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IDENTIFICATION OF DROUGHT TOLERANT MUTANT LINES BASED ON GENETIC VARIABILITY AND DIVERSITY STUDIES IN RICE (*Oryza sativa* L.)

APARNA ERAGAM*, A. SRIVIDHYA, P.LATHA, ESWARAYYA RAMI REDDY and LAKSHMINARAYANA R VEMIREDDY

Department of Molecular Biology and Biotechnology, S.V. Agricultural College,
Acharya N.G. Ranga Agricultural University, Tirupati-517 502

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ABSTRACT

The study aimed to identify suitable donors for yield and drought-tolerance and its utilization in drought breeding program. A total of 10 gamma mutant rice lines and four genotypes were studied for 12 morpho-physiological parameters under moisture stress condition during *rabi*, 2018-2019. High genotypic coefficient of variation and phenotypic coefficient of variation values were recorded for the traits spikelets per panicle, 1000 seed weight, relative membrane injury and filled grain number per panicle under control conditions. While, under moisture stress condition filled grains per panicle, grain yield per panicle, spikelet fertility and 1000 seed weight exhibited higher GCV and PCV values. High heritability coupled with high genetic advance was observed for number of filled grains per panicle and number of spikelets per panicle under both controlled and moisture stress condition representing additive gene action whose selection might be effective in future breeding programmes. Correlation studies revealed a positive and significant association of traits plant height, panicle length, number of filled grains per panicle, spikelets per panicle, SPAD chlorophyll meter reading and specific leaf area with grain yield per plant in both control and moisture stress conditions. Divergence studies categorized the population into four clusters under control condition and three clusters under reproductive stage moisture stress conditions. Based on inter-cluster distance inclusion of genotypes under cluster II and IV in future hybridization programmes may result in the development of drought tolerant high yielding varieties.

Key Words: Genetic variability, Reproductive stage moisture stress, Mutant lines

INTRODUCTION

Rice is the staple food for over two billion people in Asia and for hundreds of millions in Africa and Latin America. Rice is a high water-consuming crop requires about 3000 liters of water to produce one kg of rice (Source: http://www.knowledgebank.irri.org/step-by-step-production/growth/ water-management). Abiotic stresses such as drought, heat, salinity and

*Corresponding Author E-mail i.d: aparnareddy003@gmail.com; PhD thesis submitted to Acharya N.G. Ranga Agricultural University, Guntur

submergence are the major factors that limit the yield potential of rice (Choudhary *et al*., 2009). Among them, drought and heat stress have been identified as the most critical threats to the world food security (Farooq *et al*., 2009). Rice is highly susceptible to water stress during developmental stages such as panicle initiation stage and reproductive stage, ultimately that leading to significant reduction in grain yield. When moisture stress occurs during reproductive stage, it remarkably reduces rice grain yield due to abortion of ovule and formation of partially filled grains (Pantuwan *et al*., 2002). In general, drought stress reduces water potential and turgor pressure in cells, which increases the solute concentrations in the cytosol and extracellular matrices. When the cells sense moisture stress, it decrease the cell enlargement leads to growth reduction their by reproduction failure in plants (Farooq *et al*., 2009).

Drought stress tolerance can be potentially measured through physiological and morphological parameters. Plant metabolism primarily dependent on water status and the best way to determine plant water status is through measurement of relative water content (RWC), a crucial physiological parameter that refers to the degree of cell or tissue hydration which is responsible for maintaining growth activities and highly correlated with morphological and yield traits viz., plant height, days to flowering, panicle length and harvest index that results in better grain yield in rice (Silva *et al*., 2007).

Improving rice varieties to become less sensitive to water deficit is an essential requirement to sustain rice production (Rajiv *et al*., 2010). Identification of drought tolerance attributes such as morphological, physiological and biochemical parameters in rice would be advantageous during crop improvement (Bunnag and Pongthai, 2013). RWC was identified as a key morphological parameter to select tolerant plants under drought stress (Bunnag and Pongthai, 2013).These changes might be due to mutations and may occur either in the genes or at chromosomal level to bring the desired improvement. At present, improvement of major food crops in the world rests majorly on mutation. The use of seed irradiation to achieve chromosomal changes has been found to increase frequencies of mutation and promote gene recombination which in turn leads to mutation spectrum widening (Larik *et al*., 2009). Based on gamma radiation mutation, plant breeding has officially released over 2700 new crop cultivars in approximately 170 species (Lagoda, 2008). Now a days, breeders are interested in evaluating genetic diversity based on morphological characteristics as they are inexpensive, rapid, and simple to score and does not require sophisticated equipment. In the study, ten mutant lines along with BPT 5204, MTU1010, Swarna and *DRR Dhan 42* genotypes were evaluated under normal and drought condition at reproductive stage to identify suitable donors for yield and drought tolerance for rice breeding program.Therefore, the study was conducted at the college farm of S.V. Agricultural college, Tirupati with the objectives (i) morphological characterization of the mutant lines for grain and agronomic parameters under normal and reproductive stage moisture stress conditions; (ii) To assess genetic diversity based on yield and yield components.

MATERIALS AND METHODS

Experimental Site

A total of 10 gamma mutant lines along with MTU1010, Swarna, BPT5204 (susceptible check) and *DRR Dhan 42* (tolerant check) were selected for this study conducted during *Rabi*, 2018-2019. Seeds were sown and transplanted after 30 days in puddled field with 10 cm × 15 cm distance in Randomized Block Design (RBD) and replicated thrice for the Control and Stress plot. Fertilizer was added at a recommended rate (175:60:60 kg N, P_2O_5 and K_2O/ha) and hand weeding was done when needed.The control plot was irrigated throughout the experiment with average of five cm water above the soil level.Stress plot was subjected to moisture stress at reproductive stage by withholding water in the field. Soil

Table 1. List of morphological, physiological and yield parameters recorded under field condition

Growth traits and yield traits	Denotation	Method of evaluation
Plant height	PH (cm)	The average height from the base to the tip of the plant
Panicle length	PL (cm)	Measure the length from the node below the lowest branch on the panicle to the top of first superior spikelet
No of panicles per hill	NP/P (Number)	Number of panicles per hill
Filled grains per panicle	FG (Number)	Count the number of filled spikelets per panicle
Thousand seed weight	TSW(g)	Weightof 1000 filled grains
No of spikelets per panicle	NSP(Number)	Number of spikelets per panicle
Spikelet fertility	SF (%)	Percentage of ratio of number of filled grains with the total number of spikelets
Days to maturity	DTM(days)	Count the number of days from seeding to maturity
Relative water content	RWC (%)	Measured using the fresh weight, turgid weight and Dry weight.
SCMR chlorophyll meter reading	SCMR	Difference between the transmittance of a red (650 nm) and an infrared (940 nm) light through the leaf
Specific leaf area	SLA(cm^2/g)	Ratio of leaf area to leaf dry mass
Relative membrane injury	RMI(%)	RMI was measured by using a conductivity meter

moisture content was measured using gravimetric method (Shukla *et al*., 2014).

From each mutant line, ten plants were randomly sampled from each block for data collection. During growth period, all the data concerning morphological parameters such as plant height, panicle number, panicle length, yield and its component traits *viz.,* number of filled grains/panicle, 1000-grain weight, grain yield/ plant and the physiological parameters such as SCMR value, relative water content, specific leaf area and relative membrane injury (RMI) were recorded under moisture stress condition as well as non-stress condition.

Data analysis

Variance components.

Variance components were estimated to determine genetic variation among mutant lines and genotypes to assess genetic and environmental effects on different traits. The variance components were calculated as follows.

Genotypic variance $(\sigma^2 g)$.

$$\sigma 2 = (MSG-MSE)/r$$

In which, MSG is the mean square of genotypes, MSE is the mean square of the error, and *r* is a number of replications.

Phenotypic variance $(\sigma^2 p)$

$$\sigma^2 p = \sigma^2 g + \sigma^2 e,$$

where $\sigma 2\ g$ is genotypic variance and $\sigma 2\ e$ is the mean squares of error. Error Variance ($\sigma 2$). Consider

$\sigma 2\ e$ = MSE, in which, MSE is the mean square of error.

Phenotypic and genotypic coefficient of variation (PCV and GCV)

The estimates of phenotypic and genotypic coefficient of variation were calculated according to Singh and Choudhary (1985) as follows:

$$PCV = \frac{\sqrt{\sigma 2_p}}{\bar{x}} \times 100 \quad GCV = \frac{\sqrt{\sigma 2_g}}{\bar{x}} \times 100$$

$\sigma 2\ p$ is the phenotypic variance, $\sigma 2\ g$ is the genotypic variance, X is the mean of the trait, GCV, and PCV values were categorised as low (0-10%), moderate (10-20%), and high (20% and above) as perSivasubramanian and Madhava Menon (1973).

Heritability estimate

This heritability *h*2b (broad sense) is the ratio of genetic variance ($\sigma 2\ g$) to phenotypic variance ($\sigma 2\ p$) Falconer (1989). It is calculated as

$$h^2 (b) = \frac{(\sigma 2g)}{(\sigma 2p)} \times 100$$

In which, $\sigma 2\ g$ is the genotypic variance and $\sigma 2\ p$ is the phenotypic variance. The heritability percentage was categorized as low (0-30%), moderate (30-60%), and high (e"60%) following Robinson *et al*. (1949).

Estimation of genetic advance (GA)

Genetic advance was estimated as per formula given by Allard (1960).

$$GA = K \times \sigma p \times h^2 (b) \text{ Where,}$$

K = Selection differential at 5 per cent selection intensity, which accounts to a constant value 2.06 σp= Phenotypic standard deviation

All the morphological and yield data were subjected to Analysis of Variance (ANOVA). Also means, standard error, standard deviation, and coefficient of variation were calculated for each trait to understand the difference among lines at a significant difference of $p < 0.05$ using IBM SPSS Statistics 20.0 version. The relationship among the trait was also determined using correlation analysis.

RESULTS AND DISCUSSION

Genetic variation for morphological, yield, and yield attributes performance under moisture stress and controlled condition

The results related to yield and yield attributes performance of mutant lines along with genotypes under moistures stress at the reproductive stage and irrigated condition are presented in Table 3. Three parameters related to vegetative growth such as plant height, no of panicles per plant, and days to maturity were analysed for control and moisture stress condition at the reproductive stage. Under control condition, the plant height varied from 73.53 cm (Swarna) to 117.73 cm (SM120) with the mean value of 93.90 cm. Mutant lines grown under moisture stress condition showed decreased plant height and varied from 56.20 cm (Swarna)to 91.20cm (MM73) with mean of 78.10cm. A significant decrease in plant height was also observed in MM151 and Swarna and in BPT5204 grown under drought stress condition. Normally, rice yield is indirectly related to plant height, most of the high-yielding genotypes were short, which could equally be attributed to very effective assimilate partitioning at the expense of vegetative growth. In this experiment, most of the high-yielding mutant lines were found to be of intermediate height. This implies that moderate plant height is desirable when breeding for high-yielding varieties (Oladosu *et al*., 2014). Days to maturity varied significantly among the mutant lines and the range was from 110 to 153 days under irrigated condition. The earliest maturity mutant lines were MM151, MM152, MM155, and SM227, while mutant line SM210 matured last, whereas in the case of moisture stress condition it varied from 112 days (MTU1010) to 166 (SM210). The traits of yield in mutant lines grown under moisture stress condition produced significantly lower yields than controlled condition and yield reduction was observed in all mutant lines under stress conditions. Generally, the moisture stress heavily affected the number of panicles per plant, panicle length, filled-grains per panicles, and thousand-grain weight and, thereby, grain yield. Furthermore, data comparison between the control and moisture stress indicated that no. of panicles per plant under the controlled condition the values were between 6.73 and 11. The highest number of panicles were observed in BPT 5204 (susceptible check) followed by Swarna and SM210 line and the lowest was recorded in SM 227 line under controlled condition. Moisture stress had 5.13 and 10 for lowest and highest, respectively. The length of the panicle for the controlled condition ranged from 19.43 to 27.03cm with a mean of 22.98 cm and under moisture stress, it ranged from 18.90 to 25.30 cm with a mean of 22.45 cm.

The mean number of filled grains per panicle in controlled conditions ranged from 62.54 to 153.38 with a total mean of 114.98 and under moisture stress no filled grains were observed in susceptible check and some mutant lines and highest was recorded in SM 227 with 120.83 filled grains per panicle. Filled grains per panicle (FG) were significantly reduced in some mutant lines MM155 and no of filled grains per panicle were more in SM 227 followed by MM73, MM152, and MM151. Under non stress condition, the 1000-seed weight ranged from 9.67g to 25.97g, for moisture stress condition it was in range of 13.00-21.00g among the mutant lines. An increase in the number of filled grains could be attributed to the efficient translocation of carbohydrates from the sources to the spikelets (sinks) which consequently lead to an increase in grain yield. (Xu and Zhou, 2007). Lower test weight (1000 grain weight) and spikelet fertility were observed under moisture stress condition than the controlled condition in all mutant lines and genotypes; In contrast, MM155 showed the highest grain weight under a stress condition when compared to control but there was no significant variation. A wide variation for the 1000-seed weight (TSW), spikelet fertility (SF), and filled grain per panicle (FG) was observed in mutant lines. When the rice was exposed to moistures stress at the reproductive stage, significant decrease in spikelet fertility and GY reduction were observed with the decline in SPN and FG. Highest spikelet fertility was observed in *DRR Dhan 42* (78.70 %), MTU1010 (77.86 %), MM 155 (68.60%), SM 227 (66.67 %). The lowest spikelet fertility was recorded in Swarna (34.67 %.) This is in line with the observation of Gaballah *et al*. (2021) that the reduction of grain yields, number of panicles/plants, 100-grain weight, and high sterility percentage resulted from water stress at the reproductive stage.

Evaluation of physiological traits of mutant lines and genotypes under controlled and moisture stress condition at reproductive stage

Under moisture stress condition, relative water content (RWC) and specific leaf area (SLA) were decreased significantly and relative membrane (RMI) monitored by electrolyte leakage of the leaf was increased during moisture stress condition in all lines (Table 3). RWC was significantly reduced approximately 23.79 % under drought stress situation as compared to controlled condition among all lines and ranged from 53.90% to 73.63% with a mean of 65.08%. The RWC is highly associated with the cell turgor and further controls the cell expansion. In most of these studies, RWC decreased to an extent of 60-80% with increased water stress due to increase in osmotic potential of the plant cells (Singh *et al*., 2015). Under stress condition, SM47 (73.63%), MM73 (70.30%), SM211 (68.67%), SM210 (67.60%), SM227 (67.13%) recorded highest RWC among the lines. RWC is considered as a measurement of water status in plant and most meaningful index of moisture stress tolerance. In the case of SLA, the reduction in leaf area was observed in all mutant lines as compared to controlled environment. Under stress condition, SLA has ranged from 126.83 to 163.27 with a mean of 145.92 (cm^2/g).In control condition SLA ranged from 146.03 to 174.09 (cm^2/g) with a mean of 158.77 (cm^2/g). RMI was increased significantly across all mutant lines compared with the control condition. Under stress condition, RMI ranged 25.63 to 44.00 (%) with a mean 35.60 (%). The highest RMI recorded in BPT5204 (susceptible check) and the lowest was in *DRR Dhan 42*lines. There is not much variation in SCMR value among the lines in control and moisture stress condition other than MM155, *DRR Dhan 42*, MTU1010, and SM210. There is an increase in SCMR value at moisture stress condition as compared to the control condition. The results are in line with Nguyen *et al*.(1997). The genotypic difference for chlorophyll content observed under severe drought could attribute to the difference in their water use efficiency. Therefore, the cultivars showing higher SCMRvalues under the moisture stress effect might show higher water use efficiency through a substantial reduction in stomatal conductance without affecting carbon assimilation rate. The lower SCMR values under moisture stress effect in certain lines might be due to the production of reactive oxygen species that lead to impaired pigment biosynthetic pathways, degradation of chloroplast membrane, or increased lipid peroxidation (Jaleel *et al*., 2009).

Estimation of correlation coefficients relationships among the mutant lines and genotypes under control and reproductive stage moisture stress condition

Under normal condition, Grain yield is positively correlated with Plant height, PL, FGP, TSW, SNP, SCMR, and SLA. Panicle length is positively correlated with filled grains per panicle, TSW, DTM, and SNP. This indicates that simultaneous selection of all these characters is important for yield improvement. Similar associations between yield and other traits were revealed by Edukondalu *et al*. (2017) for panicle length, Ratna *et al*. (2015) for plant height. In this study, the highest panicle length, filled grain number per panicle, 1000 seed weight line was recorded in SM210 under control condition this can be used for yield improvement in the breeding program. Filled grains per panicle are positively correlated with TSW, SNP, DTM, SCMR, and RMI. Number of panicle per plant, spikelet fertility, days to maturity, RWC, RMI had a negative direct effect, and PH, PL, FGP, TSW, SNP, SCMR, and SLA had a positive effect on grain yield per plant. As in the case of moisture stress condition, grain yield per plant was positively correlated with the PH, PL, NP, FGP, SNP, SF, SCMR, and SLA and negatively correlated with the DTM, RWC, and RMI(Table 4). This indicates that selection is based on the panicle length, filled grains per panicle, spikelet fertility, and SCMR values to improve the yield under moisture stress conditions. MM155 performed better in all these parameters and this line can be used as a donor for selected parameters under moisture stress conditions.

Estimates of coefficients of variation, heritability and genetic advance

Under controlled condition, the GCV values ranged from 26.98% to 3.10% for the number of spikelets per panicle and relative water content, respectively. Among the traits, the spikelets per panicle, relative membrane injury, 1000 seed weight, Filled grains per panicle showed highest GCV. On the other hand, PCV was ranged from 29.09% for spikelets per panicle to 6.27% for relative water content. Spikelets per panicle, relative membrane injury, 1000 seed weight, filled grains per panicle recorded highest PCV (Table 5). Heritability estimates ranged from 99.88% for days to maturity to 24.47% for RWC while DTM, PH, RMI, GY, SNP, NP, and FGP showed the highest heritability estimates. The highest estimate of genetic advance (72.58%) was seen in SNP and the lowest estimate was for the number of panicles (Table 5).

In the case of moisture stress condition, PCV values ranged from 96.62% for grain yield to 5.85% for SCMR. Grain yield, filled grain number per panicle, spikelet fertility, and 1000 seed weight recorded the highest PCV at moisture stress condition (Table 5). GCV values ranged from 96.75% for filled grain per panicle to 4.01% for SCMR value. Filled grains per panicle, grain yield, spikelet fertility, and 1000 seed weight recorded height GCV (%) than other yield characters. Heritability estimates ranged from 99.15% for spikelet fertility to 23.19% for RWC while spikelet fertility, 1000 seed weight, filled grain per panicle, days to maturity, spikelets per panicle, plant height, panicle length, and a number of panicles showed the highest heritability than other characters. The highest estimates of genetic advance were seen in the Number of spikelets per panicle, filled grains per panicle, and spikelet fertility. The lowest genetic advance was observed in SCMR values, Number of panicle per plant, and panicle length than the other agronomic and physiological traits. Heritability is the proportion of total variance that is inherited from the parents. Higher genotypic coefficient of variation together with high heritability as well as high genetic advance gives better clues than individual parameters. Thus, the traits with the high genotypic coefficient of variation, heritability, and genetic advance are selected.

In this study, under controlled conditions filled grains per panicles, 1000 seed weight, number of spikelets per panicle had higher values for the genotypic coefficient of variation, heritability, and genetic advance. Therefore, selection to develop one trait which will positively influence other traits is of paramount importance. The positive correlation between the final yield and the total number of spikelets per panicle and filled grain per panicle indicates that better exploration of these three traits could be used to develop desired genotypes for controlled condition. This work has positive correlation coefficients with the yield parameters which is an indication that the quantitative traits measured were appropriate for yield prediction and selection for breeding programs to obtain better vigor or heterosis. The contribution of individual panicle-filled grain numbers adds up to produce the final yield. Therefore, a high filled grain number could be successfully used as an important selection index for grain yield (Meenakshi *et al*., 1999). In the study, yield per panicle (filled grains per panicle) had the best relationship with grain yield per plant production. Hence, more attention is given to this trait for final yield determination in all the assessed mutant lines.

Under reproductive stage moisture stress condition, filled grains per panicle, spikelet fertility, and a number of spikelets per panicle had higher values for the genotypic coefficient of variation, heritability, and genetic advance. When compared to control and moisture stress condition, filled grain number per panicle and number of spikelets per panicle had higher values for the genotypic coefficient of variation, heritability, and genetic advance. Hence, selection to develop one trait which will positively influence other traits is of paramount importance for both conditions. In case of moisture stress condition, positive correlation between the final yield and a total number of spikelets per panicle, filled grain per panicle and spikelet fertility indicates that better exploration of these four traits to develop desired genotypes for adverse environmental conditions.

Clustering patterns of lines

The study was conducted using 14 lines and grouped into a different cluster based on divergence analysis under control and moisture stress condition as indicated in Table. 6. Under controlled condition, the clustering pattern was random and independent. Cluster I was the largest among all clusters followed by cluster II, cluster IV and cluster 3 contained only one line. In the case of moisture stress condition, 14 lines were grouped into 3 clusters based on the 14 morphological and physiological traits. Among the 3 clusters, cluster I, cluster II had an equal number of lines, and cluster III has three lines.

Inter and intra-cluster euclidian distance

The averages inter and intra-cluster distance euclidian values are given in (Table 7). Maximum inter-cluster Euclidian distance was

Table 2. Analysis of variance for yield, yield parameters and drought physiological parameters of mutant lines and genotypesunder control and stress condition

S.No	Characters	Control	Mean squares Stress		
		Replication	Treatment	Replication	Treatment
1	PH	1.15	610.64**	2.06	311.62**
2	PL	6.20	13.99**	1.20	8.40**
3	NP	0.16	5.60**	0.34	7.38**
4	NFG	313.43	2349.38**	209.44	6647.61**
5	TSW	0.09	55.44**	1.07	198.43**
6	GY/P	2.20	24.74**	2.29	67.38**
7	NSP	43.30	4564.60**	37.40	8726.06**
8	SF	66.64	87.23**	25.93	3275.35**
9	DTM	0.87	1056.33**	25.76	884.40**
10	RWC	50.82	42.35	75.98	69.34
11	SCMR	5.86	14.19**	7.47	10.16**
12	SLA	201.15	180.49**	136.61	427.93**
13	RMI	0.61	53.64**	6.97	105.09**

PH = Plant height, PL= Panicle length, NP = No. of panicle per plant, GY/P = grain yield per plant, NFG=Number of filled grains per panicle, SF= Spikelet fertility, DTM = Days to maturity, TSW = thousand seed weight, NSP= Number of spikelets per panicle, RWC=Relative water content, SCMR= The Soil Plant Analysis Development (SCMR) chlorophyll meter. SLA= Specific leaf area, RMI= relative membrane injury.

'** ' represents significant at 1% level of significance; '*' represents significant at 5% level of significance recorded between clusters I and II followed by I and IV. Whereas, minimum inter-cluster distances were recorded between cluster I and III. The maximum inter-cluster distance indicated that genotypes/lines of II and VI are not so closely related whereas the minimum inters cluster distance indicate that the genotype is closely related. The genotypes of cluster I and II showed inters cluster distance hence these genotypes are closely related. Similar finding was also observed by Nagaraja *et al*. (2010). The intra-cluster distance revealed a wider variation within-cluster IV followed by cluster I. In case of moisture stress condition, inter-cluster euclidian distances were recorded between clusters I and II followed by cluster I and III. Whereas minimum inters cluster distance was recorded in clusters II and III. The intra-cluster distance revealed a wider variation within cluster III. Inters-cluster distance is a good indication to select diverse parental lines and it is suggested that superior pure lines from the diverse cluster may be chosen for hybridization because of the better performance of hybrids. The lower intra-cluster distance suggests that the accessions within each cluster were relatively homogenous and selection within that clusters may not be progressive. In our results, Custer II and IV had the highest inter-cluster distance and cluster IV contains mutant lines of Swarna background and cluster IV contains Swarna variety. It is indicated that these two cluster lines and parent Swarna can be used chosen for hybridization due to better performance of mutant lines in cluster II. Under moisture stress condition, cluster II and cluster III has high inter-cluster distance, cluster II has more number of MTU 1010 mutant lines such as MM151, MM73 and MM152 and in cluster III have MTU 1010 and MM155 and *DRR Dhan 42* lines. These two cluster lines can be used in the hybridization program for the development of lines for drought tolerance.

CONCLUSION

The study revealed that high heritability with high genetic advance was observed for number of filled grains/panicle and number of spikelets per panicle under control and moisture stress conditions indicating the involvement of additive gene action in the inheritance of the traits hence sufficient to follow simple selection. Most of the traits such as plant height, panicle length, number of filled grains/panicle, spikelets per panicle, SCMR, SLA were positively correlated with the grain yield per plant except number of panicle per plant, days to maturity, spikelet fertility and RMI in both the conditions. Finally, the evaluated lines were grouped into four major clusters for controlled condition and three clusters for reproductive stage moisture stress condition based on the assessed traits. So hybridization among the mutant lines of cluster II with cluster IV could be used to attain higher heterosis or vigor for the development of higher yield genotypes and cluster II with cluster III could be used in rice breeding programs for the development of drought-tolerant varieties with higher yields suitable for water-limiting environments.

Table 3.Phenotypic variations of yield related traits of selected mutant lines along with genotypes under moisture stress and irrigated conditions in *Rabi* 2018-19

Lines	PH (cm) Control	PH (cm) MS condition	PL(cm) Control	PL(cm) MS condition	NP(no) Control	NP(no) MS condition	FGP(no) Control	FGP(no) MS condition	TSW(g) Control	SW(g) MS condition
BPT 5204	75.07	59.57	19.43	18.90	11.00	8.47	107.89	0.00	9.67	0.00
DRR Dhan 42	76.67	76.33	22.20	22.53	9.80	10.00	62.54	44.13	21.67	18.00
MM151	99.53	83.70	21.33	21.60	8.00	5.40	129.67	82.20	22.00	13.33
MM152	98.27	88.23	21.13	22.30	7.20	5.47	123.33	115.87	15.67	15.67
MM155	83.13	86.60	25.93	22.73	9.40	9.07	88.07	62.47	21.33	21.00
MM73	96.07	91.20	22.47	22.40	7.60	6.60	121.80	97.93	19.00	13.67
MTU1010	82.27	84.53	21.13	21.73	7.60	9.20	87.67	63.80	20.00	16.67
SM 108	112.40	80.07	24.53	22.80	8.07	5.20	153.38	0.00	25.97	0.00
SM 47	105.80	81.80	27.03	25.30	8.60	6.47	136.83	0.00	17.44	0.00
SM120	117.73	80.43	23.60	22.00	8.87	6.60	114.95	0.00	15.40	0.00
SM210	108.73	66.30	25.33	24.07	10.53	6.20	136.83	0.00	24.84	0.00
SM211	102.60	77.50	24.07	23.20	7.60	6.87	134.87	0.00	15.23	0.00
SM227	82.73	80.90	22.87	23.53	7.67	6.20	130.20	120.83	15.67	13.00
SWARNA	73.53	56.20	20.67	21.13	10.73	7.80	81.67	32.10	15.33	14.33
Mean	93.90	78.10	22.98	22.45	8.76	7.11	114.98	44.24	18.52	8.98
Min.	73.53	56.20	19.43	18.90	7.20	5.20	62.54	0.00	9.67	0.00
Max.	117.73	91.20	27.03	25.30	11.00	10.00	153.38	120.83	25.97	21.00
C.V.	1.03	6.04	6.86	3.45	6.26	14.34	10.65	25.92	8.54	8.56
S.E.	0.56	2.74	0.91	0.45	0.31	0.58	7.27	7.19	0.91	0.46
C.D. 5%	1.62	7.93	2.65	1.31	0.90	1.67	21.05	20.84	2.62	1.34
C.D. 1%	2.18	10.70	3.57	1.77	1.22	2.26	28.40	28.12	3.54	1.80

Table 3 continued...

Lines	GYp^{-1}(g) Control	GYp^{-1}(g) MS condition	SNP Control	SNP MS condition	SF Control	SF MS condition	DTM Control	DTM MS condition	RWC(%) Control	RWC(%) MS condition	SCMR Control	SCMR MS condition	SLA (cm^{2}g^{-1}) Control	SLA(cm^{2}g^{-1}) MS condition	RMI(%) Control	RMI(%) MS condition
BPT 5204	10.51	0.00	117.84	110.33	91.19	0.00	155.67	146.00	86.22	53.90	36.41	36.73	155.12	140.07	27.01	44.00
DRR Dhan42	13.39	7.13	65.67	55.97	95.23	78.70	115.33	115.33	87.85	63.67	36.24	38.57	162.25	146.43	11.84	25.63
MM151	21.05	4.83	157.98	163.30	81.93	51.53	110.00	119.00	87.51	65.33	40.64	40.23	166.35	153.50	11.91	30.33
MM152	14.22	9.83	150.41	149.40	81.94	64.33	110.00	119.33	85.21	63.17	39.37	38.13	162.92	140.43	12.72	31.00
MM155	17.72	11.90	105.64	90.67	83.01	68.60	110.00	116.67	87.62	58.10	37.80	40.40	160.39	163.27	11.42	32.77
MM73	16.54	8.13	134.69	151.23	89.23	65.47	115.00	125.67	86.11	70.30	40.56	40.17	156.89	154.07	14.46	35.03
MTU1010	12.59	10.17	95.94	81.63	91.19	77.67	115.00	112.33	87.47	64.17	38.39	42.23	174.09	162.27	17.06	37.60
SM 108	20.67	0.00	187.91	75.73	81.67	0.00	147.67	152.33	85.63	65.70	37.25	38.17	164.40	138.70	18.75	36.27
SM 47	15.33	0.00	166.28	113.63	82.26	0.00	139.67	150.00	81.49	73.63	36.07	37.63	156.45	142.97	18.30	36.27
SM120	15.00	0.00	146.75	108.43	78.40	0.00	149.67	152.67	76.51	66.70	35.59	35.53	150.45	147.80	16.92	41.23
SM210	17.33	0.00	166.79	121.83	81.95	0.00	153.00	166.00	77.04	67.60	38.45	41.17	152.64	139.17	20.50	38.23
SM211	15.00	0.00	173.96	176.87	77.54	0.00	149.00	151.67	85.17	68.67	41.26	40.13	146.03	126.83	20.26	43.53
SM227	15.80	11.83	153.82	173.70	84.45	66.97	115.00	134.33	88.04	67.13	41.75	38.13	156.81	151.23	13.74	29.57
SWARNA	12.66	4.37	86.82	100.90	90.67	34.67	150.00	146.00	87.64	63.07	41.69	41.10	157.96	136.10	13.95	36.97
Mean	15.56	4.87	136.46	119.55	85.05	36.28	131.07	136.24	84.97	65.08	38.68	39.17	158.77	145.92	16.35	35.60
Min.	10.51	0.00	65.67	55.97	77.54	0.00	110.00	112.33	76.51	53.90	35.59	35.53	146.03	126.83	11.42	25.63
Max.	21.05	11.90	187.91	176.87	95.23	78.70	155.67	166.00	88.04	73.63	41.75	42.23	174.09	163.27	27.01	44.00
C.V.	6.77	26.56	10.88	19.40	6.19	8.35	0.49	4.12	5.45	9.30	4.28	4.26	5.88	8.04	7.97	7.24
S.E.	0.61	0.77	8.85	14.54	3.03	1.76	0.37	3.23	2.68	3.48	0.96	0.96	5.36	6.70	0.75	1.46
C.D. 5%	1.77	2.24	25.63	42.11	8.76	5.11	1.08	9.37	NA	NA	2.78	2.78	15.53	19.40	2.18	4.22
C.D. 1%	2.38	3.02	34.58	56.81	11.82	6.89	1.45	12.64	NA	NA	3.75	3.76	20.94	26.17	2.94	5.70

PH = Plant height, PL= Panicle length, NP = No. of panicle per plant, GY/P = grain yield per plant, NFG=Number of filled grains per panicle, SF= Spikelet fertility, DTM = Days to maturity, TSW = thousand seed weight, NSP= Number of spikelets per panicle, RWC=Relative water content, SCMR= The Soil Plant Analysis Development (SCMR) chlorophyll meter. SLA= Specific leaf area, RMI= Relative membrane injury

Table 4. Correlation coefficients of yield and yield related traits under moisture stress condition (above diagonal) and control (bellow diagonal) of mutant lines and genotypes at S.V. Agricultural College in *Rabi, 2018*

Character	PH (cm)	PL (cm)	NP (no)	NFG (no)	TSW (g)	NSP (no)	SF (%)	DTM (days)	RWC (%)	SCMR	SLA (cm^2g^{-1})	RMI(%)	GY p^{-1}(g)
PH (cm)	1	0.456**	-0.221	0.528***	0.345*	0.247	0.440**	-0.482***	0.164	0.006	0.249	-0.363*	0.668
PL(cm)	0.469**	1	-0.344*	0.139	-0.028	0.437**	0.054	0.137	0.311*	0.082	-0.261	-0.384**	0.54
NP	-0.304*	-0.083	1	-0.204	-0.292	-0.550**	0.307*	-0.306*	-0.264	0.145	0.340*	0.013	0.26
NFG	0.615***	0.367*	-0.486***	1	0.761***	0.480***	0.798***	-0.689***	-0.074	0.134	0.167	-0.635***	0.848
TSW(g)	0.321*	0.315*	-0.057	0.062	1	0.053	0.942***	-0.843***	-0.208	0.344*	0.300*	-0.656***	0.887
NSP	0.680***	0.383**	-0.507***	0.954***	0.11	1	-0.005	-0.018	0.063	-0.032	-0.460**	-0.269	0.135
SF(%)	-0.591***	-0.294	0.351*	-0.449**	-0.02	-0.622***	1	-0.887***	-0.126	0.297*	0.437**	-0.625***	0.917
DTM	0.299*	0.088	0.515***	0.171	-0.189	0.185	-0.132	1	0.167	-0.231	-0.390**	0.518***	-0.784
RWC(%)	-0.509***	-0.193	-0.196	-0.211	-0.014	-0.169	0.262	-0.396**	1	0.105	0.015	-0.049	-0.185
SCMR	-0.181	-0.083	-0.306*	0.145	-0.084	0.15	-0.131	-0.226	0.329*	1	0.065	0.013	0.217
SLA(cm^2g^{-1})	-0.172	-0.254	-0.031	-0.269	0.32	-0.27	0.256	-0.318**	0.241	0.115	1	-0.059	0.385
RMI(%)	0.151	-0.009	0.301*	0.291	-0.327	0.254	-0.044	0.738	-0.242	-0.292	-0.287	1	-0.598
GY p^{-1}(g)	0.547	0.404	-0.309	0.546	0.648	0.553	-0.369	-0.199	-0.049	0.127	0.096	-0.279	1

Table5. Estimation of phenotypic coefficients of variation, genotypic coefficients of variation, heritability and genetic advance of the 13 traits in *Rabi,2018* cropping season

S.O.V	Enviro-nment	PH	PL	NP	NFG	TSW	GY	NSP	SF	DTM	RWC	SCMR	SLA	RMI
Means	Control	93.76	23.08	8.63	118.21	18.37	15.61	140.81	84.70	130.33	85.09	38.79	157.82	16.36
	Stress	78.52	22.67	6.98	48.08	9.33	5.03	129.75	36.55	136.09	64.84	39.11	144.17	34.85
PCV(%)	Control	15.24(m)	10.90(m)	16.65(m)	25.22(h)	24.42(h)	19.21(m)	29.09(h)	8.13(l)	14.40(m)	6.27(l)	6.61(l)	6.87(l)	26.65(h)
	Stress	13.89(m)	7.90(l)	25.34(h)	92.17(h)	87.42(h)	96.62(h)	44.48(h)	90.67(h)	13.06(m)	10.62(m)	5.85(l)	10.57(m)	17.98(m)
GCV(%)	Control	15.21(m)	8.47(l)	15.43(m)	22.86(m)	22.88(h)	17.98(m)	26.98(h)	5.27(l)	14.40(m)	3.10(l)	5.03(l)	3.55(l)	25.43(h)
	Stress	12.50(m)	7.11(l)	20.90(m)	96.76(h)	87.00(h)	92.90(h)	40.03(h)	90.28(h)	12.39(m)	5.11(l)	4.01(l)	6.86(l)	16.46(m)
h^2B(%)	Control	99.54(h)	60.42(h)	85.88(h)	82.17(h)	87.76(h)	87.58(h)	86.00(h)	42.05(m)	99.88(h)	24.47(l)	57.99(m)	26.73(l)	91.06(m)
	Stress	81.07(h)	80.92(h)	67.99(h)	93.31(h)	99.04(h)	92.44(h)	80.97(h)	99.15(h)	90.06(h)	23.19(l)	47.03(m)	42.10(m)	83.77(h)
GA(%)	Control	29.30	3.13	2.54	50.47	8.11	5.41	72.58	5.96	38.63	2.69	3.06	5.97	8.18
	Stress	18.21	2.99	2.48	92.57	16.65	9.26	96.27	67.68	32.97	3.29	2.22	13.22	10.82

PCV: phenotypic coefficient of variation, GCV: genotypic coefficient of variation, h^2 B: broad sense heritability, GA: genetic advance (as percentage of mean); h: high, m: moderate, l: low.

Table 6. Distribution of mutant lines and genotypes into clusters based on D^2 analysis evaluated for control and moisture stress condition in *Rabi*, 2018

Condition	Clusters	Genotypes					
Control	Cluster 1	MTU1010	SM227	*DRR Dhan 42*	MM73	MM151	MM152
	Cluster2	SM108	SM120	SM210	SM211	SM47	
	Cluster3	MM155					
	Cluster4	BTP5204	SWARNA				
Moisture Stress condition	Cluster 1	SM120	SM211	SM47	SM210	SM108	BPT5204
	Cluster2	MM151	MM73	MM152	SM227	SWARNA	
	Cluster3	MM155	MTU1010	*DRR Dhan 42*			

Table 7. Intra cluster (Diagonal) and Inter (Above diagonal) cluster Euclidean distance for the mutant lines and genotypes evaluated for control and moisture stress condition

Condition	Clusters	I	II	III	IV
Control condition	I	161.92	2390.78	244.06	2497.36
	II		145.01	1350.91	819.33
	III			0.00	1574.30
	IV				209.56
Moisture stress condition	I	47.18	457.91	852.56	
	II		65.42	132.74	
	III			43.15	

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VERTICAL DISTRIBUTION OF NUTRIENTS IN GROUNDNUT GROWING SOILS IN SEMIARID REGION OF VARATHURU WATERSHED IN CHITTOOR DISTRICT

G.P. LEELAVATHY, M.V.S. NAIDU*, T. GIRIDHARA KRISHNA, K.V. RAMANA, V. CHANDRIKA and P. SUDHAKAR

Department of Soil Science and Agricultural Chemistry, S.V. Agricultural College, Acharya N.G. Ranga Agricultural University, Tirupati– 517 502

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ABSTRACT

The land survey was undertaken to study the vertical distribution of plant nutrients in the soil profiles/ pedons in groundnut growing areas of Varathuru watershed in Chittoor district to understand nutrient supply capacity of soils. The results revealed that plant available P and K in these soils were sufficient in the surface and subsurface horizons of all pedons except pedon 2 , wherein, P was deficient in the subsurface horizon. Exchangeable Ca and Mg and available S were sufficient in surface and subsurface soils of all pedons except pedon 3 wherein S was deficient in surface horizon. The available S and exchangeable Ca and Mg in pedons 1 and 4 were high in surface horizons than in subsurface horizons and pedons 2, 3 and 5 showed an inconsistent trend with depth. The DTPA-extractable Cu and Mn in these soils were found to be above critical limits in surface and subsurface horizons in all the pedons except in pedons 1 and 5 for Cu in subsurface horizons and Mn in surface horizon in pedon 4. The available Zn was deficient in all the pedons except pedons 2 and 5 in surface horizons and the available Fe was found to be above critical limits in surface horizons in all the pedons and below critical limit in subsurface horizons in pedons 2 and 4. All the micronutrients were higher in surface soils than for subsurface soils except in pedon 5 for Zn and Cu, pedons 1 and 5 for Fe and pedon 3 for Mn.

Key Words: Macronutrients, Micronutrients, Organic carbon, pH, Subsoil, Surface soil.

INTRODUCTION

Knowledge of vertical distribution of plant nutrients in soil is important for efficient nutrient management and for achieving sustainable yields (Ramalakshami and Sheshagiri Rao, 2000) as roots of most of the crops go beyond the surface layer and draw part of their nutrient requirements from the subsurface layers of the soil. Most of the earlier researchers have limited their studies on fertility status of surface layer only. Very few have attempted to study layer wise fertility status of soils, which is very important for effective nutrient application. Though information is available sporadic as on vertical distribution of

*Corresponding Author E-mail i.d: mvsnaidu66@gmail.com; PhD thesis submitted to Acharya N.G. Ranga Agricultural University, Guntur

macro and micronutrients, the detailed information regarding the vertical distribution of macro and micronutrients status in groundnut growing soils of Chittoor district in particular and in Andhra Pradesh in general is lacking. Hence, the survey was conducted to study the depth wise distribution of nutrients in groundnut growing soils of Varathuru watershed in Chittoor district, Andhra Pradesh, since groundnut is the major crop in the area.

MATERIAL AND METHODS

Location and Agro-climate: Varathuru watershed of Chittoor district, Andhra Pradesh is spread over an area of 1400 ha. The climate of the area is semi-arid monsoonic with mean annual rainfall of 923.48 mm, of which 90 per cent is received during June-December. The mean annual temperature is 29.50°C with mean summer temperature of 33.52°C and the mean winter temperature of 27°C. The maximum temperature was recorded in May that rises to 36.6°C and the minimum temperature is 22°C in December. The soil moisture regime is ustic and soil -temperature regime iso-hyperthermic.

Field survey and Taxonomic classification: Reconnaissance soil survey was conducted and five pedons were arranged in the groundnut growing areas of Varathuru watershed in Chittoor district, Andhra Pradesh during 2018-19. The taxonomy of these five pedons *viz.,* Kalaepalli-1 pedon (P1- Fine loamy, mixed, iso hyperthermic, Typic Haplustepts), Kalaepalli-2 pedon (P2- Fine loamy, mixed, iso hyperthermic, Typic Haplustepts), Ramapuram pedon (P3- Fine loamy, mixed, iso hyperthermic, Fluventic Haplustalfs), Pachigunta pedon (P4- Fine loamy, mixed, iso hyperthermic, Typic Haplustepts) and Vinjim pedon (P5 – Fine loamy, mixed, iso hyperthermic, Typic Haplustalfs). The horizon wise soil samples were collected for detailed analysis. The pedons P1, P2 and P4 belongs to Inceptisols, P3 and P5 were classified into Alfisols. The soil samples were processed and analyzed for available macronutrients and micronutrients using standard methods as described by Jackson (1973).

The critical limits proposed by Patel and Savani (1987) for available P (13 kg P ha^{-1}), Aulakh *et al.* (1988) for available K (150 kg K ha^{-1}), Tandon (1991) for exchangeable Ca (1.5 cmol (p^+) kg^{-1}), Mg (1.0 cmol (p^+) kg^{-1}) and available S (10 mg kg^{-1}), Anon (1977) for Zn (0.75 mg kg^{-1}), and Tandon (1993) for Fe (4 mg kg^{-1}), Cu (0.5 mg kg^{-1}) and Mn (2 mg kg^{-1}) were followed for classifying profile soil samples into sufficient or deficient for groundnut .

RESULTS AND DISCUSSION

The groundnut growing soils were slightly acidic to strongly alkaline in their reactivity (6.10-8.53) (Table 1) and wide variation in pH was attributed to the nature of the parent material, leaching, presence of calcium carbonate, exchangeable sodium and the release of organic acids during decomposition of organic matter. Similar findings were recorded by Leelavathy and Naidu (2020). The texture of the groundnut growing soils varied from sandy to sandy clay and this wider textural variation was caused by topographic position, nature of parent material, *in situ* weathering and translocation of clay as also reported by Leelavathi *et al*. (2010). The EC in groundnut growing soils ranged from 0.03 to1.24 dSm^{-1} indicating their non-saline nature (Table 1). The low EC of groundnut growing soils can be attributed to free drainage conditions which favoured the removal of released bases by percolation and drainage (Sashikala *et al*. 2019). The organic carbon content of the groundnut growing soils was low (0.05 to 0.44 per cent), which can be attributed to the prevalence of tropical condition, where the degradation of organic matter occurs at a faster rate coupled with low vegetative cover, thereby leaving less organic carbon in the soils (Supriya *et al.,* 2019).

Macro nutrients: The available P varied from 8.8 to 53.04kg ha^{-1} in all the pedons of groundnut growing areas with a mean of 17.6 kg ha^{-1} (Table 2). Considering 13 kg P ha^{-1} as critical level, the available P status was sufficient in the surface and subsurface soils except in pedon 2 (Kalaepalli-2) which shows deficiency in subsurface horizon. In all the pedons of groundnut growing areas, the available P content decreased with depth, which might possibly be due to the confinement of crop cultivation to the rhizosphere and supplementing the depleted P by external sources *i.e.,* fertilizers to the surface soil as well as by phytocycling (Purandhar and Naidu, 2020). The lower P content in sub-surface horizons could be attributed to the fixation of released P by clay minerals and oxides of iron and aluminum (Kumar and Naidu, 2012).

The available K of groundnut growing soils varied from 375.3 to 426.8 kg ha^{-1} with a mean value 381.7 kg ha^{-1} (Table 2). Taking 150 kg ha^{-1} as a critical limit, the highest available K content was observed in the surface horizons and showed a decreasing trend with depth in pedon 1 (Kalaepalli-1), pedons 3 (Ramapuram), pedon 4 (Pachigunta) and pedon 5 (Vinjim). This could be ascribed for greater weathering of the K bearing minerals, application of K fertilizers and upward translocation of K from lower depths along with capillary movement of ground water (Vedadri and Naidu, 2018).

The exchangeable Ca in groundnut growing soils ranged from 2.8 to 10.6 cmol(p^+) $kg^{-1}$of soil with a mean of 6.51 cmol(p^+) $kg^{-1}$of soil. Similarly, the exchangeable Mg in groundnut growing areas was found to vary from 1.4 to 6.8 cmol(p^+) $kg^{-1}$of soil with a mean of 3.49 cmol(p^+) $kg^{-1}$of soil (Table 2). Taking 1.5 cmol(p^+) $kg^{-1}$of soil for Ca and 1 cmol(p^+) $kg^{-1}$of soil for Mg as critical limits, the exchangeable Ca and Mg in both the surface and sub-surface horizons of all the pedons of groundnut growing areas, were found to be sufficient. The exchangeable Ca was found to be the dominant cation followed by Mg on the exchange complex, because of its higher mobility, earlier removal than the later and also Ca dominates in the prevailing semi-arid weathering environment and consequently occupied the major portion on the exchange complex in the groundnut growing soils (Reddy and Naidu, 2016).

The available S in groundnut growing soils varied from 8.67 to 38.82 mg kg^{-1} with a mean of 20.31 mg kg^{-1} (Table 2). Taking 10 mg S kg^{-1} soil as critical value, the available S was sufficient in all surface and subsurface horizons of groundnut growing areas except surface horizon in pedon 3. Surface horizons in the peodns of groundnut growing areas contained more available S than subsurface horizons except Bw2 horizon of pedon 2 (Kalaepalli-2 profile), 111Bt2 horizon of pedon 3 (Ramapuram profile) and Bt1 horizon of pedon 5 (Vinjim profile) which could be due to higher amount of organic matter in surface layers than in deeper layers. A significant correlation between organic carbon and available S confirmed the above trend. Similar type of correlation was also observed by Thangasamy *et al.* (2005).

Micro nutrients: The available Zn content in the soil profiles of groundnut growing areas was varied from 0.15 mg kg^{-1} to 1.17 mg kg^{-1} with a mean of 0.15 mg kg^{-1} (Table 3). Further, by taking 0.75 mg Zn kg^{-1} soil as critical limit, the surface horizons of pedon 2 (Kalaepalli-1 profile) and Pedon 5 (surface and BA sub surface horizon) (Vinjim profile) of groundnut growing areas are above the critical limit and surface and sub-surface horizons in all pedons of groundnut growing areas are below the critical limit exhibited lower values than critical limit. Lower available Zn in deeper layers can be ascribed to low amount of organic carbon in these deeper layers which was confirmed by significant and positively correlation (r =+0.340) of Zn with organic carbon. Similar findings were reported by Sireesha and Naidu (2013).

The available Fe status in all the pedons of groundnut growing areas was found to be varied from 2.05 and 15.94 mg kg^{-1} soil with a mean of 5.82 mg kg^{-1} soil (Table 3). According to critical limit of 4 mg kg^{-1} soil, the groundnut growing soils were deficient in available Fe content except Ap horizon of pedons 1, 2, 3,4, 5 and AB horizon of pedon 2 (Kalaepalli-2 profile), 1Bt1 horizon of pedon 3 (Ramapuram profile) and BA and Bt1 horizons in pedon 5 (Vinjim profile). The distribution of available Fe in all the pedons of groundnut growing areas did not show a consistent pattern but abruptly decreased. It might be due to accumulation of organic carbon and prevalence of reduced conditions in the surface horizons. The organic carbon due to its affinity to influence the solubility and availability of Fe by chelation effect might have protected the Fe from oxidation and precipitation, which consequently increased the availability of iron (Prasad and Sakal, 1991).

Available Cu in the pedons of groundnut growing areas ranged from 0.03 to 1.98 mg kg^{-1} with an average of 0.77 mg kg^{-1} (Table 3). Considering on 0.5 mg Cu kg^{-1} soil as a critical limit the available Cu in groundnut growing areas was sufficient in the horizons of all pedons except AB horizon of pedon 1 (Kalaepalli-1 profile), 11BC horizon of pedon 3 (Ramapuram profile), BA horizon of pedon 4 (Pachigunta profile) and Bt1 horizon in pedon 5 (Vinjim profile). Available Cu was positively correlated (r=+0.126) with organic carbon as accumulation of more organic carbon could have fixed more copper. Similar findings were also reported by Venkatesu *et al*. (2002).

The available Mn in groundnut growing soils varied from 2.5 to 28.98 mg kg^{-1} with a mean of 13.21 mg kg^{-1} (Table 3). The available Mn in all the pedons of groundnut growing areas, except Ap horizons in pedon 4 (Pachigunta) was found to be adequate as per the critical limit of 2 mg Mn kg^{-1} soil. In general the higher Mn in surface horizons might be due to comparatively higher biological activity and the chelating of organic compounds released during the decomposition of organic matter left after harvest of crop. However, the higher Mn (*i.e.,* above critical limit) in subsurface horizons might be derived from the parent material. It is further supported by a positive correlation between available manganese with organic carbon (r = +0.117).

CONCLUSION

Groundnut growing soils of Varathuru watershed of Chittoor district, Andhra Pradesh

Table 1. Physico–chemical properties of soils

Pedon No. & Horizon	Depth (m)	Organic-carbon (%)	$CaCO_3$(%)	pH 1:2.5		EC (dS m^{-1})
				H_2O	1*N* KCl	
Pedon 1 Kalaepalli-1						
Ap	0.00 – 0.23	0.46	2.50	6.88	5.18	0.19
AB	0.23 – 0.55	0.03	3.45	7.18	6.05	0.04
Cr	0.55	Weathered gneiss				
Pedon 2 Kalaepalli-2						
Ap	0.00 – 0.20	0.53	2.03	6.11	5.17	0.1
Bw1	0.20 – 0.54	0.37	3.93	7.14	6.40	0.13
Bw2	0.54 – 0.86	0.32	2.98	7.57	6.79	0.08
Cr	0.86	Weathered gneiss				
Pedon 3 Ramapuram						
Ap	0.00 – 0.23	0.44	6.30	8.12	6.91	0.36
1Bt1	0.23 – 0.31	0.32	8.68	8.53	7.27	0.27
11BC	0.31 – 0.80	0.19	5.83	8.47	7.36	0.06
111Bt2	0.80 – 1.41	0.12	3.45	7.92	6.56	0.21
Cr	1.41	Weathered gneiss				
Pedon 4 Pachigunta						
Ap	0.00 – 0.24	0.68	5.83	7.50	6.67	0.33
BA	0.24 – 0.56	0.15	7.25	8.14	6.94	0.25
Cr	0.56	Weathered gneiss				
Pedon 5 Vinjim						
Ap	0.00 – 0.18	0.29	2.98	6.10	5.37	0.3
A1	0.18 – 0.39	0.28	3.93	6.18	5.02	0.22
Bw1	0.39 – 0.57	0.21	4.88	6.29	5.56	0.17
Bw2	0.57 – 0.88	0.04	4.40	6.56	5.54	0.16
Cr	0.88	Weathered gneiss				
Mean		0.30	4.88	7.25	6.19	0.19
Range		0.03-0.68	2.03-8.68	6.10-8.53	5.02-7.36	0.04-0.36

Table 2. Macronutrient status of groundnut growing soils of Varathuru watershed of Chittoor district

Pedon No.& Horizon	Depth (cm)	Available (kg ha^{-1})		Exchangeable bases c mol (p$^+$) kg^{-1}		S (mg kg^{-1})
		P	K	Ca^{2+}	Mg^{2+}	
Pedon 1 Kalaepalli-1						
Ap	0.00 – 0.23	15.5	387.1	6.4	3.4	17.52
AB	0.23 – 0.55	11.1	375.3	5.2	3.2	14.39
Cr	0.55	Weathered gneiss				
Pedon 2 Kalaepalli-2						
AP	0.00 – 0.20	15.9	419.8	6.2	2.4	25.18
Bw1	0.20 – 0.54	8.8	398.8	8.2	3.6	12.36
Bw2	0.54 – 0.86	12.4	405.4	6.6	3.6	38.82
Cr	0.86	Weathered gneiss				
Pedon 3 Ramapuram						
Ap	0.00 – 0.23	24.3	399.8	5.2	2.6	8.67
1Bt1	0.23 – 0.31	15.0	390.1	6.9	1.8	12.82
11BC	0.31 – 0.80	12.4	382.9	2.8	1.4	9.5
111Bt2	0.80 – 1.41	21.2	178.3	10.6	6.8	39.1
Cr	1.41	Weathered gneiss				
Pedon 4 Pachigunta						
Ap	0.00 – 0.24	53.0	400.9	9.2	5.5	22.59
BA	0.24 – 0.56	21.7	383.3	6.5	3.7	21.76
Cr	0.56	Weathered gneiss				
Pedon 5 Vinjim						
Ap	0.00 – 0.18	14.6	426.8	4.1	2.7	20.38
BA	0.18 – 0.39	14.1	394.9	5.6	2.6	10.24
Bt1	0.39 – 0.57	11.9	394.7	7.2	5.8	34.3
Bt2	0.57 – 0.88	12.4	387.4	6.9	3.2	16.97
Cr	0.88	Weathered gneiss				
Mean		17.6	381.7	6.51	3.49	20.31
Range		8.8-53.0	375.3-426.8	2.8-10.6	1.4-6.8	8.67-38.82

Table 3. Micronutrient status of groundnut growing soils of Varathuru watershed of Chittoor district

Pedon No. &Horizon	Depth (m)	Available macronutrient			
		Zn	Cu	Fe	Mn
		(mg kg-1)			
Pedon 1 Kalaepalli-1					
Ap	0.00 – 0.23	0.51	0.78	6.6	25.23
AB	0.23 – 0.55	0.25	0.43	8.05	19.66
Cr	0.55	Weathered gneiss			
Pedon 2 Kalaepalli-2					
AP	0.00 – 0.20	1.02	0.81	15.94	23.01
Bw1	0.20 – 0.54	0.35	1.1	3.82	11.2
Bw2	0.54 – 0.86	0.29	0.61	3.2	9.44
Cr	0.86	Weathered gneiss			
Pedon 3 Ramapuram					
Ap	0.00 – 0.23	0.53	0.93	7.01	8.72
1Bt1	0.23 – 0.31	0.33	0.78	5.14	6.99
11BC	0.31 – 0.80	0.29	0.18	3.4	3.97
111Bt2	0.80 – 1.41	0.49	0.86	3.99	3.23
Cr	1.41	Weathered gneiss			
Pedon 4 Pachigunta					
Ap	0.00 – 0.24	0.42	0.57	5.95	4.93
BA	0.24 – 0.56	0.15	0.21	2.05	2.5
Cr	0.56	Weathered gneiss			
Pedon 5 Vinjim					
Ap	0.00 – 0.18	0.86	1.26	6.24	28.98
BA	0.18 – 0.39	1.17	1.98	8.21	20.77
Bt1	0.39 – 0.57	0.32	0.03	4.40	18.96
Bt2	0.57 – 0.88	0.36	1.09	3.34	10.54
Cr	0.88	Weathered gneiss			
Mean		0.49	0.77	5.82	13.21
Range		0.15-1.17	0.03 - 1.98	2.05 - 15.94	2.5 - 28.98

were classified into Inceptisols (Typic Haplustepts) and Alfisols (Fluventic Haplustalfs and Typic Haplustalfs). These soils were slightly acidic to strongly alkaline, non-saline and low in organic carbon. They were sufficient in available P, S and exchangeable Ca and Mg in surface and subsurface soils. However, the available P was sufficient in surface soils but insufficient to deficient range in subsurface soils. The DTPA-extractable Fe, Cu and Mn in these soils were found to be above critical limits in surface and subsurface horizons in all the pedons except in pedons 2, 3 and 4 for Fe in subsurface horizons and Cu in subsurface horizons in pedon 1 and 4. Hence, judicious use of organics with in-organics not only sustains soil fertility of groundnut growing soils but also the productivity.

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MOLECULAR DIVERSITY ANALYSIS IN RICE GERMPLASM

K. MADHAVI*, D. MOHAN REDDY, P. SUDHAKAR, B.V. BHASKARA REDDY, LAKSHMINARAYANA R VEMIREDDY

Department of Genetics and Plant Breeding, S.V. Agricultural College,
Acharya N.G. Ranga Agricultural University, Tirupati-517 502

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ABSTRACT

Genetic diversity estimation based on molecular markers provides a reliable measure for the development of desired variety that is not affected by environmental factors. In this study, molecular diversity analysis of 171 rice genotypes with 41 polymorphic SSR markers resulted in the generation of 84 alleles with 2.04 number of alleles per locus with an average Heterozygosity (H) value of 0.41 and polymorphism information content (PIC) value of 0.35. Average genetic diversity (He) was observed to be 0.33. The distance-based neighbor-joining cluster approaches divided the population into three groups.

Keywords: Rice, Molecular Diversity Analysis, Heterozygosity, Neighbor-Joining Cluster, Rice

INTRODUCTION

Rice (*Oryza sativa* L.) is an important cereal crop in the world both in terms of production and consumption. It is the staple food crop for almost half of the world's population. Rice is a highly diverse crop species with various genome compositions (AA, BB, CC, DD, EE, FF, GG, HH, JJ, KK, and LL). The genus *Oryza* is comprised of 27 species but only two (*O. sativa* and *O. glaberrima*) are cultivated species (GRisP 2013). The species *O. sativa* is more widely grown than *O. glaberrima* because of its broad spectrum of growth climates, high-yielding features and market-favored characteristics (Chang, 1976; Jones *et al.,* 2004; Subudhi *et al.,* 2006). Garris *et al.* (2005) classified the rice germplasm in to five distinct groups *viz., indica, aus, aromatic, temperate japonica, and tropical japonica*. There are approximately 140,000 rice genotypes in the world.

World population explosion is proceeding at a geometric rate while the area of cultivable land is downsizing due to urbanization and industrialization. Improvement in rice productivity and quality remains crucial, and is often dependent on the genetic base of breeding stocks (Vanaja and Babu, 2004). Since the time of the green revolution, the usage of wild relatives was also reduced to generate higher yields. Due to this the varieties have achieved an yield plateau owing to the narrow genetic base. This can be overcome through the inclusion of land races in the breeding program which are repositories with a wide range of

*Corresponding Author E-mail i.d: madhavi2011040@gmail.com; PhD thesis submitted to Acharya N.G. Ranga Agricultural University, Guntur

variability. Classification of the genetic variation and their relationship are critically required for enhancing the management and utilization of the germplasm resource (Ramanatha Rao and Hodgkin, 2002). Understanding the genetic relationship within germplasm resources provides insight for breeders to increase the efficiency of parental selection for future rice breeding programs (Singh *et al*, 2016). Hence, the study was carried out for the estimation of population genetic diversity studies in rice germplasm encompassing *japonica, javanica, indica, aus, wild relatives, NERICA* and *aromatic races*

MATERIAL AND METHODS

A total of 171 rice accessions comprising of *japonica, javanica, indica, aus, wild relatives, NERICA* and *aromatic types* were screened with 45 markers distributed on all 12 chromosomes. The methodology of DNA isolation and PCR amplification was discussed here under.

DNA isolation

A total of 171 rice accessions were raised during *Kharif,* 2018 at S.V. Agricultural College, Tirupati. Young leaves from rice accessions were collected for genomic DNA extraction from 28 days old transplanted seedlings. DNA was isolated using the modified Cetyl Tri Methyl Ammonium Bromide (CTAB) method developed by Murray and Thompson (1980). The quality and quantity were estimated by 0.8% agarose gel electrophoresis and Nano drop spectrophotometer, respectively. The isolated DNA samples were diluted in $T_{10}E_1$ buffer (10 mM Tris-HCl, 1 mM EDTA, pH 8.0) to obtain the final working concentration of 50 ng/μl.

PCR amplification and electrophoresis

The amplification of genomic DNA was carried out using a programmable thermal cycler (Eppendorf). The 10 μl reaction mixture consisting of 2 μl of 50 ng/ μl template DNA, 0.5 μl of 5 pmol primer (both forward and reverse primers), 0.5 μl of 10mM dNTPs, 1 μl of 10X PCR buffer with Mg^{2+} (ABM, Canada) and 0.1 μl of 5U/ μl *Taq* DNA polymerase (ABM, Canada) and 5.4 μl of sterile distilled water. PCR reaction was carried out in a thermal cycler with initial denaturation at 94^{o}C for 5 minutes followed by 34 cycles of denaturation at 94^{o}C for 45 seconds, primer annealing of 40-55^{o}C for 45 seconds and elongation/extension of 72^{o}C for 1 minute followed by final elongation/extension of 72^{o}C for 10 minutes. After completion, the PCR plate was stored at 4^{o}C and the amplified products were later resolved on 3% agarose gel containing (3g/ 100ml) ethidium bromide (10 mg ml^{-1}) using 1x TBE buffer. DNA fragments were visualized under UV transillumination using Alpha Innotech gel documentation system (Flour ChemTM 5500, Alpha Innotech, USA).

Data analysis

Amplicons were scored according to their product size for each genotype and primer combination. The scoring data was arranged in the format of CONVERT (version 1.31) software (Glaubitz, 2004). By using CONVERT, the genotypic data was converted to formats of different softwares (For Ex: .arp format for ARLEQUIN, .dat format for POPGENE). The number of alleles (na), effective number of alleles (ne) [Kimura and Crow, 1964], Shannon's information index (I)[Lewontin (1972)], Fin Wright's fixation index (Fin), Fstatistics (Fst), heterozygosity (H), and gene flow (Nm) for each SSR locus was determined by using PopGen1.32(Yeh and Yang, 1999). Polymorphism information content (PIC) values were measured using the Gene-calc, a bioinformatic tool (http://gene-calc.pl/pic).

Genetic differentiation among the assumed sub population was analyzed using Nei's gene diversity statistics (Nei, 1973) using POPGENE version 1. 32 (Yeh and Yang, 1999). A dissimilarity matrix was performed by using DARWIN software version 6.021 (Perrier and Jacquemoud-Collet, 2006).

RESULTS AND DISCUSSION

Molecular marker analysis

A total of 171 rice accessions were screened with 41 SSR markers. An example of the gel picture showing the banding pattern of germplasm screened with RM279 marker is presented (Fig.1). The results of molecular marker analysis were presented in Table 1. The total number of alleles ranged from 2-3 with an average of 2.04 alleles per locus, which is much lesser than the values observed by Hue *et al.* (2018) (7.1), Singh *et al.* (2016) (3.11) and Anupam *et al.* (2017) (2.9). This might be due to the usage of markers having a lesser amount of polymorphism with regards to the genotypes used in the study as well as due to the less number of markers used. The total number of effective alleles ranged from 1.01-2.04 with an average of 1.59. Shannnon's information index (I) an indication of population genetic diversity which in general will be low for markers having higher H values. I values ranged from 0.0672 - 0.8762. The marker SVHT801 exhibited a lower Shannon's information index (0.0672) with a 1.0253 number of effective alleles representing higher genetic diversity, while the marker RM551 has a higher value of 0.8762 with 2.04 number of effective alleles representing the lower amount of genetic diversity. Wright's F statistics (Fst) values were in the range of 0.0170 – 0.3117. Gene flow (Nm) values were in the range of 0.4094 – 14.4375. In the present study for most of the markers, Nm values were higher than one which in general is below 1 in self-pollinated crops. This might be due to the inclusion of sister lines or same landraces with different names or little amount of cross-pollination as farmers sometimes grow crops very adjacent to each other might attributed to high Nm value (Verma *et al.,* 2019). The marker RM28199 showed the highest value of Fst (0.3117) and minimal value of gene flow (0.5521), while the marker SVHT801 exhibited the least value of Fst (0.017) with higher value of Nm (14.4375) followed by RM16368 with Fst (0.0175) and Nm(14).

Heterozygosity (H) is one of the most popular parameters to determine the proportion of heterozygous individuals at a locus in populations (Liu and Muse, 2005). H ranged from 0.1276 to 0.6315 with an average of 0.41. Similar results were reported by Choudury *et al.* (2014) who have reported H of 0.002 in Nagaland to 0.42 in Mizoram. Polymorphism information content (PIC) values of the markers were observed to be in the range of 0.12 – 0.57 with an average of 0.35. The results were in agreement with Singh *et al.* (2016) having a similar PIC value of 0.29 using 36 HvSSR markers whereas Rashmi *et al*. (2017) reported PIC values in the range of 0.03 to 0.59 by evaluating 65 rice accessions using SSR markers. Out of 41 markers five (12.20%)

markers were found to be highly informative (PIC > 0.5), 29 markers (70.73%) were found to be reasonably informative (PIC = 0.25 – 0.5) and seven markers (17.07%) were found to be least informative (PIC < 0.25). Higher PIC values helps in detecting a higher number of alleles in the germplasm which is highly useful for detailed characterization of genotypes. Based on the estimates of ne, I, Fst, heterozygosity (H) and PIC values, the marker RM520 was found to be highly heterozygous with maximum values of both H (0.6196) and PIC (0.5466) followed by RM589 (H=0.6315, PIC=0.5726), RM28199 (H=0.6168, PIC =0.5415) and RM190 (H=0.5784, PIC=0.5118). The marker RM7601 was least heterozygous with minimal values of both H (0.1276) and PIC (0.1235).

Table 1. Molecular marker analysis of the rice genotypes using molecular markers

Markers	na	ne*	I*	F in	Fst	Nm	H	PIC
RM279	2	1.7664	0.6255	0.9022	0.1852	1.0997	0.4717	0.3888
RM316	2	1.2839	0.3798	0.7710	0.0792	2.9070	0.4321	0.3905
RM511	2	1.1459	0.2493	0.9024	0.0773	2.9839	0.223	0.2113
RM520	2	1.8979	0.660	0.9387	0.0693	3.3583	0.6196	0.5466
RM551	3	2.0420	0.8762	0.8566	0.2295	0.8392	0.5708	0.5129
RM555	2	1.7534	0.6211	0.9709	0.0937	2.4189	0.4966	0.4217
RM589	3	2.1023	0.8436	0.9033	0.1039	2.1563	0.6315	0.5726
RM3212	2	1.8109	0.6400	0.9591	0.1129	1.9637	0.4904	0.4039
RM5508	2	1.7048	0.6039	0.9188	0.1059	2.1113	0.5381	0.4741
RM11943	2	1.5077	0.5196	0.8303	0.2502	0.7491	0.5198	0.4655
RM16368	2	1.0258	0.0682	0.4935	0.0175	14.0000	0.1715	0.1603
RM28048	2	1.3533	0.4302	0.8972	0.1672	1.2455	0.4224	0.3842
RM28199	2	1.9188	0.6718	0.8519	0.3117	0.5521	0.6168	0.5415
GS5INDEL1	2	1.8574	0.6542	0.8956	0.1507	0.4094	0.4918	0.3963
RM167	2	1.2681	0.3672	0.9693	0.0909	2.5008	0.3505	0.3212
RM190	2	1.7555	0.6218	0.9509	0.1285	1.6948	0.5784	0.5118
RM212	2	1.8770	0.6600	0.8344	0.0687	3.3912	0.4855	0.3835
RM250	2	1.8427	0.6498	0.9374	0.1177	1.8745	0.4937	0.3879
RM252	2	1.6322	0.5758	0.8203	0.2264	0.8544	0.4712	0.4104
RM310	2	1.9971	0.6924	0.8086	0.2135	0.9212	0.5712	0.477

Table 1 Continued...

Markers	**na**	**ne***	**I***	**F in**	**Fst**	**Nm**	**H**	**PIC**
RM315	2	1.0317	0.0805	0.7968	0.0240	10.1684	0.1473	0.1399
RM340	3	1.6724	0.7185	0.8483	0.2586	0.7167	0.4562	0.4203
RM349	2	1.2512	0.3532	0.1229	0.0503	4.7194	0.3041	0.2822
RM440	2	1.5177	0.5245	0.9410	0.1392	1.5464	0.4832	0.4331
RM490	2	1.8397	0.6489	0.8812	0.1904	1.0631	0.4869	0.3935
RM3534	2	1.9590	0.6826	0.9743	0.1997	1.0020	0.5537	0.4598
RM6100	2	1.7957	0.6351	0.7863	0.2740	0.6626	0.4559	0.3621
RM7289	2	1.5414	0.5360	0.7067	0.1507	1.4090	0.3947	0.3398
RM12091	2	1.4122	0.4675	0.9779	0.1322	1.6409	0.4094	0.3705
SCM2 INDEL1	2	1.0907	0.1788	0.8506	0.0627	3.7372	0.1839	0.1756
SVHT665	2	1.0578	0.1282	0.4284	0.1332	1.6264	0.1682	0.1602
SVHT801	2	1.0253	0.0672	1	0.0170	14.4375	0.142	0.1347
DEP1S9	2	1.3975	0.4586	0.7247	0.0770	2.9968	0.3248	0.2877
RM9	2	1.5257	0.5284	0.8769	0.1221	1.7980	0.3885	0.3356
RM13	2	1.5158	0.5236	0.8905	0.1356	1.5934	0.4118	0.3623
RM231	2	1.7814	0.6305	0.8548	0.2763	0.6547	0.5201	0.4454
RM545	2	1.8361	0.6478	0.7991	0.1088	2.0481	0.4974	0.408
RM574	2	1.6434	0.5803	0.9048	0.1348	1.6042	0.4572	0.3933
RM3482	2	1.9809	0.6883	0.9268	0.1869	1.0875	0.5391	0.4359
RM7601	2	1.0564	0.1257	0.6573	0.0555	4.2523	0.1276	0.1235
RMw513	2	1.7499	0.6199	0.8577	0.3019	0.5781	0.4727	0.3932
Range	**2-3**	**1.03-2.04**	**0.07-0.88**	**0.43 - 1**	**0.02-0.31**	**0.41-14.44**	**0.13-0.63**	**0.12-0.57**
Average	**2.07**	**1.59**	**0.52**	**0.79**	**0.16**	**1.28**	**0.41**	**0.35**

na = number of alleles; *ne = Effective number of alleles [Kimura and Crow, 1964]
*I = Shannnon's information index [Lewontin,1972]; Fin Wright's fixation index
Fst = F statistics; H = Heterozygosity; PIC= Polymorphism Information Content
Nm= Gene flow estimated from Fst = 0.25(1 - Fst)/Fst

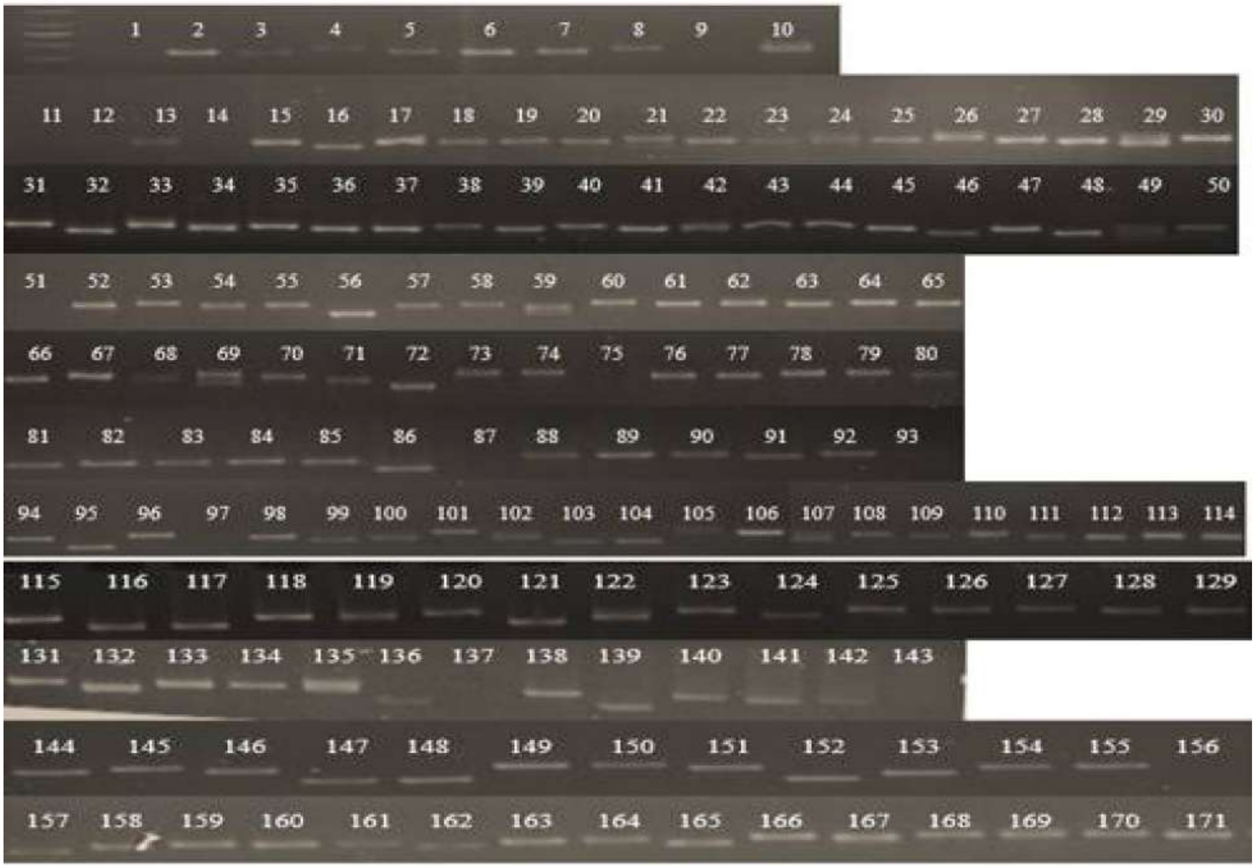

Fig. 1. Gel picture representing genetic polymorphism of the genotypes used in the study when screened with RM279 marker

Table 2. Pairwise Fst differences among populations of rice genotypes

	Aromatic	Aus	Indica	Japonica	Landrace	NERICA	Wild relatives
Aromatic	0.00000						
Aus	0.15790	0.00000					
Indica	0.02907	0.07936	0.00000				
Japonica	0.07522	0.18829	0.02836	0.00000			
Landrace	0.04117	0.04950	0.02275	0.06206	0.00000		
NERICA	0.03524	0.03682	0.03244	0.08737	0.02332	0.00000	
Wild relatives	0.14440*	0.03275	0.06842*	0.11612	0.04224	0.01233	0.00000

p<0.01*

Pair-wise Fst differences among populations were displayed in Table 2. The difference between *aus* and *japonica* populations was found to be highest (0.18829) while it was minimum between *indica* and *landrace* (0.02275) populations. As per the scale of Fst, difference between the populations *aromatic* and *indica*, *aromatic* and *landrace*, *aus* and *landrace*, *aus* and *wild relatives*, *indica* and *japonica*, *indica* and *landrace*, *landrace* and *wild relatives* were found to be non-significant. While the rest of the populations had shown moderate differentiation among themselves. Positive significant differences were observed between *aromatic* and *wild relatives* and *indica* and *wild relatives*.

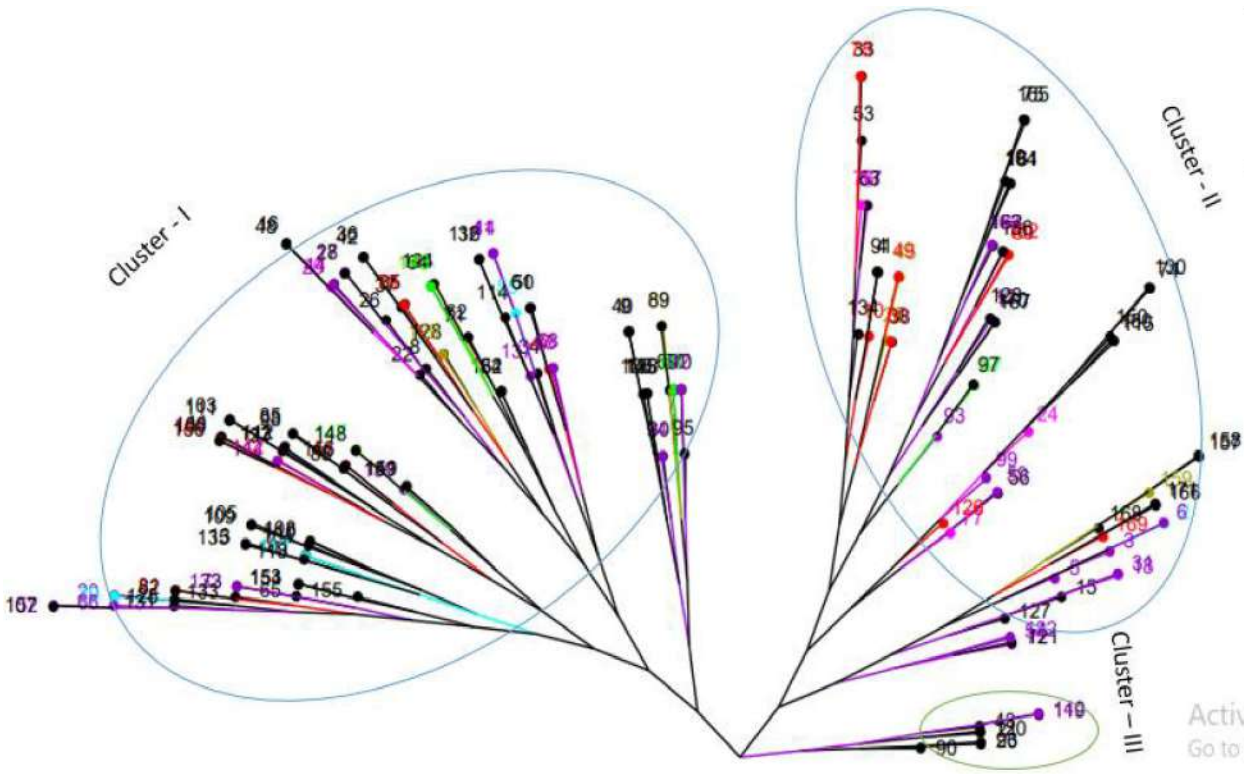

Fig.2. Dendrogram showing the genetic relationship among 171 rice genotypes using unweighed Neighbour Joining of 41 markers

The neighbourhood joining tree (Fig.2) was constructed using DARwin V6.021 software. Based on the genotypic data, the entire population was divided into 3 clusters *viz.*, cluster I, cluster II and cluster III. Each cluster is a combination of genotypes belonging to different populations. Cluster I consists of 98 genotypes encompassing majority of *indica* followed by *landraces, aromatic, aus*, *japonica, wild relatives* and *NERICA* lines. Majority of *wild relatives* and *aus* individuals falls under cluster – I. Cluster II can be sub-divided in to two sub-clusters, cluster 2A and 2B. Cluster 2A has 44 genotypes with 24 *indica*, 7 *landraces*, 7 *aromatic*, 3 *NERICA*, 2 *japonica* and a single *wild relative* individual encompassing genotypes of all the ecotypes.

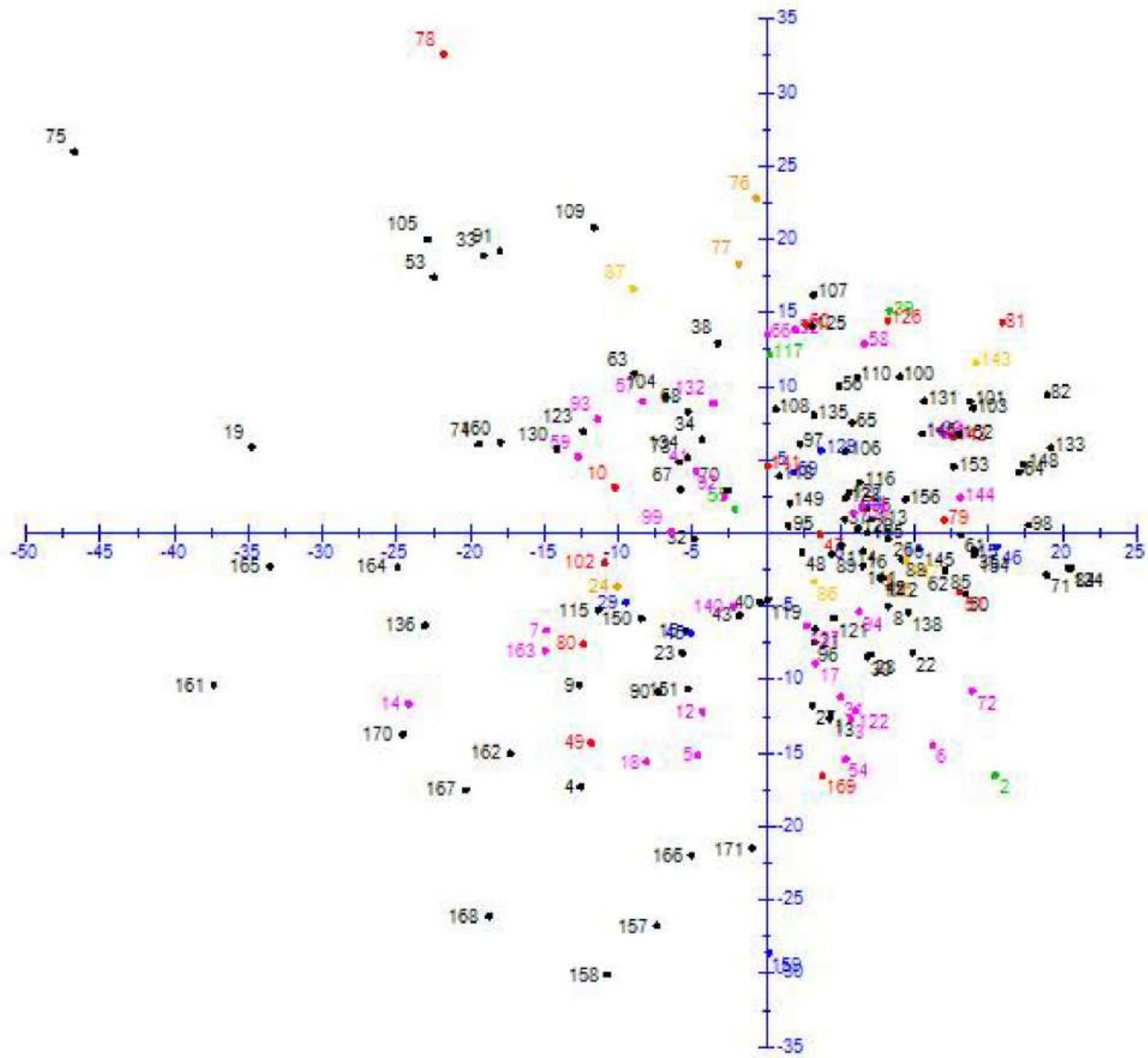

Fig. 3. Principle coordinate analysis of germplasm using 41 SSR markers

Cluster 2B includes 19 genotypes of which, most of them are *indica type* followed by 7 *landraces* and a single *aromatic, japonica* and *aus* individual. Cluster III consists of 7 *indica* types and a single *landrace.* The inclusion of genotypes from different sub-groups under one cluster might be due to natural cross-pollination or due to the inclusion of same genotype as one of the parents in the development of varieties. Salgotra *et al.* (2015) also reported similar result.

Principle coordinate analysis (PCoA) using SSR markers allelic data determines the genetic relatedness among the genotypes (Verma *et al.,* 2019). The Fig.3 represents the distribution of germplasm using principle coordinate analysis drawn with the help of DARwin software. The first four axes of differentiation explained 25.91% of the total variation. The first axis contributed 8.55 percent of variation to the total variation followed by the second axis with 6.49 percent, the third axis with 5.61 percent and the fourth axis with 5.26 percent of variation.

CONCLUSION

The genetic diversity estimates obtained by SSR analysis in the present study indicated the existence of diversity in the germplasm with seven populations *viz*., *indica, japonica, aus, aromatic, landraces, NERICA* and *wild relatives* used in the study. Molecular diversity analysis indicated the presence of a broad genetic base in the population. Distance-based cluster analysis categorized the population into three clusters (cluster I, II, III). This confirms the usage of the material from different populations for the development of variety complementing each other for various economic traits.

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EFFECT OF SEED PRIMING WITH BOTANICAL LEAF EXTRACTS ON SEED QUALITY AND YIELD OF MAIZE HYBRID, COH(M) 4

S. SRIMATHI, J. GOKULAKRISHNAN and M. PRAKASH*

Department of Genetics and Plant Breeding, Faculty of Agriculture,
Annamalai University, Annamalai Nagar-608 002

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ABSTRACT

The investigation was carried out to study the effect of seed priming with botanical leaf extracts on seed quality and yield of maize hybrid**,** COH(M) 4. The seeds of maize hybrid, COH(M) 4 were primed with various leaf extracts at 10% concentration *viz*., Papaya (*Carica papaya)*, Pungam (*Pongamia pinnata*), Prosopis (*Prosopis juliflora*), Adathoda (*Justicia adhatoda*), Tulsi (*Ocimum tenuiflorum*), Neem (*Azadirachta indica*) and Moringa (*Moringa oleifera*) along with a control. The study revealed that the seeds primed with 10% prosopis leaf extract followed by 10% moringa leaf extract recorded higher seed quality characters like germination percentage, speed of germination, seedling length, dry matter production, vigour index I and II. In the field evaluation, seeds primed with 10% prosopis leaf extract followed by 10% moringa leaf extract recorded higher seed yield and yield attributing parameters like cob length and girth, total number of seeds cob^{-1}, 100 grain weight, grain yield per ha and harvest index.

Keywords: Seed priming Meizehybrid, COH(M)4, Botanical leaf extracts

INTRODUCTION

Maize or corn (*Zea mays* L.) is an important annual cereal crop, belonging to family Poaceae. It is the third most important crop next to wheat and rice (Jeet *et al.,* 2017). It is grown in all the continents of tropics, sub-tropics and temperature regions. It ranks second in production and first in productivity among all the cereals at global level. It is cultivated in about 180.639 M ha, with a production of 103.36 million metric tons and productivity of 5.72 MT/ha (USDA, 2018). In India, it is grown in an area of 9.5 M ha with the production of about 25 million metric tons and productivity of 2.63 metric tons per hectare (USDA, 2018).

COH(M) 4 is high yielding single cross maize hybrid newly released by the Department of Millets, Tamil Nadu Agricultural University, Coimbatore. Higher production and productivity of crop is possible only through use of good quality seeds and proper management practices.

Seed priming is one of the newly developed technology of "Seed Enhancement Techniques". It is a controlled hydration process that involves exposing the seeds to low water

*Corresponding Author E-mail i.d: geeth_prakash@yahoo.co.in; M.Sc thesis submitted to Annamalai University, Annamalai Nagar

potential which restricts germination, but permits pre-germinative physiological and biochemical changes to occur, which do not allow radical protrusion through the seed coat and the rate of germination is more uniform, with greater tolerance to environmental stresses and dormancy reduction in many species. Seed priming is basically a pre-sowing seed treatment. In seed priming, metabolic and biochemical processes increase the seed vigour and seedlings attributes by controlled hydration, followed by dehydration. In the field, seeds are exposed to hydration-dehydration events in the soil, as in seed priming (Vázquez *et al.,* 2020). The botanical seed priming is one type of seed priming treatment. This may provide an alternate method to control chemical usage. Natural products are an important source of novel active chemical agents that could delay or inhibit pathogen growth and/or toxin products. The plant extracts are considered as non-phytotoxic and have the capacity to control pathogenic diseases effectively in plants (Bhateshwar *et al.,* 2020). The study was undertaken to evaluate the efficacy of botanical seed priming treatments on seed quality and seed yield of maize hybrid COH(M) 4.

MATERIAL AND METHODS

The investigation was carried by using genetically pure seeds of maize hybrid COH (M) 4, which was obtained from Department of Millets, Centre for Plant Breeding and Genetics, Tamil Nadu Agricultural University, Coimbatore during 2018-2020. The laboratory experiments were carried out in Seed Testing Laboratory of the Department of Genetics and Plant Breeding, Faculty of Agriculture, Annamalai University, Annamalai Nagar. The field experiment was conducted at Sivapuri village, Chidambaram, Cuddalore district, Tamil Nadu.

The seeds were soaked in double the volume of various botanical leaf extracts at room temperature (28±2^{0}C) for 24 hrs. After priming, seeds and solutions were separated. Then seeds were rinsed in water, shade dried at room temperature and evaluated for their performance.

Preparation of plant leaf extract

The fresh leaves of the concerned plants were collected separately and dried under shade. Using mortar and pestle, the shade dried leaves were powdered. Then exactly 10 g of powdered leaves was dissolved in 100 ml of distilled water to make 10% leaf extract and the leaf extract was filtered by muslin cloth to remove unwanted material and leaf debris.

Treatment details

The treatments imposed were T_0 - Control (pre-soaked for 24 hr); T_1- 10% Papaya leaf extract; T_2 -10 % Pungam leaf extract; T_3-10 % Prosopis leaf extract; T_4-10 % Adathoda leaf extract; T_5-10 % Tulsi leaf extract; T_6-10 % Neem leaf extract; T_{7-}10% Moringa leaf extract.

Laboratory Observations

Germination percentage (%)

Germination test was conducted with 3 replications of 100 seeds each grown in trays using sand medium at 25± 2º C and 95± 3% relative humidity. At the end of 7th day, germination percentage was calculated and expressed in percentage (ISTA, 1999).

Germination percentage = (No. of seeds germinated/ Total No. of seeds) × 100

Speed of germination

A total of 3 replications of 100 seeds each from each treatment were placed in the trays and allowed to germinate. The emergence was counted daily from the day of first count (4th day) until last count (7th day). From the mean percent germination recorded on each counting date, speed of germination was calculated employing the formula suggested by Magurie (1962).

Speed of germination $= \frac{X1}{Y1} + \frac{X2-X1}{Y2} + \ldots\ldots + \frac{Xn-Xn-1}{Yn}$, in which,

X1 – number of seeds germinated at first count

X2 – number of seeds germinated at second count

Xa – number of seeds germinated on nth day

Y1 – number of days from sowing to first count

Y2– number of days from sowing to second count

Yn – number of days from sowing to nth count.

Root length (cm)

Ten normal seedlings were taken from germination test and root length was measured from the collar region to the tip of the primary root and the mean value expressed in cm.

Shoot length (cm)

Ten normal seedlings were taken from germination test and shoot length was measured from the collar region to the tip of the plumule and the mean value was expressed in cm.

Seedling length (cm)

Ten seedlings from each replication kept for germination were taken at random on final count. The seedling length was measured from the tip of primary root to the tip of primary leaf and mean length of ten seedlings was calculated and expressed in cm.

Dry matter production (g seedlings^{-10})

Ten seedlings used for the growth measurement were placed in the paper cover and dried in shade for 24 hr and they were kept in hot air oven at 85ºC for 48 hr and cooled in a desiccator. The dried seedlings were weighed and expressed as g seedlings^{-10}.

Vigour Index I

Vigour index I was computed using the following formula and expressed as whole number (Abdul-Baki and Anderson, 1973).

Vigour index I = Germination (%) ×Total seedling length (cm)

Vigour Index II

The seedling vigour index II was calculated by using the formula suggested by Abul Baski and Anderson (1973).

Vigour index II = Germination (%) x Dry matter production (g)

Field evaluation

Field experiment was conducted during *kharif* season from May to Aug, 2018 adopting

Randomized Block Design (RBD) and replicated thrice. The crop was raised with the spacing of 60cm×35cm with plot size 4m x 2 m. All the recommended package of practices for maize was followed during the crop growth period to raise a good healthy crop. Ten plants were randomly selected in each of the treatment replication wise and observations on cob length, cob girth, total number of seeds cob^{-1} , 100 seed weight, seed yield were recorded.

Harvest Index

Harvest Index (HI) was worked out using the following formula and expressed in kg/ha.

$$\text{Harvest Index(HI)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Statistical analysis

The data collected from CRD for laboratory experiments and RBD for field experiments was analysed statistically by adopting the technique described by Panse and Sukhatme (1985). The values expressed in percentage were transferred in to Arc Sin values before analysis. The critical difference (CD) was worked out at 5 per cent (P=0.05) level and whenever 'f ' value is non-significant and denoted by NS.

RESULTS AND DISCUSSION

The results revealed significant improvement in various seed quality (Table 1) and yield attributes (Table 2) of maize hybrid, COH(M) 4 upon seed priming with leaf extracts.

Seed Quality Attributes

Germination percentage

Seeds treated with *Prosopis* leaf extracts @10% (T_3) recorded significantly higher values. Higher germination percentage (92%) was recorded by *Prosopis* leaf extract @ 10% (T_3) followed by *Moringa* leaf extract @ 10% (T_7) (89%) over control (T_0). The increase in seed germination may be due to increase in activation of the pre-germinative metabolism and might be imprinted in seeds as a sort of "Stress memory" or "Priming memory" (Chen and Arora, 2012). It may also be due to activation of gibberellin biosynthesis, synthesis of protein, activation of the enzymes in cell wall modification for protruding radicle and antioxidant mechanisms to combat DNA damage (Macovei *et al*., 2010).

Speed of germination

Higher speed of germination (15.5) and 29.67 % increase in speed of germination was recorded by *Prosopis* leaf extract 10% treated seeds followed by *Moringa* leaf extract 10% treated seeds (15.1) over the control (T_0). Early germination and increase in speed of germination by seed priming may be due to early hydration and imbibition (Vijaya Geetha and Bhaskaran, 2013).

Root, shoot and seedling length

Higher increase in seedling length (20.96 %), root length (20.12 %) and shoot length (22.26 %) was recorded by *Prosopis* leaf extract 10% treatment (T_3) followed by *Moringa* leaf extract 10% treatment (T_7) over the control (T_0). The lowest root length was noted in control (T_0). The leaf extract has phenols that would have promoted the root length. Similar observations were recorded by Nandakumar (2010) in maize, Suguna (2012) in barnyard millet and Shehzad *et al*. (2012) in forage sorghum (*Sorghum bicolour* L.).

Table 1. Effect of various botanical seed priming treatments on grain quality parameters of maize hybrid, COH(M) 4

Treatment (T)	Germination (%)	Speed of germination	Shoot length (cm)	Root length (cm)	Seedling length (cm)	Dry matter production (g 10 seedlings^{-1})	Seedling Vigour Index I	Seedling Vigour Index II
T_0	82(65.24)	10.90	12.70	25.00	37.7	1.714	3091	140.55
T_1	87(68.68)	14.53	14.60	28.80	43.4	1.897	3776	165.04
T_2	88(69.78)	13.20	14.90	29.50	44.4	1.956	3907	172.13
T_3	92(73.68)	15.50	16.40	31.30	47.7	2.132	4388	196.14
T_4	86(68.07)	13.74	15.10	28.00	43.1	1.884	3707	162.02
T_5	87(68.91)	14.70	15.50	29.90	45.4	1.992	3950	173.30
T_6	88(69.78)	14.20	13.90	28.30	42.2	1.980	3714	174.24
T_7	89(70.69)	15.10	15.90	31.00	46.9	2.002	4174	178.18
Mean	**87(68.91)**	**13.98**	**14.87**	**28.97**	**43.85**	**1.94**	**3838**	**170.20**
S. Ed	**1.54**	**0.31**	**0.27**	**0.51**	**0.79**	**0.04**	**72.62**	**3.04**
CD @ 5%	**3.11**	**0.63**	**0.54**	**1.04**	**1.59**	**0.07**	**145.98**	**6.11**

Figures in parenthesis indicate Arcsine transformed value

Table 2. Effect of various botanical seed priming treatments on yield parameters of maize hybrid, COH(M) 4

Treatments (T)	Cob length (cm)	Cob girth (cm)	Total number of seeds cob^{-1}	100 seed weight (g)	Seed yield (kg ha^{-1})	Harvest Index
T_0	10.3	10.8	269	22	3200	0.21
T_1	11.3	11.4	330	24	3714	0.23
T_2	10.6	11.0	298	22	3515	0.22
T_3	13.9	12.9	409	26	4194	0.27
T_4	11.0	11.1	314	22	3660	0.22
T_5	12.2	12.0	370	24	3991	0.23
T_6	11.8	11.8	354	24	3894	0.23
T_7	12.4	12.2	384	24	4004	0.25
MEAN	**11.75**	**11.65**	**341**	**23.5**	**3771.5**	**0.23**
S. Ed	**0.21**	**0.22**	**6.2**	**0.44**	**70.5**	**0.004**
CD @ 5%	**0.43**	**0.44**	**12.46**	**0.9**	**141.71**	**0.008**

Dry matter production

Higher dry matter production (2.13 g) and 19.71 % increase in dry matter production was recorded in *Prosopis* leaf extract 10% treatment (T_3), followed by *Moringa* leaf extract 10% treatment (T_7) over the control (T_0). The increase in dry weight with botanicals treatment may be due to the faster growth and development of seedling and hike in vigour index (Sathiya Narayanan *et al.,* 2016).

Seedling Vigour Index I & II

Higher vigour indices (4388, 196.14) with 29.55 % increase in vigour index I and 28.34 % increase in vigour index II were recorded by *Prosopis* leaf extract 10% treatment (T_3), followed by *Moringa* leaf extract 10% treatment (T_7) (4174) (178.17) over the control (T_0) respectively. The primed seeds trigger the growth promoting substances naturally present in seeds and transfer the minerals, nutrients that provide energy for the vital processes and synthesizing new organic material for seedling growth. Similar results were reported by Kamaraj and Padmavathi (2013) and Sathiya Narayanan *et al.* (2015) in green gram. Thus, the increased seed quality traits might be due to fact that the *Prosopis* leaf powder contains substances like saponin, which acts as a precursor of GA_3 as reported by Sajjan *et al. (*2017).

Yield Attributes

The seeds treated with *Prosopis* leaf extract @ 10 % treatment (T_3) recorded higher yield attributes *viz*., cob length (13.9 cm), cob girth (12.9 cm), number of seeds cob^{-1} (409), 100 seed weight (26), seed yield kg ha^{-1} (4194) and harvest index (0.27), followed by seeds treated with *Moringa* leaf extract @ 10%. Rapid and uniform field emergence are the two essential pre-requisites to increase the yield. Similar results of increased yield parameters were reported by Sathiya Narayanan *et al.* (2015) in mung bean.

The seeds pelleted with pungam leaf powder @ 150 g kg^{-1}+ foliar spray of moringa leaf powder @ 2 % also increased yield. Similar reports of increased seed yield with seed pelleting with pungam leaf powder @ 150 g kg^{-1} and foliar spray of moringa leaf powder @ 2 % were reported by Sathiya Narayanan *et al*. (2013) in mung bean and Sathiya Narayanan *et al.* (2016) in black gram. Prakash *et al*. (2013) also observed that paddy seeds of cv ADT 43 hardened with KCl @ 1 % and pelleted with pongam leaf powder @ 200g/kg recorded increased yield parameters. Higher yield parameters was also recorded in seeds hardened with *prosopis* leaf extract @ 1 % in green gram (Sathiya Narayanan *et al*. 2013) and in black gram (Sathiya Narayanan *et al*. 2016).

CONCLUSION

The seed priming process is useful in increasing seed germination, early growth, biotic and abiotic stress tolerant and increased yield. It enhances rate and percentage of germination and seedling emergence which ensure proper stand establishment under a wide range of environmental conditions. To conclude, seeds primed with prosopis leaf extract @ 10% is recommended to enhance the seed quality and yield characters of maize.

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RELATIONSHIP BETWEEN EDUCATION AND EXISTING HOUSING CONDITIONS OF ELDERLY PEOPLE

R. UNESHA FAREQ*, T. NEERAJA and V. PRASUNA

Department of Family Resource Management, Advanced Post Graduate Center,
Acharya N.G. Ranga Agricultural University, Guntur -522 034

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ABSTRACT

The study aimed to understand the relationship between education andexisting housing conditions of the elderly. The elderly women in the age group of sixty and above who were able to carry out their daily chores were selected as sample. The standard design guidelines evolved through research by various Government and Non-government organizations and researchers served as a base to identify the existing housing conditions of the elderly people.The findings of the study revealed that education of the respondent was found to be a factor that determined the design of the communication systems in the home in the residences.Comparatively, highly-educated elderly respondents *i.e.* who completed graduation degree or above graduationwere found having technical knowledge and taking the advantage of technology concerning communication systems in their homes.

Keywords: Education, Elderly people, Ageing in place, Existing housing conditions

INTRODUCTION

Education is one of the important factors that allow people to adapt to the changes in technology that benefits the housing features(Teodor *et al.,* 2010).As the elderly population in the country is increasing rapidly and many elderly people desire to remain in their homes, questions related to the affordability, physical accessibility to various services may make them feel difficult. While ageing, elderly people tend to live and remain at their place and group, this phenomenon is called "Ageing in Place".

Ageing in place among elderly people is also influenced by the physical home environment. In the current generation, most elderly people tend to live independently without the support of children. Education enables elderly people to preserve the technological and scientific advances related to housing design features that facilities the quality of their living to age in place. The desires to live independently during old age throw challenge to architects, interior designers to think up suitable dwelling that facilitates elderly to age in place.

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

The study by Abramsson and Andersson (2016)stated that as people age theytendto change from their large housing to small rental houses. Besides, older adults are likely tochange to more comfortable houses that need less maintenance. (Abramsson *et al.*, 2014, Abramsson and Andersson, 2012).Home modifications and provision of assistive devices and equipment in their current dwellings may also support elderly people to live independently (Iwarsson, 2015).The study (2019-2020) contributed to a better understanding of the relationship between education and existing housing conditions of elderly people to age in place.

MATERIAL AND METHODS

The area selected to conduct the study is the Kurnool district of Andhra Pradesh.A total of sixty elderly women in the age group of 60 and above who were able to carry out their daily chores independently and living in a separate dwelling without children with or without a spouse was selected as sample.Purposive sampling method was adopted to draw the sample from the randomly selected study locations. For the study, the standard design guidelines for elderly housing were given for different spaces and areas in the house *viz.,* living room, bathroom, bedroom, kitchen, dining area, entrance, floors, door hardware, windows, electric fixtures, ramps, balcony, corridor, communication systems in the homes. Each feature of the house was treated as a dependent variable.The existing housing design features were physically observed and evaluated. The existing housing design features were measured in terms of above therecommended guidelines, exactly as per the recommended guidelines, below the recommended guidelines with scores 3, 2 and 1, respectively.The formal education acquired by the respondent was taken as an independent variable. The scores given were 1,2,3,4 for Illiterate, Primary education, Secondary education, Graduation, respectively.

The standard design guidelines evolved through research by various Government, Non-government organizations and researchers such asthe Bureau of Indian standards (2016) formulated the National building code;Government of India (2016) published Model building bye-laws; Central public works department (2014) published guidelines under the ministry of urban development; Government of India (2019) formulated Model guidelines for regulation and development of retirement homes; Welfare housing policies for senior citizens(2007) provided guidelines authored by a European working group; Chapter 'Housing for elderly' authored by Parker (1987) in the book 'Time Saver Standards' for building types; Guidelines for designing a bathroom in the journal Senior list published by Amie Clark (2019)served as a background to identify the dependent variables. An interview schedule was designed for collecting information about the existing housing conditions of the respondents.Analysis of Variance (ANOVA) was caluclated to find out the relationship between the respondent's education and the existing housing conditions**.**

RESULTS AND DISCUSSION

Education

The education of the respondent was treated as one of the independent variables of the study with an assumption that education may play a role and influence the elderly on the provisions that were made in the house to live with comfort.

The respondents marked as illiterates had no schooling experience. Respondents who studied between first-class to seventh class were categorised as educated up to primary education. Respondents who studied from 8th class to intermediate were grouped as secondary education. Respondents who have completed a bachelor's degree and above were included in the graduation category.

Forty-three percent of the elderly had secondary school level education and 30 per cent of people had completed their graduation. The elderly respondents with primary level education constituted 20 percent of the sample and four percent were illiterates. Most of the elderly women were educated.

Table 1. Distribution of respondents by educational qualification

n=60

S.No.	Educational qualification	Frequency	Percentage
1	Illiterate	4	6.67
2	Primary education	12	20
3	Secondary education	36	43.33
4	Graduation	18	30
	Total	**60**	**100**

Existing housing conditions

The living rooms were found lacking in space allowances for circulation and wheelchair users. The bathrooms in existing elderly houses were found lacking in features like sufficient space for wheelchair, fittings and fixtures to ensure safety and convenience in usage. The clearance space for making a bed, for movement around the bed, for making use of space on one side of the bed was found to be satisfactory in more than fifty per cent of the houses. The work counters in a majority (96.67 %) of the existing kitchen were found at an appropriate height**.** Lighting fixtures, provision of exhaust fans, floor coverings were found as per design standards in the houses. Space allowances for easy circulation were found as per the recommended design guidelines in fifty per cent of the dining rooms.No extra effort was taken to make flooring non-slippery in the existing elderly houses. The latches and door hardware was found to be comfortable and as per the recommendations. Advanced features like automatic doors, peepholes, warning blocks were not found in elderly people houses.The width of the tread, ends of handrails, curved treads, minimum depth at the landing of stairs, number of risers in a flight of stairs were some of the features of a staircase that were not designed as per standards in most houses. The design of the entrance was confined to standard guidelines in case of audio and visual contact with the outside of the entry door, smooth walking surfaces, minimum walkway width, provision for the firm landing of a wheelchair. A ramp was provided near the entrance to facilitate a wheelchair or a vehicle to drive in. Ramps in place of steps or staircase were not familiar in existing houses.

Existing communication systems found in the elderly houses

Sixty-six percent of the houses were provided with a telephone with large keys easy to read for the preferred number with a light indicator that was easily visible and audible in the home. Sixteen percent of the houses were provided with an alarm pull cord for an emergency in the bedroom.Elderly people residing in apartments were provided with security camera systems,fire alarms that had remote response facility. Fifty percent of the houses had the opening system on the doors which required only one single type of key without any discomfort. Sixty-eight percent of the houses had soundproof waste ducts and pipes to limit annoying noises in the rooms where it was provided. Ninety-three percent of the houses had illuminated front doorbell. Sixty-eight percent of the houses had fuse box with automatic circuit breakers.Advanced communication devices were not popular among existing elderly houses.

The relation between the respondent's education and existing housing conditions

Analysis of variance (ANOVA) was done to find out the relationship between respondent's education, and their existing housing conditionsof the elderly.The Null hypothesis formulated was

H_0:There exists no significant relationship between existing housing conditions and the education of the elderly

Significant variation was found in the existingcommunication systems in the home in relation to the education of the respondents. No significant variation was found in the existing design of the living room, bathroom, bedroom, kitchen, dining room, flooring, door hardware, windows, electric fixtures, stairs and lifts, entrance, ramp, balcony and corridor in relation to the education of the respondents.

Table 2. Analysis of variation in existing housing conditions concerning education

S.No	Existing housing conditions	Education	N	Mean	Std	F-Value
1	Living room	Illiterate	4	28.75	6.85	0.343
		Primary education	12	25.50	4.10	
		Secondary education	26	28.31	5.20	
		Graduation	18	28.22	3.93	
2	Bathroom	Illiterate	4	50.25	5.56	0.2048
		Primary education	12	44.58	5.25	
		Secondary education	26	47.62	6.09	
		Graduation	18	48.33	4.78	

Continued...

S.No	Existing housing conditions	Education	N	Mean	Std	F-Value
3	Bedroom	Illiterate	4	39.75	6.40	0.2465
		Primary education	12	35.00	3.57	
		Secondary education	26	38.19	6.34	
		Graduation	18	37.39	2.93	
4	Kitchen	Illiterate	4	44.00	5.35	0.6342
		Primary education	12	42.42	4.06	
		Secondary education	26	43.04	4.79	
		Graduation	18	44.44	4.42	
5	Dining room	Illiterate	4	16.25	3.86	0.5911
		Primary education	12	15.92	2.84	
		Secondary education	26	17.23	3.24	
		Graduation	18	16.44	2.25	
6	Flooring	Illiterate	4	15.00	1.83	0.4561
		Primary education	12	14.17	1.99	
		Secondary education	26	14.69	1.69	
		Graduation	18	15.17	1.42	
7	Door hardware	Illiterate	4	33.75	3.86	0.3227
		Primary education	12	36.08	2.23	
		Secondary education	26	36.04	2.58	
		Graduation	18	35.72	1.49	
8	Windows	Illiterate	4	15.00	2.31	0.6681
		Primary education	12	13.83	1.75	
		Secondary education	26	13.85	1.54	
		Graduation	18	13.83	2.04	
9	Electric fixtures	Illiterate	4	13.00	1.83	0.5433
		Primary education	12	11.92	1.51	
		Secondary education	26	12.35	1.44	
		Graduation	18	12.56	1.42	

Table 2 Continued...

S.No	Existing housing conditions	Education	N	Mean	Std	F-Value
10	Stairs and lifts	Illiterate	4	29.25	3.30	0.3758
		Primary education	12	25.08	4.36	
		Secondary education	26	26.12	4.12	
		Graduation	18	26.89	4.78	
11	Entrance	Illiterate	4	11.25	2.22	0.1804
		Primary education	12	10.08	1.78	
		Secondary education	26	11.58	1.90	
		Graduation	18	11.22	1.96	
12	Ramp	Illiterate	4	7.75	3.50	0.1468
		Primary education	12	6.00	0.00	
		Secondary education	26	6.77	2.18	
		Graduation	18	6.00	0.00	
13	Balcony	Illiterate	4	6.25	2.36	0.277
		Primary education	12	4.58	2.35	
		Secondary education	26	5.42	1.94	
		Graduation	18	6.00	2.00	
14	Corridor	Illiterate	4	6.25	0.96	0.6647
		Primary education	12	5.58	1.00	
		Secondary education	26	6.15	1.71	
		Graduation	18	6.22	1.52	
15	Communication systems in the home	Illiterate	4	29.00	2.31	0.0201*
		Primary education	12	24.83	2.76	
		Secondary education	26	26.15	3.35	
		Graduation	18	27.89	2.68	

Note: * Significant 'F' value

Variation in the design of the communication systems in the home was found in respondents with different levels of education. However, level of education was not a variable that influenced the design of a living room, bathroom, bedroom, kitchen, dining room, flooring, door hardware, windows, electric fixtures, stairs and lifts, entrance, ramp, balcony and corridor.

Significant variance (F value - 0.0201) was found in the adoption of standard design guidelines while designing the communication systems in the home.Communication systems in the homes arethe devices that allow people to communicate using audio-visual aids from various spaces in the home without direct interaction in their homes.

Furthermore, to understand the significant mean difference between the respondents with four different levels of education t-test was computed (Table 3).

Table 3. Differences between mean scores on the design of the communication systems in the home by education level

Existing housing condition	Education comparision	Mean difference	t-value	Significance
Communication systems in the home	Illiterate Vs. Primary education	4.17	2.41	*
	Illiterate Vs. secondary education	2.85	1.77	NS
	Illiterate Vs. Graduation	1.11	0.67	NS
	Primary education Vs. Secondary education	-1.32	-1.26	NS
	Primary education Vs. Graduation	-3.06	-2.74	**
	Secondary education Vs. Graduation	-1.74	-1.89	NS

Note: ** Significant at 1 percent; * Significant at 5 percent; NS- Non-significant

The significant mean difference in the design of a communication system in the home was found between (i) Illiterate respondents and respondents with primary education (ii) respondents with primary education and respondents with graduation qualification.

Respondents with primary education differed significantly from illiterate respondents and graduates in the adoption of standard design guidelines in designing communication systems in the home. Relatively highly educated elderly respondents were found to havethe technical knowledge and taking the advantage of communication systems in the home.

Thus, the null hypothesis was accepted in the case of design of the living room, bathroom, bedroom, kitchen, dining room, flooring, door hardware, windows, electric fixtures, stairs and lifts, entrance, ramp, balcony and corridor and rejected in case of the communication systems in the home.

CONCLUSION

Educational level of the respondent was considered to be a factor that determined the design of the communication systems in the home residences. Many studies related to senior citizenshousing revealed that the existing housing conditions of the aged people dwellings failed to cater to the requirements of residents. The bathroom and kitchen were the places that had limited elderly people to perform their daily activities. Most of the elderly houses were provided with furniture and equipment that were not in use. In kitchen provision of unnecessary storage cabinets, positioning of shelves that cannot be reached by elderly people were noticed and most of the bathrooms were not provided with support fixtures such as handrails, grab bars which also affected the elderly people to live comfortably.

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PREVALENCE OF VITAMIN A DEFICIENCY IN FISHERFOLK CHILDREN (6-8 YEARS) OF EAST GODAVARI DISTRICT AND EFFECT OF SUPPLEMENTATION OF ORANGE FLESHED SWEET POTATO

Y. RAJYA LAKSHMI DEVI * and S. THILAKAVATHY

School of Homescience, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore - 641 043

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ABSTRACT

In today's world, poverty still exists among people from lower strata and isolated communities. In India, 60.7% of the fisherfolk community are below the poverty line (BPL) and 97.3% of the fisherfolk of Andhra Pradesh are under BPL. One thousand artisanal fisherfolk children (6-8 years) from coastal regions of Kakinada were screened clinically for symptoms of Vitamin A deficiency and other micronutrient deficiencies. Among them, 23.4% showed moderate to severe clinical symptoms of Vitamin A deficiency and were selected for the study. The biochemical test results showed that the mean serum retinol of all the subjects was significantly below the standard values (0.2-0.5 mg/L). In the study, 100 gm of boiled orange fleshed sweet potato which provides 788µg of Retinol Activity Equivalents (RAE), thus, meeting 124.7% of the Recommended Dose of Allowance (RDA) was fed to the children 5 days a week for a period of six months. Orange fleshed sweet potato is a rich source of beta carotene and fibre. The subjects showed significant improvement in their clinical symptoms and 67% showed rise in their serum retinol levels after supplementation.

Key Words: Fisher-folk community, School Children, Vitamin A deficiency, Bitot's spots, Blood Serum Retinol, Orange fleshed sweet potato, Supplementation

INTRODUCTION

India has a large coastline, approximately 8,118 km long. Nearly three million fish workers depend on fishing for their livelihood along this coastline. In India, 60.57% of the fishermen families are under the BPL category as per CMFRI (2010-2011) reports. In coastal Andhra Pradesh, 97.3% of fishing families are under BPL except for some employees and mechanized boat owners (CMFRI, Kochi 2011). Out of 1,63,427 marines fishing families in coastal Andhra Pradesh, 1,59,101 families are under BPL. Children ought to be a prime concern of all societies. The early years of a child's life are very important for his or her development.Poverty hampers growth physically, socially, emotionally, and educationally. (Yoshikawa *et al*.2012). 'Hidden Hunger' (iron, vitamin A and iodine deficiency), affects the health, learning ability as well as

*Corresponding Author E-mail i.d: yenumula.rajee@gmail.com; PhD thesis submitted to Avinashilingam Institute for Home Science and Higher Education for Women,

productivity owing to high rates of illness and disability contributing to a vicious cycle of malnutrition, underdevelopment, and poverty (Thompson and Amoroso, 2011). In India, around 0.5 percent of total deaths in 2016 were contributed by nutritional deficiencies (Gonmei and Toteja, 2018).

Vitamin A deficiency is the leading cause of preventable childhood blindness and increases the risk of death from common childhood illnesses such as diarrhoea (UNICEF, 2019). It is recognized as a public health issue in developing and underdeveloped countries. It is also pictured that xerophthalmia which occurs due to vitamin A deficiency is the initial cause of night blindness and Bitot's spots in the early stages which precedes keratomalacia. Children are the most vulnerable and are easily prone to vitamin A deficiencies due to reduced dietary intake and poor absorption leading to depleted vitamin A stores in the body. Factors that add fuel to the issue are a high incidence of infectious diseases like diarrhoea, worm infestations, measles, other respiratory diseases, and economic constraints, geographical isolation, socio-cultural limitations, and high illiteracy levels (Melissa Miller *et al.*, 2002)

A study carried out by Sachdeva *et al.* (2011) among pre-school children in the State of Uttar Pradesh reported a high prevalence of xerophthalmia (9.1%), Bitot's Spot (5.4 %) and severe forms of Vitamin A Deficiency such as corneal ulceration (0.2%) and corneal scar (0.5%). Similarly, a higher prevalence of clinical Vitamin A Deficiency (Bitot's Spot 2.1%) was reported by Naresh, *et al.* (2011) among urban children in the state of Gujarat. Nimmathota Arlappa *et al.* (2016) in their study among rural pre-school children of four South Indian states viz. Kerala, Tamil Nadu, Andhra Pradesh and Karnataka have observed that the prevalence of Bitot's spot, an objective ocular sign of Vitamin A Deficiency among the rural pre-school children of South Indian was 0.6%.

In the face of continuing poverty and malnutrition, an alternate strategy of development becomes a priority thus giving rise to several interventional programs. Holtz *et al*. (2012) in their research stated that the consumption of â carotene-rich orange-fleshed sweet potato helps to alleviate vitamin A deficiency. They have also stated that large-scale intervention to introduce orange-fleshed sweet potato as a staple food, into the diets of women and children to improve their vitamin A status and minimizes the risk of Vitamin A deficiency. Pro-vitamin A-rich orange-fleshed sweet potato works as a good strategy to reduce vitamin A deficiency particularly in children and women in developing countries (De Brauw *et al*., 2019).

Objectives

The study was aimed to assess the prevalence of vitamin A deficiencies in fisher-folk children (6-8 years) of East Godavari District; assess the effect of supplementation of boiled orange-fleshed sweet potato in improving the clinical symptoms of Vitamin A deficiency and Serum retinol level in selected children.

MATERIAL AND METHODS

The study was taken up to assess the nutritional status of artisanal fisher-folk children, aged 6-8 years which also included the assessment of intervention, planning, and execution of an effective intervention module to improve vitamin A status of the selected children residing in eight coastal villages in and around Kakinada, East Godavari District of Andhra Pradesh during July 2016 to December 2019. The areas selected for the study are the coastal areas in particular, in the District of East Godavari of Andhra Pradesh state with a focus on the children of artisanal fishing communities. Out of all the fishing villages in the district, eight fishermen villages namely, Chollangi, Nemam, Vakalapudi, Valasapaka, Uppada, Mulapeta, Ponnada and Konapaapapeta, were selected on the basis of feasibility of conducting study, availability of subjects and cooperation from the authorities. A total of 15,658 houses identified with the help of population census from panchayat records and from which 8451 houses belonged to the fishermen families. Fishermen families having the below poverty line ration card were chosen and surveyed to extract the data of the children aged 6-8 years and 1000 children aged 6-8 years were identified. They were screened for Vitamin A Deficiency with the help of a medical practitioner. Biochemical test for serum retinol was done for accurate identification of Vitamin A deficiency. The identified children with low serum retinol levels (> 0.2-0.5 mg/l) were then subjected to intervention. As orange fleshed sweet potato is a very rich source of beta-carotene, a detailed study about sweet potato was done at Central Tuber Crops Research Institute (ICAR), Thiruvananthapuram on different varieties of sweet potatoes from which a new variant of orange fleshed sweet potato known as ‘Kamala Sundari’ was selected for the supplementation due to its high beta-carotene levels and its availability in the study area. Boiled orange fleshed sweet potato of 100g which provides 788µg of Retinol Activity Equivalents (RAE) was fed to the children along with the morning breakfast at their respective schools five days a week for a period of six months. The orange fleshed sweet potato has good concentrations of pro-vitamin A â-carotene, moderate presence of phosphorus and potassium and low concentrations of calcium, magnesium, zinc and sodium. The role of orange fleshed sweet potato was reported in the prevention of Vitamin A malnutrition in developing countries (Satheesh and Workne,2019). So, introducing it in the fishermen’s diet was an innovative approach to combat Vitamin A malnutrition in the selected area of research.

This study was approved by the Institutional Human Ethics Committee with the approval no. AUW/IHEC-17-18/FSN/FHP-05. Permission to conduct the study was obtained from the District Medical and Health Department of East Godavari District.

The different methodological procedures adopted for the study have been distinctly presented under the following five phases each evolving from the previous one so that findings were validated, refined, modified and accumulated at every stage. The five phases of the study were:

Phase I — Selection of the area and screening of Fisher-folk children for vitamin A deficiencies.

Purposive sampling has been done for the selection of the area and the community. Secondary data available with the government authorities and school authorities was utilised for the identification of children aged 6-8 years belonging to fisherfolk communities below the poverty line. The clinical assessment of children was done along with a certified medical practitioner to identify the clinical signs of Vitamin A deficiency which includes Bitot's spots on the eyes, dryness of eyes, night blindness, Conjunctival Xerosis, etc., and symptoms of Iron Deficiency Anaemia such as pale pallor, pale conjunctiva, fatigue and Koilonychia

Phase II — Assessment of Blood Serum Retinol levels in selected subjects.

Serum Retinol was estimated using High-performance liquid chromatography (HPLC) method. Three ml blood was drawn from the subjects after an overnight fasting and wrapped in aluminium foils to avoid excessive light exposure. The serum or plasma was separated and refrigerated. The serum samples procured were treated with retinyl acetate in absolute ethanol and n-hexane. The mixture was the centrifuged after which the clear hexane layer was carefully drawn in another test tube, evaporated and treated with methanol. The aliquot, thus prepared was injected into the HPLC loop for serum retinol level determination.

Phase III — Selection, Preparation and nutritional analysis of boiled sweet potato for supplementation.

A detailed study about sweet potato was done at Central Tuber Crops Research Institute (ICAR), Thiruvananthapuram on different varieties of sweet potatoes from which a new variant of orange fleshed sweet potato known as 'Kamala Sundari' was selected for the supplementation due to its high beta-carotene levels and its availability in the study area. The boiled orange fleshed sweet potatoes were subjected to nutrient analysis namely moisture, protein, fat, carbohydrate, fibre, calcium, iron, thiamine, riboflavin, vitamin B6, Vitamin A, and Vitamin C was estimated at the School of Food Technology, JNTUK Food Testing Laboratory by High-performance Liquid Chromatography (HPLC) and Gas Chromatography (GC) techniques. Organoleptic testing of the boiled sweet potatoes cubes was evaluated for their acceptability by children, teachers and caretakers at randomly selected schools.

Phase IV— Grouping of children and supplementation of the boiled orange fleshed sweet potato.

One thousand children aged 6-8 years were identified in the selected fisherfolk communities residing in 8 villages. Out of them, 234 children were identified with low serum retinol levels (> 0.2-0.5 mg/l) and were placed in 2 different groups (1 experimental group and 1 control group) for intervention. Boiled orange fleshed sweet potato of 100g which provides 788µg of Retinol Activity Equivalents (RAE) was fed to the children along with the morning breakfast at their respective schools five days a week for a period of six months.

Phase V— Assessing the impact of supplementation

The serum retinol levels collected before supplementation and after supplementation were compared with the standard values recommended by the WHO by using appropriate simple statistical methods like mean, standard deviation, percentages and t test.

INCLUSION CRITERIA

Based on the following inclusion and exclusion criteria, the children were selected for the intervention programme.

School going children aged between 6-8 years.

- Children with nutritional deficiencies
- Willingness of the school management and parents to participate in the study
- Children from fishermen families categorized under the poverty line
- Children who are regular to school (at least having 75% attendance)

EXCLUSION CRITERIA

- Children with previous serious health issues like HIV, Cancer, etc.
- Children with physical deformities.
- Children who are already taking supplements.
- Children who are not enrolled into school

TOOLS AND TECHNIQUES

Venipuncture method was adapted for the collection of blood samples by trained professionals for estimating blood serum retinol levels. The concentration of Vitamin A < 0.2mg/L is recommended to indicate Vitamin A deficiency (Li *et al*., 2015).

RESULTS AND DISCUSSION

Phase I — Selection of the area and screening of Fisherfolk children for vitamin A deficiencies.

All the children were screened clinically by the investigator (with the help of a medical practitioner) for symptoms of Vitamin A Deficiency (VAD) such as Bitot's Spot, Night blindness, corneal xerosis, keratomalacia, xerophthalmia, conjunctival xerosis, etc.

The mean prevalence of Bitot's spots, an objective sign of VAD in the fisher-folk children screened, was 0.8 % (Fig.1). The mean prevalence value of 0.8 % for Bitot's spots is well above the cut off value (of > 0.5 %) indicated by WHO (2007). Thus, VAD is a significant health issue of the public among the children of the fisher-folk community screened in the present study. Although Bitot's spots and Night blindness are considered mild stages of eye disease, yet both of them represent moderate- to- severe

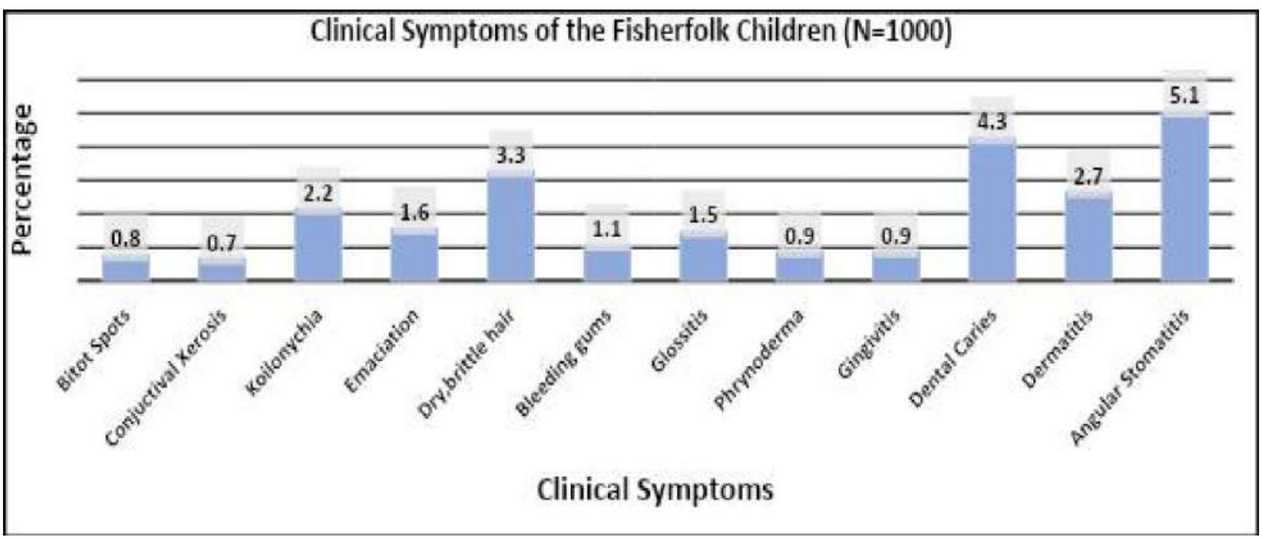

Fig.1 Clinical Symptoms of the Fisherfolk Children (n=1000)

systemic vitamin A deficiency, as they denote and are evidenced by low serum retinol concentrations (Alfred Sommer, 2008). The mean prevalence of conjunctival xerosis in fisher-folk children, a sign of VAD, was 0.7 %. The mean prevalence of koilonychia, the most visible symptom of iron deficiency anaemia in fisher-folk children, was 2.2 %. The mean prevalence of emaciation, a major symptom of protein energy malnutrition in fisherfolk children was 1.6 %. Glossitis was seen in 1.5 %, dry and brittle hair was observed in 3.3 %. The prevalence of phrynoderma was 0.9 %. Bleeding gums, a sign of vitamin C deficiency was observed among 1.1 % of children. Lack of hygiene has been anticipated by symptoms such as gingivitis in 0.9 % of children and dental caries in 4.3 %. Dermatitis was observed in 2.7 % of children and angular stomatitis, a B- complex deficiency in 5.1 % of the fisherfolk children of the present study.

The results of the study coincide with the findings of Nongrum *et al.* (2015) on "High prevalence of vitamin A deficiency among children in Meghalaya and the underlying social factors". They reported a high prevalence of clinical VAD (4.50%) in rural children of Meghalaya and much higher (5.9%) in school going children of age 5 – 15 years which is higher than the WHO global cut off of 0.5% for VAD indicating that clinical VAD is a public health problem in that area (Jenkins *et al.*2015).

The mean serum retinol of all the children was significantly below (p< 0.01) the standard values (0.2-0.5 mg/L) in all boys and girls of all age groups. As per WHO (2011), the prevalence in the population with low serum retinol (0.70 µmol/l or below) can be used to assess the severity of vitamin A deficiency in most age groups as a public health problem. If the degree of public health problem is 2-9% it is mild, 10% -

Phase II — Assessment of Blood Serum Retinol levels in selected children

Serum Retinol Levels of the Fisherfolk children

Table 1:Serum Retinol Levels of the Fisherfolk children Vs WHO Standard Values (n=234)

S. No	Age Group (years)	N=234	Standard Values (mg/L)	Serum Retinol Mean (mg/L)	T value
1	6+ boys	40	0.20-0.50	0.152 ± 0.01	-12.4**
2	7+ boys	41	0.20-0.50	0.155 ± 0.01	-10.5**
3	8+ boys	40	0.20-0.50	0.150 ± 0.02	-8.51*
4	6+ girls	40	0.20-0.50	0.151 ± 0.01	-11.7**
5	7+ girls	35	0.20-0.50	0.156 ± 0.01	-18.1**
6	8+ girls	38	0.20-0.50	0.149 ± 0.02	-15.8**

**-Significant at 1% level (p<0.01), * - Significant at 5% level

19% is considered moderate and more than 20 is considered to be a severe public health issue. The present study reveals that 23.4% of the fisherfolk children were identified as having low serum retinol concentrations in the blood thus making it a public health problem.

Phase III — Selection, preparation and nutritional analysis of boiled sweet potato for supplementation

Nutrient Analysis of Boiled Orange Fleshed Sweet Potato supplement

Orange fleshed sweet potatoes (OFSP) variety known as 'Kamala Sundari' is a rich source of beta- carotene and is available in the local market was selected, cleaned and boiled to be supplemented to the fisherfolk children.

As per the ICMR (2020) recommended guidelines, the daily recommended allowance for a child aged between 6 – 9 years is 632 µg RAE /day. In the present study, 100 gm of boiled Orange fleshed sweet potato selected for intervention provides 788µg of Retinol Activity Equivalents (RAE). So, each child has been given 100 gm piece of Orange fleshed sweet potato daily which provides 788 µg RAE which is more than the required RDA suggested by the ICMR (2020) since dietary â-carotene is a safe source of vitamin A because intestinal conversion of â-carotene to vitamin A decreases as an oral dose of â-carotene increases (Novotny *et al.* 2010). The efficiency of â-carotene conversion to vitamin A in humans is reduced at increasing doses which is why vitamin A toxicity is not observed in individuals consuming large amounts of â-carotene (Janet *et al.* 2010). Orange fleshed sweet potato also provides 72g of moisture, 1.4g of protein, 0.1g of fat, 17.7g of carbohydrates, 2.5g of fibre, 12.8mg of vitamin C, 0.17mg of Vitamin B6, 0.05mg of riboflavin, 0.06mg of thiamine, 0.7mg of iron and 27mg of calcium.

Table 2: Nutritive analysis of orange fleshed sweet potato (100g)

S.No	Nutrient	Nutritive value
1	Moisture (g)	72
2	Protein (g)	1.4
3	Fat (g)	0.1
4	Carbohydrates (g)	17.7
5	Fibre (g)	2.5
6	Vitamin A(RAE)	788
7	Vitamin C (mg)	12.8
8	Vitamin B6	0.17
9	Riboflavin (mg)	0.05
10	Thiamine (mg)	0.06
11	Iron (mg)	0.7
12	Calcium (mg)	27

Phase IV— Grouping of children and supplementation of the boiled orange fleshed sweet potato

Two hundred and thirty-four children aged between 6-8 years who were detected having Vitamin A deficiencies were selected for supplementation and were placed in 2 different groups (One experimental group and one control group). The selected 234 subjects comprising 121 were boys and 113 were girls. Group 1 comprised 115 children who were supplemented with 100g of sweet potato along with school meal,

Table 3. Mean Serum Retinol Levels of Gr.1 and Gr.2 Children Before and After Supplementation (n=234)

Mean Serum Retinol Levels of Gr.1 and Gr.2 Children Before and After Supplementation								
S. No	Age		No.	Standard Values (mg/L)	Before (mg/L)	After (mg/L)	Differ-ence	T value
1	6 years	Group 1	115	0.20-0.5	0.15±0.014	0.18±0.015	0.03±0.08	2.54*
		Group 2	119	0.20-0.5	0.15±0.016	0.15±0.014	0.0±0.009	0.78*
2	7 years	Group 1	115	0.20-0.5	0.15±0.020	0.17±0.012	0.02±0.01	2.18*
		Group 2	119	0.20-0.50	0.16±0.01	0.16±0.01	0.0±0.009	0003NS
3	8 years	Group 1	115	0.20-0.50	0.15±0.017	0.18±0.015	0.03±0.01	7.04**
		Group 2	119	0.20-0.50	0.16±0.02	0.16±0.017	0.0±0.009	0.43*
**-Significant at 1% level (p<0.01), * - Significant at 5% level, NS - Not Significant								

five days a week for a period of six months. Group 2 comprised 119 children who were the control group and were given only the school meal for a period of six months.

Phase V— Assessing the impact of supplementation.

Effect of Supplementation of Boiled Orange Fleshed Sweet Potato on Serum Retinol Levels in Children

Table 3 shows the serum retinol levels in Group 1 and Group 2 children before and after supplementation.

When compared with the standard values, the mean initial serum retinol levels in both the groups were identified to be below than required. But after supplementation, the mean final serum retinol had increased significantly at 5% and below 5 % level in Group 1 children who were supplemented with 100 gm of boiled orange-fleshed sweet potato (OFSP) for six months by 67%, whereas, Group 2 children who were not supplemented with OFSP showed no improvement. These findings are similar to the study of Jenkins *et al.* (2015), who stated that food-based approaches encouraging the consumption of vitamin A-rich foods, such as orange-fleshed sweet potato have the potential to positively affect vitamin A status in population deficit in vitamin A levels. The results of the study showed that > 50% of the intervention children who consumed orange-fleshed sweet potatoes 3-6 days a week showed a rise in their serum retinol levels. Though the increase in the serum retinol level is less when compared with the findings of a study done in Mozambique, the absorption of Vitamin A might have been reduced due to insufficient intake of fat and fibre in the diet. Carotene bio accessibility depends on the food matrix, the type of fibre and fat in food, and the heat and the homogenization caused by food processing (Veda *et al.,* 2006).

CONCLUSIONS

Vitamin A deficiency is a problem of public health among fisher-folk children. The mean prevalence of Bitot's spots, an objective sign of Vitamin A deficiency in the 1000 fisher-folk children surveyed was 0.8 % which was well above the cut off points (>0.5%) suggested by the World Health Organization. Orange flesh sweet potato has a tremendous potential to tackle the problem of Vitamin A deficiencies. Sixty -seven percent of the children showed improvement in their serum retinol levels after supplementation. The control group showed no improvement in their serum retinol levels. It is revealed that orange fleshed sweet potato consumption helps to increase serum retinol levels and if supplemented for a longer period along with the recommended amount of fat in the diet would help in alleviating Vitamin A deficiencies.

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RELATIONSHIP BETWEEN MATERNAL DIET HABITS AND BIRTH WEIGHT IN NEWBORNS- A STUDY IN JHARSUGUDA DISTRICT OF ODISHA

SURAVI SAHU* and CHANDRASHREE LENKA

P.G. Department of Home Science, Sambalpur University, Odisha-768 019

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ABSTRACT

Pregnancy is a nutritionally highly demanding period, so a balanced diet is essential for maternal health and well-being and delivering a healthy baby.The research aimed to study the relation of maternal food intakes with the birth weight of newborns.Jharsuguda district of Odisha, India, was selected as a study area. The purposive sampling method was followed. 300 women, who are in theirthird trimester of pregnancy were selected from the total population and following upto their delivery. The study was conducted for a period of 9 months *i.e.* from May 2018 to Feb 2019. Thefindings indicated that cent percent of respondents daily included cereal and pulses in their diet. Statistically, it was also observed that there was a significant difference between the mothers' actual food intakecompared to the Recommended Dietary Allowance (RDA) of Inidan Council of Medical Research (ICMR) during the last trimester of pregnancy. A significant linear correlation between food intake of mothers such as cereals, pulses, fat and oil,and the birth weight of newborns was recorded.

Keywords:Third trimester, pregnant women, Birth weight, maternal food intake

INTRODUCTION

Nutritional deficiency is widespread during pregnancy in remote India. The food and dietary requirements during the gestational period are more. On the other side, maternal dietary consumption decreases due to morbidity related to pregnancy and many other socioeconomic elements that adversely affect newborns' health. As per the research carried out in the past, health and maternal nutrition are the most significant regulators of fetal growth and development. If expectant mothers are inadequately nourished, they can give birth to unhealthy babies, thereby, causing high newborns mortality. Maternal nutrition plays a significant role and this factor is responsible not only for the newborns' health, but, also for the newborn's long-term growth and development. Thus, understanding fetal growth and maternal nutrition association is very important.

As child bearing is nutritionally and physiologically a highly demanding period, so a balanced diet is highly essential for maternal health and well-being and delivery of a healthy baby. Generally, people belonged to low socioeconomic class in developing countries

*Corresponding Author E-mail i.d: suravi.smart@gmail.com; PhD thesis submitted to Sambalpur University, Odisha-768 019

such as India take a similar diet during pre-pregnancy, pregnancy, lactating period ultimately widespread outcome of malnutrition among mothers, low birth weight newborns, and a very high chance of neonatal and maternal mortality and morbidity was observed (NIN, 2011). Diet with nutritional deficiencies during pregnancy is common in India. The nutritional and food requirements are increased during pregnancy, and on the other side, the dietary consumption decreases due to the pregnancy-related symptoms. It has negative impact on the newborn's weight. Maternal health and nutrition are the most significant regulators of human fetal growth. If women inadequately consume food and nutrient, there are more chances to delivere unhealthy babies, thereby resulting in more mortality among newborns. Maternal health and nutrition is a significant factor, which affects not only the health of newborns but also long term growth of the baby. Therefore understanding fetal growth and maternal nutrition relationship is critical (Sahu *et al*., 2015). Nutritional deficiency among expectant mothers leads to premature babies and low birth weight and abnormality. To reduce mortality and morbidity among children, focused attention on better maternal nutrition is highly essential (Agarwal *et al.,* 2012). Objective of this study is to find out the relation of maternal food intakes with the birth weight of newborns.

MATERIAL AND METHODS

For this study,Lakhanpur and Jharsuguda Block of Jharsuguda district of Odisha was selected as a study area. There are 957 Anganwadicenters at Jharsuguda district. Out of which 16 Anganwadi centers of Lakanpur block and 12 Anganwadi centers of Jharsuguda Block were selected randomly for the study.Based on the review of literature and objectives of the study an exploratory cum descriptive research was adopted for the study and the purposive sampling method was followed. The study was conducted for a period of nine months *i.e.* from May 2018 to Feb 2019. Three hundred (300) women who are in the third trimester of pregnancy till their delivery were selected from the total population.All expected mothers were interviewed on a predesigned schedule and their dietary intake was recorded.

The oral food frequency questionnaire method was used to estimate the intake of food by the pregnant women toascertain the frequency of consumption of certain foods and nutrients in the list daily, weekly, or monthly.Dietary intake was assessed by using the 24-hour recall method. For the 24-hour recall method, the subject was asked to recall all foods and beverages consumed during the past 24 hours. The use of everyday household utensils and models of portion sizes was used to estimate the quantity of food they had consumed. The food quantitywasconverted into raw amount to calculate the nutritional value. In the case of packaged foods, information was obtained from the nutrition facts given on the package. The average food intake was calculated for each respondent & compared with RDA (ICMR) using a food composition table.The weight of the newborns was recorded immediately after delivery

RESULT AND DISCUSSION

Food frequency adequacy

Table 1. Food consumptions (food frequency adequacy) during pregnancy(n=300)

Food	Daily		Weekly		Occasionally		Never		Total	
	f	%	f	%	f	%	f	%	f	%
Cereal	300	100	-	-	-	-	-	-	300	100
Pulses	300	100	-	-	-	-	-	-	300	100
Leafy Vegetables	243	81	57	19	-	-	-	-	300	100
Other Vegetables	233	77.67	67	22.33	-	-	-	-	300	100
Milk & milk product	92	30.66	49	16.33	37	12.33	112	37.33	300	100
Non-Veg.	55	18.33	102	34	87	29	56	18.67	300	100
Beverage	280	93.33	9	3	13	3.67	-	-	300	100
Fruits	130	43.33	84	28	73	24.33	11	3.66	300	100
Pickles	71	23.67	143	47.67	62	20.66	24	8	300	100

f - Frequency; % - Percentage

Table 1 shows the food consumption pattern of women during the third trimester of pregnancy. Out of 300 respondents cent percent of respondents daily included cereal and pulses in their diet. Rice, wheat, and pulses found to be used as a staple food in this study area. The highest percentage of respondents (93.33%) consumed tea, coffee, or any beverage such as fruit juice daily, whereas 81%, and 77.67%, and 30.66% of mothers were consuming leafy vegetables and other vegetables daily during pregnancy. Only 18.33%, 43.33%, and 23.67% of respondents consumed milk and milk products, non-veg items, fruits, and pickles respectively daily in their diet during pregnancy. It was interesting to note that 37.33% never consumed any type of milk product during their pregnancy. 24.33% of respondents consumed fruits, and 20.66% of respondents like to eat pickles occasionally during pregnancy. Similar findings were observed by Amaranth *et al.*(2014) and Srivastava *et al.* (2019) who also recorded that cent percent of respondents included cereal and pulses daily in their diet in their study.

Table 2 reveals the mean of actual food intake of respondents in comparision to Recommended Dietary Allowance (RDA) of Indian Council of Medical Research (ICMR) value. It was noted that the mean of actual food intake of pregnant mothers for different foodstuffs was less than RDA *i.e.* 386.61 g ± 50.35, 47.52 g ± 4.25, 61.3 g ± 8.75, 63.96 g± 8.87, 20.05 l ± 6.52, 193.77 l ±103.85 and 19.97 g ± 6.87 for cereals, pulses, green leafy vegetable, other vegetables, oil & fat, milk & milk product, and sugar &jaggery respectively. The percentage of food adequacy

Food intake of mothers

Table 2. Diffrence in actual food intake and RDA of pregnant women in 3rd trimester of pregnancy(n=300)

Food Intake	Actual Mean ± S.D.	RDA (ICMR-2010)	Percentage of Adequate Intake	Z Calculated Value
Cereals (g)	386.61 ± 50.35	445	86.88	20.09*
Pulses(g)	47.52 ± 4.25	55	86.4	30.48*
Green Leafy Vegetable(g)	61.3 ± 8.75	100	61.3	76.60*
Other Vegetable(g)	63.96 ± 8.87	100	63.96	70.37*
Oil & Fat(l)	20.05 ± 6.52	20	100	0.13**
Milk & Milk Product(l)	193.77±103.85	200	61.88	1.04**
Sugar &Jaggery(g)	19.97 ± 6.87	35	57.06	37.89*

***Significant ; ** Not Significant**

was more for cereals that is 86.88%, pulses 86.4%, and fat and oils,*i.e.* 100%. A positive trend for pulses and oil and fat consumption by pregnant mothers was found in this study. However, the percentage of adequacy for green leafy vegetables, other vegetables, milk and milk products, sugar, and jaggery varied from 61.3% to 57.06% which was about 40% less than the required amount. Statistically, it was also observed that there was a significant difference between mothers' actual food intake for all food items compared to the RDA of ICMR during the third trimester of pregnancy. Similar findings were also observed by Tyagi *et al.* (2019) and Srivastava *et al.* (2019).

Correlation of newborns birth weight of newborns with food intake of mothers

Table 3. Correlation of newborns birth weight of newborns with food intake of mothers (n=300)

Model	R	R Square	F	Sig.
1	.926[a]	.857	249.623	.000[b]

a. Dependent Variable: birth weight

b. Predictors: (Constant), sugar, milk and milk products, pulses, oil and fat, other veg, cereal, green leafy veg

From Table 3, it is observed that R2 (coefficient of determination) is 0.857. It indicates that 85.7% of the variation in newborns' birth weight can be explained by seven independent variables, *i.e.* types of food intake of mothers. However, with F= 249.623 and the signifant value is 0.000, this indicates that the regression model is statistically significant. Hence, the result of the model explains that the newborn's BMI is affected by 85.7% by maternal food intake. Similar findings was also reported by Prudhivi *et al.*, (2015) mothers who had inadequate diet had higher incidences of LBW babies (72%).

Regression output of birth weight of newborns and food intake of mothers

Table 4. Regression output of birth weight of newborns and food intake of mothers(n=300)

Coefficients						
Model		**Unstandardized Coefficients**		**Standardized Coefficients**	**T**	**Sig.**
		B	Std. Error	Beta		
1	(Constant)	-1.641	.141		-11.673	.000
	Cereal	.003	.000	.272	6.544	.000
	Pulses	.072	.004	.694	17.126	.000
	Green leafy veg	.006	.008	.111	.816	.415
	Other veg	-.007	.007	-.123	-.935	.351
	Milk and milk products	-0.00003106	.000	-.007	-.260	.795
	Oil and fat	-.005	.003	-.062	-1.750	.081
	Sugar	.002	.003	.030	.837	.403
a. **Dependent Variable: birth weight**						

From Table 4, it is observed that only cereal and pulses intake of mothers were statistically significant with values of 0.00 which are less than 0.05 (marked). The other five independent variables are individually not significant because all the p-values corresponding to these independent variables is greater than 0.05 (insignificant). The regression model can be written as follows:

Birth weight newborn = -1.641 (birth weight newborn) + 0.003 (cereal) + 0.072 (pules)+ 0.006 (green leafy vegetables) + 0.007 (others vegetables) + -0.00003106 (milk and milk products) + - 0.005 (fat and oil) + 0.002 (sugar).

Thus, the birth weight of newborns was statistically correlated with cereal, pulses, and oil and fat intake of the expectant mothers, whereas, no significant relationship was found between intake of green leafy vegetables, other vegetables, milk, and milk products, sugar intake of pregnant women and new-borns birth weight which may be a chance factor. The above Table reveals that with an increase in mothers' food intake, the birth weight of newborns also increases. Similar findings was also observed that Tyagi *et al.* (2019) who recorded that even though birth weight and weight at 12 months increased consistently with increase in maternal energy and protein adequacy, the association was not significant at 12 months of ageand Ajantha *et al*. (2015) who reported that sixty four percent of the participants preferred eating of rice daily followed by chapati (30%).

CONCLUSION

Cent percent of respondents included cereal and pulses daily in their diet. Most mothers were found to take an inadequate amount of calories in their diets compared to ICMR value. Statistically, found a significant difference between actual food and nutrient intake of mothers in comparison to RDA of ICMR was found in this research. A strong linear correlation between mothers' food intake such as cereals, pulses, fat and oil,and newborns' birth weight found in this study.Thus, it can be concluded thatshort term training programmes, workshops, and training programmes should be organized by the government and voluntary organization for the women to help them to improve cooking and food-processing techniques to minimize the nutrient losses during cooking and processing of food. Investing on maternal nutrition is the key as maternal health is central to newborn growth,cognitive development,and future productivity.

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ESTIMATION OF AREA SOWN AND SOWING DATES OF IN-SEASON *RABI* CROPS USING SENTINEL-2 TIME SERIES DATA

SANDEEP V.GAIKWAD*, AMOL D. VIBHUTE and KARBHARI V. KALE

Department of Computer Science & IT, Dr. Babasaheb Ambedkar Marathwada University, Aurangabad - 431 004

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ABSTRACT

An estimation of the area sown and sowing dates with their frequent updates in crop growing season are crucial for devising the Nation's food secuirty policies. These areas and dates were estimated in India through a crop simulation model at a 5km X 5km grid across the states. Therefore, a pilot study was conducted crop of sown area estimation, and sowing dates of r*abi* (post-rainy) crops for 2017-2018 using nine (09) high-resolution Sentinel-2 images. These images were acquired from October 1, 2017, to January 31, 2018 and were used to prepare the Satellite Image Time Series (SITS) dataset. A new methodology was implemented using a time-series vegetation index at 10m spatial resolution Sentinel-2 data to detect *rabi* crops' growth in Vaijapur Tehsil of Maharastra. Normalized Difference Vegetation Index (NDVI) was computed from the dataset, and further used for a research study. A composite of 15 images was prepared for analysis of the temporal profile of NDVI. The temporal profile trend starts from the emergence of crops and shows the maximum value at the maturity state of crops. Furthermore, it starts decreasing and shows a minimum threshold value >0.03 at the crop's harvesting state. Additionally, it was correctly used to differentiate early, normal, and late sown crops in the study area. Furthermore, sown area estimation was carried out by an unsupervised ISODATA (Iterative Self-Organizing Data Analysis) algorithm. The overall accuracy was 88.39 with 0.84 kappa coefficient through the conducted experiment. Sentinel-2 is a suitable data source for sown area estimation and sowing date extraction with acceptable accuracy.

Key Words: Sown area estimation, sowing dates extraction, NDVI temporal profile, Sentinel 2, ISODATA classification

INTRODUCTION

Traditionally, area sown or sowing dates is being recorded by the Revenue Mandal Officer (Gram Sevak) using a paper-based survey method. Traditional methods are tedious and time-consuming, which cannot efficiently and effectively acquire every block's records. The government uses such information for decision-

*Corresponding Author E-mail i.d: sandeep.gaikwad22@gmail.com; PhD thesis submitted to Dr. Babasaheb Ambedkar Marathwada University, Aurangabad making and planning of mitigation policy (Narayanamoorthy, 2013). Therefore, inaccurate data may lead to the catastrophic failure of crop insurance scheme (Narayanamoorthy, 2013; Smith and Glauber, 2012). Such type of problem can be overcome through satellite-based observations. The satellite provides the periodical observation of the landscape in multi-resolution and multi-temporal which is essential for crop health monitoring and yield prediction (Marj and Meijerink, 2011). Additionally, Sentinel-2 satellite provides 10, 20 and 60m spatial resolution data with 13 bands freely to the researchers. Availability of high spatial and temporal resolution (5 days') data of Sentinel-2 satellites can help sown area analysis, which is bigger than 10m of each plot. Therefore, it is significant for a country, where the average landholding is 1.57 ha (Sitokonstantinou *et al.,* 2018).

Consequently, monitoring of crops is an imperative task to ensure the nation's food safety and security (Patel *et al*., 2015). Agricultural monitoring can be done through vegetation indices, which are a band ratio of satellite images (Gaikwad *et al*., 2018). Subsequently, vegetation indices are used to analyse vegetation health, phenology, leaf water and mineral stress monitoring, sowing date and area estimation (De Beurs and Ioffe (2014); Vyas *et al*. (2013), Gaikwad *et al*. (2019).The NDVI is the popular vegetation indexfor drought monitoring and assessment in the world. It is significantly used for crop area estimation and yield prediction of the region (Bingfang and Qiangzi, 2004). Vyas *et al*., 2013,in their study used INSAT 3A CCD data of 1 km×1 km resolution for sown area estimation of India. Similarly, crop area estimation and crop monitoring were done (Nigam *et al*., 2015) with INSAT 3A data which is utilised for generation of NDVI temporal profile of the crops. The study by Bisht *et al*. (2014) demonstrated the use of LISS-III datasets along with the ISODATA method to assess the spatial dynamics of cropping patterns. On the other hand, most researchers used MODIS, AWiFS, and Landsat 7/8 and LISS III datasets to estimate sown area and sowing date for a large area. These type of datasets are helpful for block, tehsil and district level cropland analysis.

However, previous studies did not fulfil the requirements for assessing the in-season evaluation of *rabi* crops. These studies did not provide in-season phenology information of *rabi* crops using the high spatial resolution datasets. Hence, the study aims to estimate sowing dates and areasown of in-season *rabi* crops using Sentinel-2 time-series datasetof the study area.

MATERIAL AND METHODS

The Area of Study (AOS)

The research has been carried out for the Vaijapur tehsil of the Marathwada region, facing drought episodes for a decade. It is located at a latitude of 19^0 55' 12" N and longitude 74^0 43' 78" E covering approximately 1510.5 sq. km (Fig. 1). Yearly average precipitation is 750mm, and the temperature ranges between 26°- 43° C. The study area includes five full test sites of Vaijapur Tehsil, such as Ghaigaon, Maski, Vaijapur rural, Jarul and Khandala. The test sites were selected based on soil types and irrigation facilities available in the region.

Datasets and tools

For this research study, precipitation data of the year 2017-2018 was acquired from the

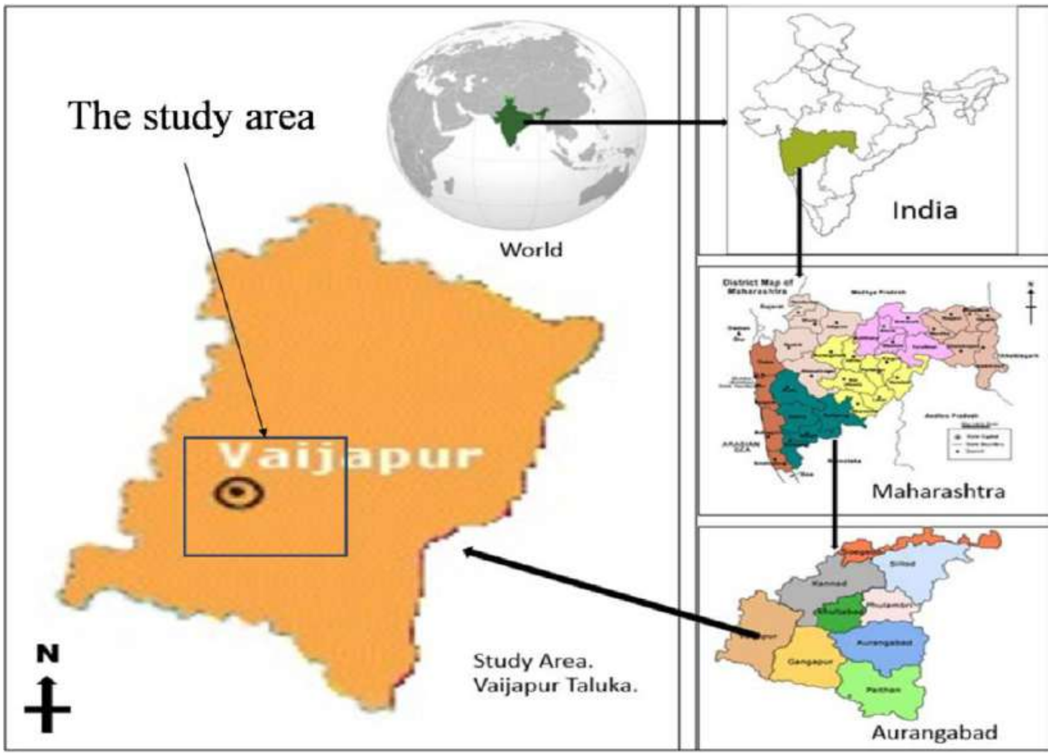

Fig. 1. The area of study of Vaijapur, District Aurangabad, MS, India.

Department of Agriculture, Vaijapur. Moreover, the Sentinel 2 satellite datasets were used for experimental analysis, which were acquired from the European Space Agency (ESA) scientific hub portal. Sentinel provides high spatial resolution (10m) images to support free and open access policy to the research community (Malenovsky *et al*., 2012). It includes a total of thirteen (13) bands ranging from 296.6 nm to 1373.5 nm (Clerici *et al*., 2017; Mahdianpari *et al*., 2019). The Sentinel-2 dataset used is provided in Table 1. Additionally, ESA also provides a Sentinel Application Platform (SNAP) software tool for sentinel data processing and it is released under the open source license agreement (Belgiu and Csillik 2018; Vanino *et al*., 2018; Zhang *et al*., 2017; Delgado *et al*., 2019). SNAP 6.0 tool comes with three tool-boxes STB1, STB3 including Sen2Core 2.5 plug-in for atmospheric correction of a dataset (Kukawska *et al*. 2017; Muller-Wilm *et al*., 2013). The time profile analysis was performed using SNAP tool and classification was performed in the ENVI (Environment of Visualising Images) software. The classified map was prepared using ArcGIS 10.1.4 software.

Field measurements

Field campaigns were carried out every fortnight of the month, synchronizing with a day of satellite overpasses. The developed Android application named Geo-Mapper (Gaikwad *et al*. 2018) was used to collect ground truth data, which includes photos of crops, GPS coordinates, sowing dates and crop type information. Plot size of more than one hectare, including irrigated and non-irrigated (rainfed) fieldswas selected. Focused Group Discussions with farmers regarding sowing dates, cultivation procedure, irrigation facilities, fertilizers and expected yield were conducted.The work-flow

Table 1. Detailed information of Sentinel datasets

S. No.	Month	Obtained Dates	Remarks
1	November	01/11/2017,16/11/2017	Cotton Harvest stage, *rabi* season start, early sowing of *rabi* crops
2	December	11/12/2017,26/12/2017	Maturity stage of *rabi* crop, Wheat crop
3	January	10/01/2018,20/01/2018	Yield Stage of *rabi* crop (early)
4	February	09/02/2018,24/02/2018	Yield formation stage of *rabi* crop (late sown), *end of rabi* season
5	March	31/03/2018	Harvesting stage of *rabi*, summer season beginning

architecture of the adopted methodology is provided in Fig. 2.

Satellite data pre-processing

Total 9 images were pre-processed using Sen2Core plug-in of SNAP software (Louis *et al.*, 2016). Atmospheric, geometric, and radiometric corrections of satellite data were carried out forSentinel 2 Level 1C product. It was further converted from Top-of-Atmosphere (TOA) Level 1C product into Level-2A Bottom-of-Atmosphere (BOA) reflectance product. Additionally, allbands were resampled to10m spatial resolution using a Bilinear Interpolation (BI) resampling method and projected into UTM Zone 43, WGS-84. The VNIR (visible and Near-Infrared) bands were useful for various applications like LULC change detection and mapping, water, and agriculture. Moreover, Sentinel-2 data includes Red Edge bands (5, 6, 7, 8a) with 20m spatial resolution, which is essential for vegetation analysis (Clerici *et al.*, 2017).

Computation of Vegetation Indices (VI) and stack image preparation

NDVI is a normalized difference of red (664.6nm) and NIR (832.8nm) band as given in Equation 1. Red wavelength is sensitive to the absorption of crops or vegetation. Alternatively, the green wavelength is responsible for emitting crop reflectance(Vibhute *et al.,* 2020). Therefore, healthy plants appear as green in the visible spectrum (Jakubauskas *et al.,* 2002). NDVI index was computed from Sentinel images, which were further used for generating composite layers using the layer stacking function of the SNAP tool. The composite of time series data is essential for sown date analysis. Moreover, it was also used for sown area classification using the ISODATA algorithm. The non-agricultural area was masked from the imagery because it was not needed for further analysis. In this case, the criteria of the non-agricultural region were “unclassified <0”. Table 2 shows the criteria of NDVI, which is used for further analysis.

$$NDVI = \frac{(NIR - RED)}{(NIR + RED)} \qquad (1)$$

Table 2. The criteria of NDVI algorithm (Kafira*et al.,* 2015)

NDVI value			
Sr. No.	**Land cover**	**NDVI Scale**	**Scale 0 to 255**
1	Thick Vegetation	0.500 <=NDVI <=1	210 <=NDVI >=
2	Medium Vegetation	0.140<=NDVI <0.500	118<=NDVI<210
3	Scarce Vegetation	0.090<=NDVI<0.140	105<=NDVI<118
4	Bare ground	0.025<=NDVI<0.090	88<=NDVI<=105
5	Clouds	0.002<=NDVI<0.002	83<=NDVI<=88
6	Ice and Snow	-0.046<=NDVI<0.002	70<=NDVI<=83
7	Water	-1<=NDVI<-0.046	0<=NDVI<70

ISODATA classification and time series cluster analysis

The unsupervised classifier uses machine intelligence to generate clusters from datasets (Springenberg, 2015; Vibhute and Gawali, 2013). The cluster includes a homogenous group of data or data space. ISODATA is a pixel-based classifier that generates a cluster of similar spectral values. It calculates the standard deviation within each cluster and measures the distance of the cluster to

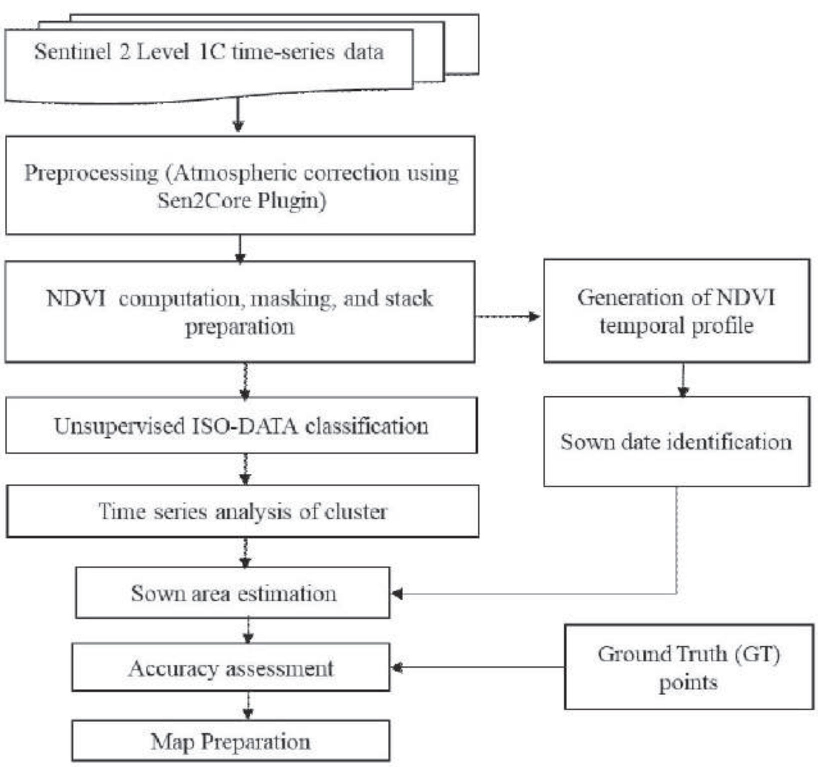

Fig. 2. The workflow of methodology for estimation of sown area and sowing date

the centroid. In each iteration, the cluster splits and merges based on a user-defined threshold value. Therefore, many classes can be varied, and classification completes after iterations reach the maximum user-defined limit (Nigam *et al*., 2015).Therefore, ENVI software tool for the ISODATA classification was adopted and used the default values like minimum and maximum number of classes, maximum iterations, change threshold % field, minimum pixels in class field, maximum class standard deviation (in DN), maximum standard deviation from mean or maximum distance error fields, respectively.

NDVI time profile generation for sown dates estimation

The SNAP tool provides an excellent time profile plugin used to generate the time-series graph of the pixel value. It requires the stacked images of the NDVI so that the user can check the vegetation response of the selected location over the images' acquisitions dates. Such types of utility will be helpful to estimates the sown date of the crops (Vyas *et al*., 2005; Nigam *et al*., 2015).

RESULTS AND DISCUSSION

A total of 574mm rainfall was received in the study area, out of which a total of 139.6mm was received in June (Fig. 3). The highest rainfall(153.6mm) was received in September, whereas only 68.9mm was received in the mid-rainy season (July). Merely no rainfall (Fig. 3) was received in the entire *rabi* season. Hence, rainfed croplands could not be able to sustain the health of the crops.

Fig. 4(a) shows field photographs acquired during the field campaign, and Fig. 4(b) is False Colour Composite (FCC) of Sentinel-2 satellite images of November to January, which shows temporal changes of vegetation in marked circle. Field photos are indicated by numbers that are similarly related to satellite images. From Fig. 4a, it is seen that the first three (1, 2 and 3) images show cotton crops in their production to harvest stage. As the cotton crop was planted in June and its production starts from October or November. Furthermore, it was harvested in January or February. However, other crops like Soybean, Corn and Barley were harvested in

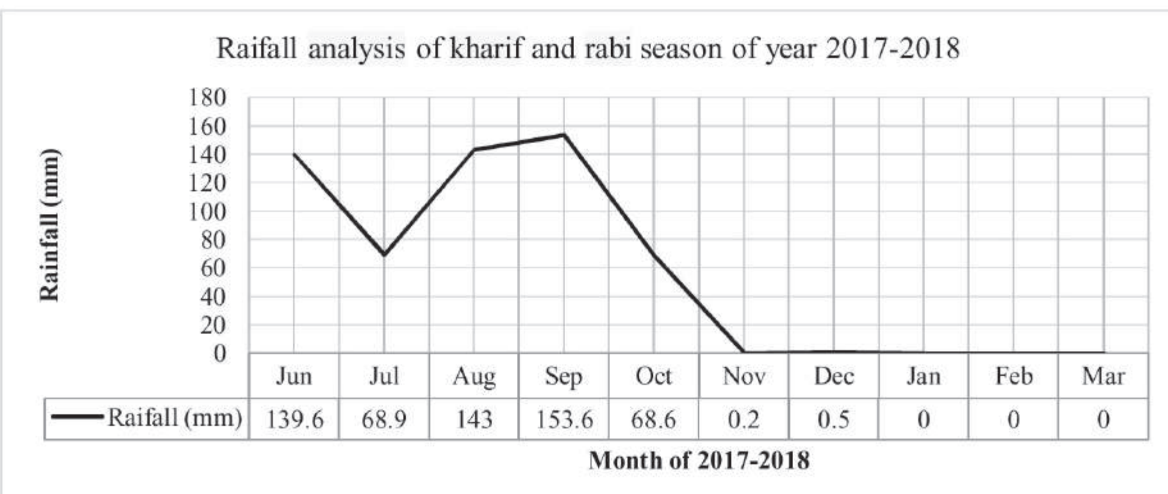

Fig.3. Rainfall analysis of study area

September to October, *i.e.,* at the end of the *Kharif* season (b).

Fig. 5 shows the temporal profile of NDVI based on the growth stage of the wheat crop in the study area. This profile is created by using the time series satellite dataset and ground truth information collected during the field campaign. The NDVI profile (Fig 5) is not a standard for the entire study area because of varied topographic conditions. The dates can be varying due to many parameters such as irrigation, soil type, fertiliser, and cultivation practices in the region (Chakraborty *et al*., 2014). The X-axis shows the acquired date of images and the Y-axis shows the NDVI range. The NDVI is an indicator of vegetation vigour, thus, the NDVI curve changes as per the growth stage of crops. From November to December, the NDVI profile of wheat crops has increased due to matured growth stages. It is seen that the crop stages were emergence, heading, mature, ripening and harvesting from 1 November to mid-February (Fig. 5).

The weekly NDVI time profile of early, normal, and late sown wheat crop(Fig. 6) shows that the early sown crop is better from 30 October to December compared to the normal and late sown crops. However, the NDVI profile of stock and the late sown area has slightly enhanced from December to January due to irrigation sources' availability.

Figure 7 shows that a total of 7550ha area was considered for the study and classification of area sown. In 2017, the region received adequate rainfall in the study area. Therefore, agricultural production was increased in the *kharif* and rabi season of the year 2017. The classification was performed using the ISODATA classifier. Total 1051ha area was classified as kharif crops like maize, pigeon pea (red gram), sorghum (hybrid-Jowar), pearl millet (Bajra), groundnut, mung bean and *Vigna mungo* (Urad bean) in the region. *Kharif* crops were harvested in the last week of September to mid-October. After harvesting *kharif* crops, farmers started preparing land for the *rabi* crops in the region. Total 866ha land was classified as fallow land in the studied region.

Wheat is a primary *rabi* crop in the study area and the ground truth information of wheat crop was collected for the accuracy assessment.

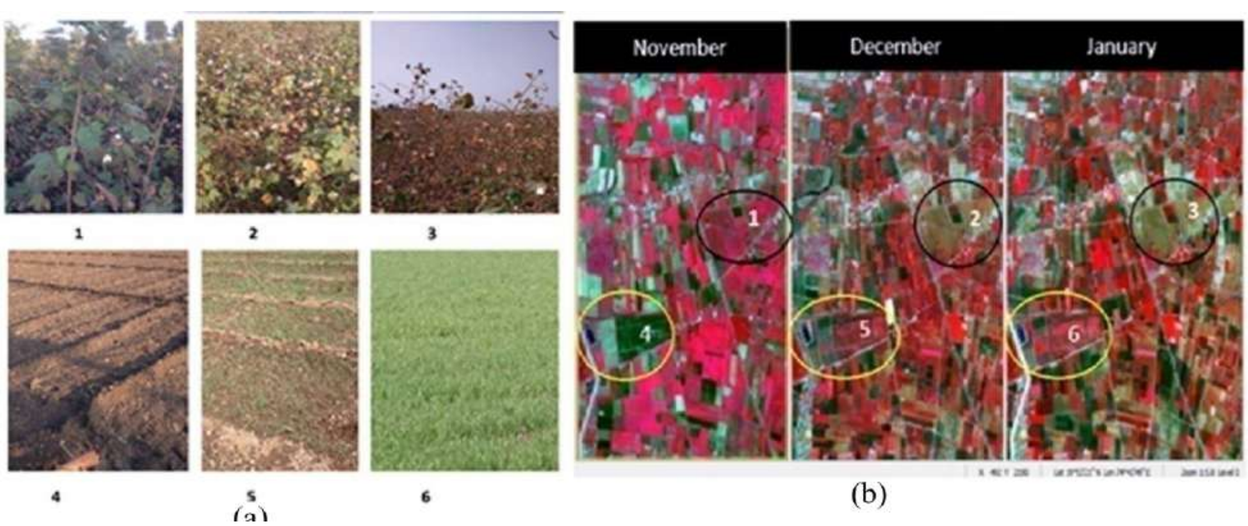

Fig. 4.(a) **The field photograph of study site, (b) The satellite photos of same study site**

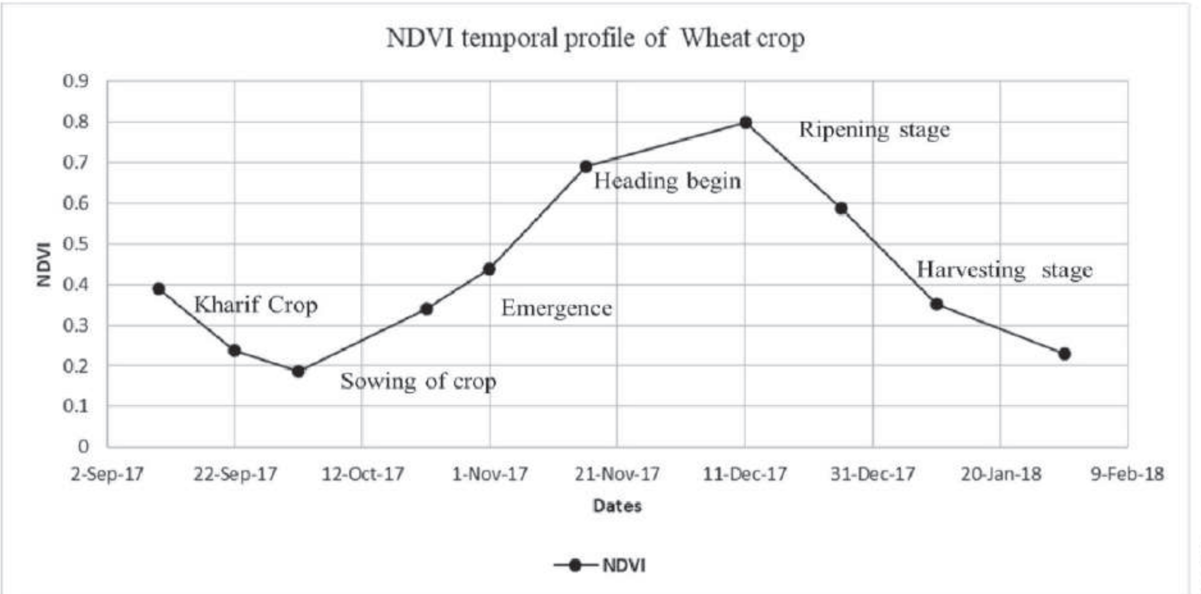

Fig. 5. The NDVI time profile of wheat crop

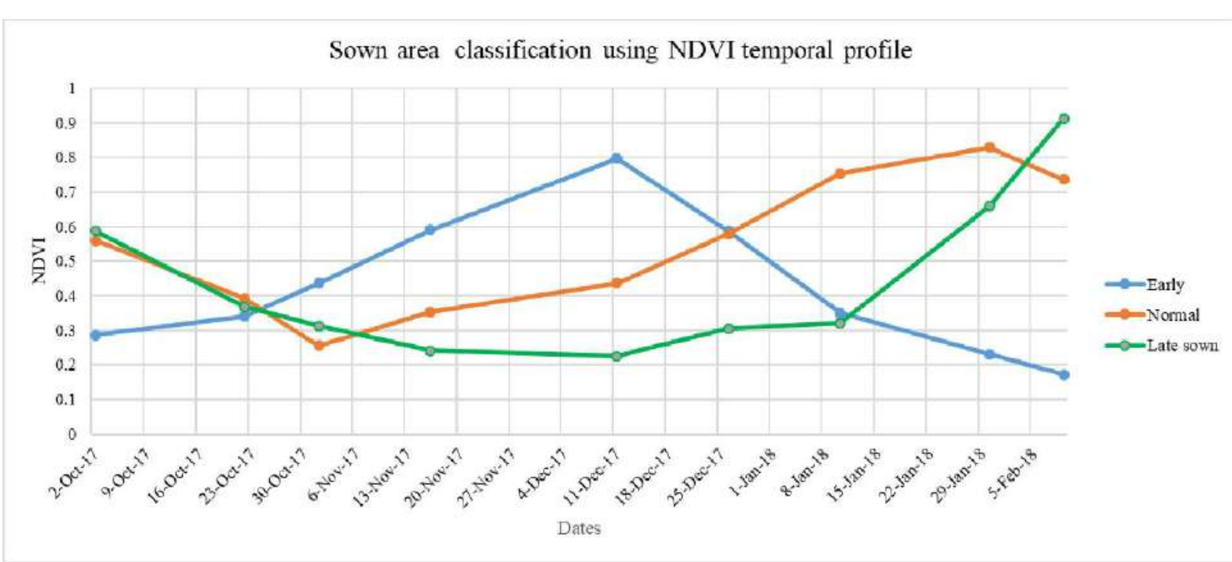

Fig. 6. The NDVI time profile of early, normal and late sown area

Furthermore, the area is categorised into three sowing patterns such as early, normal, and late sown area. It was observed that there was a clear difference between early, normal, and late sowing of wheat crop. Additionally, crop growth depends on various parameters such as seeds, soil types, irrigation, and weather conditions. Therefore, the sowings dates were recorded during the field campaign. The total 1675ha area was classified as an early sown region by the classifier. It was noticed that rainfed agricultural prefers early sowing of *rabi* crops due to residual soil moisture availability for germination. Early sowing can be done from 25 October to 10 November. Thus, these crops may get the advantage of post-monsoon rain, which generally occurs in November – December. These crops can sustain in winter season due

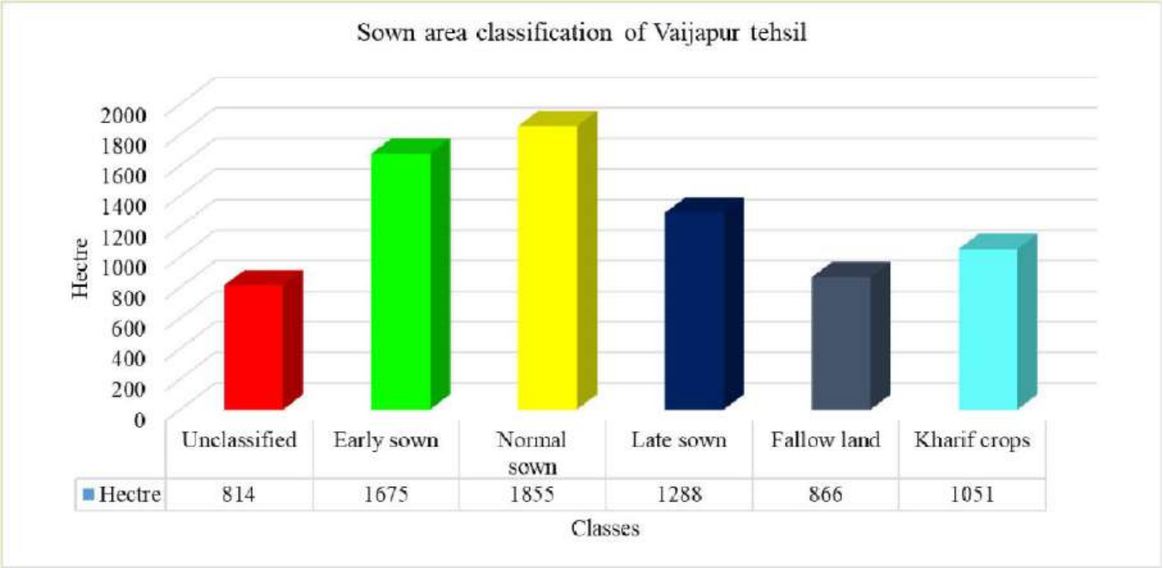

Fig.7. **Classification of area sown of 2017-2018**

to less evapotranspiration. Thus, it requires less water for irrigation. Total 1855ha area was classified as a normal sown area of *rabi* crops that were sown from 11thto 25th November. It was observed that normal sown crops have given better yield than late sown crops. These crops were harvested in March. As a result, farmers have prepared lands for sowing summer crops. Total 1288ha land was confirmed as late sown *rabi* crops. It was also identified that late sown *kharif* crops and irrigation sources were responsible for the late sowing of r*abi* crops. Figure 8 shows the classified map of the sown area categorized into various classes like unclassified, fallow land, *kharif* crop, early, normal, and late sown area. The southeast side of the region comes under the irrigation of the Godavari and Nandur-Madhmeshwar canal. Therefore, the farmers of this region prefer the late sowing of wheat crops due availability of water in the summer season.

The accuracy assessment is an important procedure for evaluation of obtained results (Vibhute *et al*., 2016). Field campaign was carried out on every fortnight during October to January and collected 1155 Ground Truth (GT) points on the same day of satellite over pass on study area. Overall, accuracy of NDVI was 88.39% with 0.84 Kappa coefficients(Table 3).

On the other hand, discrimination of early, normal, and late sown crop was challenging task. Consequently, focus was aimed on critical stages stages of wheat crop. It was also found that irrigation and fertilizer plays significant role for growing the crops. Crops sown in November month were labelled as normal sown crop which were misclassified with early and late sown crops due to similar spectral values. Pixels belong to late sown crop were mixed with early and normal sown classes due to similar spectral values of the crop.It was noticed that, late sown crops were planted during last week of December to 10 January. Additionally, farmers preferred late sowing after harvesting the cotton crop. Pixels are belonging to the late sown area mixed with early and normal sown classes due to the crop's similar spectral values.

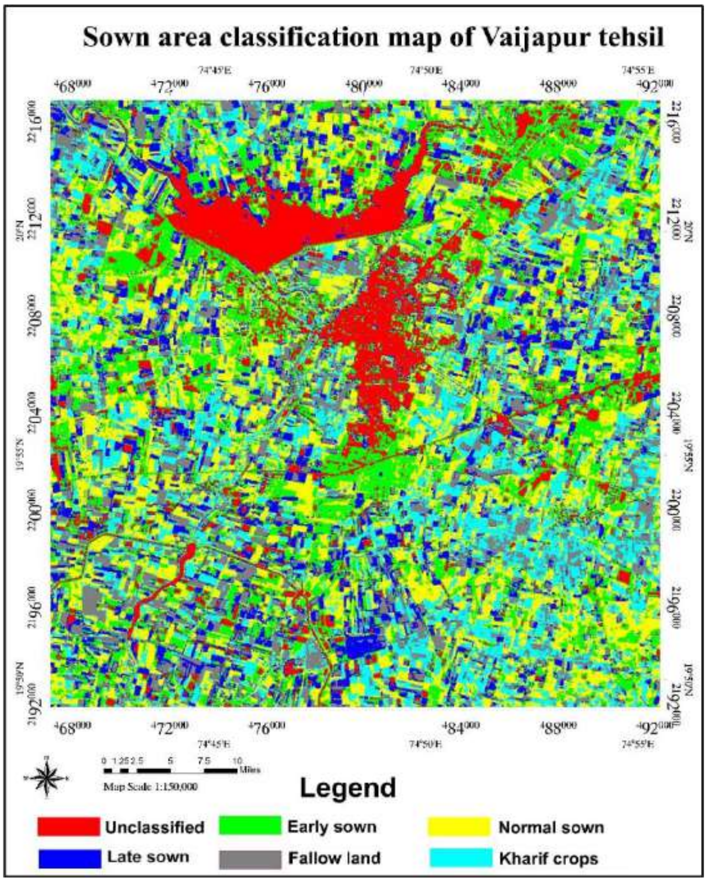

Fig.8. Classified map of area sown under different crops of Vaijapur Tehsil of 2017-18 Accuracy Assessment

Table 3. Error matrix resulting from ISODATA classification

Error matrix of NDVI classification						
Classes	**Early sown**	**Normal Sown**	**Late sown**	**Fallow land**	***Kharif* crops**	**Total**
Early sown	220	25	0	0	10	255
Normal Sown	22	221	15	0	2	260
Late sown	10	20	200	0	0	230
Fallow land	0	0	0	150	0	150
Kharif crops	10	20	0	0	230	260
Total	262	286	215	150	242	1155
User Accuracy (UA)	83.96	77.27	93.2	100	95.04	
Producer Accuracy (PA)	86.27	85	86.95	100	88.46	
Overall Accuracy(OA) of ISODATA = 88.39, Kappa 0.84						

CONCLUSION(S)

Each crop has unique NDVI profile in its life cycle,thus, NDVI profile was used for sowing date extraction and classifications of late and early sown crops. Sentinel data has provided sufficient information of small areas for the estimation of crop sowing date and crop growth profile at the plot scale. It can be concluded that Sentinel satellite constellations are useful for monitoring frequent activities in agricultural land. NDVI composite is an essential parameter for crop health and sowing classification. The ISODATA classification algorithm identified early and late sown areas. Classification results of late and early sown *rabi* crops are sufficient to develop a yield prediction model at the plot level. Sowing dates are also helpful for developing temporal models for crop simulation. Moreover, the methodology used,and the resultsobtained help the crop insurance scheme of the Indian government. In conclusion, Sentinel-2 is a suitable data source for estimation of area sown and sowing date estimation satisfactorily.

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INFORMATION NEEDS OF MUSHROOM CULTIVATORS IN UDHAM SINGH NAGAR DISTRICT OF UTTARAKHAND

ARPITA SHARMA*

Department of Agricultural Communication, College of Agriculture
G.B. Pant University of Agriculture &Technology, Pantnagar-263 145

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ABSTRACT

The study was conducted to identify the needs of the mushroom cultivators. Seven villages were selected randomly and 100 respondents were selected. A list of 10 major areas of needs in relation to improved package of practices of mushroom cultivation was prepared. The collection of information is completed by pre-tested questionnaire. The study revealed that majority of mushroom growers were middle aged (45 percent) and possess secondary education (37 percent). The major sources of information were cell phone and T.V and majority have access to WhatsApp (social media) on their phones. The overall need assessment depicted that the training required of the mushroom growers was high especially regarding cultivation of mushroom, crop management, spawn preparation and the other procedures.

Key words: **Mushroom Cultivation, Need assessment, Information needs**

INTRODUCTION

Mushrooms have significant nutritive value. These are fungi with distinctive fruiting bodies. They are rich in fibre and have high Vitamin B12 and folic acid content. They are ideal food for patients suffering from hypertension, diabetes and obesity. Total mushroom production in India is approximately 0.13 million tons. From 2010-2017, the mushroom industry in India has registered an average growth rate of 4.3 percent per annum. Out of the total mushroom produced, white button mushroom share is 73 percent followed by oyster mushroom (16 percent), paddy straw mushroom (7 percent) and milky mushroom (3 percent). Compared to other vegetables, per capita consumption of mushrooms in India is meagre and data indicates that it is less than 100 grams per year. By considering the production statistics, the spawn demand in India is estimated about 8000-10000 tons per annum.(Sharma and Annepu, 2017).

Although Mushroom cultivationis a good source of income, majority of people in India are unaware about the nutritive values of mushroom.People want to start the business related to mushroom but due to lack of knowledge, awareness and education on many aspects they are not able to it.Singh *et al*. (2013) reported that farmers were ignorant about identification of mushroom therefore suffered

*Corresponding Author E-mail i.d: sharmaarpita615@gmail.com

loss in their farming enterprise. They were also ignorant about provision of appropriate crop loan schemes and procedure to obtain the same. Mushroom cultivation constitutes an important and crucial segment for increasing food production, which provides extra income to the farmers other than their field crops during winter in Haryana. (Singh *et al.*, 2008). People are also unaware about how to grow mushroom, spawn making and use of agro waste, maintenance of temperature, etc. Mishra and Shukla (2007) reported that agro wastes could beused as an alternative substrate for mushroomcultivation. According to Shirur (2020), knowledge on any entrepreneurial venture forms an important basis for making wise decisions in an enterprise. The knowledge of mushroom entrepreneurship is still more critical considering the technical skills involved in mushroom cultivation associated jobs like; spawn production, compost preparation, environment management to suit to different mushroom varieties, pest and disease control, marketing management, processing of mushrooms, etc. According to Sharma *et al.* (2010) training need identification and curriculum prioritisation is prerequisite to ensure the quality of training programmes.Shiruret *al.* (2016) reported that lack of technical skills,low level of information supply both on production and marketing aspects are the major impairments that have constrained the spread of mushroom industry in India.

Past researches revealed that farmers are ignorant about thecommercial cultivation of mushroom. Keeping the above in view, the study was conducted with the objectives-To study the socio-economic characteristics of mushroom cultivators and to assess the needs of the mushroom cultivators.

MATERIAL AND METHODS

The study was conducted in Rudrapur block of district Udham Singh Nagar,Uttarakhand. Seven villages were selected randomly and 100 respondents were selected purposively (Only those respondents were selected who were engaged in mushroom farming). General information was collected through questionnaire. Information needs of mushroom cultivators were recorded by interview schedule and Focused Group Discussions.Observation was also used a tool in all steps. A list of 10 major areas of needs in relation to improved package of practices of mushroom cultivation was prepared for need assessment. Mushroom cultivators were asked to indicate in which area they need further information as well as 'aware' or 'unaware' about all the aspects.Scores were assigned and their responses were quantified.

RESULTS AND DISSCUSSION

General information of mushroom cultivators

Age: Majority of respondents were in middle age group 25-30 years (45 percent) followed by young age group less than 25 years (30 percent) and elderly people were more than 40 percent in number.

Educational Level: Nearly fourty percent of respondents (37 percent) were educated upto the secondary level followed by primary education (34 percent) and 20 percent of the respondents received no formal education. Only 9 percent of the respondents completed graduation.

Use of Information Sources: All the respondents were using television and mobile phone.Majority of respondents (92 percent) were using internet followed by print media (89 percent). A total of 67 respondents were interested to take information from neighbors and friends. Fifty- four percent respondents were listening to radio for Information .

Use of social media: All the respondents were using WhatsApp followed by Facebook (76 percent) and You Tube (91 percent).

Table 1. Socio-economic characteristics of mushroom cultivators (n=100)

S.No.	Category	Frequency	Percentage
A.	**Age**		
1.	Young (>25)	30	30
2.	Middle (25-40)	45	45
3.	Old (>40)	25	25
C.	**Educational Level**		
1.	No formal Education	20	20
2.	Primary Education	34	34
3.	Secondary Education	37	37
4.	Graduation	9	9
E.	**Use of Information Sources**		
1.	Internet	92	92
2.	Television	100	100
3.	Radio	54	54
4.	Print Media	89	89
5.	Mobile Phone	100	100
6.	Extension Agent	78	78
7.	Neighbours and Friends	67	67
F.	**Use of social media**		
1.	Facebook	76	76
2.	WhatsApp	100	100
3.	You Tube	91	91

Need assessment of Mushroom Cultivators

Mushroom Cultivation: Rural people want to start the enterprise, however, due to lack of knowledge on many aspects, they are unable to start. Majority of respondents (80 percent) were unaware about type of composting followed by mixing of substrate (79 percent) and temperature maintenance (75 percent). Total 68percent respondents were unaware about cultivation technologies and choice of species (66 percent). Maximum respondents were also not aware about additive to substrate. Thus, it can be said that more than half of the respondents were unaware about mushroom cultivation technology (Table 2).

Preparation of Spawn: With reference to preparation of spawn concerned, majority of respondents (85 percent) were unaware about bajra grain and jowar grain (80 percent). Total 79 percent were unaware about the preparation of spawn through rice bran (79 percent) and wheat grain (73 percent). The result is in conformity with the findings reported by Ayanfunke (2019).

Substrate Preparation: Table 2 revealed that 87 percent respondents were unaware about Stem Pasteurization and 79 percent aboutchemical sterilization. Seventy Sevenpercentrespondents were unaware about sterile technique followed by infection free environment (74 percent). These findings were in agreement with the findings of Singh *et al.* (2013).

Seeding of Spawn: Seeding of spawn is divided into two major areas as sprouting period and incubation period. Most of respondents (85 percent) were unaware about sprouting period followed by incubation period (83 percent).Rural people were unaware about the many aspects related to mushroom cultivation(Table 2).

Substrate Supplementation: The data presented in Table 2 clearly showed that the sub areas of substrate supplementation were rice bran, wheat bran, mustard seed cake etc. Total 88 percent respondents were unawareof rice bran and wheat bran (83 percent). Most of the respondents (77 percent) were unaware about mustard seed cake. Thus, it can be said that majority of mushroom cultivators were unaware about many aspects related to substrate supplementation.

Spawning Stage: A perusal of data presented in Table 2 reveal that majority of respondents were unaware aboutpreparation of fresh spawn followed by spawn mixed (78 percent) and storage of old spawn (77 percent). The results are in conformity with the findings reported by Singh *et al*. (2013).

Crop management: Crop management is also one of the important areas in the field of mushroom cultivation. Majority of respondents (90 percent) were unaware aboutincubation and fruit body induction (87 percent).A total of 82 percent respondents were unaware about temperature, humidity, Light. Thus, we can say that rural people do not know how to maintain these parameters light to grow the mushroom.

Water Management: Data related to water management was divided into sub-areas such as spray timings, spray in bag and amount of water necessary for mushrooms. Majority of the respondents (87 percent) were unaware about the time of spraying followed by 'use of excess of water' (79 percent) and 'spray after open the bag' (76 percent). Thus, it can be concluded that there is urgent need of training on the water management aspects.

Crop Protection Measure: Crop protection measure aspects were divided into three main aspects viz; identification of disease, proper handling techniques of sprayer, identification of pest ,etc. A total of 79 percent respondents were unaware about identification of disease followed by proper handling techniques of sprayer (75 percent) and identification of pests (71 percent). Similar type of results has also been reported by earlier researchers.(Sharma *et al.*, 2017).

Finance: Knowledge of finance is a major aspect in starting any business or enterprise.Total 65 percent respondents wereunaware about financing agencies. Rural people do not know from where they canget credit. Government has started many schemes related to finance but unfortunately rural people were unaware about these schemes.

Harvesting: Harvesting aspect was divided into various sub topics. It is clear from analysis that majority of respondents (90 percent) were unaware about 'quick freezing' followed by 'uprooting process 'and 'chemical preservation' (89 percent). A total otal 88 percent respondents were unaware about drying and sorting/ packaging. Thus, majority of respondents were unaware of harvesting aspects.

Mushroom House Practices: Mushroom house practices were divided into various aspects. Data revealed that out of 100 respondents, 90 percent were unaware about 'duration of heat' followed by 'light intensity'. A total of 89 percent respondents were unaware about the 'hour of cooling' and 'humidity' (88 percent). Thus, it can be concluded that most of the respondents were unaware about many aspects related to mushroom house practices (Table 2).

Table 2. Need assessment of Mushroom Cultivators (n=100)

S. No.	Category	Aware (percentage)	Unaware (percentage)
A.	**Mushroom Cultivation**		
1	Additive to substrate	26	74
2	Choice of species	34	66
3	Cultivation technologies	32	68
4	Mixing of Substrate	21	79
5	Type of Composting	20	80
6	Temperature Maintenance	25	75
B.	**Preparation of Spawn**		
1	Wheat grain	27	73
2	Rice grain	21	79

Sl. No.	Category	Aware (percentage)	Unaware (percentage)
3	Jowar grain	20	80
4	Bajara grain	15	85
C.	**Substrate Preparation**		
1	Stem Pasteurization	13	87
2	Hot Water Treatment	45	55
3	Sterile Technique	23	77
4	Chemical Sterilization	21	79
5	Infection Free Environment	26	74
D.	**Seeding of Spawn**		
1	Sprouting Period	15 (15%)	85 (85%)
2	Incubation Period	17 (17%)	83 (83%)
E.	**Substrate Supplementation**		
1	Wheat Bran	17	83
2	Rice Bran	12	88
3	Mustard Seed cake	23	77
F.	**Spawning Stage**		
1	Preparation of Fresh Spawn	16	84
2	Storage of Old Spawn	23	77
3	Spawn Mixed	22	78
G.	**Crop management**		
1	Incubation	10	90
2	Fruit Body Induction	13	87
3	Temperature, Humidity, Light	18	82
H.	**Water Management**		
1	Time of Spray	13	87
2	Spray after open the bag	24	76
3	Excess of Water	21	79
I.	**Crop Protection Measures**		
1	Identification of Disease	21	79

Sl. No.	Category	Aware (percentage)	Unaware (percentage)
2	Identification of Pest	29	71
3	Proper handling Techniques of Sprayer	25	75
J.	**Finance**		
1	Finance agencies for loan	35	65
J.	**Harvesting**		
1	Economic and Efficient Method of harvesting	24	76
2	Equipment	25	75
3	Uprooting Process	11	89
4	Sorting/Packaging	12	88
5	Quick Freezing	10	90
6	Cold Processing	14	86
7	Drying	12	88
8	Canning	16	84
9	Chemical Preservation	11	89
F.	**Mushroom House Practices**		
1	Duration of Heat	10	90
2	Hour of Cooling	11	89
3	Light Intensity	10	90
4	Humidity	12	88

Training needs in relation to mushroom cultivation

Table 3 reveals that majority (67) of the respondents had high level of needs in relation to scientific mushroom cultivation practices, followed by medium level of need (20 percent) and low level of need (13 percent).

Table 3. Needs in relation to mushroom cultivation(n=100)

Sl. No.	Training Needs	Score range	Frequency	Percentage
1.	Low	>15	13	13
2.	Medium	15-40	20	20
3.	High	>40	67	67

CONCLUSION

Farmers' training needs on mushroom production was high as they do not have sufficient knowledge and awareness. It is observed that rural people in the villages have less knowledge about many aspects related to mushroom cultivation. Mushroom cultivators were unaware about the different aspects of cultivation *viz.,* water management, temperature management, harvesting,seedling of spawn, crop management aspects, etc. Thus, there are various need -based tranings that should be conducted by the extension staff among the mushroom cultivators.

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E-mail : angraujournal@gmail.com, Website URL: www.jorangrau.org