviour and results are discussed in the Table 5.

From Table 5, it can be observed that majority of the children living in the joint family scored high in unoccupied, solitary, onlooker, associative, cooperative play behaviour and games with rules than children of nuclear family. With regard to anxious behaviour it was found that majority of children of nuclear family showed high score in anxious play behaviour than children of joint family. Results of the study also revealed that there is no significant differences in unoccupied, solitary, onlooker, anxious and associative play behaviour among the children of nuclear family and children of joint family. Significant difference was found in the co-operative play behaviour and the games with rules among the children of nuclear family and children of joint family.

Results also showed that children of joint family had higher involvement in co-operative play and games with rules. It is well known that family forms the basis of a child's development and it acts as a child's first school where he/she learns about the surroundings, behavior, discipline, etc. Since in joint family, members under different age groups live together, the child can get more exposure for learning new experiences with all the family members. The other family members involve in taking care of the child, in the absence of parents. Hence, child get the environment to learn new things by interacting with each other. Compared to children of nuclear family, there is higher bond of unity and affection of children living in joint family. Thus, joint family helps children to provide nurturing environment for their social development better than the nuclear family (Gurav and Vageriya, 2019). Moreover, children in the joint family who receive qualitative child care are better in thinking, responding with others and interacting with friends and world around them which influences their play behaviour to adopt better co-operative play and could be able to listen and follow the games with rules. They are somewhat better in play behaviour and adopting the skills related to play than those of who lived in nuclear families. They also may have good home environments; parents' and siblings support towards play and child care and also the structure of care and help for children's overall development with respect to play. Researches also has shown that children who are brought up in a lively and engaging joint family are likely to be more socially adaptive and responsive in the later years of the life compared to their contemporaries brought up in isolated nuclear families (Gupta 2021). Thus, joint families have an obvious advantage when it comes to learning interpersonal and social skills and improving their play behaviour skills as well.

CONCLUSIONS

The study aimed to find out play behaviour among the primary school children. The study reported that children in the age group of eight years who had better child care in joint families were able to take better decisions, respond, and interact with the other children and world around them which influences their play behaviour to adopt better co-operative play and could be able to listen and follow the games rules compared with 6 and 7 years aged children. This age group are better in play behaviour and adopting the skills related to play than those of who lived in nuclear families.

Table 5. Distribution of level of play behaviour and differences of play behaviour based on types of family (in reference to multi-responses of the respondents)

S. No.	Play Behaviour	Gender	High		Average		Low		Mean	SD	t-test
			n	%	n	%	n	%			
1.	**Non-Social**										
	Unoccupied	Nuclear	119	34.2	119	34.2	110	31.6	8.30	2.44	.203
		Joint	101	40.1	69	27.4	82	32.5	8.57	2.83	
	Solitary	Nuclear	160	46.0	127	36.5	61	17.5	19.39	4.67	.057
		Joint	126	50.0	86	34.1	40	15.9	20.13	4.81	
	Onlooker	Nuclear	70	20.1	227	65.2	51	14.7	11.50	3.01	.112
		Joint	64	25.4	147	58.3	41	16.3	11.90	3.10	
	Anxious Behaviour	Nuclear	115	33.0	157	45.1	76	21.8	14.54	3.57	.094
		Joint	78	31.0	107	42.5	67	26.6	15.06	3.95	
2.	**Social**										
	Associative	Nuclear	147	42.2	140	40.2	61	17.5	17.46	4.77	.206
		Joint	116	46.0	88	34.9	48	19.0	17.98	5.26	
	Cooperative	Nuclear	140	40.2	131	37.6	77	22.1	29.20	7.13	.040*
		Joint	118	46.8	81	32.1	53	21.0	30.52	8.52	
	Games with rules	Nuclear	91	26.1	166	47.7	91	26.1	14.10	2.92	.038*
		Joint	77	30.6	98	38.9	77	30.6	14.66	3.61	

* Significant at 5% level; NS= Non significant at 5% level

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PREPAREDNESS OF MIDDLE AGED COUPLES FOR OLD AGE

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ABSTRACT

The study was undertaken in the year 2018 to assess the preparation level of middle aged couples for old ageliving in the Udaipur City. The sample for the study consisted of 100 single earner middle aged couples belonging to the age range of 50 – 60 years. A general information proforma was used to collect the background information of the subjects. 'Preparation for Old Age Scale' was developed to assess the level of preparation. The data obtained were analysed and assessed using percentage distribution, mean scores and z-test. Major findings of the study indicated that majority (59%) of the couples had moderate level of preparation for old age with men scoring higher than women, respectively. Couples were best prepared in the mental dimension of preparation area and had lowest preparation in socio-emotional dimension with mean scores of 34.085 and 29.515, respectively.

INTRODUCTION

As person grows older and moves through different stages of life, one has to face many changes and subsequently witness many challenges. Longevity of life, if not planned well, could imply high burden on the individuals, government and other public and private sector to look after the welfare of the elderly. Despite the efforts by the government, the elderly comparatively lack the security needed during old age and lead a life with increasing cases of deprivation, deteriorating health, dependency, functional disability, neglect, isolation and humiliation.The fast ageing process calls for a good preparedness starting early in life with a wide supporting policies and deliberate concern from the society, citizens and the elderly themselves. It is very imperative to accept the impending changes of old age and be prepared to face them particularly in those cultures and societies where familial system do not provide an inbuilt safety net for their aging populations, Independence in terms of housing arrangements, investments for future, health insurances, good social life, etc. are of utmost importance for a person to have during their middle years so that they could lead peaceful lafter years.

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Middle age is the period just before old age where one's energy and talents are directed towards building and maintaining the structures for future life as well as future generations. It is a pivotal period in the life course in terms of balancing growth and decline, bridging younger and older generations (Lachman *et al.,* 2015). This is the time when an individual is expected to shoulder the responsibilities of younger and older generations as well as plan for the imminent changes linked with old age.

Gender is a very important variable that influences quality of life at all ages. Generally, women consider themselves "old" as they approach middle age. This awareness of self as being "old" can be attributed to cultural biases, injustices and inequities of gender and aging; and lack of recognition and contributory role of women in society (Hofmeier *et al.,* 2017). This does not hold to a very secure future for the elderly women as they are relatively the mostvulnerable segment of the population.

Preparation for imminent changes that comes with old age have been documented to increase well-being and quality of well-being in later life (Guptan *et al.,* 2021; Liu *et al.,* 2022). Preparation for the later years of life paves the way to better deal with the challenges associated with ageing and make use of all the opportunities that old age offers. Therefore, it is important for individuals in middle and late adulthood to be prepared for later years in order to maintain functioning and well-being in older age.A plethora of literature is available on preparation for old age (For Ex: Khedekar-Swaminathan and Kulkarni, 2018; Shendkar, 2016; Trivedi and Soni, 2021) however,most of the studies focus on post retirement financial readiness but preparation is an over-going lifelong multidimensional process that goes beyond monetary readiness (Kornadt *et al.,* 2015).

Retirement is an important transition during later years of life but overlooking other dimensions that affects this phase of life might not leave behind a comprehensive picture. For example, unemployed women do not face retirement but they have other challenges that they need to be ready for. Similarly, employed persons might also have multiple apprehensions which are not related to place of work. Researches seems to analyze on supple side (current analysis and situation), but not actually look at the demand side (awareness and preparation on the part of the elderly and their family.) Hence, it is imperative to investigate preparation across different domains of life (Kornadt *et al.,* 2018).

Keeping this in view, the preparation of the middle-aged couples for old age was assessed across four different dimensions *i.e.,* physical, socio-emotional, mental and financial. Gender differences regarding preparation for later years of life were also investigated.

MATERIALS AND METHODS

This quantitative study was undertaken in the year 2018 with the objective to assess the preparation of middle aged couples for old age. The sample included 100 middle aged couples (100 men and 100 women) between 50 and 60 years of age. For the selection of the respondents, Udaipur City was divided into four zones geographically *i.e.,* East, West, North and South, respectively. Two colonies were selected from each zone for a representative sample. Thus, eight colonies were purposively selected on the basis of ease

of accessibility and availability. Online Google forms and door to door survey was conducted on the identified localities for the purpose of data collection. Participation involved the completion of a self-standardized tool "Preparation for Old Age Scale".The content validity of the scale was calculated to be 4.38. The split half reliability of the scale using Spearman Brown Prophecy formula was 0.77. The scale consisted of 84 items under four categories *i.e.* physical dimension, socio-emotional dimension, psychological dimension and financial dimension. Items were rated by using dichotomous responses assigned for responses of respondent *i.e.* '2' for Yes or '1' for No. The higher was the score, better was the preparation level of middle aged couples for their old age. Since the total number of statements was 84, the minimum score was 84*1=84 and maximum score was 84*2=168. An individual with a score of 141-168 was considered to have high level of preparation, scores ranging from 112-140 represented moderate preparation and scores from 84-111 represented low level of preparation.To analyse the data, the collected information was scored, coded, categorized, and statistically analysed according to the requirements of objectives of the study. Means and z-test were used to analyze the data.

RESULTS AND DISCUSSION

Results revealed that majority of the couples fell into moderate level of preparation for their later years. Figure 1 depicts majority (59%) of the couple falls in the moderate level of preparation followed by 24% low preparation level. Only 17% couples were in high level category. The profile given in the tables evidently suggests that the middle aged couples were in the phase of transitioning from non-acceptance to acceptance of old age. Couples falling in low level of preparation may be in the same because of their denial and unawareness.

Data in the Table 1 reveals that majority of the respondents reported moderate level of preparation for old age. According to the finding of An and Kim (2012), economic and physical preparation for old age by the middle aged employees were made below average level but senior life plans related to relations,

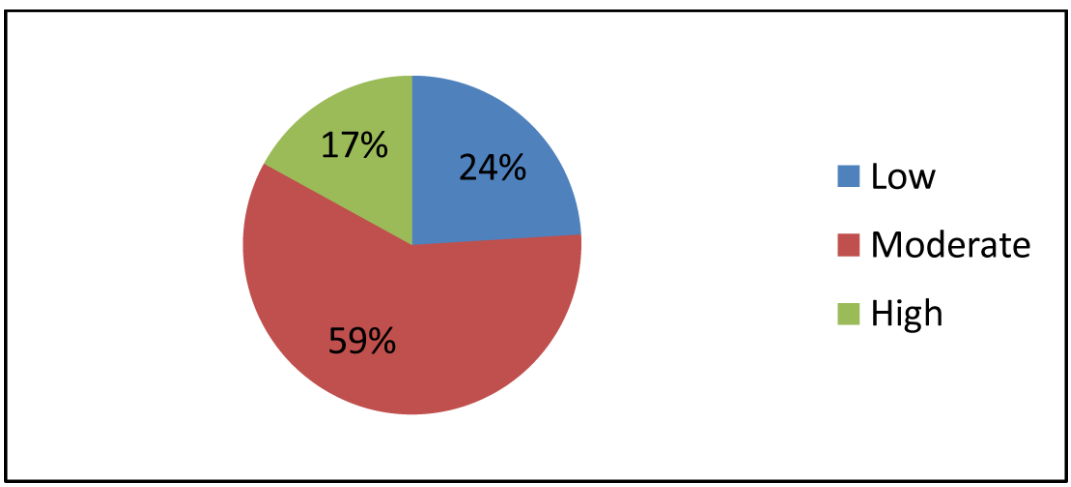

Fig. 1. Preparation level of middle aged couples for old age

leisure and social activities were made above average level.The number of females were more in low level of preparation than male. Only nine percentwomen had high level of preparation, whereas, 13% men had higher preparation level. It can be seen that women (33%) were leading men (21%) in low level of preparation for their old age. The results concluded thatwomen lag behind in preparation level particularly in mental and financial dimensions as per the role expectations of community and society towards these dimensions. The financial security during old age is generally expected as a major assigned task for the male members in the family.

Table 2 shows dimension-wise preparation of middle aged couples for old age. It is clearly depicted that mental (34.085) dimension of preparation obtained highest mean score.This is in agreement with the results obtained in a study conducted by Tuohy and Stephens (2016) which stated that older adults viewed age related preparedness as a way to maintain independence in their lives. Health concerns influenced their choices all the while consciously strategizing goals and actions that prioritizes mental health and well-being.

Lowest mean score was recorded for socio-emotional (29.515) dimension of preparation which means although the subjects were prepared mentally for their age but they were not equipped to face the challenges of their age which, as a result may effect on their role performance and role acceptance as well. This preparation is a must as it provides means for adaptation during the forthcoming stage of life span. Financial and physical dimension of preparation had more or less similar mean scores. Least preparation was in socio-emotional dimension. The reason behind this may be that the current trend of living is such that individuals do not get time to see each other and socialize outside of their family. Most of the time of middle aged individuals is utilized in taking care of younger and older generation of the family. To add to this, with the changing scenario, people have become more self-centered with their sole focus on themselves and on their family. Making outside connections, working for the welfare of others and devoting their time for themselves is last on their list of priority.

The data in Table 3 depicts the profile of gender differences that exist in preparation for old age across various dimensions. The mean scores of male for socio-emotional preparation, psychological preparation and financial preparation was more than women, though women lead the men in physical preparation for old age. Men and women had lowest mean score for socio-emotional dimension of preparation *i.e.,* 29.87 and 29.23 respectively. Highest mean scores were observed for financial preparation with men scoring 32.17 and women (31.58). For socio-emotional preparation, mean score was found to be 29.87 for men and 29.23 for women. The scores for mental preparation of men were 31.27 and women were 30.97. The mean scores predict that men were better prepared than women to face old age in mental dimension of ageing which is in contradiction to the finding by Casey and Rebecca (2011) which stated that there are no differences according to gender on the level of anxiety, depression and well-being. The results are in line with findings of Kvrgic *et al*. (2013) who reported that when mental health is considered, female population is more vulnerable compared to males.

Significant difference was found in overall preparation (11.86) among male and female respondents. This may be due to the fact that men and women have different needs and requirements. With age, women go through different changes while male experiences a completely different story. Physical changes, sexual desires and urges, personality type, body strength, resilience, coping strategies, challenges, etc. are slightly different for male and female. Hence, while preparing for the last phase of life, it might become important to prepare differently.

The level of physical preparation was more or less similar for male and female as no significant difference was found between physical dimension of male and female. This finding stands in line with the result given by Badgujar (2014) which suggest that men and women do not feel insecure going and

Table 1. Percentage distribution of preparation level of men and women (n=100 couples)

S. No.	Range	Men	Women
1	84-111 (Low)	21	33
2	112-140 (Moderate)	66	58
3	141-168 (High)	13	9

Table 2. Mean scores of preparation level of couples across various dimensions (n=100 couples)

S. No.	Dimensions	SD	Mean Score
1	Physical	2.52	30.805
2	Socio-emotional	2.80	29.515
3	Mental	4.07	34.085
4	Financial	3.05	31.845

Table 3. Gender differences in preparation across different dimensions

S. No.	Dimensions	Male		Female		z-value
		Mean	SD	Mean	SD	
1.	Physical	30.83	2.98	30.86	2.70	0.07 (NS)
2.	Socio-emotional	29.87	3.38	29.23	3.47	1.32 (NS)
3.	Mental	31.27	3.41	30.97	3.44	0.61 (NS)
4.	Financial	32.17	3.81	31.58	3.65	1.11(NS)
5.	Overall	130.02	6.702	116.76	8.944	11.86*(S)

Note: NS= Non-Significant difference; S= Significant difference; * = Significant difference at 5% level

interacting with others because of changes in their physical appearance since they have accepted the process of ageing. Slightly better mean score of women than men indicate that women were better physically prepared for their old age. Women are becoming self-aware about their health and appearances as well as government is also making efforts in the same direction. Thus, the acceptance is more, hence preparation is more. It came into view that very few numbers of respondents opt for regular health checkups and do not feel the need to bring changes in their eating habits.

A significant gender difference was observed for the overall preparation for old age with men better prepared than women to face the later years of life. The results are consistent with the findings of Lim (2021) who found that although both men and women had low preparation for old age and economic independence, still men were better prepared than women. The results also stated that married men with a spouse were expected to be better prepared for old age.

A non-significant difference was found among gender differences between socio-emotional preparations. This may be because an individual understands that human being is a social animal. As and when person ages, the importance of having social ties and emotional support becomes more evident. Person transitioning from middle adulthood years to old age comes to a realization that, with the increasing age, the dependency on social resources will increase. Therefore, whether a male or a female, the importance of readiness is same for both. The mean scores of men indicate that their social-emotional preparation for the coming years is better than women. According to Kvrgic*et al,* (2013) women are more often exposed to stressful situations and emotional problems and more often faced with negative conditions and feelings. Stressful situations and emotional problems and more often faced with negative conditions and feelings (Sharma *et al*., 2016). Indian society which is still gender stratified makes it easier for men to socialize, find new groups, seek out for new hobbies and interest and explore different types of activities. Dwindling self-esteem of women due to physical changes and increasing dependency may be correlated with low social and emotional preparation of women for their golden years. Low social preparation may also be accounted to the fact that current trend of living keeps everyone busy whereby individuals lack time for each other.

Mental dimension of preparation also had a non-significantgender differences. Middle adulthood and late adulthood years bring with it a very observable shift in the role of male and female. Male begins to embrace the latent feminine characteristics within them. The rigid masculine roles adopted by the person throughout life become somewhat flexible. On the other hand, masculine traits within a woman become more apparent. The non-significant difference between male and female preparation for old age are due to these changing beliefs. Male and female experienced both type of traits equally. Thus, the focus might not be on the differences but rather on the steps that need to be taken in order to mentally prepare for the coming years. Table 3 suggests that men with higher mean score are slightly better prepared mentally for old age. Men does not have to go through as many changes as women do while transitioning from middle adulthood years to old age years. All the young years, the women are expected to

behave according to the norms set for them. They are not expected to deviate from their assigned behavior, physical appearance, and role fulfillment and managing multiple responsibilities together trained to be fit in their tailor made garment. Thus, when such a conditioned individual is asked to adapt and change for the changes coming ahead in life, it may become very difficult to cope and adjust. This might be the reason behind the slightly low mean scores of women than men regarding mental preparation for old age.

A non-significant difference was observed regarding gender differences in financial preparation for old age. This result is consistent with the findings of Petkoska and Earl (2009) which states that there is no difference between females and males regarding financial preparation (savings, insurance). The high mean scores of males than females provides the evidence that males were better financially prepared than females.

CONCLUSIONS

Majority of the middle aged couples had moderate level of preparation for old age.Results indicated a significant better preparation of men (M= 130.02, SD= 6.702) over women (M=116.76, SD = 8.944), z = 11.86, á= 0.05. Couples were best prepared in financial dimension of preparation and had lowest preparation in socio-emotional dimension. The findings showed that individuals are in a transitory process where they are accepting the perils associated with old age, gradually adapting to the situation, making changes in their life style and preparing for the second phase of life. However, the situation is not per se as it should be. Still, there are people denying the unavoidable circumstances and preferring to focus their attention in the present rather than thinking and investing their time, money and energy for future.

The changing role of families and familial support, increasing older populations and the resulting strain on societal welfare and provision systems makes individual preparation for age-related changes immensely The findings will be helpful for various Government and Non-Government Organizations, program planners and counselors for program and policy making to form policies and programs to enhance the preparedness levels of middle aged for older age which results in life satisfaction in view of SDG-3.

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LEARNING STYLE AND ACADEMIC ACHIEVEMENT OF SCHOOL CHILDREN - AN EXPLORATORY STUDY

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ABSTRACT

This study explored the interrelationship between Learning Style (LS) and Academic Achievement (AA) of students (11-15 years old) enrolled in schools following the Samacheer Kalvi syllabus (Unified Education Board of the state of Tamil Nadu) among a total of 3026 school-going children from the four zones of Coimbatore in the state of Tamil Nadu during November 2021 to March 2022. A cross-sectional research design was used. Misra's Learning Style Inventory (LSI) was administered to define the Learning Style of the children. AA was analysed using their yearly report card for five major exams. Subject–wise average marks scored (Tamil, English, Mathematics, Science, and Social Science) were computed and graded. Children's learning style was found to be significantly associated with all the subjects except the second language (Tamil). The enactive reproducing style had a positive impact on their academic achievement in English, Mathematics, and Science. Verbal constructive style affected their academic achievement negatively. Figural constructive and figural reproducing learning styles were found to have a positive impact on Mathematics, Science, and Social Science.

Keywords: Academic Achievement, Learning Style, School-going children

INTRODUCTION

Learning Styles (LS) are how children learn, observe, process, and retain information and have immensely influenced education. Learning Style (LS) is a concept that can be traced back to as early as 334 BC when Aristotle opined that each child possesses a specific set of talents and skills. In the early 1900s, there were many theories relating to this but later on, research in this area witnessed a downtrend as students' IQ and academic achievement garnered more attention comparatively. However, in the last half of the 1900s it again picked up momentum and a lot of research has been happening relating learning style to teaching and academic achievement of children (Sabnam and Usashi, 2022).

"Styles play a role in the way students learn. Each one of us is born with certain

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biological characteristics favouring a particular style which are later influenced by other factors such as culture, family, self-experience, etc." (Tiwana, 2019). Educationist and Learning Style Inventory developer Karuna Shankar Misra defined "Learning style as how one internally represents experiences and recalls or processes information. He also categorized learning styles as Enactive Reproducing - Preferences towards processing action-based concrete experiences, and its emphasis is on imitation and practice, Enactive constructive - Preferences towards conceptualizing one's experiences based on the processing of enactive information. Figural reproducing - Preferences for visual experiences related to making diagrams, charts, pictures, maps, and photographs. The emphasis is on imitation and practice. Figural constructive - Preferences to process the figural experiences and facilitates leading to conceptualization. Verbal reproducing - Preferences for written or spoken information related to the subject matter communicated through words. Verbal constructive - Preference for reflective, accommodative, and abstract thinking about the subject matter to develop conceptualizations".

There is general acceptance of the perception that the manner in which an individual chooses a learning style has a direct impact on their Academic Achievement (AA). Many research studies have proved this fact. Nissei (2015) carried out a correlation study between learning styles and academic achievement among secondary school students in Kenya. The study's findings revealed that there exists a positive correlation between the LS and the AA of their target respondents.

Singh and Cutting's (2018) study focused to determine the interrelationship between LS on AA of government and private secondary school students. The key findings stated that the kinesthetic learning style was found to be more used than the visual and auditory styles of learning. Though all three types of learning styles (visual, auditory, and kinesthetic) were found to be significant with respect to academic achievement, a strong positive correlation between kinesthetic learning style and academic achievement was observed.

Munir *et al.* (2018) carried out a study to identify secondary school children's LS and AA. Learning Style Inventory (LSI) by Canfield (1992) was used to analyze the students' learning styles and their previous academic year examination results were used to assess their academic achievement. This study revealed no remarkable relationship between LS and AA.

In line with the above, the researcher made an attempt to explore the association between the LS and AA of school-going children. The study was unique in two ways 1) Almost all studies on learning style focused on the influence of learning style with that of academic achievement as a whole except for a few on various subjects of learning 2) No study had been conducted with Samacheer Kalvi (Unified Education Board of Tamil Nadu). The objective of the study is to assess the relative contribution of the learning styles (predictors) over the subject-wise academic achievement (outcome).

MATERIALS AND METHODS

A descriptive cross-sectional research design (with certain inclusion criteria) was used in identifying the 18 schools and the study sample. A total of 3026 school-going (11-15 years) children (Girls -1569, boys - 1457) participated from the schools following the Samacheer Syllabus in Coimbatore city of Tamil Nadu and the study was carried out during the period of November 2021 to March 2022.

Learning Style Inventory (LSI) tool developed by Karuna Shankar Misra (2012) was applied to define the learning style of the selected school children. "A total of 42 statements on this inventory assess the six types of learning styles, which are: enactive reproducing, enactive constructive, verbal reproducing, verbal constructive, figural reproducing, and figural constructive. Each domain had seven statements. Every statement was scored on a Likert Scale of Very much - 5, Much - 4, Average - 3, Less - 2, Very less - 1. The score ranged from 42 to 210. An average score had been calculated in determining the learning style of the children, dividing the scores received by the children from every seven statements in total for each style. According to the standard values identified in the LSI assessment guideline, the raw score of each inventory, based on the respondent's answer was taken into account for statistical analysis. A time limit of 15 minutes was provided to the target respondents to fill up the Inventory".

To appraise the Academic Achievement (AA) of the selected school children, their report/mark cards were procured. The average marks of five major subjects (Tamil, English, Mathematics, Science, and Social science) in the five major exams conducted in an academic year were taken into account. The subject-wise average marks were categorized into six grades. The Likert Scale of grading system (a commonly used grading system by the schools of Tamil Nadu) was used, *i.e.* Outstanding (95%-100%), Excellent (81%-94%), Very good (61%-80%), Good (60%-41%), Average (40%-21%), and Poor (20%-1%).

Considering the six types of learning styles as predictor variables and each of the five academic subjects as outcome variables (separately) the concerned data was subjected to multiple linear regression analysis as this type of regression aids best in estimating the relationship between two or more independent variables and one dependent variable.

RESULTS AND DISCUSSION

The results of multiple regression in terms of overall contribution to the subject-wise academic achievement (R^2=.019, F=9.924, p<.01; R^2=.019, F=9.649, df =6, p<.01; R^2=.040, F=20.708, p<.01 and R^2=.006, F=3.157, p<.01) revealed that the academic achievement in English, Mathematics, Science, and Social Science were significantly influenced by the learning style adopted by the selected children. However, the second language – Tamil, the regional language of the State of Tamil Nadu was not predicted by the learning style adopted by the selected children.

The independent 't' and 'p' values denoting the relative contribution of the types of learning style with the academic achievement in the specified subjects were:

Tamil: Looking at the t and p-value of each predictor and the overall R-value of the academic achievement in the Tamil subject, it was confirmed that none of the learning styles was found to influence the learning of the subject Tamil (second language).

English: Enactive reproducing style of learning (5.607, p<.01) and verbal constructive style of learning (-4.304, p<.01) were the significant predictors of the academic achievement of children as far as the English Subject was concerned.

The enactive reproducing learning style emphasizes learning through imitation and practice. Hence, the selected set of children was said to learn English as a subject by just using the action-based concrete experience and hence, the positive regression weight. In other words, learning by imitation practice without conceptualizing or processing information facilitated their learning of English. The absence of just reproducing the learned vocabulary (verbal reproducing style) among these children has to be looked at as lacunae of academicians in bridging the gap towards learning a foreign language. The significant negative weight of the verbal constructive type of learning, vividly portrayed that, a child when using this constructive style, they do not perform well in their English subject. However, the reason was owed to the fact that these children do not use the verbal constructive style of learning appropriately as it necessitated the conceptualizing skills.

A study conducted by Anuradha and Rakhi (2021) found that the enactive type of learning style had a positive impact on the academic achievement of senior secondary school students in English subject, which was in concordance with the study.

Mathematics: Figural constructive style (2.571, p<.01) and enactive reproducing style (5.999, p<.01) were significant at 1 percent level in impacting the school-going children's academic achievement in Mathematics. Figural constructive style of learning leading to better performance in Mathematics was well understood as the processing and conceptualizing of figural experiences was crucial to perform Mathematics.

The verbal constructive style of learning (-3.915, p<.01) was found to be significant at a 1 percent level. The negative regression weight indicated an inversely proportional relationship between the LS and AA of children with respect to Mathematics. Higher was the level of verbal constructive style of learning lower was the level of their performance in Mathematics. A study carried out by Gopalakrishnan and Palanivelu (2018) was in accordance with the study which pointed out that enactive and figural types of learning played a significant role in influencing the academic achievement of children with respect to mathematics.

Science: The t and p-value of each independent variable for the Science subject showed that enactive reproducing (6.297, p<.01), figural reproducing (5,968, p<.01), verbal constructive (-3.885, p<.01), and verbal reproducing (-4.036, p<.01) style of learning were significant at a 1 percent level.

Compared to other academic subjects, science learning ideally requires the usage of multiple learning styles. The above table inferred that the enactive and figural

Table 1. Regression analysis predicting the relationship between the Predictors (LS) and the outcome (Subjects-wise AA)

S.No.	Predictors	Regression Coefficients (B)	Std. Error	Beta	T	Significance	R	R Square	F (df-6)	N-3026 Sig.
				Tamil Learning						
1	(Constant)	67.455	2.151		31.355	.000	.032	.001	.501ns	.808
2	Enactive reproducing	.007	.065	.002	.104ns	.917				
3	Enactive constructive	-.066	.130	-.022	-.508ns	.612				
4	Verbal reproducing	-.039	.058	-.013	-.681 ns	.496				
5	Verbal Constructive	.052	.057	.019	-.907 ns	.394				
6	Figural reproducing	.033	.071	.010	.462 ns	.644				
7	Figural Constructive	.095	.127	.031	.748 ns	454				
				English Learning						
1	(Constant)	34.668	3.564		9.729	.000	.139	.019	**9.924****	**.000**
2	Enactive reproducing	.602	.107	.119	**5.607****	**.000**				
3	Enactive constructive	.272	.216	.053	1.260ns	.208				
4	Verbal reproducing	.067	.096	.013	.699	.484				
5	Verbal Constructive	-.407	.095	-.089	**-4.304****	**.000**				
6	Figural reproducing	-.053	.118	-.009	-.450ns	.653				
7	Figural Constructive	.075	.211	.015	.353ns	.724				
				Mathematics Learning						
1	(Constant)	37.460	3.679		10.182	**.000**	.137	.019	**9.649****	**.000**
2	Enactive reproducing	.665	.111	.127	**5.999****	**.000**				

Table 1 Contd…

Table 1 Continued…

S.No.	Predictors	Regression Coefficients (B)	Std. Error	Beta	T	Significance	R	R Square	F (df-6)	Sig.
3	Enactive constructive	-.327	.223	-.062	-1.466ns	.143				
4	Verbal reproducing	.113	.099	-.021	1.139 ns	.255				
5	Verbal Constructive	-.382	.098	-.081	**-3.915 ****	**.000**				
6	Figural reproducing	-.093	.122	-.016	-.763ns	.446				
7	Figural Constructive	.560	.218	.106	**2.571****	**.010**				
					Science Learning					
1	(Constant)	15.863	3.527		4.495	**.000**	.199	.040	**20.708****	**.000**
2	Enactive reproducing	.670	.106	.132	**6.297****	**.000**				
3	Enactive constructive	-.090	.214	-.018	-.421ns	.674				
4	Verbal reproducing	-383	.095	-.074	**-4.036****	**.000**				
5	Verbal Constructive	-364	.094	-.079	**-3.889****	**.000**				
6	Figural reproducing	.673	.117	.117	**5.768****	**.000**				
7	Figural Constructive	.290	.209	.057	1.390ns	.165				
					Social Science					
1	(Constant)	33.083	3.316		9.977	.000	.079	.006	**3.157****	**.004**
2	Enactive reproducing	.136	.100	.029	1.360ns	.174				
3	Enactive constructive	.-.129	.201	-.027	-.640ns	.522				
4	Verbal reproducing	.000	089	.000	.004ns	.997				
5	Verbal Constructive	.177	.088	.027	1.325ns	.185				
6	Figural reproducing	.241	.110	.045	**2.195***	**.028**				
7	Figural Constructive	.147	.196	.031	.750ns	.453				

Note: **Significant at 1 percent level, *Significant at 5 percent level, NS- not significant

reproducing with their positive regression weight did play a positive role in influencing academic achievement in science. Whereas verbal style of learning with negative regression weight exerted a negative influence as far as the children's academic achievement in science was concerned. More scores in the verbal type of learning lower the academic scores in science, as science learning doesn't involve much word manipulation but involved the actual concept understanding that was based on the enactive and figural type of learning.

Social Science: Going by the t and p-value of each predictor of the academic achievement in the subject - Social science, figural reproducing (2.195, $p<.05$) style of learning alone significantly influenced children's academic achievement in Social Science at a 5 percent level. A study done by Aasia Maqbool (2015) was in accordance with this study and stated that overall, the learning styles did play a role in influencing the scores of Social Science.

CONCLUSIONS

The findings of this study reported that there existed a significant relationship between the LS and the AA of children (11-15 years of age). Except for Tamil (the regional language of Tamil Nadu). The academic results of the other four subjects namely English, Mathematics, Science, and Social Science were significantly influenced by the learning style adopted by the school children. The enactive reproducing style of learning emerged as the strongest positive predictor with respect to core subjects (Mathematics, Science, and English), whereas, the verbal constructive style of learning exhibited a negative impact with respect to these subjects. The figural reproducing style of learning was found to influence significantly Academic Achievement with respect to core subjects alone (Mathematics and Science) and the figural constructive style of learning contributed positively to the academic outcome of Mathematics.

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IMPACT OF CLIMATE CHANGE ON MILLET YIELD IN INDIA SINCE 1991: AN ECONOMETRIC ANALYSIS

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ABSTRACT

This study examines the effects of climate change on millet yield in India using secondary data for thirty years (1991-2020). The variation in agricultural millet production in India is estimated using average annual temperature, precipitation, CO_2 emissions per capita, and the rural population. Assessing the order of integration using the unit root test and augmented Dickey-Fuller (ADF). Estimations of the unit root demonstrate that all variables are stationary at the level and first difference. The autoregressive distributive lag (ARDL) bound test is applied to establish the relationship between variables. The study demonstrates that the average yearly temperature has a negative and significant effect on millet yield, whereas, CO_2 emission per capita has a favourable long-term impact on millet yield. In India, 1% increase in yearly average temperature results in a 3.06% decrease in millet yield, while 1% increase in CO_2 emissions per capita results in a 0.42% gain in millet yield on average. In the short run, independent variables do not affect millet yield. As the population of India grows, the nation will face food security issues. There is a need for strategies to mitigate the negative impact of temperature on agricultural yield and secure sufficient food for a growing population.

Keywords: ARDL, Climate Change, India, Millet yield

INTRODUCTION

India is the largest producer of millet in the world, with a production of 12.49 million tonnes, produces 40% of the total output and covers 30% of the total area under millet cultivation worldwide and export value of US$ 24.95 million (FAOSTAT, 2020). Millets are an excellent source of protein, dietary fibre, minerals, iron, and calcium and have a low glycemic index. In April of 2018, the Government of India designated millets as Nutri-cereals due to their nutritional benefits. The Government of India suggested to United Nations that 2023 be declared the International Year of Millets (IYoM). Seventy-two countries supported India's suggestion, and in March

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2021, the United Nations General Assembly (UNGA) declared 2023 as the International Year of Millets. The Government of India is promoting Nutri-cereals by funding research and development and establishing three centres of excellence (CoE)(GoI, 2022).

Climate change is affecting the Earth's ecosystems. Although climate change is a constant on earth, its pace has accelerated in the last 100 years. Due to greenhouse gas (GHG) emissions, the average temperature has risen by 0.9 °C since the 19th century. Increased GHG emissions pollute soil, water, and air. The unprecedented temperature rise has increased droughts, floods, irregular precipitation, heat waves, and other extreme events worldwide (Arora, 2019). Over 70% of people in South Asia depend on agriculture as their primary source of income, which also employs 60% of the labour population and accounts for about 22% of the region's GDP. The effects of climate change, including floods, sea level rise, salt intrusion, increased storm frequency and intensity, pests, and water scarcity, continue to limit the amount of arable land, lower agricultural yields and threaten farmers' ability to feed their families (Wang *et al*., 2017). Rural livelihoods are significantly impacted by climate change. The severity of climate change's effects will vary depending on the household and the surrounding environment, ranging from mild to substantial. Over the last ten to twenty years, a drop in seasonal rainfall and a growing tendency in temperature have been seen. Forest depletion has changed livelihood systems (Matarira *et al*., 2013).

An increase in annual rainfall of about 100 mm might boost grain yield by 1.31 percent, and a 1 °C increase in average yearly temperature could decrease it by 1.45 percent (Holst *et al*., 2013). There is a high degree of uncertainty considering the future of the agriculture sector due to climate change. Changes in production depending on the crop type, assumptions on the CO_2 fertilization effect, climate scenarios, and adaptability all influence changes in yield. Water resources will deplete in many areas due to climate change. The water needed for irrigation can be increased significantly by declining precipitation and rising temperatures (Karimi *et al*., 2018). Net incomes are more greatly impacted by seasonal temperature than by seasonal rainfall. Clay soils negatively impact net revenues, but farm and household variables, including the availability of extension services, farm size, access to irrigation, and farming experience, have positive correlations with net incomes. A temperature change has a more significant impact on net income than a change in rainfall. Climate changes will not affect all climatic zones equally (Hossain *et al*., 2019).

Crop production decreases due to the impact of CO_2 emissions-induced decline in agricultural factor productivity. Due to CO_2 emissions, maize, wheat, coffee, oilseeds, and pulse production decrease (Eshete *et al*., 2020). Increased temperatures during the *kharif* and *rabi* seasons harm agricultural productivity. Although more rainfall has a positive effect, unless it is excessive, it is insufficient to counteract the adverse effects of temperatures. In the short term, productivity

will decline by 6% by 2035, but this decline will rise to 12% by 2065 and 16% by 2100. The arid and semi-arid tropics will see more severe consequences (Birthal *et al*., 2014).

Agricultural output is positively influenced by average annual rainfall, temperature, and forest cover, while it is negatively impacted by drought, floods, and agricultural nitrous oxide (N_2O) emissions. A larger forest area will offer additional farmland for farming, increasing agricultural output. The reduction in available water for agriculture caused by rising temperatures and little rain significantly impacts agricultural productivity (Adeosun *et al*., 2021). Rainfall had a favourable impact, and a temperature rise impacts farm income negatively. The average maximum temperature rising by 1 ^oC during the Kharif season causes a 17–21.8 percent drop in net revenue (Kalli and Jena, 2022). The agricultural value added is positively impacted by CO_2 emissions, cereal cropland area, fertilizer use, and energy use. On the other hand, while having a beneficial short-term impact, temperature and rainfall have a long-term adverse effect on agricultural value added (Chandio *et al*., 2020). In case of most of the crops, an increase in yearly average temperature affects land production (Praveen and Sharma, 2020). Considering the importance of millet for India objective of the study is to assess the impact of climate change on millet yield in India.

MATERIAL AND METHODS

The study is based on secondary data from the FAOSTAT,2020, World Bank Group, Climate Change Knowledge Portal, and World Development Indicators (WDI). The research's sample period spans 30 years, from 1991 to 2020.

ECONOMETRIC MODEL

The research employed a well-known method known as the autoregressive

Selected Variables

S. No.	Variables		Explanation	Data Source
1	MY	Dependent Variable	Millet Yield (Kg/Hectare)	FAOSTAT
2	TEMP	Independent Variable	Average Annual Temperature (^oC)	World Bank Group, Climate Change Knowledge Portal
3	PP	Independent Variable	Average Annual Precipitation (mm)	World Bank Group, Climate Change Knowledge Portal
4	CO_2	Independent Variable	CO_2 Emissions (metric tons per capita)	World Development Indicators (WDI)
5	RP	Independent Variable	Rural Population	World Development Indicators (WDI)

distributed lag (ARDL) method. When the variables are stationary at I(0) or integrated to order I(1), the ARDL model is regarded as the superior econometric technique. Based on the study objectives, this model is selected for others in capturing independent variables' short- and long-term effects on yield(Nasrullah *et al*., 2021) (Jadaun *et al*., 2022). The following model can be specified to examine the impact of climate change variables, such as CO_2 emissions, temperature, and rainfall, on millet yield in India from 1991 to 2020:

$$MYt = f(TEMP_t, PP_t, CO_{2t}, RP_t) \quad \textbf{(1)}$$

The variables in equation (1) are MY_t for millet yield, $TEMP_t$ for average annual temperature, PP_t for precipitation; CO_{2t} for CO_2 emissions; and RP_t for the rural population. Equation (1) can be expressed as follows:

$$MY_t = \lambda_0 + \lambda_1 TEMP_t + \lambda_2 PP_t + \lambda_3 CO_{2t} + \lambda_4 RP_t + \mu_t \quad \textbf{(2)}$$

The variables in this study were all represented in their natural logarithmic forms to reduce the multicollinearity and volatility of the annual time series data. Using equation(2) and natural logarithm, the following log model is described:

$$LnMY_t = \lambda_0 + \lambda_1 LnTEMP_t + \lambda_2 LnPP_t + \lambda_3 LnCO_{2t} + \lambda_4 LnRP_t + \mu_t \quad \textbf{(3)}$$

The ARDL model consists of two primary parts. The first step is to examine the presence of a long-term link between the research variables. Equation (4) describes the ARDL model specification as follows:

where α_0 represents the intercept; the lag order is indicated by p; Δ represents the first difference operator, and the error term is shown by ε_t. The long-run equilibrium relationship between LnMY, LnTEMP, LnPP, $LnCO_2$, and LnRP was examined in this study using the F-test. The null hypothesis states that LnMY, LnTEMP, LnPP, $LnCO_2$, and LnRP do not cointegrate (H_0: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$; H_1: $\delta_1 \neq \delta_2 \neq \delta_3 \neq \delta_4 \neq \delta_5 \neq 0$). According to (Pesaran *et al*., 2001), the calculated F-test or Wald-test is compared to the lower and upper bound values. The null hypothesis of no cointegration between LnMY, LnTEMP, LnPP, $LnCO_2$, and LnRP is rejected if the computed F-test is greater than the upper level bound. If the computed F-test is less than the upper bound, the null hypothesis of no cointegration between LnMY, LnTEMP, LnPP, $LnCO_2$, and LnRP cannot be rejected. The null hypothesis of no cointegration of LnMY, LnTEMP, LnPP, $LnCO_2$, and LnRP becomes inconclusive, however, if the computed F-test lies between the lower and upper levels of the

$$\Delta(\mathrm{LnMY})_t = \alpha_0 + \sum_{i=1}^{p} \delta 1 \mathrm{LnMY}_{t-k} + \sum_{i=0}^{p} \delta 2\ \mathrm{LnTEMP}_{t-k} + \sum_{i=1}^{p} \delta 3\ \mathrm{LnPP}_{t-k} + \sum_{i=1}^{p} \delta 4\ \mathrm{LnCO2}_{t-k} + \sum_{i=1}^{p} \delta 5\ \mathrm{LnRP}_{t-k} + \lambda 1 \mathrm{LnMY}_{t-1} + \lambda 2 \mathrm{LnTEMP}_{t-1} + \lambda 3 \mathrm{LnPP}_{t-1} + \lambda 4 \mathrm{LnCO2}_{t-1} + \lambda 5 \mathrm{LnRP}_{t-1} + \varepsilon t \quad \textbf{(4)}$$

$$\Delta(\mathrm{LnMY})_t = \alpha_0 + \sum_{i=1}^{p} \delta 1\ \mathrm{LnMY}_{t-k} + \sum_{i=0}^{p} \delta 2\ \mathrm{LnTEMP}_{t-k} \sum_{i=0}^{p} \delta 3\ \mathrm{LnPP}_{t-k}$$

$$+ \sum_{i=1}^{p} \delta 4\ \mathrm{LnCO2}_{t-k} + \sum_{i=1}^{p} \delta 5\ \mathrm{LnRP}_{t-k} + \alpha \mathrm{ECM}_{t-1} + \varepsilon t \qquad \textbf{(5)}$$

bands. The second step is to examine the short-term relationship between temperature, precipitation, CO_2 emissions, rural population, and millet yield in India using the following ECM in ARDL formulation:

RESULTS AND DISCUSSION

Time series data consisting of 30 years of annual observations from 1991 to 2020. Table 1 shows the descriptive statistics of log values of the variables. The average millet yield was 6.838333, with a standard deviation of 0.239509. The average annual mean temperature was 3.212269, with a standard deviation of 0.011596. The average yearly precipitation was 7.007273, and the standard deviation was 0.082171. The average annual CO_2 emission per capita was 0.09656, with a standard deviation of 0.334568. The average rural population was 20.49983, with a standard deviation of 0.095424. All the variables were negatively skewed except annual mean temperature and CO_2 emissions, which were positively skewed. Kurtosis statistics showed that millet yield, precipitation, CO_2 emission, and rural population were Platykurtic or lower peak because their kurtosis statistics were less than 3. The annual mean temperature was Laptokurtic or high peak because its kurtosis statistics value was greater than 3. The Jarque-Bera probability values of millet yield, annual

Table 1. Results of descriptive statistics

S.No.	Statistics	Ln Yield	LnTempe -rature	LnPreci -pitation	$LnCO_2$ Emission	LnRural Population
1	Mean	6.838333	3.212269	7.007273	0.09656	20.49983
2	Median	6.808961	3.211851	7.017913	0.016012	20.5205
3	Maximum	7.159136	3.237894	7.186076	0.594816	20.61571
4	Minimum	6.346688	3.185939	6.811355	-0.383743	20.31005
5	Std. Dev.	0.239509	0.011596	0.082171	0.334568	0.095424
6	Skewness	-0.280081	0.081104	-0.064937	0.148965	-0.514435
7	Kurtosis	1.957724	3.201452	2.96005	1.551469	1.995876
8	Jarque-Bera	1.750149	0.083618	0.023079	2.733754	2.583547
9	Probability	0.416831	0.959053	0.988527	0.254902	0.274783

Source: Author's calculation

Table 2. Results of the correlation matrix

S.No.	Variables	Yield	Tempe -rature	Preci -pitation	CO_2 Emission	Rural Population
1	Yield	1	0.3839	0.4751	0.8703	0.8561
2	Temperature	0.3839	1	0.0587	0.5461	0.6400
3	Precipitation	0.4751	0.0587	1	0.3902	0.3557
4	CO_2 Emission	0.8703	0.5461	0.3902	1	0.9579
5	Rural Population	0.8561	0.6400	0.3557	0.9579	1

Source: Author's calculation

mean temperature, precipitation, CO_2 emission, and rural population were 0.41, 0.95, 0.98, 0.25, and 0.27, respectively. The Jarque-Bera p values of all the variables were greater than 10%, hence, we accepted the null hypothesis means data was normally distributed.

All the variables were significantly correlated with the millet yield. The same variables, millet yield and millet yield, annual mean temperature and annual mean temperature, precipitation and precipitation, CO_2 emission and CO_2 emission, and rural population and rural population, were entirely

Table 3. Results of ADF test

S. No.	Variables	At level			First Difference			Decision
		With Constant	With Constant and Trend	Without Constant and Trend	With Constant	With Constant and Trend	Without Constant and Trend	
1	Millet Yield	-0.2791 (0.9154)	-6.0618 *** (0.0002)	3.4012 (0.9995)	-7.6272 *** (0)	-7.4463 *** (0)	-7.3674 *** (0)	I(0)
2	Temperature	-3.2115 ** (0.0295)	-3.8554 ** (0.0276)	0.2022 (0.7378)	-7.2442 *** (0)	-4.4162 ** (0.0105)	-7.3463 *** (0)	I(1)
3	Precipitation	-4.3658 *** (0.0018)	-4.9126 *** (0.0024)	0.7805 (0.8762)	-9.7089 *** (0)	-9.5089 *** (0)	-9.7411 *** (0)	I(0)
4	CO_2 Emission	-0.4473 (0.8878)	-3.374 * (0.0787)	-1.1993 (0.205)	-3.7122 *** (0.0095)	-3.5831 ** (0.0498)	-1.2354 (0.1934)	I(1)
5	Rural Population	-2.3459 (0.1658)	0.1154 (0.9958)	-5.2103 *** (0)	1.0215 0.9956	-3.8486 ** (0.0312)	-1.9751 ** (0.0478)	I(0)

Source: Author's calculation

***significant at 10%, **significant at 5%, ***significant at 1%**

dependent on each other. The numeric value shows the degree of association between variables. It's denoted by 'r'. The absolute value of r should be between 0.3 and 0.7 (|0.30| < r < |0.70|). An absolute value of r less than 0.3 shows a low degree of association, and greater than 0.7 indicates a high degree of correlation. Temperature and precipitation showed a weak degree of the association because the value of r was 0.058, which was less than 0.30.

Table 3 shows the stationary and non-stationary variables. The stationary meaning is that the variable has a constant mean and variance, and autocovariance does not depend on time. Time series data must be stable to prevent incorrect regression analysis, as obtaining outstanding results and making predictions using a non-stationary series is hard. According to the augmented Dickey-Fuller test, some variables were stationary at the level, and others were stationary at the first difference. The null hypothesis for ADF was that 'The variable has a unit root.' This means the variable was non-stationary. Millet yield was stationary at the level with t-statistics -6.0618 and p-value 0.0002. The temperature was stationary at first difference with t-statistics -7.2442 and p-value 0. Precipitation was stationary at the level with t-statistics and p-value -4.3658 and 0.0018, respectively. CO_2 emission was stationary at first difference with t-statistics and p-value -3.71 and 0.0095, respectively. The rural population was stationary at the level with t-statistics of -5.21 and a p-value of 0. The time series analysis revealed that all variables were integrated into distinct orders. Therefore, there was no

Table 4. ARDL bound test of dependent and independent variables

S.No.	Test Statistic	Value	Significance	I(0)	I(1)
1	F-statistic	19.09	10%	2.45	3.52
2	K	4	5%	2.86	4.01
			2.5%	3.25	4.49
			1%	3.74	5.06

Source: Author's calculation

Table 5. Long-Run ARDL analysis of dependent and independent variables

S. No.	Variables	Coefficient	Standard Error	t-statistic	Probability (p-value)
1	Temperature	-3.06	1.46	-2.09	0.047
2	Precipitation	0.14	0.17	0.82	0.418
3	CO_2 Emission	0.42	0.14	3.00	0.006
4	Rural Population	0.81	0.55	1.47	0.155

Source: Author's calculation

cointegration among variables, and the ARDL model can be applied.

Bound test

This econometric method identifies both short- and long-term causal relationships. Table 4 displays the critical values of the upper and lower bounds, I(1) and I(0). The observed F-statistic value of 19.09 exceeded the upper limit of F-statistics. We rejected the null hypothesis in favour of the alternative hypothesis, which explained the long-term relationship between the variables. The cointegration bound test demonstrated the long-term relationship between the variables.

The results of the long-run ARDL model are presented in Table 5, which indicated that the temperature coefficient value is significant in the long run. It showed a negative relationship between millet yield and average annual temperature, meaning that if the yearly average temperature increases by one per cent, the millet yield will likely decrease by 3.06 per cent in the long run. In the long run, the coefficient value of precipitation was statistically insignificant and positively correlated with yield (Haque, 2022). Rainfall may increase yield upto a specific limit; if there was excessive rainfall in wet areas, it reduced the yield. Therefore, there was a small positive effect of precipitation on millet yield. The coefficient of CO_2 emission was statistically significant in the long run, revealing a positive association with millet yield. If the CO_2 emission per capita increases by 1 per cent, the millet yield increases by 0.42 per cent in the long run. The coefficient of the rural population was statistically insignificant in the long run, but it revealed a positive association with millet yield.

Table 6 demonstrates that the short-run ECM coefficient has a negative and statistically significant value of -1.48. The short-term ECM's value revealed the transition rate from disequilibrium to equilibrium. None of the variables significantly impacts millet yield in India in the short run. The R^2 was 0.80,

Table 6. Short-Run ARDL analysis of dependent and independent variables

S.No.	Variable	Coefficient	Standard Error	t-Statistic	Probability
1	C	-1.67	0.16	-10.35	0.000
2	CointEq(-1)	-1.48	0.14	-10.58	0.000
3	R-squared	0.805	Mean dependent var	0.028	
4	Adjusted R-squared	0.798	S.D. dependent var	0.199	
5	S.E. of regression	0.089	Akaike info criterion	-1.92	
6	Sum squared resid	0.215	Schwarz criterion	-1.83	
7	Log-likelihood	29.93	Hannan-Quinn criterion	-1.89	
8	F-statistic	112.07	Durbin-Watson stat	2.16	
9	Prob(F-statistic)	0.000			

Source: Author's calculation

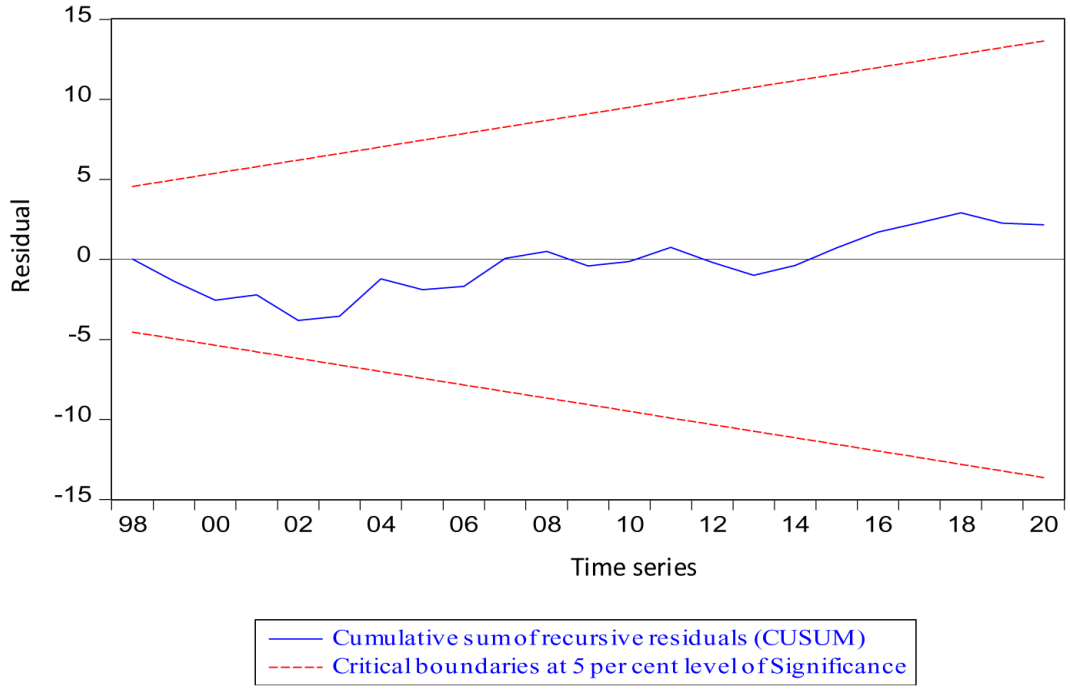

Figure 1. Plot of the cumulative sum of recursive residuals (CUSUM) for the ARDL model

indicating that the change in independent variables accounts for 80% of the variation in millet yield (the dependent variable). The probability of the F-statistic was statistically significant at a 5 percent significance level, indicating that the model's goodness of fit was quite good because the value of R^2 was greater than 60 percent.

Stability of the model

The cumulative sum of recursive residuals (CUSUM) indicates the model's stability in terms of short-run and long-run variable relationships. Below is the graph representing the cumulative total of recursive residuals.

The stability of the model was evaluated by plotting time series data along the horizontal axis and residual along the vertical axis in Figure 1, demonstrating that CUSUM falls under the 5 percent critical range. The graph did not exceed the limit. It is therefore concluded that the model is stable and has a slight discrepancy due to the insignificance of precipitation and rural population. This correct specification model rejects the null hypothesis at a 5 percent level of statistical significance.

CONCLUSIONS

Climate change is projected to negatively impact agriculture output and rural incomes in an economy. Therefore, smart adaptation is required to minimize the risk of agricultural productivity losses. The primary objective of this study was to investigate the relationship between climate change impacts and agricultural millet yield in India from 1991 to 2020. The unit root test was used to

determine the stationarity of the variables, while the ARDL method was applied to examine the causal relationship between the research variables using long-run and short-run analyses. Estimations based on the unit root test revealed that all variables are stationary at the intersection of I(0) and I(1). Furthermore, at a significance level of 5%, the ARDL technique revealed a long-term connection between millet yield, temperature, and CO_2 emissions. According to the analysis of the long-run coefficients, precipitation, CO_2 emissions, and rural population have a favourable effect on millet output. Temperature, however, has a negative impact on millet output. No variable was shown to be significant in the short term. Climate change will negatively impact unirrigated areas more than irrigated ones (Government of India, 2017). Based on the conclusions of this study, it is advised that the Indian government should adopt new laws and advanced technology for accurate weather forecasting and that preventive and immediate actions be made to establish and support an upgraded irrigation system.

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SCIENTIFIC IMPACT ANALYSIS OF WATERSHED PROJECTS IN THE SRIKAKULAM DISTRICT OF ANDHRA PRADESH

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ABSTRACT

The study was undertaken to investigate the utility of Remote sensing and Geographic information system (GIS) tools for the evaluation of four watershed projects implemented under Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) project during 2011-2016 in Srikakulam district of Andhra Pradesh. The study was carried out using high resolution Resourcesat-2, Linear Imaging self-scanning sensor (LISS)-IV data of 2011 (pre-treatment) and 2016 (post-treatment) to assess the changes in land use / land cover and biomass over a period of five years (2011-16). Due to implementation of the watershed developmental activities, an additional area of 2301 ha has been brought under cultivation. The vegetation maps indicated that the areas under dense vegetation category increased by 33 percent and 62 percent of the fallow land converted to during the project period due to adoption of soil and water conservation practices. An additional area of 103 ha (2.37%) increased under water bodies and 83 ha waste land was converted to cultivable land due to construction of farm ponds, percolation tanks and check dams. This area is attributed to cropland and plantations in the year 2016-17.

Keywords: LISS-IV data, PMKSY project, Remote sensing and Geographic information system (GIS), Resourcesat-2, Vegetation Maps

INTRODUCTION

Watershed is an area that supplies water by surface or subsurface flow to a given drainage system or body of water such as a stream, river, wetland, lake or ocean. Remote sensing (RS) and Geographical information system (GIS) have been proved as effective tools to monitor and manage the natural resources, and assess the impact on watersheds during the pre and post development. In order to reduce the cost and time, satellite remote sensing has been used as an evaluation tool. Unfortunately monitoring and evaluation has not got its share of attention and therefore, it is very difficult to quantify and assess the changes, which have taken place

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not only in natural resources but also in livelihoods of people due to these programmes and in the long run to justify the need for these schemes (Gopal Kumar *et al.,* 2014, Meenakshi Bai *et al.,* 2018). There is often not enough room for midterm adjustments in ongoing programmes due to lack of a proper monitoring system. The need therefore arises to identify a quick and cost-effective technique for monitoring the impact of such schemes on a 'before project – after project' temporal scale as well as during project implementation stage (Gopal Kumar *et.al.,* 2014, Meenakshi Bai *et al.,* 2018).

Srikakulam district is located in the North Eastern parts of Andhra Pradesh and lies in 18° 20' - 19° 10' of North latitudes and 83° 05' - 84° 50' of East Longitudes with an area of 5,837 sq.km. The district is bounded by Vizianagaram district in the south and west, Odissa state on the North and Bay of Bengal on the East. In the study, four watersheds have been implemented under Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) project (Phase-1) during 2009-10.

MATERIALS AND METHODS

The study was undertaken to investigate the utility of Remote sensing and Geographic information system (GIS) tools for the evaluation of four watershed projects implemented under Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) project during 2011-2016 in Srikakulam district of Andhra Pradesh. The Remote sensing based methodology is adopted through temporal satellite data for monitoring the watersheds. The study is carried out using Resourcesat-2 LISS-IV data of 2009-11 for the watershed before the implementation of program. Satellite data sets of 2015-16 are used after the treatment of each watershed. Similar studies were reported by Gopal Kumar *et al.* (2014) and Meenakshi Bai *et al.* (2018). The list of watershed projects is presented in Table 1.

The comprehensive methodology is presented in Figure 2. The images were classified into different land use / land cover categories using supervised classification by maximum likelihood algorithm with minimum mapping unit of 2.5 ha. They were also classified into different vegetation levels using Normalized difference vegetation index (NDVI) approach. The classified outputs of land use / land cover and vegetation cover form NDVI of the two time periods were compared to derive information on changes that occurred over a period of time for each watershed. In order to understand the effect of soil moisture and rainfall over the watershed area, daily soil moisture and rainfall data have been analysed from 2009 to 2016.

Land use / Land cover changes

Supervised classification was performed using maximum likelihood algorithm for both pre and post treatment and the satellite data have been clustered with the pixel similar spectral characteristics into homogenous classes. This algorithm assumes Gaussian distribution and each pixel is considered a separate entity independent of neighbours. The classified images have different land use / land cover categories pertaining to pre and post treatment periods. The classified outputs have been compared in order to evaluate the changes which have taken place over a period of time.

Vegetation vigour changes

The NDVI is highly correlated with vegetative parameters such as green leaf biomass, leaf area and is an indicator of photosynthetic activity. Hence, it is of considerable value for vegetation discrimination and seasonal growing conditions for making primary productivity analysis. NDVI is computed using the infrared and red reflectance bands. These values for NDVI range from -1 to 1. Vegetative areas show generally high values of NDVI because of their relatively high NIR reflectance and low visible reflectance. Water, snow and clouds have negative IR radiation. Rocks and bare soil have NDVI values around zero. Only green vegetation has positive NDVI values and high values being associated with higher vegetation vigour. The difference of NDVI images generated for both the dates has been carried out to derive information on changes with reference to vegetation vigour. Based on these NDVI values, vegetation vigour was classified into dense, open and degraded vegetation. The fallow was classified as no vegetation.

Data used for the study

The temporal satellite data is used for monitoring the watersheds. The study is carried out using the following data sets:

- LISS IV satellite data (Pre and Post treatment)
- Fusion (LISS IV + Cartosat-2) data
- SOI topo sheets for reference
- PMKSY monitoring reports from the department
- Soil moisture data from AMSRE-2 data
- Rainfall data

Indicators considered for evaluation of watershed

In order to analyse the changes taken place during the project period, the following indicators are chosen:

- Vegetation cover
- Water body area
- Shift from annual crops to perennial crops
- Additional area brought under cropped area
- Soil moisture availability through wetness indicators
- Reclamation of wastelands

Major developmental activities of the watersheds

The development activities taken-up in the watershed are as follows:

1. The structures are constructed like loose boulder structure, rock fill dams and check dams for soil water conservation.
2. Farm ponds and percolation tanks are constructed.
3. Plantations in individual farmer's land are another major activity.

Other works such as drainage line treatment, nalla bank stabilization, filter strips etc., have also been implemented.

RESULT AND DISCUSSION

Changes in vegetation cover

The Normalized difference vegetation index (NDVI) maps are generated for each watershed area during 2011 and 2016. They were classified into different vegetation vigour classes like Dense, Open Degraded and

Fallow. Spatial distribution of vegetation cover during 2011 and 2016 is represented in Figure 3 and 4 and statistics are presented in Table 2. The vegetation maps indicated that the areas under dense and open vegetations increased significantly during the period between 2011 and 2016. This increase in vegetation is mainly due to decrease in degraded and fallow land categories. There is a reduction in degraded vegetation from 5039 to 3073 ha and fallow land from 2288 ha to 864 ha during 2011 and 2016. Figure 5 showed the vegetation index during the project period of the watershed areas. It clearly shows that there is a slight positive change of increase in vegetation cover. In the Table 2, dense vegetation has the highest positive value, indicating high increase of 33% from its initial 7763 ha. On the contrary, fallow land has the highest negative value, indicating a high level of conversion to vegetation categories which reduced its size by 62% from its initial 2288 ha.

Similar results were noticed by Shanwad *et al.* (2008). Figure 4 showed the vegetation index during the project period of the watershed area. It clearly states that there is a positive change of increase in vegetation cover.

Changes in land use / land cover during 2011 and 2016

The satellite images of both periods (pre and post) were classified into different land use / land cover categories. Spatial distributions of different land use / land cover categories during 2011 and 2016 are presented in Figure 6 and land use changes are shown in Figure 7. It is observed that the area under agriculture increased considerably and reductions in the area under current fallow was noticed, due to adoption of water conservation measures and implementation of watershed activities, which is similar to the study conducted by Shanwad *et al.* (2008) and Venkataramamuni Reddy *et al.* (2022).

The statistics of the area under different land use / land cover categories for both periods is presented in Table 3. Significant increase in area under crop land was observed, which is due to promoting agriculture and horticulture crops. Under land use, cropland occupied an area of 7453 ha during 2011 and 9754 ha in 2016, indicating an increase of 30.87% from its initial 7453 ha. The current fallows are decreased significantly from 6028 ha to 3571 ha during 2011 and 2016. This is mainly due to implementation of drought proofing works which is accounted in crop land in 2016.

Changes in water body area

Changes in water body area is a good indicator of watershed intervention activities. Water body area is extracted by using LISS-IV satellite data for the years 2011 and 2016. The water body area contributed to 1814 ha in 2011 and 1917 ha in 2016.The water body area has slightly increased due to the developmental activities of the watershed. The check dams constructed and farm ponds are shown in Figure 8.

Table 1. List of watersheds in Srikakulam district

S.No.	Project Code	Name of the Project	Name of the Mandal	Project area (ha.)
1	Srikakulam-IWMP-1/2009-10	Kallada	Nandigam	5007
2	Srikakulam-IWMP-2/2009-10	Laveru	Laveru	4476
3	Srikakulam-IWMP-3/2009-10	Kondalogam	Mandasa	2799
4	Srikakulam-IWMP-4/2009-10	J.L.Kota	Kanchili	7226

Shift from annual crops to perennial crops

The plantation cover occupied 2865 ha (10.52%) in 2011 and it has slightly increased to 2904 ha (10.67%). It is found that 39 ha of area under croplands is converted into perennial crops during the project period in 2016. This may helps control of soil erosion, improve soil structure, increase ecosystem nutrient retention, carbon sequestration, water infiltration leading to climate change adaptation and mitigation.

Additional area brought under cropped area

Due to implementation of the watershed developmental activities, an area of 2301 ha has been brought under cropped area. This is attributed to crop land and plantations in the year 2016. It clearly shows that the changes occurred in the project area are progressive. The changes in cropland have been shown in Figure 9. Similar results noticed by Shanwad *et al.* (2008) and Venkataramamuni Reddy *et al.* (2022).

Table 2. Changes of vegetation cover (ha) in Srikakulam district

S. No.	Vegetation Vigour Type	Pre-Treatment		Post-Treatment		Change ±	
		Area	%	Area	%	Area	Increase / Decrease
1	Dense Vegetation	7763	29	10343	38	2580	33
2	Open Vegetation	9718	36	10376	38	658	7
3	Degraded Vegetation	5039	19	3073	11	-1966	-39
4	Fallow	2288	8	864	3	-1424	-62
5	Built-Up	607	2	656	2	49	8
6	Water bodies	1814	7	1917	7	103	6
	Total	27229	100	27229	100		

Reclamation of wastelands

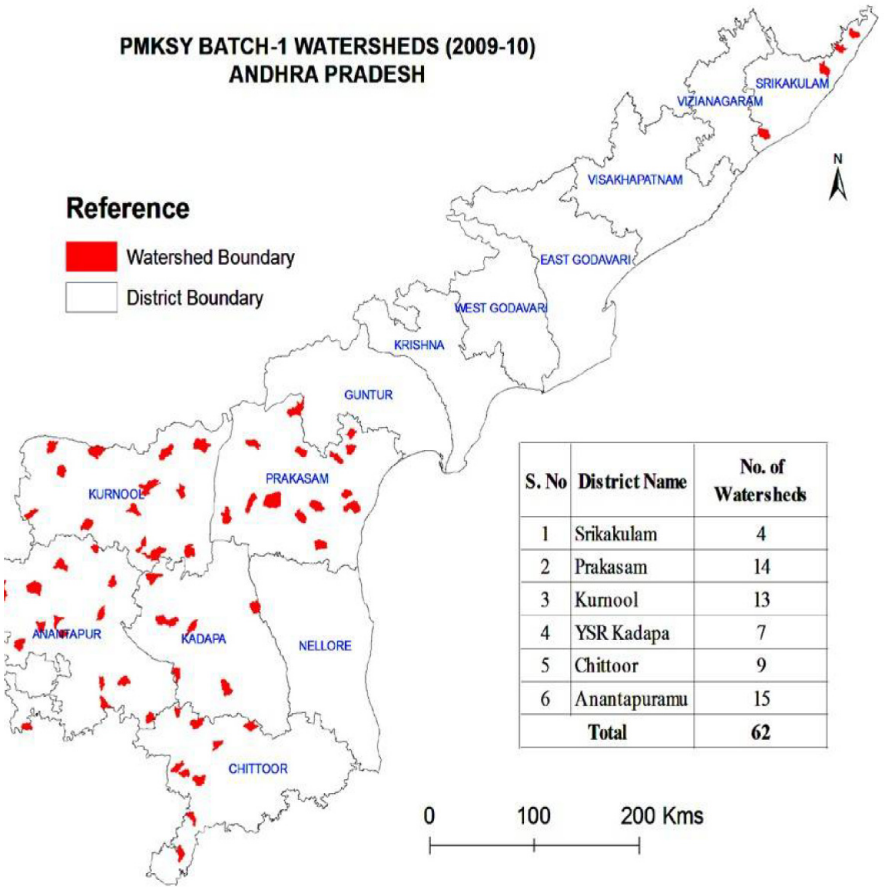
The wasteland reclamation measures are implemented in project area and resulted in 83 ha brought into cultivable land. Under the watershed development activities, reclamation of wastelands is one of the major activities and it includes contour ploughing, strip farming, terracing and changing agriculture practices. The major land use changes are shown in Table 4. Similar results of decreased wastelands were observed by Shanwad *et al.* (2008) and Venkataramamuni Reddy *et al.* (2022). The major land use changes are shown in Table 4.

Table 3. Land use / land cover distribution and its changes (ha) in Srikakulam district

S.No.	Land use / land cover class	Pre-Treatment		Post-Treatment		Change ±	
		Area	%	Area	%	Area	Increase / Decrease
1	Built-up	607	2.23	656	2.41	49	8.07
2	Crop land	7453	27.37	9754	35.82	2301	30.87
3	Plantation	2865	10.52	2904	10.67	39	1.36
4	Current Fallow	6028	22.14	3571	13.11	-2457	-40.76
5	Forest	3398	12.48	3398	12.48	0	0.00
6	Wasteland/Scrubland	4980	18.29	4937	18.13	-43	-0.86
7	Water bodies	1814	6.66	1917	7.04	103	5.68
8	Quarry area	84	0.31	92	0.34	8	9.52
	Total Area(ha)	**27229**	**100**	**27229**	**100**		

Table 4. Major land use/ land cover changes (ha) in Srikakulam district

S. No.	Changes		Area (ha).
	From (Pre)	To (Post)	
1	Annual Crops	Perennial Crops	85
2	Wastelands	Built-up	03
3	Wastelands	Cropland	36
4	Wastelands	Plantation	24
5	Wastelands	Current Fallow	23
6	**Additional cropped area (ha)**	2301	



S. No	District Name	No. of Watersheds
1	Srikakulam	4
2	Prakasam	14
3	Kurnool	13
4	YSR Kadapa	7
5	Chittoor	9
6	Anantapuramu	15
	Total	62

Figure 1. Location Map of watersheds

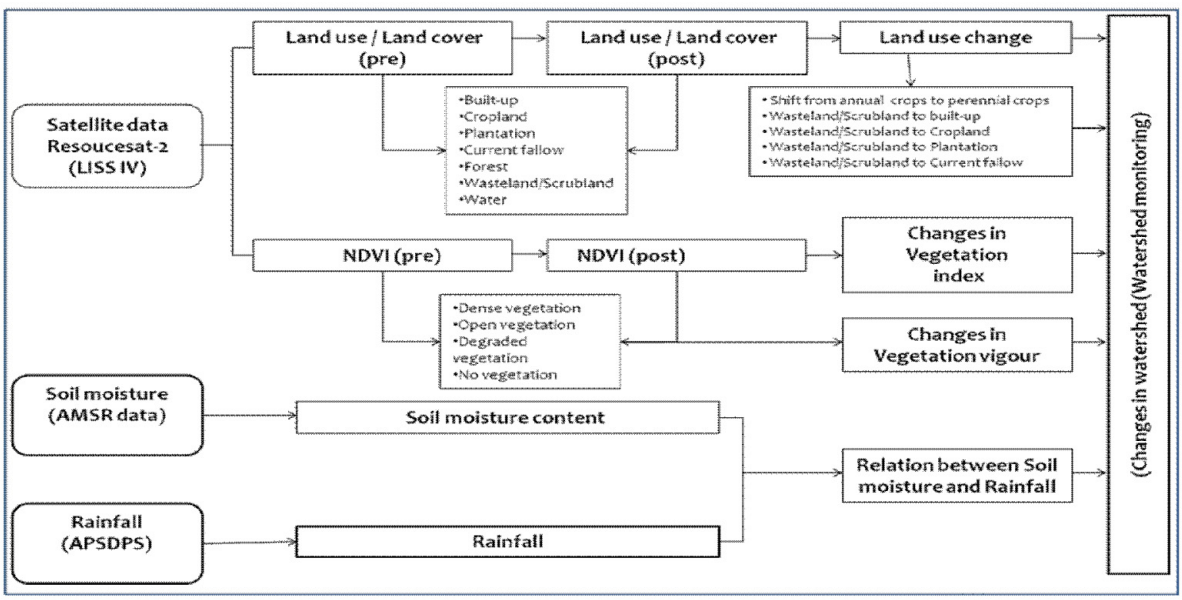


Figure 2. Methodology

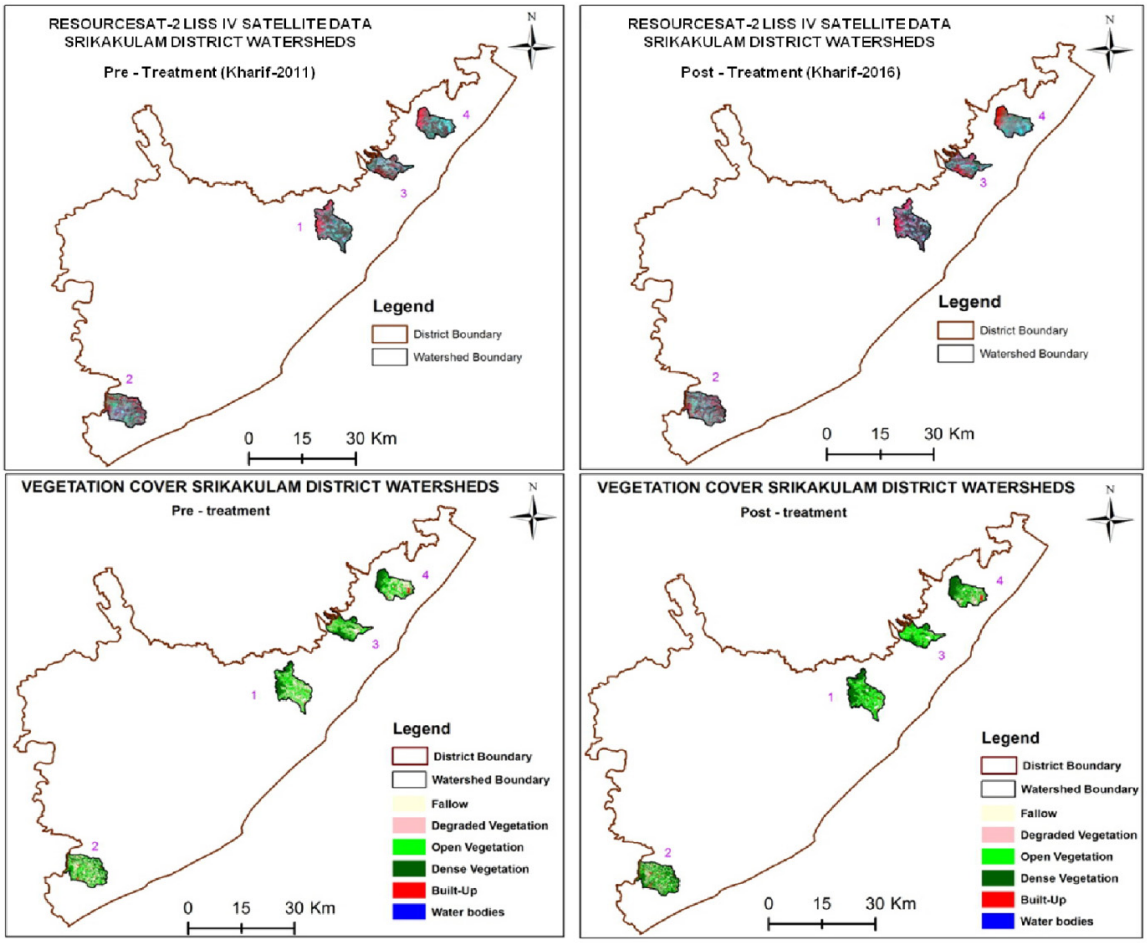
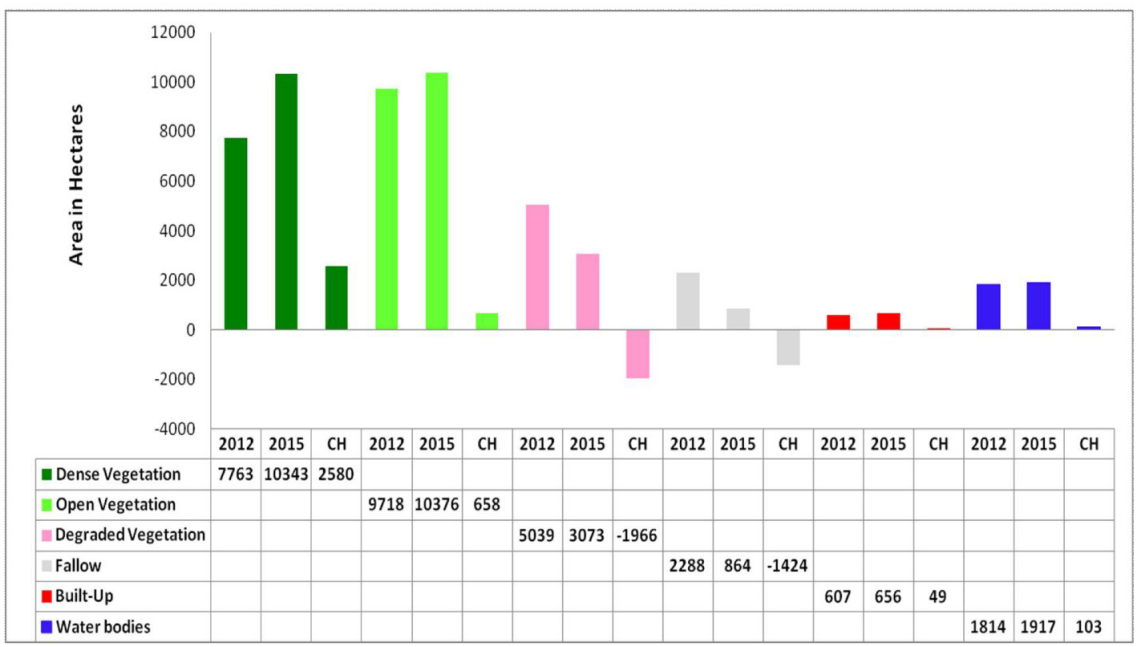


Figure 3. Comparision of vegetation cover maps



	2012	2015	CH	2012	2015	CH	2012	2015	CH	2012	2015	CH	2012	2015	CH	2012	2015	CH
Dense Vegetation	7763	10343	2580															
Open Vegetation				9718	10376	658												
Degraded Vegetation							5039	3073	-1966									
Fallow										2288	864	-1424						
Built-Up													607	656	49			
Water bodies																1814	1917	103

Figure 4. Distribution of vegetation cover change

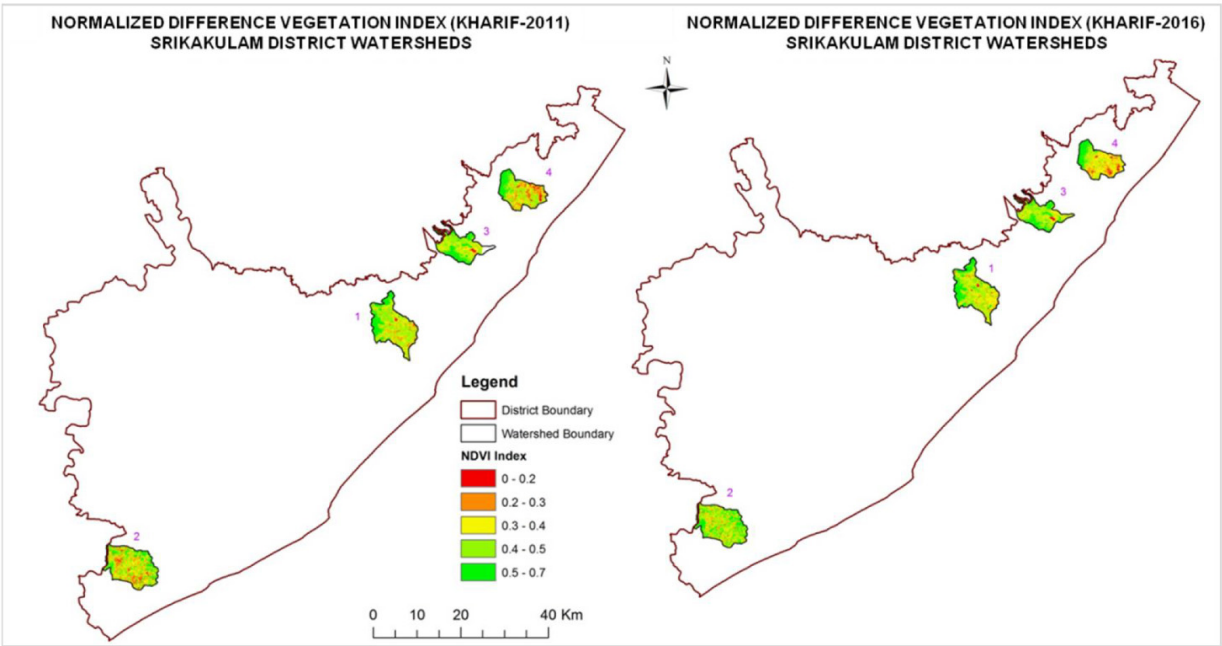


Figure 5. Comparision of Normalized difference vegetation index

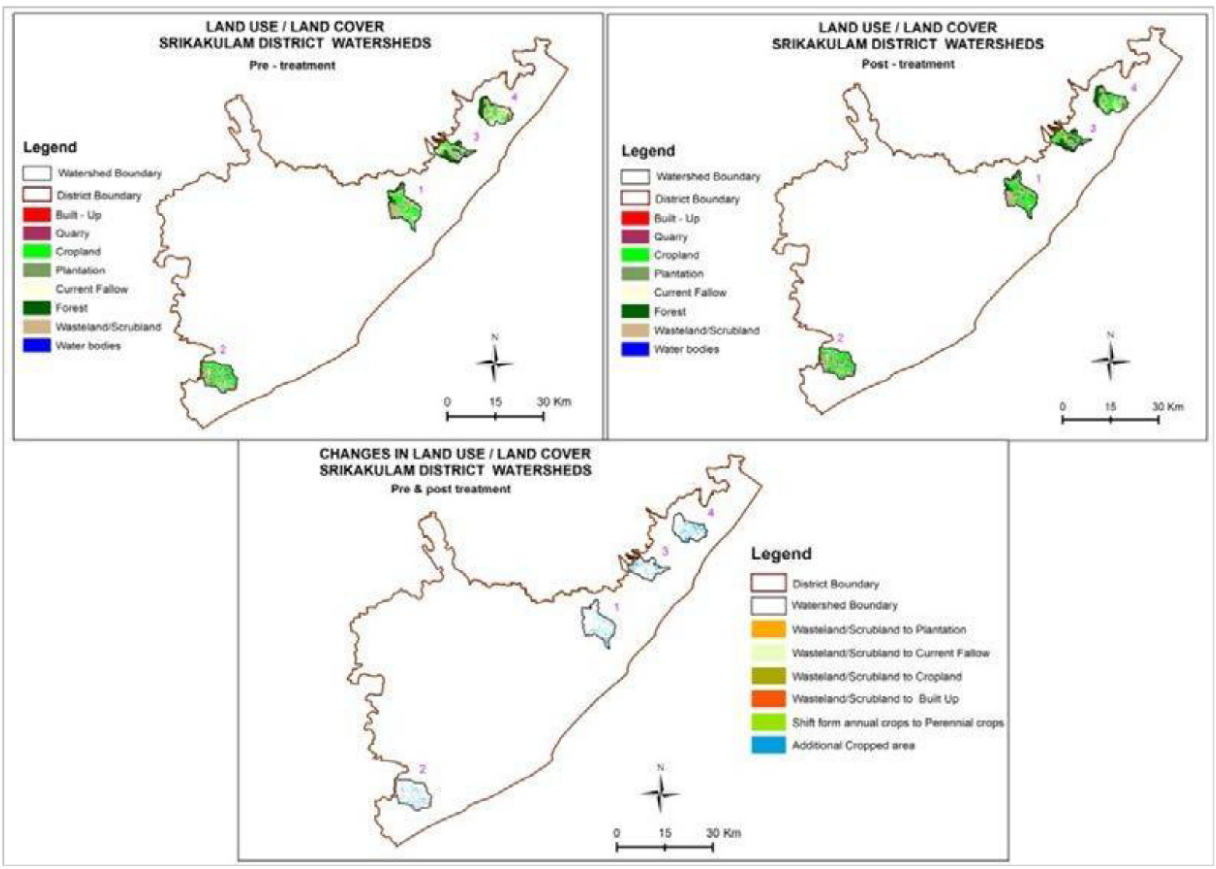


Figure 6. Comparision of land use / land cover maps

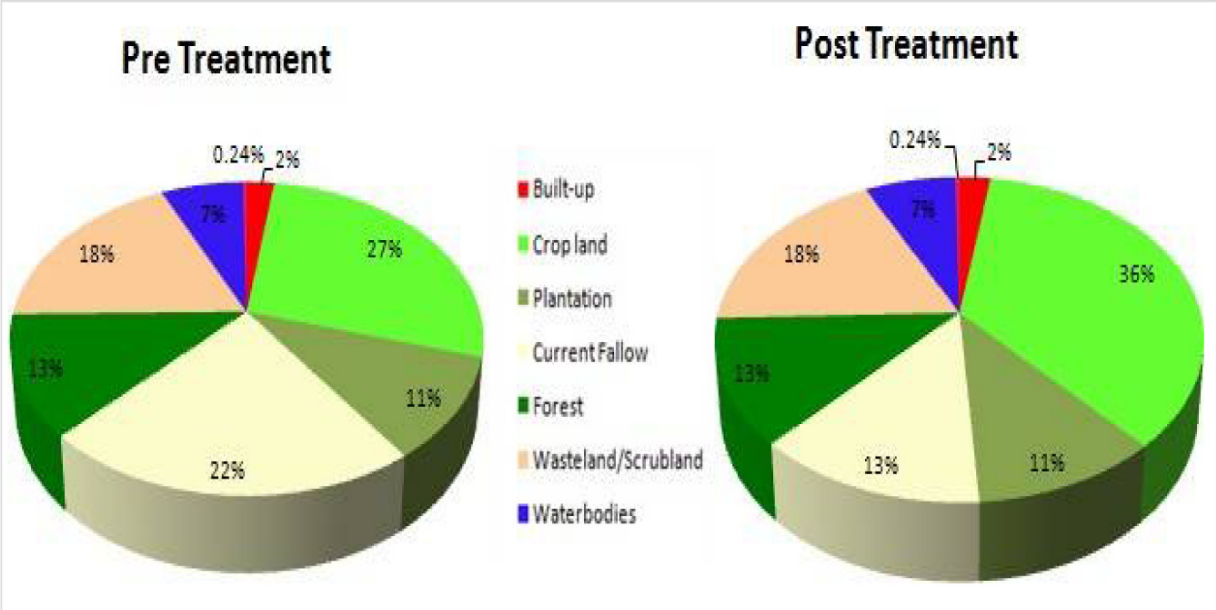


Figure 7. Land use / Land cover distribution

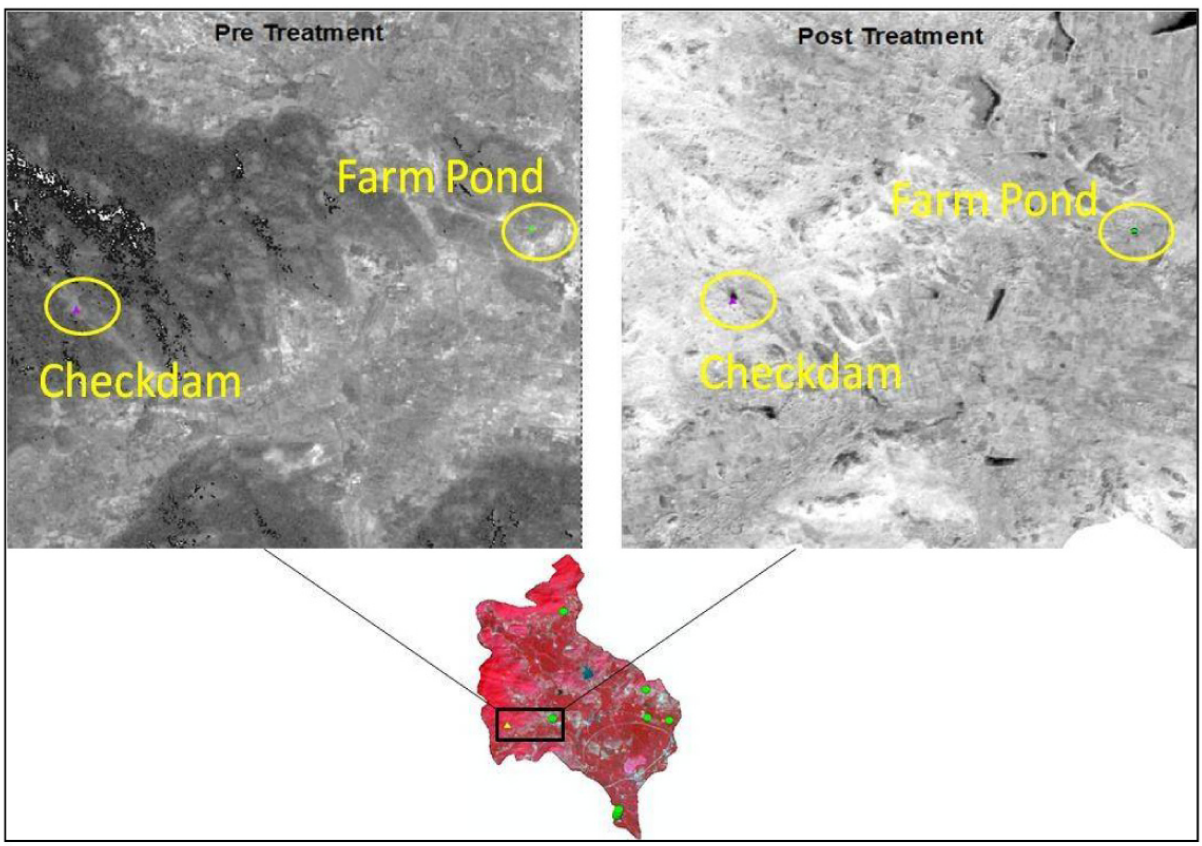


Figure 8. Major activities in watershed project area

Table 5. Major changes in seven watersheds in Srikakulam district (ha)

S.No.	District Name	Vegetation Cover			Cropland			Plantation			Water bodies		
		Pre	Post	Chan ge	Pre	Post	Change	Pre	Post	Change	Pre	Post	Change
1	Kallada	6687	7110	423	2854	3240	386	264	303	39	512	547	35
2	Laveru	6085	6711	626	2497	3287	790	1549	1549	0	624	653	29
3	Kondaloga m	4856	4961	105	924	1312	388	652	652	0	175	194	19
4	J.L.Kota	4892	5010	124	1178	1915	737	400	400	0	503	523	20
	Total	**22520**	**23792**	**1278**	**7453**	**9754**	**2301**	**2865**	**2904**	**39**	**1814**	**1917**	**103**

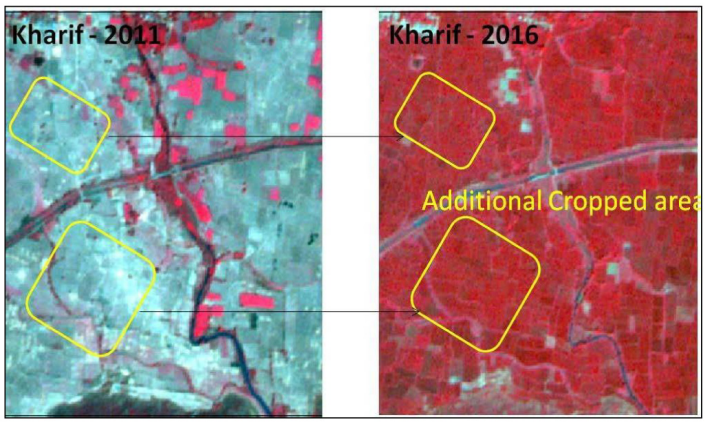


Figure 9. Major changes in watershed project

CONCLUSIONS

Change detection studies have been carried out for evaluation of all the four watersheds in the district. It was observed that there is an increase in plantation area from 2865 ha to 2904 ha. The cropland has also increased from 7453 ha to 9754 ha from 2011 to 2016. The overall increased area under crops is 2301 ha during the project period. It is also noticed that cropland area is increased at the cost of fallow land. The output of NDVI classification indicates increase in dense vegetation from 7763 ha to 10343 ha. NDVI studies indicated a slight improvement in open vegetation category due to the reduction of fallow land and a drastic change noticed in dense vegetation area for the watershed during 2011 and 2016 with an increase of 2580 ha. The major changes in the watersheds are presented (Table 5).

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SERVICES OFFERED BY THE RBKS AND TRAINING NEEDS OF VILLAGE AGRICULTURAL ASSISTANTS IN GUNTUR DISTRICT

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Date of Receipt : Date of Acceptance :

ABSTRACT

The attempt was made to analyse the awareness and utility of RBK services by the farmers and training needs of Village Agricultural Assistants (VAAs) in Guntur district. Hundred farmers from 10 subdivisions and 165 VAAs from 55 mandals were selected asthe respondents. Majority of the farmers were aware of distribution of quality fertilizers (88.00%), e-crop booking (86.00%), soil & water testing facility (78.00%), free crop insurance/ animal insurance (75.00%), provision of quality seed (green manure/ crop seed/fodder seed/concentrate feed) (73.00%), distribution of quality pesticides (60.00%) and provision of need based information to farmers on crop health management (57.00%). With respect to utility, only few services are utilised by the farmers' viz., e crop booking (82.00%), free crop insurance / animal insurance (59.00%) and distribution of quality fertilizers (58.00%). Majority of the Village Agricultural Assistants expressed that Integrated Disease Management (87.27 TNI & Rank I), Integrated Pest management (83.64TNI &Rank II), new varieties (81.41TNI & Rank III),Micro nutrient management (80.80TNI & Rank IV), Integrated weed management (80.20 TNI & Rank V) are the major areas of training needed by them. Major constraints expressed by VAAs are inability to meet the demands of farmers with respect to providing all of them with subsidies, inability to maintain sufficient fertilizers, pesticides and other stocks as required by farmers and Heavy work load.

Keywords: Awareness, Utilization, RBKs, Training needs,VAAs and Constraints

INTRODUCTION

Andhra Pradesh being an agrarian state, to meet each and every need of the farmers an innovative system in the form of Rythu Bharosa Kendras was introduced.The government started 10,641 RBKs across the state on 30th May 2020.They are playing crucial role in meeting the needs of the farmers at local level. The problems of the farmers in the field of agriculture and allied sectors will be addressed by the professionals available at RBKs. Establishment of RBKs at village level not only made all the services available at one point but also serve farmers with hassle free experience. Agriculture assistants, Horticulture assistants, Veterinary assistants and Fishery assistants with diploma and above qualifications in their respective fields were

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recruited by the Government to work at the RBKs. The major services offered at RBKs are Input delivery, soil testing,training farmers, crop insurance**, c**rop booking, demonstrations, selection of the beneficiaries, providing market intelligence, issuing health and insurance cards for livestock, vaccination for animals, guidance on extent of loan eligibility through Bank Mitra and information on government schemes, plant health clinics, interaction with scientists and other experts through audio and video conference on smart TV, technical advisories on best management practices of crops and animals, first aid for animals and treatment after consulting veterinary doctor,prophylactic vaccinations, deworming and semen collection, etc.

For supply and management of inputs and farm machinery RBKs partnered with Andhra Pradesh State Agro Industries Development Corporation Limited and the technical partners in the state were Acharya N.G Ranaga Agriculture University (ANGRAU), Dr. YSR Horticultural University and Sri Venkateswara Veterinary University. RBK system was introduced in the state to bring the extension system very close to farming community at grass root level. It aims to supply quality inputs and services with increased accessibility. The training of agricultural extension workers is an integral part of the overall agricultural production (Jasim *et al.,* 2016). Training need identification is a tool utilized to identify what educational courses or activities should be provided to employees to improve their work productivity (Ahmad, 2022). Need assessment helps to discover problems and identify future challenges to be dealt by means of appropriate training interventions (ICAR, 2020).In order to fulfil the purpose of establishing RBKs at village level, strengthening of VAAs technically is inevitable with suitable training strategy to meet prioritized training needs. Identifying constraints in performing VAAS roles also plays acrucial role in making RBKs more effective.With this backdrop, an attempt was made to analyse the RBK system with the following objectives: 1. To study the awareness and utility of RBK services by the farmers; 2. To elicit the Training needs of VAAs and to know the constraints of VAAs in performing their roles.

MATERIALS AND METHODS

The study was conducted in Guntur district of Andhra Pradesh where 852 RBKs were established throughout the district. From 33 mandals of Guntur district five Village Agricultural Assistants from each Mandal were selected thus making the total sample size of one hundred and sixty five Village Agricultural Assistants (VAAs). Ten subdivisions of Guntur were selected and from each subdivision two mandals were identified and from each mandal 5 farmers were randomly selected thus making the sample size of 100 farmers. To study the awareness and utility of RBK services by the farmers 32 services offered at RBKs were mentioned and farmers' response was recorded using personal interview method. With respect to training needs of Village Agricultural Assistants training needswere divided into 3 major areas *viz*., cultivation related aspects, other related aspects and general aspects. Various training needs under these three major areas were administered to VAAs on three point

continuum mostly needed, needed and not needed with the scores of 3, 2 and 1, respectively. Training needs were prioritized using the Training Need Index. Formula used to calculate Training Need Index (TNI) was

$$TNI = \frac{\text{Score obtained}}{\text{Maximum obtainable score}} \times 100$$

Constraints of VAAs were studied using open ended questions.

RESULTS AND DISCUSSION

Awareness and utilization of services of RBKs by the farmers

From Table 1 it could be inferred that with respect to awareness of farmers on RBK services greatmajority of the farmers expressed that they were aware of Distribution of quality fertilizers (88.00%), e-crop booking (86.00%), Soil & water testing facility (78.00%), Free crop insurance/ animal insurance (75.00%), Provision of quality seed (green manure/ crop seed/fodder seed/concentrate feed) (73.00%), Distribution of quality pesticides (60.00%) and Provision of need based information to farmers on crop health management (57.00%). The first and foremost reason for this awareness was VAAs were majorly focussing on e crop booking, provision of quality inputs viz., seed, fertilizers and pesticides, free crop/animal insurance and providing need based suggestions for crop health management. Majority of the farmers were approaching RBK for quality inputs as they used to get exploited more by the private dealers with respect to seeds, fertilizers and pesticides.Regarding other services majority of them were unaware of Assistance in organic certification (94.00%), Provision of separate market for organically produced goods and services (91.00%), Provision of godowns to store the produce during glut (88.00%), Conduct of advisory board meeting once in a month (87.00%), Provision of bio fertilizers and bio fungicides (78.00%), Promotion of organic farming/ natural farming/ ZBNF, etc.(78.00%), Purchase of surplus produce at MSP when market price falls below MSP (78.00%), Maintenance of custom hiring centres (75.00%), Provision of guidance on extent of loan eligibility through bank mitra and information on government schemes (75.00%), Maintenance of digital library and information material for enhancement of farmers knowledge (74.00%), Provision of free vaccination to animals, first aid for animals and treatment after consulting VAS, Deworming and semen collection (74.00%), Identification of beneficiaries for various government schemes (73.00%), Provision of farmer groups like FPO's, Cooperative societies, FIGs etc (73.00%), Provision of organic inputs like neemcake, vermin compost, neem oil, natural farming productsetc (71.00%), Provision of IPM kits like pheromone traps, sticky traps, lures etc. (69.00%), Provision of inputs readily or on demand (68.00%), Provision of animal health cards (62.00%), Integrating with ICC, RBK channel for farmers queries and farmers-scientists interaction (59.00%), Maintenance of smart TV for interaction with scientists and other experts through audio and video conferences and dissemination of technology, Organization of polambadi/thotabadi/ pasuvigyanbadi (58.00%), Maintenance of

digital kiosk for booking inputs (56.00%), Seed germination test facility (54.00%) and Provision of loan, weather and market prices information through CM APP (51.00%). Majority of the farmers were unaware of the above mentioned services as some of the services were not yet initiated at RBKs like soil and water analysis, godowns, organic certification and custom hiring centres as very few RBKs were working in own buildings, others in hired buildings . In some villages RBK services were majorly confined to a very narrow group of farmers who used to be in regular contact with RBK.

With respect to utilization of RBK services by the farmers very few services like e-crop booking (82.00%), free crop insurance/ animal insurance (59.00%) and distribution of quality fertilizers (58.00%) were utilized by the farmers. The reason behind was these were the services majorly focussed by the Department of Agriculture. Great majority of the farmers were not utilizing the services like provision of separate market for organically produced goods and services (98.00%), assistance in organic certification (97.00%), maintenance of custom hiring centres (95.00%), provision of godowns to store the produce during glut, provision of organic inputs like neemcake, vermin compost, neem oil, natural farming productsetc (93.00%), provision of IPM kits like pheromone traps, sticky traps, lures etc., provision of farmer groups like FPO's, Cooperative societies, FIGs etc. (92.00%), provision of bio fertilizers and bio fungicides, purchase of surplus produce at MSP when market price falls below MSP (91.00%), conduct of advisory board meeting once in a month (90.00%), promotion of organic farming/ natural farming/ ZBNF etc.(89.00%), distribution of quality pesticides (87.00%), identification of beneficiaries for various government schemes (86.00%), provision of free vaccination to animals, first aid for animals and treatment after consulting VAS, deworming and semen collection (85.00%), seed germination test facility (84.00%), maintenance of digital kiosk for booking inputs, provision of guidance on extent of loan eligibility through bank mitra and information on government schemes (83.00%), Provision of loan, weather and market price information through CM APP, Maintenance of digital library and information material for enhancement of farmers knowledge (82.00%), Provision of all inputs viz., fertilizers, pesticides, seed etc at a lower price compared to local market, provision of need based information to farmers on crop health management (77.00%), provision of quality seed (green manure/ crop seed/fodder seed/ concentrate feed) (76.00%), Maintenance of smart TV for interaction with scientists and other experts through audio and video conferences and dissemination of technology (75 .00%), provision of animal health cards (74.00%), integrating with ICC, RBK channel for farmers queries and farmers-scientists interaction, provision of inputs readily or on demand, provision of inputs readily or on demand (73.00%), organization of polambadi/ thota badi/pasu vigyanbadi (69.00%), soil & water testing facility (67.00%) and organization of capacity building programmes to farmers in recent advances in agriculture by scientists (65.00%). Lack of awareness among the farming community on various services provided at RBKs and non availability of these

services at RBKs were the major reasons for not utilizing of the services offered at RBKs. Hence creating awareness among the farming community and creating facilities for utilising all the services are the need of the hour to meet the very purpose of establishing RBKs.

Training needs of Village Agricultural Assistants in Guntur District

Training needs of Village Agricultural Assistants (VAAs) in Guntur District were categorized and presented under three major aspects cultivation related, other related aspects and general aspects (Table 2). The top prioritized training areas under cultivation related aspects were Integrated Disease Management (87.27 TNI & Rank I), Integrated Pest management (83.64TNI &Rank II), new varieties (81.41TNI & Rank III), Micro nutrient management (80.80TNI & Rank IV), Integrated weed management (80.20 TNI & Rank V), Post harvest technology (79.93 TNI & Rank VI), Soil test based fertilizer management (79.59TNI and Rank VII), Integrated Nutrient Management (79.39 TNI and Rank VIII), Drought/Heavy rains affected crop management (78.18 TNI & Rank IX), Manures use (76.36 TNI & Rank X), Organic farming (74.94 TNI & Rank XI), Seed treatment (72.52TNI & Rank XII), Irrigation management (71.31TNI & Rank XIII) and Rodent management (66.67 TNI & Rank XIV).Regarding other related aspects majority of the VAAs felt that Soil analysis (75.15 TNI & Rank I), Seed certification (74.75TNI & Rank II), Input subsidies (74.34TNI & Rank III), Seed testing (72.12TNI & Rank IV), Climate resilient technologies (71.92 TNI & Rank V), Farm machinery, Bio fertilizers, Crop loans (71.71TNI & Rank VI), Fertilizer and pesticide testing (70.91TNI & Rank VII), Marketing (70.50 TNI & VIII), Crop insurance (70.10 TNI & Rank IX), Soil and water conservation measures (68.48 TNI & Rank X), Departmental schemes and programmes (68.08 TNI & Rank XI) and Animal husbandry (56.16 TNI and Rank XIII). General aspects on which VAAs need training wereITCs use in agriculture (TNI 73.73 and Rank I), Extension programmes implementation and methods (TNI 73.53 and Rank II), Groups formation and Group dynamics (TNI 73.13 and Rank III), Monitoring and evaluation of programmes implemented (TNI 71.11 and Rank IV) and Communication skills (TNI 69.03 and Rank V). Mohan *et al.*(2021) reported similar training needs *viz.,* pest and disease management, crop varieties, manures and fertilizers and weed management.

Constraints of VAAs in disseminating recent technologies to the farmers

It is evident from Table 3 that major constraints expressed by the VAAS were inability to meet the demands of farmers with respect to providing them with subsidies (73.94%), inability to maintain sufficient fertilizers, pesticides and other stocks as required by farmers (71.52%), heavy work load (64.85%), lack of technical expertise in solving field problems (59.39%), insufficient time (50.90%), lack of awareness on recent and high yielding varieties (47.88%), Illiteracy among farmers (40.60%), inability to provide farmers subsidy on organic inputs (38.18%) and insufficient infrastructure due to rented buildings (27.88%),

Table 1. Awareness and utilization of services ofRBKs by the farmers

(n=100)

S.No	Item	Awareness				Utilization			
		Aware		Not aware		Yes		No	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%
1.	Soil & water testing facility	78	78.00	22	22.00	33	33.00	67	67.00
2	Seed germination test facility	46	46.00	54	54.00	16	16.00	84	84.00
3	e-crop booking	86	86.00	14	14.00	82	82.00	18	18.00
4	Free crop insurance/ animal insurance	75	75.00	25	25.00	59	59.00	41	41.00
5	Provision of quality seed (green manure/ crop seed/fodder seed/concentrate feed)	73	73.00	27	27.00	24	24.00	76	76.00
6	Distribution of quality fertilizers	88	88.00	12	12.00	58	58.00	42	42.00
7	Distribution of quality pesticides	60	60.00	40	40.00	13	13.00	87	87.00
8	Provision of loan, weather and market prices information through CM APP	49	49.00	51	51.00	18	18.00	82	82.00
9	Maintenance of custom hiring centres	25	25.00	75	75.00	5	5.00	95	95.00
10	Provision of need based information to farmers on crop health management	57	57.00	43	43.00	23	23.00	77	77.00
11	Maintenance of digital library and information material for enhancement of farmers knowledge	26	26.00	74	74.00	18	18.00	82	82.00
12	Organization of capacity building programmes to farmers in recent advances in agriculture by scientists	55	55.00	45	45.00	35	35.00	65	65.00
13	Organization of polambadi/thotabadi/pasuvigyanbadi	42	42.00	58	58.00	31	31.00	69	69.00

Table 1 Contd.

Table 1 Contd.

S.No	Item	Awareness		Utilization					
		Aware		Not aware		Yes		No	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%
14	Maintenance of digital kiosk for booking inputs	44	44.00	56	56.00	17	17.00	83	83.00
15	Maintenance of smart TV for interaction with scientists and other experts through audio and video conferences and dissemination of technology	42	42.00	58	58.00	25	25.00	75	75.00
16	Integrating with ICC, RBK channel for farmers queries and farmers-scientists interaction	41	41.00	59	59.00	27	27.00	73	73.00
17	Provision of free vaccination to animals, first aid for animals and treatment after consulting VAS, deworming and semen collection	26	26.00	74	74.00	15	15.00	85	85.00
18	Provision of animal health cards	38	38.00	62	62.00	26	26.00	74	74.00
19	Provision of guidance on extent of loan eligibility through bank mitra and information on government schemes	25	25.00	75	75.00	17	17.00	83	83.00
20	Identification of beneficiaries for various government schemes	27	27.00	73	73.00	14	14.00	86	86.00
21	Provision of biofertilizers and biofungicides	22	22.00	78	78.00	9	9.00	91	91.00
22	Provision of IPM kits like pheromone traps, sticky traps, lures etc.	31	31.00	69	69.00	8	8.00	92	92.00
23	Provision of farmer groups like FPO's, Cooperative societies, FIGs etc.	27	27.00	73	73.00	8	8.00	92	92.00

Table 1 Contd.

S.No	Item	Awareness		Utilization					
		Aware		Not aware		Yes		No	
		Freq.	%	Freq.	%	Freq.	%	Freq.	%
24	Purchase of surplus produce at MSP when market price falls below MSP	22	22.00	78	78.00	9	9.00	91	91.00
25	Provision of godowns to store the produce during glut.	12	12.00	88	88.00	7	7.00	93	93.00
26	Conduct of advisory board meeting once in a month	13	13.00	87	87.00	10	10.00	90	90.00
27	Provision of all inputs viz., fertilizers, pesticides, seed etc at a lower price compared to local market	54	54.00	46	46.00	23	23.00	77	77.00
28	Provision of inputs readily or on demand	32	32.00	68	68.00	27	27.00	73	73.00
29	Promotion of organic farming/ natural farming/ ZBNF etc.	22	22.00	78	78.00	11	11.00	89	89.00
30	Provision of organic inputs like neemcake, vermin compost, neem oil, natural farming productsetc	29 0	29.00	71	71.00	7	7.00	93	93.0
31	Provision of separate market for organically produced goods and services	9	9.00	91	91.00	2	2.00	98	98.00
32	Assistance in organic certification	6	6.00	94	94.00	3	3.00	97	97.00

Table 2. Training needs of Village Agricultural Assistants in Guntur District of Andhra Pradesh

(n=165)

S.No.	Training area	TNI	Rank
	Cultivation related aspects		
1.	New varieties	81.41	III
2	Manures use	76.36	X
3	Organic farming	74.94	XI
4.	Seed treatment	72.52	XII
5	Irrigation management	71.31	XIII
6	Integrated Nutrient management	79.39	VIII
7	Soil test based fertilizer management	79.59	VII
8.	Micro nutrient management	80.80	IV
9	Integrated pest management	83.64	II
10	Integrated Disease management	87.27	I
11	Integrated weed management	80.20	V

Table 3. Constraints of VAAs in disseminating recent technologies to the farmers

(n=165)

S.No	Constraints	Freq.	%
1.	Inability to meet the demands of farmers with respect to providing them with subsidies	122	73.94
2	Inability to maintain sufficient fertilizers, pesticides and other stocks as required by farmers	118	71.52
3	Heavy work load	107	64.85
4	Lack of technical expertise in solving field problems	98	59.39
5	Insufficient time	84	50.90
6	Lack of awareness on recent and high yielding varieties	79	47.88
7.	Illiteracy among farmers	71	43.00
8.	Lack of motivation among the farmers	67	40.60
9	Inability to provide farmers subsidy on organic inputs	63	38.18
10	Insufficient infrastructure due to rented buildings	46	27.88

Table 3 Contd...

S.No	Constraints	Freq.	%
12	Post harvest technology	79.93	VI
13	Rodent management	66.67	XIV
14	Drought/Heavy rains affected crop management	78.18	IX
	Other related aspects		
1.	Seed certification	74.75	II
2.	Animal husbandry	56.16	XIII
3	Seed testing	72.12	IV
4	Fertilizer and pesticide testing	70.91	VII
5	Marketing	70.50	VIII
6	Climate resilient technologies	71.92	V
7	Marketing aspects	67.07	XII
8	Farm machinery	71.71	VI
9	Soil analysis	75.15	I
10	Bio fertilizers	71.71	VI
11	Input subsidies	74.34	III
12	Crop loans	71.71	VI
13	Crop insurance	70.10	IX
14	Soil and water conservation measures	68.48	X
15	Departmental schemes and programmes	68.08	XI
	General aspects		
1	Communication skills	69.09	V
2	Extension programmes implementation and methods	73.53	II
3	Groups formation and Group dynamics	73.13	III
4	ITCs use in agriculture	73.73	I
5	Monitoring and evaluation of programmes implemented	71.11	IV

CONCLUSIONS

Even though RBKs were established to meet every need of the farmers at their door steps, very few services viz., e crop booking (82.00%), free crop insurance/ animal insurance (59.00%) and distribution of quality fertilizers are known and utilised by the majority of the farmers. The prominent reason for their non utilization is lack of awareness and lack of provision for all services at RBKs locally. Hence it is very much needed to create awareness among the farming community on the services available at RBKs along with provision of facilities to utilize all these services by the

farming community. The major training areas VAAs needed areIntegrated Disease Management, Integrated Pest management, new varieties, Micro nutrient management, integrated weed management and Post harvest technology. These training needs need to be addressed regularly in order to update the knowledge of VAAs from time to time, further to solve the field problems of the farmers. The major constraints expressed by the VAAs were inability to meet the demands of farmers with respect to providing them with subsidies, inability to maintain sufficient fertilizers, pesticides and other stocks as required by farmers, heavy work load, lack of technical expertise in solving field problems and insufficient time. Hence they need to be provided with suffice quantities of stocks and advisories from time to time and also the work load needs to be minimised to perform effectively.

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PRODUCTION OF MULTI-UTILITY BIO-ENZYME

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Every year, large amounts of peel waste are generated from the fruit and vegetable industry and household cooking. Most of these wastes are highly rich in valuable bioactive compounds. The utilization of the low-cost horticultural wastes for the production of value-added products is a novel step towards the sustainable utilization of these wastes. Enzymes such as protease, lipase and amylase produced by the simple fermentation of vegetable and fruit wastes using microorganisms are an alternative to synthetic cleaning solutions. This bio-enzyme solution is not only a cleaning agent but can also serve as an excellent fertilizer for growing various crops. It is also known to purify ground water and can be used as a natural pesticide and herbicide(Panicker *et. al.,*2021; Galintin*et al*, 2021). It was proposed to carry out the production of bio-enzyme by using fruit/ vegetable peels/flower waste in the Department of Biotechnology, Parvatibai Chowgule College of Arts and Science, Margao, Goa in the year 2022.

Collection and Preparation of samples

Citrus fruit peels (Pineapple and orange) / vegetable wastes(mixture of tomato and potato peels in approximately equal quantity)/ flower wastes(mixture of Marigold, Hibiscus and Periwinkle in approximately equal quantity) were collected from the local market of Margao, Goa. The samples were brought to the laboratory in sterile plastic bags, cut into small pieces and dried in an oven at 45^0C until they were ofconstant weight and used for further experiments.

Production of the bio-enzyme

The collected fruit and vegetable samples were mixed with 1 part molasses: 3 part fruits peels: vegetable peels/ flower waste:10 parts water (1:3:10) in an airtight clean jar for the fermentation process. In this mixture, three table spoonful of yeast powder (*Saccharomyces cerevisiae*) were added to accelerate the fermentation processand stored in a dark and cool place toavoid direct sunlight. During the first month of the fermentation process, gasses were vented daily to prevent the container from bursting due to built-up pressure. After three months of fermentation, the mixture was filtered to obtain the bio enzyme solution which is used to test its efficacy for various applications (Thirumurugan, 2016; Naik, 2022).

Screening for enzyme activity

The presence of various enzymes such as amylase, protease, lipase and cellulose in the bio-enzyme extract was confirmed using the well diffusion method described by Thirumurugan (2016).

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Qualitative detection of secondary metabolites

The presence of various secondary metabolites such as flavonoids, quinone, saponins, alkaloids and terpenoids were determined using the standard proced uredescribed by Vama and Cherekar (2020).

Effect of bio-enzyme on plantlet growth

Green gram (*Vigna radiata*) seeds were surface sterilized with 70% ethanol and then treated with 1% sodium hypochlorite for 2 minutes followed by repeated washing with sterile water.Ten treated seeds in this way were kept equally spaced in four sterilized petriplates with sterile filter paper, plate 1 served as a control which received 5 ml ofwaterdaily for upto six days, plate 2 received 5 ml of water mixed with 5% bio-enzyme from citrus peels, plate 3 received 5 ml of water mixed with 5% bio-enzyme from vegetable peels and plate 4 received 5 ml of water mixed with 5% bio-enzyme from floral waste and the petriplates were incubated at room temperature (28+ 2 °C). The effect of different bio-enzyme extract on seed germination was evaluated by measuring the radical length overa period of six days(Vama and Cherekar, 2020).

Effect of bio-enzyme in waste water treatment

The domestic waste water (grey-water) sample was collected from the college campus. The raw sewage sample was analysed according to the standard procedure (Naik, 2022). Two BOD bottles filled with the wastewater sample mixed with 5% and 10% bio-enzyme were incubated for three days and BOD were estimated in comparison with the control whichdid not receive the bio-enzyme.

Production of bio-enzyme

In the study, peels of citrus fruits, vegetable wastes and floral wastes were used as substrate for bio-enzyme production. The following abbreviation sareusedhence for th to denote differentbio-enzyme samples: CBE (citruspeel bio-enzyme); FBE (flower waste bio-enzyme); VBE (vegetable peel bio-enzyme).

Screening of enzyme activity

The bio-enzyme solutions CBE, VBE and FBE were tested for the presence of various enzymes and the order of activity was Protease>Amylase>Lipase>Cellulase. Many researchers have reported the presence of enzymes in bio-enzyme solution. Fruit peels of pineapple (*Anana scomosus)*, papaya (*Carica papaya)* and mixed fruits showed protease enzyme activity while only Pomegranate peels (*Punica granatum)* showed lipase enzyme activity as reported by Neupane and Khadka (2019). Similarly Panicker *et al.* (2021) detected multiple enzymes such as amylase,protease, cellulase and lipase, produced by simple fermentation of fruit waste with yeast and bacteria.

Qualitative detection of secondary metabolites

All three bio-enzyme extracts tested for the presence of secondary metabolites (Table 1).

A similar result was obtained by Vama and Cherekar (2020) in the production of bio-enzyme from citrus waste that promoted the germination of wheat seedling by reducing the germination time from nine days in the control to six days in the test plant. Due to the presence of various secondary metabolites, the bio-enzyme produced in the study could be used as a potential plant growth promoter.

Effect of Bio-enzyme on seed germination

The efficacy of bio-enzyme solutions (CBE, FBE and VBE) as plant growth promoters was tested using Green gram seeds(*Vigna*

Table 1. Qualitative detection of secondary metabolites in bio-enzyme solutions

S.No.	Bio-enzyme sample	Alkal-oids	Flavo-noids	Sapo-nins	Phenolic compo-unds	Tannins	Antho cyanins	Quino-nes
1.	CBE	+	+	+	+	+	+	+
2.	VBE	+	+	-	+	-	-	+
3.	FBE	-	+	-	+	-	-	+

+ indicates presence; - indicates absence

radiata).Maximum and rapid growth was observed in seeds treated with bio-enzyme solution compared to the control (Table 2).

Metabolism of seed protein is the necessary step in seed germination which occurs in several step with the help of proteolytic enzymes.Bio-enzymes being rich in proteases contribute to embryo germination by metabolizing stored food such as proteins inside the seeds thus supporting the embryo growth(Vama and Cherekar, 2020).

Bio-enzyme in wastewater treatment

The result of wastewater treatment with bio-enzyme from citrus peel is shown in Fig. 1.Treatment of grey water showed that BOD was reduced to 20% and 58% in waste water treated with 5% and 10% bio-enzyme respectively. Bio-enzyme can be used as an economical option for waste water treatment and making it fit for various other purposes (Kumar *etal.,*2020; Kerkar and Salvi, 2020).In a research study conducted by Galintin *et al.* (2021), the maximum efficiency of eco-enzyme in the removing pollutants from aquaculture sludge measured in terms of BOD was observed when using 15% eco enzyme dosages.

In this work, low- cost production of bio-enzyme from various household wastes has been demonstrated with new applications in waste water treatment and seed germination.

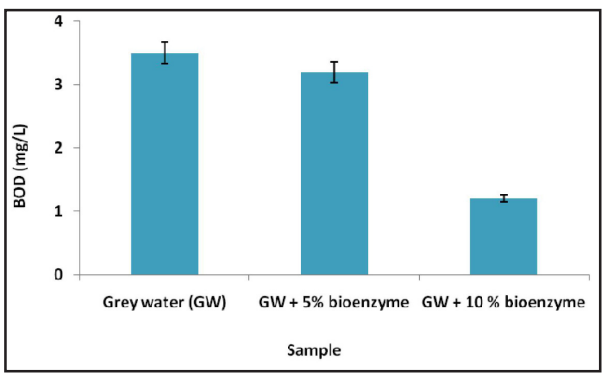

Figure 1. Effect of bio-enzyme on BOD of greywater

Table 2. Measurement of radicle length of mung bean treated with bio-enzyme solutions

S.No	Sample	Day 2 (cm)	Day 4 (cm)	Day 6 (cm)
1.	Control	No growth	0.5 ± 0.01	1.1 ± 0.05
2.	CBE	1.1 ± 0.01	2.2 ± 0.3	3.5 ± 0.6
3.	VBE	1.3 ± 0.6	1.5 ± 0.4	1.7 ± 0.5
4.	FBE	No growth	0.7 ± 0.01	0.8 ± 0.008

+ indicates mean + SD from triplicate experiment

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EFFECT OF TRAINING ON FARMERS PRACTICING ORGANIC FARMING IN THE ADOPTED VILLAGES OF ERODE DISTRICT

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Agriculture has a major role in quality of life. Agriculture is a primary activity which includes Crops, fruits, vegetables, flowers, and cattle. Around the world, 50% of people are depending on agriculture. India's population still relies on agriculture for two-thirds of its income (Lichtenberg, 2020). An organic agricultural practice is a choice that will increase the profitability of Indian agriculture because organic farming is more environmentally responsible. Consequently, it needs to be considered a priority in agriculture. (Calicioglu *et al.,* 2019). Using organic farming methods is the only solution to nurture the land and to regenerate by the soil going back to the traditional method of farming *i.e.,* free from chemicals, pesticides and fertilizers. Here is apossible step for sustainable development by choosing not to use chemicals, synthetic materials, pesticides and growth hormones to produce high nutritional quality food and in adequate quantities (Elayaraja and Vijai, 2020).

The research was carried out in 15 villages in Bhavani block of Erode District, Taminadu state in the year 2021. A household survey was performed in 450 households from the 15 villages with equal representation from marginal, small and large categories of the women farmers, using an interview schedule to elicit the information on food grain production, storage and the problems encountered. Based on the household survey, research content was formulated and trained the farmers on the significance of organic farming. A five-day training programme was conducted on organic farming practices such as preparation of organic fertilizers, growth boosters and pesticides. The thrust areas covered during the training programme included preparation of organic fertilizers through the Mud pot, Plastic container, grow bags, movable silpaulin vermibed, compost pit. Preparation of organic growth boosters such as amuthakaraisal, jivamrutham, Neem leaf extract and neem kernel extract. Preparation of Organic storage practices such as circulation of air with neem treated dunnage, preparation of storage rooms and structure, treatment many gunny bags and polythene bags using neem leaf extractfor storage and neem leaf pellet to control Insect and pest attack. The methods used for communication was group discussion, lecture, demonstration, meetings, exhibitions and field visits. The visual aids used during the programme were charts, posters, pamphlets, booklets, monograph, book, film and slide shows. For a period of one year't' test was carried undertaken to evaluate the pre-and post-of the training programme. By

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way of knowledge gained attitude developed the adoption level of the selected households.

Socio-economic profile of the selected households

A majority (55 percent) of farmers were among the womenabove 45 years and older 60 percent of the farmers had only received their primary education. Agriculture was the primary occupation followed by 33 percent of women farmers. Over 87 percent of the women farmers belonged to nuclear families, this indicates the trend towards the breakdown of thejoint family system even in rural areas. With regard to family size, 69 percent belonged to small families. A majority (51 percent) of the women farmers had previous farming experience more than 10 years. Based on the land holding pattern of the farmers they are classified into three types, As marginal farmers (below 1hectare), small farmers(1-2 hectare), largefarmers(above 2 hectare). A total of 450 farmers were chosen for this study with 150 farmers from each category (marginal, small and large). All the respondents had an annual family income of less than Rs.1,00,000 per annum indicating low economic status.

Knowledge gained by the women farmers

Knowledge was operationalized as the quantity of information possessed regarding organic farming practices both before and aftertraining programme. The acquired knowledge was evaluated using knowledge inventory comprised questions related to various aspects such as agricultural situation in India, effects of chemical farming, importance of organic agricultural practices for agricultural sustainability and organic methods of pest and disease management. The mean scores, pre and post, was recorded and the't' value was calculated to test the significant difference.

Table 1 revealed that 't' value for knowledge score was revealed to be 59.36, 70.71 and 91.87 for marginal, small and large farmers respectively which were significant at one percent level. It is concluded that the mean score for knowledge gained for large farms was highest and lowest for marginal farmers. The reasons may result fromhaving more land for cultivation and for the storage of grain food and also showed interest in adopt new concepts and technology to improve agricultural production and conservation of food grains. Jaganathan *et al*. (2016) opined that few farmers both in organic and inorganic categories had very low and high levels of knowledge about organic farming.

Attitude developed by the women farmers on organic farming

In order to find the right reflection, an attitude scale was developed based on Likert's Summated Rating Scale technique. The

Table 1. Knowledge gained by the Women Farmers about Organic Farming

n = 450

S.No.	Farmers	frequency	Before Training	After Training	Difference	't' value
1	Marginal	150	2.29±0.73	15.64±0.63	13.35±0.10	59.36**
2	Small	150	2.57±0.76	15.79±0.43	13.22±0.33	70.71**
3	Large	150	1.64±0.50	15.86±0.36	14.22±0.14	91.86**

**-significant an one percent level

attitude measurement consists of assessing an individual's response to a set of social objects or situation. Table 2 represents the attitudes developed by the women farmers towards organic methods of pest and disease management.

The attitude scores of the women farmers of all categories increased and also had shown significant 't' values of 11.02, 11.44 and 21.48 for marginal, small and large farmers respectively. Therefore, it can be inferred that the training programme had a positive impact on the change of attitude of women farmers in the adoption of organic methods of pest and disease management for sustainable agriculture. Janjhua *et al*. (2019) opined that many farmers have been found to be positive for organic farming but were concerned about its viability. Although the majority of farmers in the study had favourable perceptions about organic farming, but most had not yet adopted it farming.

willingness for of adoption of organic agriculture as expressed by the women farmers

After providing training in the preparation of organic fertilizers, pesticides, growth boosters and storage practices for organic farming, the women farmers were willing to adopt the organic farming practices effectively. From the Table 3, it is evident that the adoption of organic farming by the selected women farmers has improved significantly (1% level) after undergoing the training programme. The results proved that the women farmers had accepted organic farming is a way to prevent pest and diseases.

Effectiveness of teaching methods as expressed by the women farmers

Various teaching approaches helped to understand the organic farming in a better way and improve their farm income in long term (Table 4).

Over 92 percent of the women farmers who belonged to marginal land holding category opined that group discussion was the best method and easiest way to communicate the organic farming practices mainly because it placed responsibility on every individual to think about the process of adoption and to clarify doubts and also to contribute towards. Ninety five percent of the women farmers belonged to marginal land holding category expressed that field visit was highly useful. Field visit helps the women farmers to study the real pictures with evidence. Brown *et al.* (2020) pointed out that real picture are more evident and highly influential. It shows a picture is equivalent to1000 words. Ninety two percent women farmers belonged to small and large land holding categories opined that demonstration and lecture method were

Table 2. Attitude scores obtained by the women farmers on organic farming

n = 450

S. No.	Farmers	frequency	Before Training	After Training	Difference	't' value
1	Marginal	150	32.50±12.45	70.64±12.18	38.14±0.27	11.02**
2	Small	150	32.86±9.18	67.43±7.00	34.57±2.18	11.44**
3	Large	150	36.43±10.07	86.86±3.91	50.43±6.16	21.48**

**: Significant at 1% level

Table 3. Level of adoption on organic farming by the women farmers

n=450

S.No.	Farmers	frequency	Before Training	After Training	Difference	't' value
1	Marginal	150	3.50±1.45	10.38±1.58	6.88±0.13	39.949**
2	Small	150	3.26±1.59	12.94±1.19	9.68±0.4	60.780**
3	Large	150	4.26±1.88	14.99±0.94	10.73±0.94	61.989**

** Significant at 1% level

Table 4. Effectiveness of teaching methods as expressed by the women farmers

n = 450

S.No.	Teaching method	Marginal (150)		Small (150)		Large (150)	
		f	%	f	%	f	%
1	Group discussion	138	92	150	100	150	100
2	Field visit	143	95	128	85	128	85
3	Demonstration	104	69	138	92	150	100
4	Lecture	116	77	116	77	138	92
5	Meeting	81	54	93	62	69	46
6	Exhibition	69	46	93	62	104	69

satisfactory mainly because lectures helped them to acquire the back ground knowledge and demonstration offered a chance for participation and observation.

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