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# GENETIC DIVERSITY STUDIES FOR ECONOMICALLY IMPORTANT TRAITS IN RICE USING PRINCIPAL COMPONENT ANALYSIS

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## ABSTRACT

Genetic diversity in rice using principal component analysis in 86 advanced breeding lines developed at Agricultural Research Station, Utukur and 7 popularly grown varieties was studied. The analysis of variance revealed significant differences for all the nine economically important yield traits measured. Use of principal component analysis revealed nine components, out of which three components with eigen values greater than one (1) could explain 57% of the variability. Based on the loading scores, characters viz., panicle weight, panicle length, number of filled grains per panicle were found to be most contributing towards the construction of the first principal component. Also, different entries viz., UTR 83-1, UTR 256 (high yield), UTR 258, UTR 209, UTR 202 (higher tiller number), UTR 224, UTR 253, UTR 257 (higher panicle weight), UTR 224, UTR 253, UTR 257 (higher panicle length), UTR 253, UTR 218, UTR 222 (lower test weight indicating fine grain nature) and UTR 224, UTR 253 and UTR 217 (higher filled grains panicle<sup>-1</sup>) were identified.

**Keywords:** Rice, genetic diversity, principal component analysis

## INTRODUCTION

Rice (*Oryza sativa* L.,  $2n=2x=24$ ) is the second most widely cultivated cereal crop. It is a staple food crop for the people of Asia, Africa and Latin American countries. China, India and Indonesia are the top rice producers, whereas, in India, West Bengal, Andhra Pradesh and Uttar Pradesh are the top rice cultivating states. In total, rice is grown in 43 mha with a production and productivity of 104 million tonnes and 2404 kg ha<sup>-1</sup>, respectively, during 2016 (Indiastat, 2017).

Rice is a domesticated crop and is subjected to genetic erosion due to adoption of few mega varieties such as BPT-5204, MTU 1010 and MTU 7029 in Andhra Pradesh. As a result of genetic erosion, there is a huge loss of genetic diversity

among traditional varieties/landraces from the farmer's fields. The modern-day varieties are developed by hybridization of elite parents and with selection in subsequent generations with emphasis laid on yield and grain quality based on the local preferences. Grain yield is dependent on the contributory characters viz., tiller number, duration, panicle weight, panicle length, test weight and filled grains per panicle, etc. A handful and thorough knowledge of the relationships among any of the characters used in the plant breeding is a must for their utilization in the trait improvement. Estimation of the genetic diversity in the available material and mining of such information helps in assessing the strength of the material on which our efforts could be channelized for obtaining fruitful results.

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The phenotypic evaluation of the different traits spread over several cultivars often will be tedious, time consuming and cost involving process. Evaluation of the traits which are genetically linked may not ensure optimal selection gain. To analyse the genetic variability in the available advanced breeding lines developed at Agricultural Research Station, Utukur, Principal Component Analysis (PCA) is employed to classify traits into groups based on similarities. PCA also measures how important a character's impact in explaining and expressing the variability (Sanni *et al.*, 2012). PCA reduces the dimensionality of a data and creates a new set of uncorrelated variables called principal components. Thus, PCA establishes the connection between traits and also help in dissecting the total variances of original traits into a new set of uncorrelated new variables (Wiley and Liberman, 2011). PCA also allows visual differentiation of entries and possible character amalgamation for a set of entries in each quadrant which help to identify closely and distantly related individuals (Warburton *et al.*, 2002). The study was undertaken in 2018 to identify the representative and principal traits for effective phenotyping and to assess the genetic diversity in the rice material developed at Agricultural Research Station, Utukur, Kadapa.

## **MATERIAL AND METHODS**

The experimental material used in the study consists of 86 advanced breeding lines developed by Agricultural Research Station, Utukur, Kadapa and seven (7) popularly grown varieties *viz.*, BPT-5204, NDLR-7, NDLR-8, NLR-40054, NLR 34449, RNR-15048 and Jaisriram. The experiment was laid out in

a randomized complete block design with three replications in *Kharif*, 2018. Entries were germinated on raised nursery beds and transplanted at 28 days after sowing with a spacing of 20 cm X 15 cm. The data was recorded on days to 50% flowering, plant height, number of tillers plant<sup>-1</sup>, number of filled grains panicle<sup>-1</sup>, number of ill-filled grains panicle<sup>-1</sup>, panicle length, panicle weight, test weight and grain yield ha<sup>-1</sup>. Data on days to 50 % flowering was recorded on the whole plot basis and for other parameters five plants were used to record the observations. Data was subjected to PCA as mentioned by Banfield (1978) using correlation matrix as the characters studied in this context were in different scale. Data analysis was performed in the PAST software (Version 3.26).

## **RESULTS AND DISCUSSION**

PCA helps to derive an interpretation from the multi-dimensional data. The actual data is projected into latent or underlying variables called principal components (PC). The first principal component explains the maximum amount of variance followed by subsequent principal components. Visualization of the significant differences among the genotypes indicates the existence of genetic variability for the nine quantitative characters traits studied. This was expected as the parents used in the development of the breeding lines were obtained from a diverse gene pool (Oladosu *et al.*, 2014). A total of nine (9) principal components were created with a linear combination of all nine traits under study. Dimensionality reduction of the data can be observed by studying data from three principal components (PC1, PC2 and PC3)

**Table 1. Eigen values, per cent variance and cumulative variance values for rice genotypes**

Principal Component	Eigen Value	Per cent variance	Cumulative per cent variance
1	2.15	23.9	23.9
2	1.72	19.1	43.1
3	1.30	14.5	57.6
4	0.97	10.8	68.5
5	0.81	9.0	77.0
6	0.77	8.5	85.6
7	0.64	7.1	92.8
8	0.36	4.5	97.3
9	0.24	2.7	100.0

which are having eigen values greater than one. PC1 accounted for 24.03 % variance followed by PC2 with 19.13% and PC3 with 14.50 % variance of the total variability. Put together, these 3 principal components accounted for 57.6% of the variability. The principal components with eigen values less than one were considered as non-significant and not included in the interpretation of results. All the principal components with eigen values, percent variance and cumulative percent variances are presented in Table 1. A cumulative variance of 57.6% by three principal components is indicative of the pronounced effect of traits such as panicle weight, panicle length, number of filled grains panicle<sup>-1</sup> and grain yield on the phenotype of the accessions. Reports by Ranjith *et al.* (2019), Tejaswini *et al.* (2018), Rabara *et al.* (2014), Chakraborty *et al.* (2013) and Gana *et al.* (2013) are in support of this finding.

The principal components are rotated using

varimax rotation method, which is most commonly applied and it increases the loading of different variables along the axis. This method increases the clear pattern of loading, *i.e.*, we derive the list of variables which are contributing positively and negatively in constructing a principal component. Higher the loading score of a variable in principal component implies its larger contribution to the variation (Table 2). With respect to PC1, panicle weight (0.57), panicle length (0.49), number of filled grains panicle<sup>-1</sup> (0.42) grain yield (0.26) and plant height (0.23) were having higher loading scores. In case of PC2, number of filled grains panicle<sup>-1</sup> (0.46), days to 50% flowering (0.44), number of tillers plant<sup>-1</sup> (0.39) and number of ill-filled grains panicle<sup>-1</sup> (0.34) were the positive loaders, whereas, for PC3, grain yield (0.58), plant height (0.53) and days to 50% flowering (0.43) were the positive loaders.

Score values of each principal component for each genotype are presented in Table 3. From the scores of the PC1, it is interpreted that panicle weight, panicle length, number of filled grains panicle<sup>-1</sup>, grain yield and plant height were higher for UTR 257, UTR 261, UTR 224 and UTR 253. Similarly, from PC2, it is interpreted that days to 50% flowering, number of filled grains per panicle, number of ill-filled grains per panicle and number of tillers plant<sup>-1</sup> were higher for UTR 257, UTR 273, UTR 218, UTR 218, UTR 274, UTR 229, UTR 216 and UTR 219. Also, it can be noted from PC 3 that plant height, days to 50% flowering and grain yield were higher for UTR 83-1, UTR 202, UTR 199, UTR 212, UTR 263, UTR 6 and UTR 46. Genotypes under study are clustered based

**Table 2. Loading scores of the different variables on to the principal components**

Character	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6	PC 7	PC 8	PC 9
Plant height	0.23	0.14	0.53	-0.08	0.30	-0.68	-0.14	0.23	0.05
Days to 50% flowering	0.04	0.44	0.44	0.16	-0.41	0.10	0.58	-0.05	-0.25
Tillers plant <sup>-1</sup>	-0.24	0.31	0.13	0.37	0.73	0.39	0.05	0.10	0.01
Panicle length	0.50	-0.10	-0.27	0.12	0.35	-0.20	0.35	-0.56	-0.23
Panicle weight	0.58	-0.07	-0.08	-0.09	0.04	0.33	-0.05	0.60	-0.42
Test weight	0.15	-0.53	0.12	0.56	-0.08	-0.02	0.31	0.25	0.45
Grain yield	0.27	-0.22	0.58	-0.03	-0.03	0.42	-0.39	-0.45	0.05
Number of filled grains panicle <sup>-1</sup>	0.43	0.47	-0.17	-0.23	-0.02	0.17	0.06	0.00	0.70
Number of ill-filled grains panicle <sup>-1</sup>	0.17	0.35	-0.20	0.66	-0.27	-0.15	-0.51	-0.06	-0.09

**Table 3. Scores of rice genotypes for the first three principal components**

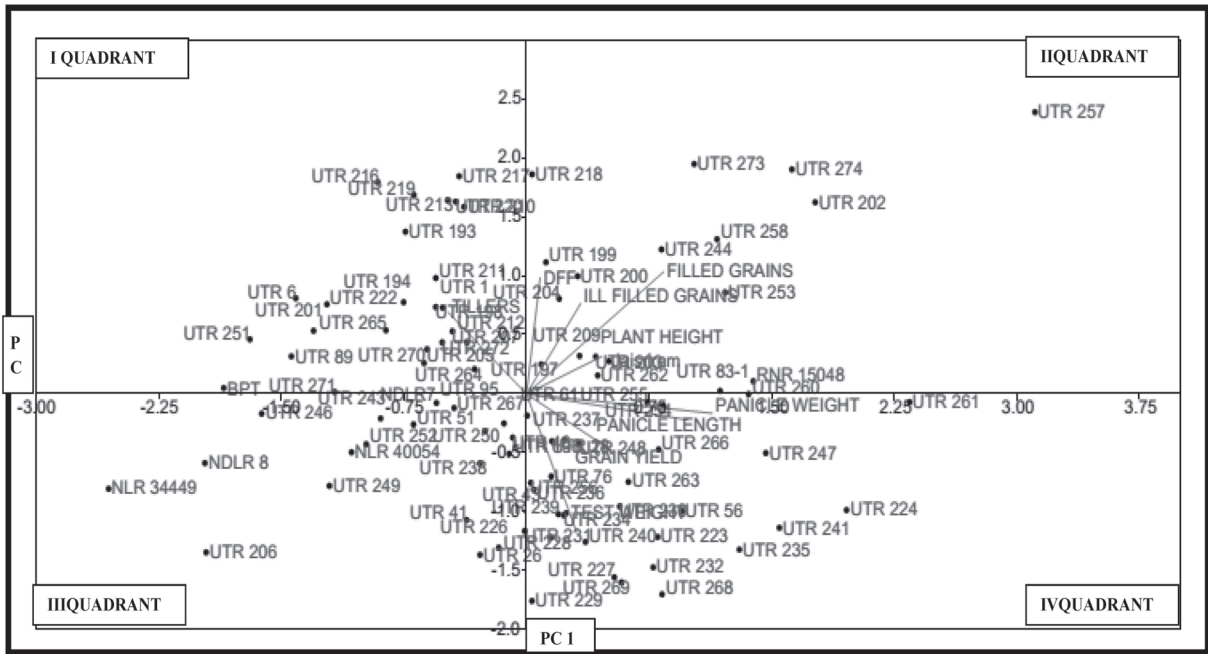
Entry	PC 1	PC 2	PC 3
UTR 224	2.87	-1.29	-0.29
UTR 253	1.78	1.13	-0.26
UTR 257	4.57	3.13	-1.18
UTR 223	1.18	-1.59	0.10
UTR 83-1	1.74	0.04	2.12
UTR 200	0.46	1.31	0.97
UTR 218	0.05	2.44	-0.26
UTR 220	-0.64	2.14	0.65
UTR 217	-0.61	2.42	0.01
UTR 194	-1.10	1.02	0.04
UTR 216	-1.34	2.35	0.54
UTR 219	-1.01	2.21	-0.37
UTR 193	-1.09	1.80	0.13
UTR 203	0.62	0.42	1.44
UTR 274	2.38	2.49	-2.75
UTR 198	-0.82	0.96	0.02
UTR 201	-1.91	0.70	0.89

Entry	PC 1	PC 2	PC 3
UTR 254	1.23	-0.13	-0.86
UTR 197	0.13	0.33	1.07
UTR 256	0.04	-0.99	1.17
UTR 213	-0.71	2.15	-0.49
UTR 207	-0.67	0.70	0.24
UTR 211	-0.81	1.29	0.83
UTR 261	3.44	-0.09	-0.85
UTR 268	1.22	-2.23	0.87
UTR 258	1.71	1.72	-1.11
UTR 209	0.48	0.42	0.73
UTR 202	2.59	2.13	2.00
UTR 269	0.85	-2.10	0.53
UTR 231	-0.02	-1.52	-0.70
UTR 247	2.15	-0.66	-1.72
UTR 244	1.21	1.60	-2.95
UTR 246	-2.38	-0.22	-1.84
UTR 238	-0.42	-0.77	-0.37

Table 3 Contd...

Entry	PC 1	PC 2	PC 3
UTR 266	1.19	-0.62	0.28
UTR 240	0.53	-1.65	0.08
UTR 243	-1.31	-0.27	-2.61
UTR 262	0.64	0.21	-0.63
UTR 265	-1.26	0.70	-0.27
NLR 34449	-3.75	-1.05	-1.35
RNR 15048	2.04	0.14	-0.66
Jaisriram	0.74	0.36	-0.59
NDLR 8	-2.89	-0.77	-0.81
UTR 230	0.84	-1.25	-0.19
UTR 227	0.79	-2.04	-0.12
UTR 228	0.22	-1.60	0.27
UTR 232	1.14	-1.93	0.03
UTR 226	-0.25	-1.71	-0.54
UTR 239	0.29	-1.34	0.86
UTR 234	0.33	-1.35	0.95
UTR 235	1.91	-1.73	-1.17
UTR 229	0.05	-2.30	-0.70
UTR 199	0.17	1.46	1.87
UTR 250	-0.37	-0.41	0.51
UTR 248	0.47	-0.55	-0.34
UTR 222	-1.79	0.99	1.07
UTR 252	-1.44	-0.56	0.54
UTR 260	1.99	0.00	0.42
UTR 196	-0.16	-0.67	0.62
UTR 212	-0.53	0.57	2.19
UTR 204	0.29	1.06	0.90
NDLR7	-0.81	-0.10	0.18
NLR 40054	-1.57	-0.65	-0.38
UTR 264	-0.47	0.28	0.53

Entry	PC 1	PC 2	PC 3
UTR 205	-0.89	0.50	1.27
UTR 267	-0.20	-0.33	-0.07
UTR 251	-2.48	0.60	-0.22
UTR 263	0.91	-0.98	2.10
UTR 270	-0.92	0.34	-0.29
UTR 271	-1.72	0.02	-1.82
UTR 249	-1.77	-1.02	-1.43
UTR 241	2.27	-1.49	-0.08
UTR 237	0.34	-0.51	0.59
UTR 1	-0.75	0.96	-0.21
UTR 6	-2.07	1.06	2.79
UTR 28	0.23	-0.52	1.04
UTR 26	-0.42	-1.79	0.65
UTR 41	-0.54	-1.40	0.48
UTR 43	0.06	-1.06	0.19
UTR 46	-0.12	-0.48	2.11
BPT 5204	-2.72	0.07	0.05
UTR 236	0.36	-1.33	-1.73
UTR 210	-0.56	2.08	1.50
UTR 272	-0.76	0.57	-2.86
UTR 273	1.51	2.56	-1.22
UTR 255	1.08	-0.09	-0.74
UTR 206	-2.88	-1.76	-1.31
UTR 51	-1.01	-0.34	0.16
UTR 56	1.40	-1.30	1.66
UTR 61	0.01	-0.24	0.30
UTR 76	0.22	-0.92	-0.58
UTR 89	-2.11	0.42	-1.20
UTR 95	-0.65	-0.16	-0.39



**Fig. 1. Biplot analysis of relationships groups between entries based on PC1 and PC2**

on score generated for each genotype in PC1 against PC2. Further, 2D scatter diagrams represents the results of cluster analysis. Entries falling in one quadrant are closely related from the entries falling in different quadrants. Visualizing the biplot using PC1 and PC2 (Fig.1) revealed the distribution of accessions into two groups based on their distribution in four quadrants.

A number of factors such as panicle weight, panicle length, number of filled grains per panicle, plant height, tillers per plant, days to 50 % flowering and grain yield are positively correlated with first three principal components PC1, PC2 and PC3. From the biplot, it can be observed that cultivars with higher number of filled grains per panicle, plant height and longer duration are distributed in II quadrant. Cultivars with higher panicle weight, panicle length, test weight and grain yield are distributed in IV quadrant. Entries

with more number of tillers and poor yields are in I quadrant, whereas, entries with lower number of tillers and poor yields are in quadrant III. Normally, high tillering should correlate with high yields (Dixit *et al.*, 2014), however, the situations that we observed in quadrant I is not a special case as this happens very often. Producing more number of tillers exerts a negative influence on other traits by creating a bushy plant type. Therefore, an optimum number of tillers per hill is preferable at a given spacing and in a specific variety. This promotes optimization of resource use efficiency at the most critical physiological and growth stages (Kang and Kin, 2012). Dingkun *et al.* (1993) reported the excessive use of nitrogenous fertilizers to put up more vegetative growth such as tillers lead to sub-optimal availability of nutrient at flowering and grain filling, thus, resulting in poorer yields. With respect to grain type, slender grain types

amalgamated with higher grain yields are available in quadrant IV. This type of grain type is getting higher preference among the farmers and in the market. Entries UTR 255, UTR 61, UTR 193, UTR 248 and UTR262 are some of the cultivars having slender grain types coupled with higher yields which are comparable with the popularly grown varieties such as BPT 5204 and NDLR 7. Genotypes in quadrant II are having higher number of filled grains panicle<sup>-1</sup> coupled with higher grain yields and genotypes in quadrant-IV are characterized with high grain yields coupled with panicle length and tillers plant<sup>-1</sup>. The results from this study are in agreement with the findings of Pandey *et al.* (2011) and Tuhina-Khatun *et al.* (2015).

## CONCLUSION

The study brought out the existence of genetic variability in the advanced breeding lines developed at Agricultural Research Station, Utukur. It was observed that the traits such as panicle weight, panicle length, number of filled grains panicle<sup>-1</sup>, grain yield and plant height were responsible for the genetic variability. From the biplots, it can be visualized that entries were grouped based on the filled grains panicle<sup>-1</sup>, plant height and days to 50% flowering into quadrant-II and panicle weight, panicle length, test weight and grain yield into quadrant-IV. Thus, entries *viz.*, UTR 200, UTR 273, UTR 244, UTR 258, UTR 202, and UTR 253 from quadrant-II and UTR 266, UTR 263, UTR 56, UTR 241, UTR 6, UTR 247, UTR 263 and UTR 230 can be employed for hybridization program to recover better segregant lines with superior characters for the mentioned traits.

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# ASSESSMENT OF VARIABILITY IN CHICKPEA GENOTYPES FOR YIELD, DROUGHT TOLERANCE AND MECHANICAL HARVESTABLE TRAITS USING GENETIC DIVERSITY ANALYSIS

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## ABSTRACT

Genetic divergence among thirty chickpea genotypes utilising 19 yield, drought tolerance and mechanical harvestable traits was studied under rainfed and irrigated conditions. Thirty genotypes were grouped into five distinct clusters both under rainfed and irrigated conditions, however, the pattern of grouping was different under two growing conditions. Genetic diversity under rainfed condition was attributed largely to 100 seed weight (33.56 %), days to 50 % flowering (20.92 %), seed yield per plot (10.34 %) and harvest index (9.89 %). However, under irrigated condition, the grouping of the genotypes was mainly due to days to maturity (38.8 %) followed by 100 seed weight (22.76 %) and protein content (10.11 %). Traits related to mechanical harvest and drought tolerance viz., height of the first pod (5.06 %) and SPAD Chlorophyll Meter Reading (SCMR) (2.07 %) under rainfed; Specific leaf area (SLA) (6.67 %) and plant height (6.9 %) under irrigated; proline under both rainfed (2.07 %) and irrigated (5.52 %) conditions also contributed towards genetic diversity to some extent. In rainfed environment, NBeG 868 with high proline (cluster III) and NBeG 865, ICCV 181602 and ICCV 181664 (Cluster IV) with higher mean values for height of the first pod and plant height; MH 14 (Cluster V) with higher yield and superior performance for SCMR, Relative Water Content (RWC at 30 DAS) with lesser SLA; and in irrigated condition, NBeG 776, NBeG 779, NBeG 780, NBeG 868, NBeG 49, JG 11 (cluster II); NBeG 865, ICCV 181602, ICCV 181664 (Cluster V) for seed yield and machine harvestable traits and MH 11, NBeG 47, ICCV 181607 (Cluster IV) with desirable angle of primary branch. RWC at 30 DAS and proline could be chosen to test for their combining ability *vis a vis* to improve yield, drought tolerance and machine harvestability in chickpea.

**Keywords :** Genetic diversity analysis, chickpea, machine harvestability

## INTRODUCTION

India is the largest producer of chickpea (*Cicer arietinum* L.) in the world with an annual production of 9.07 million tons from an area of 9.54 mha with the productivity of 951.4 kg ha<sup>-1</sup> (FAO STAT, 2019). In India, chickpea area is mainly cultivated in six states viz., Madhya Pradesh, Uttar Pradesh, Rajasthan, Maharashtra, Andhra Pradesh and Karnataka. In Andhra Pradesh, the area under chickpea has increased many times from less than one lakh ha (1993-94) to more than 6.0 lakh ha by 2007-08

registering the highest productivity of 1449 kg ha<sup>-1</sup>. Introduction and widespread adaptation of short duration, wilt resistant varieties such as 'JG 11', 'JAKI 9218' and 'KAK 2' and mechanization of farming operations have contributed to witness the highest productivity. However, farmers are unable to go for machine harvest operation, as the existing varieties have semi spreading growth habit and attain a short plant height of 35 cm - 40 cm in warm growing environments of Southern India. To enable complete mechanization (machine harvest and threshing) of

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chickpea cultivation, development of chickpea cultivars with 30 % to 40% greater height than the existing cultivars with semi-erect to erect growth habit and with branching starting from 25 cm- 30 cm from ground level with yield potential equal to or more than existing popular cultivars is the pressing need of current chickpea breeding programmes.

In Southern India, moisture stress, particularly at the end of the growing season, is a major constraint to chickpea production and yield stability. This problem is more serious in Andhra Pradesh, where in, chickpea is traditionally planted towards the end of the rainy season and generally grown on progressively declined residual soil moisture. With predicted climate change scenarios and continuous population explosion, there is a great need to develop high-yielding chickpea varieties with improved drought tolerance (Krishnamurthy *et al.*, 2013). Therefore, breeding efforts are needed to develop chickpea varieties suitable for machine harvest and with inbuilt resistance to drought conditions. Breeding strategies for the development of drought tolerant varieties using physiological traits as selection criteria have been proposed by some researchers (Nigam *et al.*, 2005). Drought resistance breeding is being addressed utilising several physiological characters such as Harvest Index (HI), Water Use Efficiency (WUE), Specific Leaf Area (SLA) and Soil plant analysis development (SPAD) Chlorophyll meter reading (SCMR) (Nigam *et al.*, 2005). Therefore, the study of genetic divergence (utilising physiological traits to be utilised in breeding) for drought tolerance along with seed yield, yield components and traits which make cultivar amenable to machine harvest will be useful for planning suitable breeding strategies to develop chickpea genotypes with increased drought tolerance.

## MATERIAL AND METHODS

The experiment was carried out during *rabi* 2018-19 at Regional Agricultural Research Station, Nandyal, situated at 15°29' N latitude and 78°29' E longitude at an altitude of 211.76 m above MSL. The research station comes under scarce rainfall climatic zone of Andhra Pradesh. The experimental material comprised of 25 *desi* chickpea genotypes and five checks *viz.*, NBeG 47, NBeG 49, JG 11, GBM 2 and HC 5 were sown on 24<sup>th</sup> October *rabi*, 2018 in a Randomized Block Design (RBD) with three replications under both rainfed and irrigated situations. Since meagre rainfall was received during *rabi* season, a pre sowing irrigation was given to take up sowing of the experiments. In rainfed condition genotypes were grown on receding soil moisture, whereas, in irrigated condition two supplemental irrigations were given at 35 DAS and 55 days after sowing (DAS) through sprinklers. Each genotype was sown in two rows in a plot of 3m row length at spacing of 30 cm x 10 cm. Observations were recorded on 19 traits *viz.*, angle of the primary branch (°), height of the first pod (cm), plant height (cm), days to 50 per cent flowering, days to maturity, duration of reproductive phase, number of primary branches per plant, number of secondary branches per plant, SPAD Chlorophyll Meter Reading, number of pods per plant, biological yield (g), harvest index (%), seed yield (g), 100 seed weight (g), SLA (cm<sup>2</sup>g<sup>-1</sup>), RWC (%) at 30 DAS and 60 DAS, proline (μ mole g<sup>-1</sup>) and protein content (%). To assess genetic diversity among the genotypes, data was subjected to divergence analysis using Mahalanobis D<sup>2</sup> statistic (1936) and the genotypes were grouped into different clusters according to Tocher's method as described by Rao (1952).

## RESULTS AND DISCUSSION

In any programme intended at genetic amelioration of yield, genetic diversity is the essential requirement. Genetic diversity analysis can also be utilized for identifying groups of genotypes that have beneficial traits for breeding and instructing the patterns of variation in genotype accession, to recognize relationships between genotypes (Cowen and Frey, 1987). Effective hybridization program between genetically diverse parents will lead to a sizeable amount of heterotic response in  $F_1$  hybrids which in turn can throw a broad spectrum of variability in segregating generations. In order to plan breeding strategies to develop chickpea varieties suitable for machine harvest and with inbuilt resistance to drought conditions, the data generated in the present experiment on 19 characters of thirty genotypes were subjected to genetic diversity analyses; the clustering of genotypes under rainfed and irrigated condition was studied.

The results of cluster analysis and the distribution of the genotypes into clusters and cluster means are presented in Table 1 and Table 2, respectively. The genotypes were grouped into five clusters each under rainfed and irrigated conditions. Under the rainfed condition, Cluster I had the maximum number of 18 genotypes where it did not exhibit higher mean values for any of the traits being studied. Cluster II consisted of seven genotypes which exhibited higher mean values for the angle of a primary branch ( $75.22^\circ$ ) and RWC at 60 DAS (65.35%). Cluster III had one genotype that showed earliness for Days to 50% flowering (36.33), days to maturity (82.33) and higher mean values for the number of secondary branches per plant (13.40), harvest index (59.03%) and proline ( $4.59 \mu$

mole  $g^{-1}$ ). Cluster IV had three genotypes and characterized by maximum mean values for height of the first pod (30.44 cm), plant height (42.60 cm), number of primary branches (3.27), 100 seed weight (30.11 g) and protein (19.11%). Cluster V had one genotype that exhibited lesser SLA ( $138.37 \text{ cm}^2 \text{ g}^{-1}$ ) and maximum values for duration of reproductive phase (52.33), SCMR (63.67), number of pods per plant (38.93), biological yield per plot (740.0 g), RWC at 30 DAS (78.33%) and seed yield per plot (403.33 g).

Under irrigated condition, Cluster I had maximum number of 10 genotypes characterized by higher mean values for number of pods per plant (34.77), biological yield per plot (683.67 g) and lesser SLA ( $182.23 \text{ cm}^2 \text{ g}^{-1}$ ), Cluster II comprised of six genotypes and recorded higher mean values for number of secondary branches per plant (9.28), harvest index (52.51%) and seed yield per plot (355.28 g) accompanied with earliness to flowering and maturity, Cluster III comprised of eight genotypes and showed maximum mean values for duration of reproductive phase (53.33) and RWC at 60 DAS (65.67 %), Cluster IV and Cluster V consisted of three genotypes each, wherein, Cluster IV exhibited higher mean values for angle of primary branch ( $80.38^\circ$ ), RWC at 30 DAS (84.71 %), proline ( $4.03 \mu$  mole  $g^{-1}$ ) and protein (20.54 %) and Cluster V recorded maximum mean values for height of the first pod (30.87 cm), plant height (45.80 cm), number of primary branches per plant (3.24), SCMR (65.13) and 100 seed weight (31.00 g). This deviation in the clustering might be due to the differential response of genotypes to irrigation. However, exception being genotypes NBeG 776, NBeG 779, NBeG 49, NBeG 780 and JG 11 were grouped together in Cluster II

and genotypes ICCV 181606, ICCV 181608, ICCV 181612, ICCV 181610, MH 1, MH 4, MH 12, MH 13, MH 14 and MH 15 were grouped in Cluster I under both rainfed and irrigated conditions.

The relative contribution of characters towards genetic divergence under rainfed and irrigated conditions was assessed and presented in Table 3. The clustering under rainfed conditions was mainly due to 100 seed weight (33.56%) which contributed maximum towards divergence followed by days to 50 % flowering (20.92%), seed yield per plot (10.34%), harvest index (9.89 %), number of pods per plant (4.14%), days to maturity (2.07%), number of secondary branches per plant (1.84%), biological yield per plot (1.84 %), protein (1.38 %) and number of primary branches per plant (0.23%). Under irrigated condition, grouping of the genotypes was mainly due to days to maturity which contributed maximum percent towards divergence (38.8%) followed by 100 seed weight (22.76%), protein content (10.11%), seed yield per plot (1.61%) and days to 50% flowering (0.92%). The maximum percentage of contribution towards divergence by days to 50% flowering and 100 seed weight were reported earlier by Jayalakshmi *et al.* (2014), Parhe *et al.* (2014) and Vishnu *et al.* (2018). Vishnu *et al.* (2018) and Vijayakumar *et al.* (2017) also reported that 100 seed weight and days to maturity as major contributors towards divergence. Among the traits related to mechanical harvest and drought tolerance *viz.*, height of the first pod (5.06%) and SCMR (2.07%) under rainfed; SLA (6.67%) and plant height (6.9%) under irrigated; proline (rainfed: 2.07%, irrigated: 5.52%) under both rainfed and irrigated conditions also contributed towards genetic diversity to some extent. RWC at 60 DAS did not exhibit any contribution under both rainfed and

irrigated conditions. Vishnu *et al.* (2018) reported that the traits that are suitable for mechanical harvest particularly, the height of the first pod and plant height contributed more (8.3% and 8.1%, respectively) towards the genetic divergence under irrigated than under rainfed condition (3% and 5.5%, respectively). Whereas, the angle of the primary branch did not show any influence on the divergence under both the tested environments.

The distance between the clusters is also a measure of the degree of diversification (Table 4). The crosses between divergent genotypes belonging to divergent clusters as indicated by utmost inter-cluster distance will be expected to yield better recombinants and superior lines derived from these crosses will produce desirable progeny. Inter cluster distance stretched between 9.18 and 18.66 under rainfed condition. The most divergent clusters under rainfed condition were Cluster III and Cluster IV (18.66) followed by Cluster IV and Cluster V (16.55), Cluster II and Cluster IV (14.43), Cluster I and Cluster II (14.03) and Cluster II and Cluster V (13.78). Under the irrigated condition, clusters separated by maximum distance were Cluster II and V (23.80) followed by Cluster II and Cluster III (21.22), Cluster IV and Cluster V (18.29), Cluster III and Cluster IV (17.06) and Cluster I and Cluster V (16.44). Cluster II under rainfed and Cluster V under irrigated condition had high intracluster distance which in turn revealed the presence of genetic diversity among the genotypes which were grouped in those clusters. Thus, the best combination of parents for improvement of seed yield, drought tolerance and machine harvestable traits can be recommended based on the degree of divergence and the *per se* performance of the genotypes.

NBeG 868 from Cluster III and NBeG 865, ICCV

181602 and ICCV 181664 from Cluster IV under rainfed condition were identified as desirable genotypes for drought tolerance and machine harvestability from these divergent clusters with higher mean values for proline in Cluster III and higher mean values for height of the first pod, and plant height in cluster IV. MH 14 from Cluster V with higher yield and superior performance for SCMR, RWC at 30 DAS with lesser SLA could also be involved in a hybridization programme with genotypes NBeG 865, ICCV 181602 and ICCV 181664 from cluster IV for simultaneous improvement of yield, drought tolerance and machine harvestability. For irrigated condition, hybridization between the genotypes *viz.*, NBeG 776,

NBeG 779, NBeG 780, NBeG 868, NBeG 49, JG 11 from cluster II that had higher mean values for seed yield with the genotypes *viz.*, NBeG 865, ICCV 181602, ICCV 181664 from cluster V with maximum mean values for height of the first pod (30.87 cm) and plant height (45.80 cm) would improve seed yield as well as machine harvestability. Crossing genotypes from cluster IV *viz.*, MH 11, NBeG 47, ICCV 181607 which recorded higher values for angle of primary branch, RWC at 30 DAS and proline with the genotypes *viz.*, NBeG 776, NBeG 779, NBeG 780, NBeG 868, NBeG 49, JG 11 from cluster II would improve yield, drought tolerance and machine harvestability.

**Table 1. Genetic diversity (clustering) in 30 genotypes under rainfed and irrigated condition during rabi 2018-2019**

<b>RAINFED</b>		
<b>Cluster number</b>	<b>Number of genotypes</b>	<b>Genotypes</b>
I	18	PG 08108, MH 21, MH 22, ICCV 08102, HC 5, ICCV 181667, MH 4, MH 5, ICCV 181610, GBM 2, MH 15, MH 1, ICCV 181612, ICCV 181608, MH 11, ICCV 181606, MH 12, MH 13
II	7	NBeG 776, NBeG 779, NBeG 49, JG 11, NBeG 780, NBeG 47, ICCV 181607
III	1	NBeG 868
IV	3	NBeG 865, ICCV 181602, ICCV 181664
V	1	MH 14
<b>IRRIGATED</b>		
<b>Cluster number</b>	<b>Number of genotypes</b>	<b>Genotypes</b>
I	10	ICCV 181608, ICCV 181610, ICCV 181606, MH 4, ICCV 181612, MH 1, MH 13, MH 15, MH 14, MH 12
II	6	NBeG 776, NBeG 779, NBeG 780, NBeG 868, NBeG 49, JG 11
III	8	PG 08108, MH 22, MH 5, HC 5, ICCV 08102, GBM 2, MH 21, ICCV 181667
IV	3	MH 11, NBeG 47, ICCV 181607
V	3	ICCV 181602, ICCV 181664, NBeG 865

Table 2. Cluster means for 19 characters in 30 chickpea genotypes under rainfed and irrigated condition during *rabi* 2018-19

Characters	RAINFED					IRRIGATED				
	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V
Angle of primary branch (°)	74.73	75.22	71.17	74.76	74.87	76.18	74.96	74.33	80.38	75.84
Height of the first pod (cm)	26.03	22.82	22.20	30.44	18.40	26.03	22.10	26.58	30.07	30.87
Days to 50% flowering	48.96	38.14	36.33	50.67	44.00	46.20	35.78	53.00	46.33	53.33
Days to maturity	91.09	82.90	82.33	96.44	91.00	88.63	83.00	95.50	87.44	97.78
Duration of reproductive phase (days)	52.04	49.67	46.67	45.78	52.33	51.07	50.28	53.33	48.89	48.44
Plant height (cm)	39.10	38.52	33.27	42.60	34.40	39.86	37.26	39.24	44.56	45.80
No. of primary branches plant <sup>-1</sup>	2.59	2.09	2.20	3.27	2.93	2.77	2.24	2.79	2.42	3.24
No. of secondary branches plant <sup>-1</sup>	6.79	9.35	13.40	7.78	8.80	7.65	9.28	7.70	7.04	8.04
SCMR	53.78	53.65	57.00	60.88	63.67	56.43	52.32	55.01	58.53	65.13
SLA (cm <sup>2</sup> g <sup>-1</sup> )	177.99	160.16	232.00	142.68	138.37	182.23	213.29	223.71	196.32	183.82
No. of pods plant <sup>-1</sup>	26.79	29.95	29.87	22.49	38.93	34.77	27.68	34.45	28.22	24.31
Biological yield plot <sup>-1</sup> (g)	542.78	512.67	613.33	527.78	740.00	683.67	670.00	633.96	621.11	609.22
Harvest index (%)	39.91	55.07	59.03	30.08	54.60	45.24	52.51	47.83	48.92	35.66
100 Seed weight (g)	21.85	29.95	24.67	30.11	28.00	22.80	28.83	22.17	30.22	31.00
RWC at 30 DAS %	76.37	76.67	78.00	74.87	78.33	77.97	80.67	82.78	84.71	80.44
RWC at 60 DAS %	61.99	65.35	58.33	59.20	56.00	62.60	60.94	65.67	65.11	63.89
Proline (µ mole g <sup>-1</sup> )	3.56	4.07	4.59	3.95	2.34	2.61	2.65	2.45	4.03	2.31
Protein (%)	17.92	18.41	17.00	19.11	18.90	19.25	18.12	18.46	20.54	19.80
Seed yield plot <sup>-1</sup> (g)	216.13	283.62	361.67	158.67	403.33	309.63	355.28	304.29	300.67	228.33

**Table 3. Relative contribution of 19 characters for genetic diversity in 30 chickpea genotypes under rainfed and irrigated conditions during rabi 2018-2019**

Character	Times ranked 1 <sup>st</sup>		Contribution (%)	
	Rainfed	Irrigated	Rainfed	Irrigated
Angle of primary branch (°)	4	2	0.92	0.46
Height of the first pod (cm)	22	4	5.06	0.92
Days to 50% flowering	91	4	20.92	0.92
Days to maturity	9	169	2.07	38.8
Duration of reproductive phase (days)	0	0	0	0
Plant height (cm)	0	30	0	6.9
No. of primary branches plant <sup>-1</sup>	1	0	0.23	0
No. of secondary branches plant <sup>-1</sup>	8	0	1.84	0
SCMR	9	2	2.07	0.46
SLA(cm <sup>2</sup> g <sup>-1</sup> )	4	29	0.92	6.67
No. of pods plant <sup>-1</sup>	18	0	4.14	0
Biological yield plot <sup>-1</sup> (g)	8	0	1.84	0
Harvest index (%)	43	17	9.89	3.91
100 seed weight (g)	146	99	33.56	22.76
RWC at 30 DAS (%)	0	4	0	0.92
RWC at 60 DAS (%)	0	0	0	0
Proline (μ mole g <sup>-1</sup> )	9	24	2.07	5.52
Protein (%)	6	44	1.38	10.11
Seed yield plot <sup>-1</sup> (g)	45	7	10.34	1.61

**Table 4. Average inter and intra cluster distances in 30 chickpea genotypes under rainfed and irrigated condition during rabi 2018-19**

RAINFED					
	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V
Cluster I	9.42	14.03	13.20	12.97	12.32
Cluster II		10.01	13.70	14.43	13.78
Cluster III			0.00	18.66	9.18
Cluster IV				9.87	16.55
Cluster V					0.00
IRRIGATED					
	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V
Cluster I	8.10	13.69	12.30	10.95	16.44
Cluster II		7.66	21.22	11.40	23.80
Cluster III			7.60	17.06	11.98
Cluster IV				7.35	18.29
Cluster V					10.40

**CONCLUSION**

The study revealed substantial genetic diversity among thirty genotypes for traits of importance. Promising genotypes indicated for yield, yield attributes and traits contributing to drought tolerance and machine harvestability should be evaluated further in targeted environments besides testing the combining ability of the genotypes for initiating crop improvement programmes.

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# LONG-TERM INFLUENCE OF INTEGRATED NUTRIENT MANAGEMENT ON SOIL FERTILITY CHANGES AND TOTAL UPTAKE UNDER RICE-RICE CROPPING SYSTEM

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## ABSTRACT

A long-term field experiment was initiated during *Kharif*, 1989 to study the effect of the combination of organic and inorganic fertilizers on yield, fertility status and uptake pattern of nutrients in rice-rice cropping system. The results pertaining to 2013-14 were presented in this article. The pH values of 1:2.5 soil-water suspensions ranged from 5.3 to 5.9 after harvest of *Kharif* and *Rabi* rice, indicating moderately acidic to slightly acidic in reaction. EC decreased slightly from the initial (1.09 dSm<sup>-1</sup>) and ranged from 0.78 dSm<sup>-1</sup> to 0.95 dSm<sup>-1</sup> indicating non-saline nature. The highest organic carbon content (1.70% and 1.88%, respectively) was noticed in the treatment receiving 50% RD of NPK + 50% N through FYM in *Kharif* and *Rabi*. Application of FYM along with 100% NPK produced significantly higher yields under both *Kharif* (7402 kg ha<sup>-1</sup>) and *Rabi* (7267 kg ha<sup>-1</sup>) than the application of 100% NPK (7075 and 7150 kg ha<sup>-1</sup>) and FYM (5777 kg ha<sup>-1</sup> and 4533 kg ha<sup>-1</sup>) alone treated plots. Nutrient uptake (kg ha<sup>-1</sup>) of straw under *Kharif* indicated that nitrogen, phosphorus and potassium uptake was higher in T4 with uptake values of 93.5 kg ha<sup>-1</sup>, 44.9 kg ha<sup>-1</sup> and 184.2 kg ha<sup>-1</sup>, respectively. Application of 100% RD of NPK + FYM @ 5 t ha<sup>-1</sup> was effective in increasing grain and straw yield of rice.

## INTRODUCTION

Rice (*Oryza sativa* L.) is the main staple food crop of India, covering an area about 431.94 mha with a total production of 110.15 mt during the year of 2016-2017 (GoI, 2018). Use of chemical inputs has increased the crop yield but caused many environmental problems including soil, air and water pollution and making the crop productivity unsustainable (Eid *et al.*, 2006). The importance of soil organic matter is to sustain agricultural productivity and to maintain soil quality by adopting the new approach *i.e.* integrated nutrient management (INM) which reduces the input cost of inorganic fertilizer and secures the soil health. Sustainable production of crops cannot be maintained by using chemical fertilizers alone due to deterioration in soil

physical and biological environments and soil fertility status (Islam *et al.*, 2011; Khan *et al.*, 2008). Keeping this in view, the study was undertaken to compare the performance of organic and chemical farming and integrated nutrient management in rice.

## MATERIAL AND METHODS

The field experiment was initiated during *Kharif*, 1989 in Godavari Alluvials (Verticchromusters) at Andhra Pradesh Rice Research Institute, Maruteru. It was located at 81°44' E to 81°73'E Longitude, 16°37' N to 16°62' N Latitude and 5m above MSL. The annual rainfall ranges from 800-1100 mm. The monthly mean maximum temperatures during the crop growth period ranged from 27.3°C to 35.1°C with an average of 30.5°C, while the monthly mean minimum

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temperature ranged from 17.7°C to 27.5°C with an average of 23.1°C. The total rainfall received during the crop growth period was 1319 mm distributed throughout the year and had a total of 62 rainy days. The initial soil during the year 1989 was clay loam, neutral in reaction pH 7.0 (Jackson, 1973), non-saline in nature (1.09dSm<sup>-1</sup>) (Jackson, 1973), medium in organic carbon (0.55 %) (Walkley and Black (1934), high in available nitrogen(394 kg ha<sup>-1</sup>) (Subbiah and Asija, 1956), low in available phosphorus (17.0 kg ha<sup>-1</sup>) (Olsen *et al.*, 1954) and high in available potassium content(384 kg ha<sup>-1</sup>) (Jackson, 1973). DTPA extractable micronutrients (Lindsay and Norvell, 1978) and plant analysis (Piper, 1966) were completed by following standard procedures. This experiment was laid out in a randomized block design with eight treatments and replicated thrice during 2013-14. The treatment details during *Kharif and Rabi* were as follows:

T<sub>1</sub> – Control

T<sub>2</sub> – 100 % RD of NPK + ZnSO<sub>4</sub> @ 40 kg ha<sup>-1</sup>

T<sub>3</sub> – FYM @ 10 t ha<sup>-1</sup>

T<sub>4</sub> – 100 % RD of NPK + FYM @ 5 t ha<sup>-1</sup>

T<sub>5</sub> – 50% RD of NPK+ 50% N through Green leaf manure (*Calotropis* spp)

T<sub>6</sub> – 50 % RD of NPK + 50 % N through FYM

T<sub>7</sub> – 50 % RD of NPK + 25 % N through Green leaf manure (*Calotropis*) + 25% N as FYM

T<sub>8</sub> – 50 % RD of NPK + *Azospirillum* @ 2.5 kg ha<sup>-1</sup>

\* RD - Recommended dose

Kharif, 2013 : 90:60:60 NPK

Rabi, 2013-14 : 180:90:60 NPK

The organic sources and biofertilizers were applied at the time of field preparation. MTU 1061 was selected and raised in the field with a spacing of 20 cm X 10 cm. The recommended fertilizer dose (120-60-40 kg N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O ha<sup>-1</sup>) was applied in the form of urea, diammonium phosphate and muriate of potash, respectively. Green leaf manure and farmyard manure were applied one week before sowing of crops as per the treatments. *Azospirillum* was applied along with FYM to the treatment plots. Harvesting was completed at physiological maturity. After harvest, grains were separated from plant parts and yield was recorded at 14 per cent moisture level and expressed in kg ha<sup>-1</sup>. Straw and grain samples, collected plot-wise at harvest, values of dry matter production (kg ha<sup>-1</sup>) were used to compute nutrient uptake (kg ha<sup>-1</sup>) after harvest of the crop. The data on the observations made was analysed statistically by applying the technique of analysis of variance for randomized block design as suggested by Panse and Sukhatme (1978).

## RESULTS AND DISCUSSION

### Soil properties

Continuous cultivation with fertilizers and manures decreased the pH value from the initial value (7.0). The pH values of 1:2.5 soil-water suspensions ranged from 5.3 to 5.9 after harvest of *Kharif and Rabi* rice, indicating moderately acidic to slightly acidic in reaction. Similarly, EC decreased slightly from the initial (1.09 dSm<sup>-1</sup>) and ranged from 0.78 dSm<sup>-1</sup> to 0.95 dSm<sup>-1</sup> indicating non-saline nature. The highest organic carbon content (1.70% and 1.88%, respectively) was noticed in the treatment receiving

Table 1. Long-term effects of INM on physico-chemical and chemical properties of soil after harvest of rice-rice system during 2013-14

Treatments	pH		EC(dS m <sup>-1</sup> )		OC (%)		Available N		Available P <sub>2</sub> O <sub>5</sub> (kg ha <sup>-1</sup> )		Available K <sub>2</sub> O	
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
	T <sub>1</sub> – Control	5.7	5.7	0.95	0.92	0.58	0.53	200.7	200.7	15.5	14.1	312.5
T <sub>2</sub> – 100 % RD of NPK + ZnSO <sub>4</sub> @ 40 kg ha <sup>-1</sup>	5.6	5.9	0.92	0.90	1.15	1.25	243.6	250.9	46.3	50.3	425.4	405.1
T <sub>3</sub> – FYM @ 10 t ha <sup>-1</sup>	5.4	5.6	0.82	0.78	1.69	1.85	235.9	213.6	39.3	42.5	404.4	395.1
T <sub>4</sub> – 100 % RD of NPK + FYM @ 5 t ha <sup>-1</sup>	5.5	5.7	0.83	0.87	1.39	1.58	250.1	288.5	49.4	52.1	432.2	416.3
T <sub>5</sub> – 50 % RD of NPK + 50 % N through Green leaf manure ( <i>Calotropis</i> spp)	5.5	5.6	0.81	0.93	1.65	1.80	259.2	313.6	51.8	55.5	441.6	424.7
T <sub>6</sub> – 50 % RD of NPK + 50 % N through FYM	5.3	5.7	0.95	0.82	1.70	1.88	263.4	326.1	59.8	62.7	462.2	455.2
T <sub>7</sub> – 50 % RD of NPK + 25 % N through Green leaf manure + 25 % N through FYM	5.4	5.7	0.85	0.96	1.62	1.75	228.3	238.3	42.3	46.8	420.1	396.5
T <sub>8</sub> – 50 % RD of NPK + <i>Azospirillum</i> @ 2.5 kg ha <sup>-1</sup>	5.9	5.9	0.87	0.95	1.40	1.60	233.3	280.5	39.6	43.8	416.9	401.6
Initial	7.0		1.09		0.55		300.0		17.0		384.0	
CD (P=0.05)	NS	NS	NS	0.07	0.16	0.17	15.69	23.53	4.22	6.65	42.63	51.53
SEm±	0.38	0.11	0.06	0.02	0.05	0.06	5.12	7.69	1.38	2.17	12.78	15.73

50 % RD of NPK + 50 % N through FYM in *Kharif* and *Rabi*. A marked increase in soil organic carbon following incorporation of FYM and marginal changes in rest of the treatments indicate that increase in root biomass was responsible for such observed changes. Similar results were reported by Akhilesh *et al.* (2009). However, T<sub>6</sub> showed significantly increased organic carbon content than other treatments (Table 1).

The soil available nitrogen content ranged from 200.7 kg ha<sup>-1</sup> to 326.1 kg ha<sup>-1</sup>. T<sub>6</sub> showed highest available nitrogen 263.4 kg ha<sup>-1</sup> and 326.1 kg ha<sup>-1</sup> under both *Kharif* and *Rabi*, respectively. Application of FYM in conjunction with mineral fertilizers significantly increased available N, P and K content in soil over 100% NPK alone treatments and significantly superior to other treatments. Continuous cropping for 29 years resulted in a decline of more than 50% in available N in all the treatments in comparison to the initial level. Such a decline in available N has been reported (Sharma *et al.*, 2003) due to the leaching losses of unutilized fertilizer N under very high rainfall. However, higher available N content in T<sub>6</sub> was due to favourable soil conditions under crop residues might have helped in the mineralization of soil N leading to the buildup of higher available N (Vipin Kumar and Prasad, 2008). Higher available phosphorus content (62.7 kg ha<sup>-1</sup>) was recorded in T<sub>6</sub> followed by T<sub>5</sub> and T<sub>4</sub> (55.5 and 52.1 kg ha<sup>-1</sup>, respectively). The enhanced availability of soil P after the harvest of rice might be due to the production of organic acids during microbial decomposition of the crop residues in soil (Geetha Sireesha *et al.*, 2017a).

The available potassium in these soils was

influenced by INM treatments. T<sub>6</sub> recorded the highest available K<sub>2</sub>O content of 462 kg ha<sup>-1</sup> and 455 kg ha<sup>-1</sup>, respectively, during both *Kharif* and *Rabi* followed by T<sub>5</sub> (442 kg ha<sup>-1</sup> and 425 kg ha<sup>-1</sup>). This might be due to solubilized K from K-bearing minerals by the organic acids released as a decomposition of FYM and green manuring. The micronutrient contents *viz.*, Fe, Cu and Mn were higher in treatment receiving FYM @ 10 t ha<sup>-1</sup> under both *Kharif* (9.24 mg kg<sup>-1</sup>, 1.52 mg kg<sup>-1</sup> and 7.25 mg kg<sup>-1</sup>, respectively) and *Rabi* (9.41 mg kg<sup>-1</sup>, 1.64 mg kg<sup>-1</sup> and 7.85 mg kg<sup>-1</sup>, respectively) compared to application 100 % RDF through inorganic fertilizers except Zn which was higher in T<sub>2</sub> (1.74 mg kg<sup>-1</sup> and 1.98 mg kg<sup>-1</sup>, respectively) (Table 2). These higher values might be due to highest content of organic carbon as well as finer fraction of soils leading to increase in the surface area for ion exchange and hence, contributed to the higher amount of micronutrients in soil (Sharma *et al.*, 2003).

### Grain and Straw Yields

Application of FYM along with 100% NPK produced significantly higher yields under both *Kharif* (7402 kg ha<sup>-1</sup>) and *Rabi* (7267 kg ha<sup>-1</sup>) than the application of 100 % RD of NPK + ZnSO<sub>4</sub>@ 40 kg ha<sup>-1</sup> (7075 kg ha<sup>-1</sup> and 7150 kg ha<sup>-1</sup>) and FYM @ 10 t ha<sup>-1</sup> (5777 kg ha<sup>-1</sup> and 4533 kg ha<sup>-1</sup>) treated plots (Table 3). Incorporation of FYM and green manures in rice showed increased grain yield, however, it was not significant. Application of 50% NPK along either FYM or green manure for 26 years could save 50% fertilizers in rice. Similarly, higher content of straw yields were observed in T<sub>4</sub> (100 % RD of NPK + FYM @ 5 t ha<sup>-1</sup>) under both *Kharif* (9348 kg ha<sup>-1</sup>) and *Rabi* (9633 kg ha<sup>-1</sup>) followed by treatments receiving 100 % RD of

**Table 2. Long-term effects of INM on available micronutrient status (mg kg<sup>-1</sup>) of the soils after harvest of rice – rice cropping system****Rice (Kharif)**

Treatments	Zn	Fe	Cu	Mn
T <sub>1</sub> – Control	0.78	5.40	0.74	6.14
T <sub>2</sub> – 100 % RD of NPK + ZnSO <sub>4</sub> @ 40 kg ha <sup>-1</sup>	1.74	7.51	1.13	7.19
T <sub>3</sub> – FYM @ 10 t ha <sup>-1</sup>	1.58	9.24	1.52	7.25
T <sub>4</sub> – 100 % RD of NPK + FYM @ 5 t ha <sup>-1</sup>	1.44	8.14	1.43	7.12
T <sub>5</sub> – 50 % RD of NPK + 50 % N through Green leaf manure ( <i>Calotropis</i> spp)	1.22	7.22	1.22	7.24
T <sub>6</sub> – 50 % RD of NPK + 50 % N through FYM	1.36	8.43	1.37	7.17
T <sub>7</sub> – 50 % RD of NPK + 25 % N through Green leaf manure + 25 % N through FYM	1.26	7.90	1.14	7.22
T <sub>8</sub> – 50 % RD of NPK + <i>Azospirillum</i> @ 2.5 kg ha <sup>-1</sup>	1.31	7.73	1.07	7.02
CD (P=0.05)	0.20	1.18	0.22	0.27
SEm±	0.06	0.39	0.07	0.09

**Rice (Rabi)**

Treatments	Zn	Fe	Cu	Mn
T <sub>1</sub> – Control	0.95	5.90	0.84	7.23
T <sub>2</sub> – 100 % RD of NPK + ZnSO <sub>4</sub> @ 40 kg ha <sup>-1</sup>	1.98	7.83	1.38	7.68
T <sub>3</sub> – FYM @ 10 t ha <sup>-1</sup>	1.80	9.41	1.64	7.85
T <sub>4</sub> – 100 % RD of NPK + FYM @ 5 t ha <sup>-1</sup>	1.65	8.32	1.53	7.64
T <sub>5</sub> – 50 % RD of NPK + 50 % N through Green leaf manure ( <i>Calotropis</i> spp)	1.79	8.04	1.45	7.52
T <sub>6</sub> – 50 % RD of NPK + 50 % N through FYM	1.82	8.22	1.50	7.66
T <sub>7</sub> – 50 % RD of NPK + 25 % N through Green leaf manure + 25 % N through FYM	1.73	7.63	1.15	7.72
T <sub>8</sub> – 50 % RD of NPK + <i>Azospirillum</i> @ 2.5 kg ha <sup>-1</sup>	1.64	7.44	1.23	7.73
CD (P=0.05)	0.25	1.23	0.20	0.10
SEm±	0.08	0.40	0.06	0.03

NPK + ZnSO<sub>4</sub> @ 40 kg ha<sup>-1</sup> (9298 kg ha<sup>-1</sup> and 9317 kg ha<sup>-1</sup>) and 50 % RD of NPK + 50 % N through FYM (8256 kg ha<sup>-1</sup> and 9207 kg ha<sup>-1</sup>). Increase in root biomass might have improved the nutrient uptake by exploiting greater volume of soil resulting in better physiological and metabolic function inside the plant body which in turn laid down the foundation for higher yields (Srinivas *et al.*, 2015; Ganapathy and Ullasa, 2019).

**Nutrient Uptake**

The results pertaining to uptake (kg ha<sup>-1</sup>) by grain under *Kharif* indicated that T<sub>4</sub> showed higher uptake of N, P and K (99.9 kg ha<sup>-1</sup>, 31.1 kg ha<sup>-1</sup> and 109.5 kg ha<sup>-1</sup>, respectively). Similar trends were observed by *Rabi* with N, P and K uptake of 101 kg ha<sup>-1</sup>, 32.7 kg ha<sup>-1</sup> and 114.1 kg ha<sup>-1</sup>, respectively recorded in T<sub>4</sub> followed by T<sub>2</sub> (100 % RD of NPK + ZnSO<sub>4</sub> @ 40 kg ha<sup>-1</sup>) (Table 4). Nutrient uptake by straw was higher in T<sub>4</sub> (93.5, 44.9 kg ha<sup>-1</sup> and 184.2 kg ha<sup>-1</sup>, respectively)

after harvest of *Kharif* rice. Similar trends were observed at harvest of *Rabi* rice with uptakes of N, P and K of 111.7, 56.8 and 189.8 kg ha<sup>-1</sup>, respectively followed by T<sub>2</sub> (Table 4).

Higher total N, P and K uptake (grain + straw) of during *Kharif* (193.4 kg ha<sup>-1</sup>, 75.9 kg ha<sup>-1</sup> and 293.7 kg ha<sup>-1</sup>, respectively) and *Rabi* (212.8 kg ha<sup>-1</sup>, 89.5 kg ha<sup>-1</sup> and 303.9 kg ha<sup>-1</sup>, respectively) were recorded in treatment receiving 100 % RD of NPK + FYM @ 5 t ha<sup>-1</sup>. The nutrient uptake by the whole plant was increased significantly in the above treatments. Geetha Sireesha *et al.* (2017b) observed that higher nutrient uptake in rice growing soils of Jagtial district was mainly due to higher drymatter accumulation since FYM supply both major and minor nutrients along with organic acids provide good soil physical condition for plant growth. This increased uptake of nutrients augmented photosynthesis and yield.

**Table 3. Long-term effects of INM on grain and straw yields (kg ha<sup>-1</sup>) after harvest of rice-rice cropping system**

Treatments	Grain Yield		Straw yield	
	<i>Kharif</i>	<i>Rabi</i>	<i>Kharif</i>	<i>Rabi</i>
T <sub>1</sub> – Control	4522	3168	6470	5917
T <sub>2</sub> – 100 % RD of NPK + ZnSO <sub>4</sub> @ 40 kg ha <sup>-1</sup>	7075	7150	9298	9317
T <sub>3</sub> – FYM @ 10 t ha <sup>-1</sup>	5777	4533	7507	6033
T <sub>4</sub> – 100 % RD of NPK + FYM @ 5 t ha <sup>-1</sup>	7402	7267	9348	9633
T <sub>5</sub> – 50 % RD of NPK + 50 % N through Green leaf manure ( <i>Calotropis</i> spp)	6358	6883	8225	8483
T <sub>6</sub> – 50 % RD of NPK + 50 % N through FYM	6984	7050	8256	9207
T <sub>7</sub> – 50 % RD of NPK + 25 % N through Green leaf manure + 25 % N through FYM	6563	6885	8156	8000
T <sub>8</sub> – 50 % RD of NPK + <i>Azospirillum</i> @ 2.5 kg ha <sup>-1</sup>	5754	5233	7825	7433
CD (P=0.05)	949.5	935.6	710.9	718.9
SEm±	310	305.5	232.1	234.5

Table 4. Long-term effects of INM on N, P and K uptake (kg ha<sup>-1</sup>) by grain after harvest of rice-rice cropping system during 2013-14

Treatments	Grain						Straw					
	N		P		K		N		P		K	
	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi
T <sub>1</sub> – Control	45.2	33.3	13.6	9.8	55.6	39.6	45.3	44.4	20.1	21.3	99.0	78.1
T <sub>2</sub> – 100 % RD of NPK + ZnSO <sub>4</sub> @ 40 kg ha <sup>-1</sup>	91.3	94.4	28.3	30.7	101.2	107.3	88.3	96.9	41.8	42.9	177.6	177.0
T <sub>3</sub> – FYM @ 10 t ha <sup>-1</sup>	64.1	55.3	20.8	17.2	77.4	57.1	66.1	51.3	33.0	30.2	134.4	94.7
T <sub>4</sub> – 100 % RD of NPK + FYM @ 5 t ha <sup>-1</sup>	99.9	101.0	31.1	32.7	109.5	114.1	93.5	111.7	44.9	56.8	184.2	189.8
T <sub>5</sub> – 50 % RD of NPK + 50 % N through Green leaf manure ( <i>Calotropis</i> spp)	78.2	85.3	24.2	26.2	87.1	95.7	78.1	84.8	37.0	35.6	157.1	159.5
T <sub>6</sub> – 50 % RD of NPK + 50 % N through FYM	88.7	88.8	24.4	25.4	92.2	102.2	72.7	95.8	36.3	42.4	151.9	174.9
T <sub>7</sub> – 50 % RD of NPK + 25 % N through Green leaf manure + 25% N through FYM	70.9	77.1	23.6	22.0	89.3	97.8	71.8	73.6	31.0	31.2	146.8	140.0
T <sub>8</sub> – 50 % RD of NPK + <i>Azospirillum</i> @ 2.5 kg ha <sup>-1</sup>	69.0	63.8	19.6	19.9	77.1	65.9	63.4	64.7	25.8	29.7	138.5	133.8
CD (P=0.05)	4.8	5.5	5.7	2.6	6.1	5.6	3.1	5.5	3.3	2.9	9.3	9.9
SEm±	1.6	1.8	1.9	0.8	2.0	1.8	1.0	1.8	1.1	0.9	3.0	3.2

## CONCLUSION

Organics in conjunction with inorganic fertilizers improved the sustainability of crop production. Recycling of crop residues on a long-term basis along with application of FYM and green manure increased organic carbon, fertility status of soil and nutrient uptake of rice. However, the application of organic manure alone could not sustain high crop yield. Application of 100 % RD of NPK + FYM @ 5 t ha<sup>-1</sup> was effective in increasing grain and straw yield of rice, improving the nutrients uptake and build-up of N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O and organic carbon content in the soil. Integrated nutrient management found to be a good option to stabilize the production and profits besides maintaining soil health.

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# CORRELATION AND PATH COEFFICIENT ANALYSIS FOR YIELD AND ITS COMPONENT TRAITS IN SUNFLOWER HYBRIDS (*Helianthus annuus L.*)

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## ABSTRACT

A study was carried out in sunflower to ascertain the character association between yield and its component traits and to assess the nature and extent of direct and indirect effects of component characters on seed yield. Ten parental lines (4 lines and 6 testers), twenty-four hybrids and four checks were evaluated during *Rabi*, 2018-19 in a randomized block design with two replications. A total of eighteen traits were recorded and subjected these for correlation and path coefficient analysis. The results indicated that seed yield had strongest positive association with oil yield followed by head diameter, number of seeds per head, leaf area index, seed set per cent, plant height, stem girth, 100 seed weight and number of leaves per plant. Whereas, the path coefficient analysis indicated that the traits *viz.*, oil yield followed by number of seeds per head and leaf area index exhibited significant positive direct effects on seed yield. In addition, the indirect effects of most of the traits were also high with seed yield via oil yield, days to 50 % flowering and number of seeds per head.

**Keywords:** Sunflower, correlation coefficient and path-coefficient analysis

## INTRODUCTION

Sunflower (*Helianthus annuus L.*) crop is one of the most important oilseed crop in the world. In India, importing of vegetable oil is still undergoing process from other countries to meet the domestic requirements. Among vegetable oil sources, sunflower oil is preferred one and it is recommended to the heart patients due to its highly polyunsaturated fatty acid (PUFA) content. Due to its high economic importance, the development of effective hybrids is required with superior yield and quality traits. In sunflower, the yield is a complex trait which cannot be improved to a greater extent on its own. Because, it is influenced by a set of other characters known as yield components which are related among themselves and with yield either favourably or unfavourably (Pandya *et al.*, 2014). Therefore, the knowledge on the association of several characters

with yield and themselves will be very essential for planning a successful breeding programme (Chandirakala *et al.*, 2015). Therefore, an attempt was made to assess the correlation between yield and its component traits and to know the extent of direct and indirect effects on seed yield.

## MATERIAL AND METHODS

The experimental material for the investigation comprised of 24 hybrids developed by crossing four lines and six testers in a L x T mating design during *Rabi*, 2017-18. Further, the developed 24 hybrids along with their 10 parental lines and four standard checks (NDSH-1012, DRSH-1, KBSH-44 and Kaveri) were evaluated at Regional Agricultural Research Station, Nandyal during *Rabi*, 2018 - 19 in a randomized block design with two replications. Each genotype was raised in two rows in a row length of 3 m with a spacing

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of 60 cm x 30 cm. All the recommended package of practices were followed to raise the crop. At maturity five plants from each genotype in each replication were selected randomly for collecting data on yield and yield-related characters viz., days to 50 per cent flowering, SPAD chlorophyll meter reading, leaf area index, specific leaf area, plant height, stem girth, head diameter, number of leaves per plant, days to maturity, 100 seed weight, number of seeds per head, volume weight, seed set per cent, autogamy per cent, seed yield, hull content, oil content and oil yield.

## RESULTS AND DISCUSSION

### Correlation Coefficient Analysis

The genotypic and phenotypic simple correlation for yield and its component traits in sunflower among 18 characters was presented in (Table 1). The results of the study revealed that existence of higher genotypic correlations compared to phenotypic correlations (Pandya *et al.*, 2015; Latha *et al.*, 2017 and Baraiya *et al.*, 2018) indicating a high degree of association between two characters at genotypic level and their phenotypic association was lessened due to influence of environment over the inherent association of the traits.

The examination of results indicated that the dependent variable *i.e.*, seed yield reported to have the strongest positive association with independent variables viz., oil yield ( $r_p = 0.981^{**}$ ,  $r_g = 0.982$ ) followed by head diameter ( $r_p = 0.896^{**}$ ,  $r_g = 0.928$ ), number of seeds per head ( $r_p = 0.876^{**}$ ,  $r_g = 0.892$ ), leaf area index ( $r_p = 0.820^{**}$ ,  $r_g = 0.930$ ), seed set per cent ( $r_p = 0.789^{**}$ ,  $r_g = 0.898$ ), plant height ( $r_p = 0.722^{**}$ ,  $r_g = 0.810$ ), stem girth ( $r_p = 0.672^{**}$ ,  $r_g = 0.935$ ), 100 seed weight ( $r_p = 0.606^{**}$ ,  $r_g = 0.682$ ) and number of leaves per plant ( $r_p = 0.527^{**}$ ,  $r_g = 0.631$ ). These results were in consonance with the findings of Reddy *et al.* (2014) for oil yield; Kalukhe *et al.* (2010) for volume weight, oil content, head diameter, 100 seed weight, number

of seeds per head and plant height; Neelima *et al.* (2012) and Kamble *et al.* (2018) for seed set per cent; Latha *et al.* (2017) for leaf area index; Tyagi and Khan (2013) and Baraiya *et al.* (2018) for number of leaves per plant and stem girth.

With regard to inter-character association, a strong, positive correlation of leaf area index with oil yield, number of seeds per head, plant height, head diameter, number of leaves per plant, seed set per cent and stem girth was noticed. Similarly, plant height with oil yield, number of leaves per plant, oil content, stem girth, head diameter, number of seeds per head and seed set per cent; head diameter with oil yield, number of seeds per head, seed set per cent and 100 seed weight; days to 50 per cent flowering with days to maturity and volume weight; stem girth with seed set per cent and head diameter; days to maturity with volume weight; 100 seed weight with oil yield and seed set per cent; number of seeds per head with oil yield and seed set per cent and seed set per cent with oil yield. Thus, it can be concluded that most of the characters showed highly significant inter-character associations with the trait oil yield followed by seed set per cent, number of seeds per head, head diameter and volume weight.

Similar findings were also reported by Neelima *et al.* (2012) for seed set per cent with plant height, head diameter, number of leaves per plant and number of seeds per head; Jalil *et al.* (2014) for oil content with head diameter and 100 seed weight and Reddy *et al.* (2014) for volume weight with oil content; Pandya *et al.* (2015) for stem girth with number of leaves per plant and number of seeds per head; Latha *et al.* (2017) for leaf area index with plant height, head diameter, number of leaves per plant, 100 seed weight and number of seeds per head. Thus, the character association analysis revealed that leaf area index, plant height, stem girth, head diameter, number of leaves per plant, 100 seed weight, number of seeds

per head, volume weight, seed set per cent, oil content and oil yield were found to have significant positive association with seed yield and in yield improvement programmes importance may be given for these traits.

Further, the analysis also revealed negatively significant inter-character association of specific leaf area with most of the traits and strongly with oil yield followed by plant height, stem girth, head diameter, seed set per cent, number of seeds per head, 100 seed weight, oil content, number of leaves per and volume weight; while hull content showed strong negative association with oil content followed by volume weight, days to 50 per cent flowering and days to maturity. These results were in accordance with the earlier findings of Sowmya *et al.* (2010), Neelima *et al.* (2012), Latha *et al.* (2017) and Kamble *et al.* (2018) for hull content and oil content; Reddy *et al.* (2014) for volume weight and hull content and Kamble *et al.* (2018) for days to maturity and hull content.

### Path Coefficient Analysis

Correlation simply measures the mutual association without any regard to caution, while path coefficient analysis provides an effective means of direct and indirect causes of association and permits a critical examination of the specific forces acting to produce a given correlation and measures the relative importance of each factor.

The path coefficient analysis (Table 2) indicates that the traits *viz.*, oil yield ( $p_p = 0.895$ ,  $p_g = 1.058$ ), number of seeds per head ( $p_p = 0.140$ ,  $p_g = 0.050$ ) and leaf area index ( $p_p = 0.069$ ,  $p_g = 0.039$ ) exhibited significant positive direct effects on seed yield both at phenotypic and genotypic level. These results were similar with the findings of Ozturk and Ada (2009) for positive direct effect of oil yield; Kalukhe *et al.* (2010),

Yasin and Singh (2010), Kholghi *et al.* (2011), Neelima *et al.* (2012), Baraiya *et al.* (2018) and Latha *et al.* (2018) for positive direct effect of number of seeds per head. Further, the traits SPAD chlorophyll meter reading ( $p_p = 0.017$ ,  $p_g = 0.055$ ) and days to 50 per cent flowering ( $p_p = 0.011$ ,  $p_g = 0.142$ ) showed positive direct effects on seed yield. Similar results for days to 50 % flowering was also reported by Pandya *et al.* (2015) and Baraiya *et al.* (2018) and the contrary results were given by Kalukhe *et al.* (2010), Patil (2011) and Neelima *et al.* (2012).

The traits number of seeds per head ( $p_p = 0.140$ ,  $p_g = 0.050$ ) and leaf area index ( $p_p = 0.069$ ,  $p_g = 0.039$ ) exhibited low direct effects on seed yield but registered strong correlation with seed yield due to high indirect effects *via* oil yield. Similar results were reported by Kalukhe *et al.* (2010), Neelima *et al.* (2012) and Latha *et al.* (2017) for the number of seeds per head and the contrast results of negative direct of leaf area index with seed yield was given by Latha *et al.* (2017).

However, the traits, plant height ( $p_p = -0.018$ ,  $p_g = -0.149$ ), number of leaves per plant ( $p_p = -0.028$ ,  $p_g = -0.051$ ) and oil content ( $p_p = -0.158$ ,  $p_g = -0.236$ ) even though exhibited significant negative direct effects on seed yield a strong association was noticed due to high indirect effects of these traits *via* oil yield, days to 50 per cent flowering and the number of seeds per head. Similar findings of negative direct effect on seed yield was also quoted by Iqbal *et al.* (2013) and Razzaq *et al.* (2014) with plant height; Pandya *et al.* (2015), Razzaq *et al.* (2014) and Latha *et al.* (2017) with number of leaves per plant and Kamble *et al.* (2018) with oil content. Similarly, significant negative direct effect of specific leaf area ( $p_p = -0.012$ ,  $p_g = -0.019$ ) with seed yield was also recorded but the indirect effect through oil content ( $p_p = 0.052$ ,  $p_g = 0.095$ ) was high.

Table 1. Genotypic and phenotypic correlation among seed yield and its attributes for 18 characters in sunflower (*Helianthus annuus* L.)

	DF	SPAD	LAI	SLA	PH	SG	HD	NLP	DM	SW	NSH	VW	SS	AU	HC	OC	SY
DF	r <sub>p</sub>																0.065
	r <sub>g</sub>																0.089
SPAD	r <sub>p</sub>	0.348															0.175
	r <sub>g</sub>	0.314**															0.136
LAI	r <sub>p</sub>	0.216	-0.036														0.820**
	r <sub>g</sub>	0.228	-0.010														0.930
SLA	r <sub>p</sub>	-0.048	0.063	-0.681**													-0.646**
	r <sub>g</sub>	-0.069	0.078	-0.719													-0.752
PH	r <sub>p</sub>	0.455**	0.323**	0.755**	-0.547**												0.722**
	r <sub>g</sub>	0.471	0.362	0.776	-0.587												0.810
SG	r <sub>p</sub>	0.273*	0.183	0.612**	-0.449**	0.652**											0.672**
	r <sub>g</sub>	0.437	0.383	0.844	-0.607	0.880											0.935
HD	r <sub>p</sub>	-0.006	0.135	0.708**	-0.587**	0.629**	0.635**										0.896**
	r <sub>g</sub>	0.006	0.088	0.864	-0.705	0.751	0.951										0.928
NLP	r <sub>p</sub>	0.420**	0.153	0.682**	-0.309**	0.657**	0.452**	0.503**									0.527**
	r <sub>g</sub>	0.454	0.188	0.706	-0.327	0.688	0.580	0.730									0.631
DM	r <sub>p</sub>	0.878**	0.335**	0.016	0.110	0.192	-0.158	0.308**									-0.109
	r <sub>g</sub>	0.891	0.360	0.021	0.110	0.202	-0.180	0.333									-0.120
SW	r <sub>p</sub>	-0.073	0.307**	0.384**	-0.405**	0.487**	0.630**	0.312**	-0.166								0.606**
	r <sub>g</sub>	-0.084	0.381	0.436	-0.432	0.552	0.726	0.385	-0.178								0.682
NSH	r <sub>p</sub>	0.167	0.138	0.771**	-0.513**	0.629**	0.762**	0.507**	0.029	0.200							0.876**
	r <sub>g</sub>	0.219	0.078	0.915	-0.650	0.732	0.806	0.623	0.034	0.333							0.892
VW	r <sub>p</sub>	0.742**	0.237*	0.371**	-0.223	0.530**	0.193	0.351**	0.640**	-0.051	0.447**						0.309**
	r <sub>g</sub>	0.798	0.282	0.399	-0.310	0.585	0.247	0.376	0.694	-0.006	0.521						0.354

Table 1 Contd...

<b>SS</b>	$r_p$	0.034	0.097	0.640**	-0.528**	0.600**	0.636**	0.731**	0.351**	-0.128	0.596**	0.656**	0.283*				0.789**	
	$r_g$	0.053	0.128	0.701	-0.587	0.645	0.805	0.872	0.402	-0.125	0.672	0.803	0.337				0.898	
<b>AU</b>	$r_p$	-0.071	-0.094	-0.484**	0.445**	-0.385**	-0.430**	-0.527**	-0.296**	0.059	-0.433**	-0.480**	-0.183	-0.379**			-0.559**	
	$r_g$	-0.101	-0.068	-0.598	0.572	-0.474	-0.523	-0.525	-0.394	0.068	-0.494	-0.443	-0.239	-0.485			-0.540	
<b>HC</b>	$r_p$	-0.362**	-0.121	-0.184	0.108	-0.491**	-0.077	0.003	-0.218	-0.250*	0.076	-0.141	-0.422**	-0.018	-0.089		-0.082	
	$r_g$	-0.428	-0.194	-0.244	0.120	-0.617	-0.337	-0.053	-0.314	-0.298	0.064	-0.255	-0.530	0.005	-0.010		-0.181	
<b>OC</b>	$r_p$	0.352**	0.156	0.486**	-0.326**	0.655**	0.291*	0.399**	0.388**	0.131	0.131	0.411**	0.426**	0.222	-0.117	-0.559**	0.418**	
	$r_g$	0.377	0.197	0.515	-0.405	0.696	0.403	0.516	0.450	0.132	0.206	0.470	0.427	0.234	-0.144	-0.718	0.479	
<b>OY</b>	$r_p$	0.121	0.172	0.827**	-0.640**	0.779**	0.668**	0.887**	0.555**	-0.079	0.567**	0.870**	0.359**	0.754**	-0.520**	-0.196	0.571**	0.981**
	$r_g$	0.149	0.140	0.925	-0.748	0.861	0.916	0.927	0.658	-0.087	0.645	0.882	0.401	0.840	-0.501	-0.322	0.625	0.982

$r_g$ = Genotypic correlation  $r_p$ = Phenotypic correlation \*, \*\* Significant at 5% and 1% levels, respectively

DF- Days to 50% flowering; SPAD - SPAD chlorophyll meter reading; LAI- Leaf area index; SLA- Specific leaf area; PH- Plant height; SG- Stem girth; HD- Head diameter; NLP- Number of leaves per plant; DM- Days to maturity; SW- 100 seed weight; NSH- Number of seeds per head; VW- Volume weight; SS- Seed set per cent; AU- Autogamy per cent; SY- Seed yield; HC- Hull content; OC- Oil content; OY- Oil yield

Table 2. Genotypic and phenotypic path coefficients for seed yield and its attributes for 18 characters in sunflower

	DF	SPAD	LAI	SLA	PH	SG	HD	NLP	DM	SW	NSH	VW	SS	AU	HC	OC	OY
DF	P <sub>g</sub>	0.142	0.032	-0.001	0.067	0.062	0.001	0.064	0.126	-0.012	0.031	0.113	0.008	-0.0143	-0.061	0.053	0.021
	P <sub>p</sub>	<b>0.011</b>	0.003	-0.001	0.005	0.003	-0.0001	0.005	0.010	-0.001	0.002	0.008	0.0004	-0.001	-0.004	0.004	0.001
SPAD	P <sub>g</sub>	0.019	<b>0.055</b>	0.0043	0.020	0.021	0.005	0.010	0.020	0.021	0.004	0.016	0.007	-0.004	-0.011	0.011	0.008
	P <sub>p</sub>	0.005	<b>0.017</b>	0.001	0.005	0.003	0.002	0.003	0.006	0.005	0.002	0.004	0.002	-0.002	-0.002	0.002	0.003
LAI	P <sub>g</sub>	0.009	-0.0004	<b>0.039</b>	0.030	0.033	0.033	0.027	0.001	0.017	0.035	0.015	0.027	-0.023	-0.009	0.020	0.036
	P <sub>p</sub>	0.015	-0.003	<b>0.069</b>	0.052	0.042	0.049	0.047	0.001	0.026	0.053	0.026	0.044	-0.033	-0.012	0.033	0.057
SLA	P <sub>g</sub>	0.001	-0.002	0.014	0.011	0.012	0.013	0.006	-0.002	0.008	0.012	0.006	0.011	-0.011	-0.002	0.008	0.014
	P <sub>p</sub>	0.001	-0.001	<b>-0.012</b>	0.007	0.005	0.007	0.004	-0.001	0.005	0.006	0.003	0.006	-0.005	-0.001	0.004	0.007
PH	P <sub>g</sub>	-0.070	-0.054	0.087	<b>-0.149</b>	-0.131	-0.112	-0.102	-0.030	-0.082	-0.109	-0.087	-0.096	0.07042	0.092	-0.104	-0.128
	P <sub>p</sub>	-0.008	-0.006	0.009	<b>-0.018</b>	-0.011	-0.011	-0.012	-0.003	-0.009	-0.011	-0.009	-0.010	0.007	0.009	-0.011	-0.013
SG	P <sub>g</sub>	0.012	0.011	-0.017	0.025	<b>0.028</b>	0.027	0.021	0.012	0.018	0.025	0.023	0.023	-0.0147	-0.010	0.011	0.026
	P <sub>p</sub>	-0.006	-0.004	0.009	-0.014	<b>-0.021</b>	-0.013	-0.011	-0.004	-0.011	-0.012	-0.010	-0.014	0.009	0.001	-0.006	-0.014
HD	P <sub>g</sub>	0.001	0.008	-0.062	0.066	0.084	<b>0.088</b>	0.051	-0.016	0.064	0.071	0.022	0.077	-0.046	-0.005	0.046	0.082
	P <sub>p</sub>	0.0001	-0.003	0.013	-0.014	-0.014	<b>-0.023</b>	-0.010	0.004	-0.014	-0.017	-0.004	-0.017	0.012	-0.0001	-0.009	-0.020
NLP	P <sub>g</sub>	-0.023	-0.010	0.017	-0.035	-0.037	-0.030	<b>-0.051</b>	-0.017	-0.020	-0.032	-0.019	-0.021	0.0202	0.016	-0.023	-0.034
	P <sub>p</sub>	-0.012	-0.004	0.009	-0.018	-0.014	-0.012	<b>-0.028</b>	-0.008	-0.009	-0.014	-0.010	-0.001	0.008	0.006	-0.011	-0.015
DM	P <sub>g</sub>	-0.025	-0.010	-0.003	-0.006	-0.009	0.005	-0.095	<b>-0.029</b>	0.005	-0.001	-0.198	0.004	-0.002	0.008	-0.004	0.002
	P <sub>p</sub>	-0.006	-0.002	-0.001	-0.001	-0.001	0.001	-0.002	<b>-0.006</b>	0.001	-0.0001	-0.004	0.0008	-0.0003	0.001	-0.0008	0.001
SW	P <sub>g</sub>	0.001	-0.003	0.004	-0.005	-0.006	-0.006	-0.003	0.002	<b>-0.009</b>	-0.003	0.0001	-0.006	0.00418	-0.0005	-0.002	-0.005
	P <sub>p</sub>	-0.007	0.031	-0.041	0.049	0.051	0.063	0.031	-0.017	<b>0.100</b>	0.020	-0.005	0.060	-0.043	0.008	0.013	0.057

Table 2 Contid...

	DF	SPAD	LAI	SLA	PH	SG	HD	NLP	DM	SW	NSH	VW	SS	AU	HC	OC	OY
NSH	P <sub>g</sub>	0.011	0.004	0.045	-0.032	0.036	0.045	0.031	0.002	0.017	<b>0.050</b>	0.026	0.040	-0.022	-0.013	0.023	0.044
	P <sub>p</sub>	0.023	0.019	0.108	-0.072	0.088	0.107	0.071	0.004	0.028	<b>0.140</b>	0.063	0.092	-0.067	-0.020	0.058	0.122
VW	P <sub>g</sub>	-0.093	-0.033	-0.047	0.036	-0.068	-0.029	-0.044	-0.081	0.001	-0.061	<b>-0.117</b>	-0.039	0.0279	0.062	-0.050	-0.047
	P <sub>p</sub>	0.004	0.001	0.002	-0.001	0.003	0.002	0.002	0.003	-0.0003	0.002	<b>0.005</b>	0.002	-0.0001	-0.002	0.002	0.002
SS	P <sub>g</sub>	0.001	0.003	0.014	-0.012	0.013	0.018	0.008	-0.003	0.014	0.017	0.007	<b>0.021</b>	-0.010	0.0001	0.005	0.017
	P <sub>p</sub>	-0.0001	-0.001	-0.003	0.003	-0.003	-0.003	-0.002	0.0006	-0.003	-0.003	-0.001	-0.005	0.002	0.0001	-0.001	-0.004
AU	P <sub>g</sub>	0.002	0.001	0.012	-0.012	0.010	0.011	0.008	-0.001	0.010	0.009	0.005	0.010	<b>-0.020</b>	0.0002	0.003	0.010
	P <sub>p</sub>	-0.0004	-0.001	-0.003	0.002	-0.002	-0.003	-0.002	0.0003	-0.002	-0.002	-0.001	-0.002	<b>0.005</b>	0.0005	0.0006	-0.003
HC	P <sub>g</sub>	0.033	0.015	0.019	-0.009	0.048	0.026	0.024	0.023	-0.005	0.020	0.041	-0.0004	0.0008	<b>-0.077</b>	0.055	0.025
	P <sub>p</sub>	-0.008	-0.003	-0.004	0.002	-0.010	-0.002	-0.005	-0.005	0.002	-0.003	-0.009	-0.0004	-0.002	<b>0.022</b>	-0.012	-0.004
OC	P <sub>g</sub>	-0.089	-0.046	-0.122	0.095	-0.164	-0.122	-0.106	-0.031	-0.049	-0.111	-0.101	-0.055	0.03404	0.169	<b>-0.236</b>	-0.148
	P <sub>p</sub>	-0.056	-0.025	-0.077	0.052	-0.103	-0.046	-0.061	-0.021	-0.021	-0.065	-0.067	-0.035	0.018	0.088	<b>-0.158</b>	-0.090
OY	P <sub>g</sub>	0.158	0.148	0.978	-0.792	0.911	0.969	0.696	-0.092	0.683	0.933	0.423	0.889	-0.5305	-0.341	0.662	<b>1.058</b>
	P <sub>p</sub>	0.108	0.154	0.741	-0.573	0.698	0.794	0.497	-0.071	0.508	0.779	0.321	0.675	-0.466	-0.175	0.511	<b>0.895</b>
SY	P <sub>g</sub>	0.089	0.136	0.930**	-0.752**	0.810**	0.928**	0.631**	-0.120	0.682**	0.892**	0.354**	0.898**	-0.540**	-0.181	0.479**	0.982**
	P <sub>p</sub>	0.065	0.175	0.820**	-0.646**	0.722**	0.896**	0.527**	-0.109	0.606**	0.876**	0.309**	0.789**	-0.559**	-0.082	0.418**	0.981**

Residual effect (Phenotypic) = 0.067 Residual effect (Genotypic) = 0.062 Diagonal values = Direct effects Off-Diagonal values = Indirect effects; \*, \*\* Significant at 0.05 and 0.01 levels, respectively

DF- Days to 50% flowering; SPAD - SPAD chlorophyll meter reading; LAI- Leaf area index; SLA- Specific leaf area; PH- Plant height; SG- Stem girth; HD- Head diameter; NLP- Number of leaves per plant; DM- Days to maturity; SW- 100 seed weight; NSH- Number of seeds head ; VW- Volume weight; SS- Seed set per cent; AU- Autogamy per cent ; SY- Seed yield; HC- Hull content; OC- Oil content; OY- Oil yield

**CONCLUSION**

This study concludes the differential association among the traits studied. A strong correlation of seed yield with most of the traits viz., oil yield, head diameter, number of seeds per head, leaf area index, seed set per cent, plant height, stem girth, 100 seed weight and number of leaves per plant, and, hence, in yield improvement programmes importance may be given for these traits. Further, most of the traits also showed highly significant inter-character association with oil yield followed by seed set per cent, number of seeds per head, head diameter and volume weight. However, path analysis concludes that direct selection for seed yield would be easier with the component traits such as oil yield and number of seeds per head as these traits exhibited direct effects on seed yield and most of the other traits also exhibited indirect effect to seed yield via these traits.

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# A STUDY ON GOVERNMENT COMPENSATION PACKAGE AND LAND POOLING PROGRAMME IN NEW CAPITAL REGION OF ANDHRA PRADESH

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## ABSTRACT

This paper highlights the land pooling programme in Andhra Pradesh and A.P. State compensation package for new capital region development. The Compensation package for owner farmer included monetary compensation and provision of residential and commercial plots who surrendered their lands to The Capital Region Development Authority (CRDA). The package to tenants and agricultural labourers include only monetary compensation. While the compensation along with residential and commercial plots is found to be satisfactory to the owner farmers, the tenants and agricultural labourers found to be under-compensated, as they had only monetary compensation.

**Keywords :** Government Compensation Package, Land Pooling Programme, CRDA, Andhra Pradesh

## INTRODUCTION

The concept of land pooling is based on The Right to Fair Compensation and Transparency in Land Acquisition, Rehabilitation and Resettlement (Amendment) Bill, 2015 that was introduced in Lok Sabha on February 24<sup>th</sup>, 2015. The pooling of privately held land parcels by a public agency is variously known as land pooling and reconstitution (LPR). LPR is considered one of the viable solutions that unlock land for urban use in a politically acceptable manner (Mathur, 2013). The broad objective of Land Pooling Scheme (LPS) is to do justice to affected families by the construction of a livable and sustainable capital city for the state of A.P. by making the landowners and residents as partners in development. Raghuram and Sunny (2015) stated that the Compensation Act provided compensation of four times the market price in rural areas and twice the market price in urban areas. This included a solatium (things given as compensation)

of 100 per cent of the compensation. Apart from this, the value of assets attached to the land would also be part of the compensation package.

Post-bifurcation of United Andhra Pradesh into Telangana state and residual A.P. state in 2014, A.P. state decided to relocate from Hyderabad to a new capital, named Amaravathi, in an area spread over 25 villages and four hamlets in Thullur, Tadepalli and Mangalagiri mandals of Guntur District, on the right bank of the Krishna River.

The villages marked for the capital region include both irrigated and drylands with complete linkages from farm to market and large sections of people deriving livelihoods include landowners, sharecroppers, tenants and agricultural workers earning secured livelihood from agriculture. Drastic urbanization of these areas due to land pooling policy may adversely impact the food security of these areas and state as well. Dev (2015) stated that the AP Capital Regional Development Authority (CRDA) would

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develop and return a portion of the developed land with infrastructure to the land owners in proportion to their land contribution. Half of the land procured from landowners will be used for common assets such as roads, open spaces and social infrastructure. The other half will be shared equally between the landowners and the government.

'*Mana Amaravathi*' app (2018) facilitates beneficiaries to buy/sell, "development", "lease" functionalities of A.P. CRDA returnable plots in capital city villages through Aadhaar integration, thereby eliminating brokerage and bringing buyer and seller on a single platform in "Buy & Sell" service of "Farmers First" module.

## MATERIAL AND METHODS

Guntur district of A.P. was purposively selected for the research study because the Capital formation is mainly concentrated in the Thullur mandal of Guntur district. A number of eight(8) owners, eight (8) tenants, four (4) agricultural labourers were selected randomly from each village of top-six villages having highest area under land pooling and land acquisition, constituting a sample of 48 owners, 48 tenants, 24 agricultural labourers, thus, making a total of 120 affected households. Primary data on various aspects such as the occupation of family members, reasons to surrender land for acquisition, opinion about compensation package were collected from affected households and compensation particulars through field survey by the interview and recall memory method with the help of a pre-tested and well-structured schedule. Secondary data such as the population of villages, number of owner farmers and tenant farmers, agricultural labourers, total land under pooling and acquisition, etc. was obtained from

various sources such as mandal offices, A.P. CRDA Office, A.P. government official websites and CRDA website. This study was carried out during 2014-16.

The Conventional analysis was completed for studying land acquisition/pooling procedure and state compensatory package for New Capital Region Development in Andhra Pradesh. Compounding and Discounting techniques were used to calculate the future accumulated value of monetary compensation and the present value of future compensation for residential and commercial plots.

Annuity factor for Future accumulated value of compensation was calculated by the formula,

$$(FV) = (((1 + i)^n - 1) / i) \times A$$

i = rate of interest (10 %), n = number of years (10 years),

A = yearly compensation given for 10 years

Compounding formula has been used to estimate the future values of residential and commercial plots by using the present market value of land

$$F = P (1 + i)^n$$

P = Present market value of residential / commercial plots, i = rate of interest (10 %), n = number of years (10 years)

Future value of total compensation was obtained by adding the future accumulated values of compensation given in monetary terms and future values of residential and commercial plots.

Discounting method was used to analyze the present value of future compensation.

$$P = F / (1 + i)^n$$

F = Total future compensation after 10 years, i = rate of interest (10 %), n = number of years (10

years), P=Present value of total future compensation.

### **Procedure for Acquisition of Land**

In case of land acquisition, the government takes the private land required for public purposes like road construction, irrigation projects etc. According to Land Acquisition Act-2013, 4(1), the officials have to conduct the survey, study its impact and submit a detailed report (Social Impact Analysis). The proposals such as Budget Provision Certificate, Administrative Approval Certificate and Technical Sanction Orders scrutinized. The proposal includes certificates for "Small Landholders", issued by local government authorities as well as related information submitted by the concerned agencies. Commissioner's permission has to be taken for land acquisition if the landowner does not agree for it. The objections of landowners are invited, and resolved. Under section 9 (1), if any objections are received during the enquiry, they are resolved by the divisional office of the agency. Town Planning and Valuation Department evaluates the compensation for the land to be acquired. The department gives compensation after the declaration of the award. In case of disputes after the payment of compensation between cultivators and government officials, when not solved, then such type of compensation is deposited under section 30 of the Land Acquisition Act 1894 in the name of the District Civil Judge and matter disposed of by the District Judge (**Source:**<http://www.amravati.nic.in/htmldocs/LAO.html>).

The time-consuming procedures mandated by 2013 law might delay the upcoming future projects by three to five years. These include a Social Impact Assessment (SIA), scrutiny by an expert committee, obtaining the consent of 70% to 80% of affected people and a detailed relief and rehabilitation

programme.

### **Land Pooling Scheme**

The A.P. State Government overlooked the suggestions made by K.C. Sivarama Krishna committee appointed by the Gol, which was against the one 'super capital' concept and use of fertile, water-rich locations for capital development. However, the interesting point of A.P. land pooling model was making the displaced villagers, a part of the development process.

Under the land pooling scheme, small pockets of land being pooled and after completion of the development with all modern facilities, a small portion will be returned to the owner. The land pooling for Amaravati capital was done based on "The A.P. Capital Region Development Authority Act, 2014". The government had proposed to complete the development in ten years and return 30 per cent of the developed land to the original landowner. The government guaranteed the return of reconstituted land in the range of 800 yd<sup>2</sup> to 1000 yd<sup>2</sup> of residential plots and 100 yd<sup>2</sup> to 450 yd<sup>2</sup> of commercial plots per every acre of original land surrendered and also payments of annual compensation in the range of Rs. 30,000 to Rs. 50,000 depending on land quality with a 10 per cent increment every year for ten years from March, 2015.

The farmers have to sign the development agreement with CRDA to avail the compensation. Land owners have also been exempted from capital gains tax and stamp duty on the first sale. The AP government also offered waiver of previous loans and government jobs to the local youth and issue of the 'Land Pooling Ownership Certificates (LPOC) once

plotting of the capital region begins. The state government also proposed to setup a Capital Region Social Security Fund for paying annuity to the estimated 12,000 displaced families of agricultural labourers and tenant farmers. The government acquired around 33,000 acres from farmers without much protest under Land Pooling Scheme of Andhra Pradesh for building capital city, Amaravati. (**Source:** Government of Andhra Pradesh, Municipal Administration & Urban Development Department – The Andhra Pradesh Capital City (Formulation and Implementation Rules, 2015 - Notification – Issued Dated 1.1.2015). The government employed lottery system for allotting commercial and residential plots on paper and this was started first in Nallapadu village of Thullur mandal and later extended to all farmers, who gave up their lands to facilitate the construction of A.P.'s new capital, The Amaravati.

Land distribution study of sample households indicate that 28 owner farmers had an area of 160.5

acres of agricultural land with an average of 5.73 acres per household comprising 20.29 per cent of total cultivated area. There were 20 owner cum tenant farmers cultivating an area of 266.5 acres comprising 33.70 per cent of total cultivated area. Average area of owner cum tenant farmers observed to be 13.32 acres. The total affected area of 42 pure tenant farmers was 330 acres constituting of 41.72 per cent of the total cultivated area. Apart from 42 pure tenants, the sample also had 6 tenant farmers, who worked as agricultural labour in others' fields. Tenant cum agricultural labourers had 34 acres of leased in land comprising 4.29 % of the total cultivated area with an average area of 5.67 acres. Hence, the sample comprises of 96 farmers with a total affected area of 791 acres of which 80 per cent are tenant cultivators of different kinds. Apart from the above category of farmers, there were 24 agricultural labourers in the sample area making a total sample of 120 households (Table 1).

**Table 1. Distribution and Acquired area of sampled households**

S. No.	Main occupation of head of household	No. of households	Percentage to total sample (%)	Total land Area (acres)	Average area (acres)	Percentage to the total cultivated area(%)
1	Owner	28	23.33	160.5	5.73	20.29
2	Owner + Tenant	20	16.66	96.5+170	13.32	33.70
3	Pure Tenant	42	35	330	7.85	41.72
4	Tenant + agricultural labour	6	5	34	5.67	4.29
	<b>Total</b>	<b>96</b>	–	<b>791</b>	<b>32.57</b>	<b>100</b>
5	Agricultural Labour	24	20	–	–	
	<b>Total</b>	<b>120</b>	<b>100</b>	–	–	

The distribution of the owned and leased-in-land to total acquired area of the sample revealed that out of total 791 acres, 257 acres of owned land i.e. 32.49 per cent to total cultivated area and 534 acres of leased in land i.e. 67.51 per cent to total cultivated

area was affected in the study area indicating that landless cultivators contributed more to the New Capital Region development in Thullur mandal than the owners.

**Table 2. Compensation particulars of owner sample farmers (n= 48)**

S. No.	Variable	Total Area (acres)	No. of farmers	Rs./ acre	Rs./ household
1	<b>Compensation received (up to Feb,2016) (Rs.)</b>				
	1. Irrigated	61	11	50,000	2,77,273
	2. Dry	196	37	30,000	1,58,919
	3. All land types	257	48	34,583	1,85,163
2	<b>Future accumulated value of money compensation (Rs.)</b>				
	1. Irrigated	61	11	7,96,871	44,19,012
	2. Dry	196	37	4,78,122	25,32,754
	3. All land types	257	48	5,51,169	29,51,051
3	<b>Registered Government value (official land rates)</b>				
	1. Irrigated	61	11	8,20,415	45,49,574
	2. Dry	196	37	7,61,646	40,34,665
	3. All land types	257	48	7,75,114	41,50,090

Table 2 presents the compensation particulars of owner sample farmers. Government registered values of irrigated and dry land types were taken from Stamps and Registration department to compare the compensation with land values. Average government value was Rs. 7,75,114 per acre and Rs.41,50,090 per household for 257 acres out of which 61 acres of irrigated land had average government value of Rs. 8,20,415 per acre and Rs.45,49,574 and 196 acres of dry land had average

government value Rs.7,61,646 per acre and Rs.40,34,665per household. The average money compensation received as on February 2016, for irrigated land was Rs. 50,000 per acre and Rs. 2,77,273 per household and for dry land it was Rs. 30,000 per acre and Rs.1,58,919 per household. Average monetary compensation received irrespective of land types found to be Rs.34,383 per acre and Rs.1,85,163 per household.

Future accumulated value of money compensation was calculated by compounding annual money compensation given based on area and type of land at 10 percent rate of interest for 10 years. For 61 acres of irrigated land, future accumulated value of money compensation estimated as Rs.7,96,871 per acre and Rs. 44,19,012 per household. In case of 196 acres of dry land, it was Rs. 4,78,122 per acre while Rs.25,32,754 per household and for the whole 257 acres it was Rs. 5,51,169 per acre and Rs. 29,51,051 per household on an average. From this, it can be inferred that average registered government value of agricultural land was more than future accumulated value of money compensation for both irrigated and dry lands in both per acre and per household terms.

Owners were given compensation in terms of acres, while tenants and agricultural labourers were given compensation in terms of households. It can also be inferred that compensation received for irrigated land was more compared to dry land types in both per acre and per household terms. Thus, the compensation given in monetary terms would not be justifiable and sufficient for owner farmers as it was less than the registered government rates which were far less than the prevailing market rates.

Hence, other forms of compensation were also offered by the government to farmers who surrendered their land for New Capital Region development. This package with annual compensation in monetary terms and as developed plots after 10 years would be less expensive and beneficial to government.

**Table 3. Other forms of compensation offered to owner farmers (n = 48)**

S.No.	Variable	Total Area (Sq. yd)/ acre of land	Present Value		Future value	
			Rs. / acre	Rs. / household	Rs. / acre	Rs. / household
1	Residential plots					
	1. Irrigated	1000	25,45,455	1,10,90,909	66,02,254	2,87,66,962
	2. Dry	1000	28,64,865	1,05,94,595	74,30,722	2,74,79,650
2	Commercial Plots					
	1. Irrigated	450	64,53,409	3,49,36,364	1,67,38,481	9,06,15,930
	2. Dry	250	28,29,392	3,33,72,973	73,38,714	8,65,60,879

The other forms of compensation offered to owner farmers were stated in Table 3. For government offered compensation in monetary terms, benefits occur immediately. In addition to this money compensation, residential and commercial plots will be given to farmers who surrendered their lands for A.P. Capital Region development and the benefits from this compensation occur after 10 years. According to this, 1000 Sq. yd of residential plots

will be given to farmers per each acre of dry and irrigated land. The present value of 1000 Sq. yd of residential area in irrigated area was of Rs. 25,45,455 per acre and Rs. 1,10,90,909 per household, while for dry area, it was Rs. 28,64,865 per acre and Rs. 1,05,94,595 per household on an average. The present values of 1000 Sq. yd residential plots were compounded at 10 per cent interest rate for 10 years to obtain the future values of Rs. 66,02,254 per acre

and Rs. 2,87,66,962 per household for irrigated and Rs. 74,30,722 per acre and Rs. 2,74,79,650 per household for dry land farmer. Apart from residential plots, commercial plots of 450 Sq. yd for irrigated land and 250 Sq. yd for dry land would be given in fully developed area of new capital region after 10 years. 450 Sq.yds of Commercial plot had a present value of Rs. 64,53,409 per acre while it was Rs. 3,49,36,364 per household, which will be Rs. 1,67,38,481 per acre and Rs. 9,06,15,930 per household on an average in future respectively. Commercial plots of 250 Sq.yds had an average present value of Rs. 28,29,392 per acre and Rs.3,33,72,973 per household, but in future it will be around Rs. 73,38,714 per acre and Rs. 8,65,60,879 per household respectively. From this, it can be

inferred that future values to be received by owners for these residential and commercial plots would be a bonanza having huge monetary value due to the expected development in new capital region after 10 years. Farmers, who accepted the compensation package voluntarily, might have got lured by the offer of developed plots expecting high margins from the parted land with the government.

The present value of future compensation offered by government to owner farmers as well as to tenants and agricultural labourers was furnished in Table 4. Future accumulated value of monetary compensation after 10 years was Rs. 7,96,871 for irrigated land per acre and Rs. 44,19,012 per household. For dry land, it was Rs. 4,78,122 per acre and Rs. 25,32,754 per household, while it was Rs. 4,78,122 per household

**Table 4. Comparison of Present value of future compensation with government registration value of land acquired and crop income (n= 120)**

Particulars	Owners (48)				Tenants (48) and Agril. Labour (24)  (Rs. / household)
	Irrigated		Dry		
	(Rs. / acre)	(Rs. / household)	(Rs. / acre)	(Rs. / household)	
Monetary compensation	50,000	2,77,273	30000	1,58,919	30,000
Future accumulated value of money compensation (1)	7,96,871	44,19,012	4,78,122	25,32,754	4,78,122
Future value Residential plot (2)	66,02,254	2,87,66,962	74,30,722	2,74,79,650	—
Future value of commercial plot (3)	1,67,38,481	9,06,15,930	73,38,714	8,65,60,879	—
Future value of total compensation(1+2+3)	2,41,37,606	12,38,01,904	1,52,47,558	11,65,73,283	—
Present value of future compensation	93,06,092	4,77,30,993	58,78,594	4,49,44,047	1,84,337
Government's registration value of land	8,20,415	45,49,574	7,61,646	40,34,665	—
Crop income	15,312	49,181	24,972	1,36,729	—

for tenants and agricultural labour on an average. Future values of residential plots, which would be given to owners after 10 years had a value of Rs. 66,02,254 per acre and Rs.2,87,66,962 per household for irrigated land and Rs. 74,30,722 for dry land per acre of land surrendered and Rs. 2,74,79,650 per household, respectively.

Future values of commercial plots that would be given in fully developed area in new capital region had a value of Rs.1,67,38,481 per acre and Rs. 9,06,15,930 per household for irrigated land. While for dry land, it had a value of Rs. 73,38,714 per acre of land surrendered and Rs.8,65,60,897 per household.

Future Value of monetary compensation was added to future values of residential and commercial plots to get the total future compensation which would be received by owner farmers after 10 years. Total Future compensation thus obtained was discounted to get present value of future compensation. The future compensation for irrigated land was estimated to be Rs.2,41,37,606 per acre and Rs.12,38,01,905 per household and its present values found to be Rs.93,06,092 per acre and Rs.4,77,30,993 per household. In case of dry land farmers, future compensation value was Rs.1,52,47,558 per acre and Rs.11,65,73,283 per household, while the present value of future compensation was Rs.58,78,594 per acre and Rs.4,49,44,047 per household. Average Present value of future compensation for tenants and agricultural labour was estimated as Rs.1,84,337 per household.

It can also be inferred that official land rates were about Rs.8,20,415 per acre and Rs.45,49,574

per household for irrigated land and Rs.7,61,646 per acre and Rs. 40,34,665 per household for dry land. Average crop income of owner farmer was Rs.15,312 per acre and Rs. 49,181 per household from irrigated land and Rs.24,972 per acre and Rs.1,36,729 per household from dry land. This shows that present value of total future compensation was far more than per acre income and government value of land. The compensation offered in all forms was more for irrigated land than for dry land farmers. Thus, it can be concluded that A.P. land pooling model offered an attractive package to owner farmers considering government rates of acquired land. However, comparing the same package with market rates, may disappoint the owner farmers. They could get equal or more amount than the offered compensation immediately if the same land sold outside. Hence there are cases where, farmers who were not satisfied with the package and found it risky, sold their lands and bought lands and settled down in new locations. Many farmers opined that there is uncertainty whether the government will fulfill its promise of developing the plots and handing back to them (Sreenivas, 2015).

## CONCLUSION

Owner farmers were sufficiently compensated with money for 10 years and commercial and residential plots that would realize excessive value when they are allotted to them after 10 years. While tenants and agricultural labourers were under-compensated as they were given only Rs. 30,000 per year, irrespective of household size which would not be sufficient for the household with more number of members. Hence, owner farmers expressed satisfaction for package while agricultural labourers

and tenant farmers were disappointed.

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## Research Note

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# SOIL QUALITY INDEX OF SOILS UNDER THOTAPALLI IRRIGATION PROJECT AYACUT OF NORTH COASTAL ANDHRA PRADESH

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Soil quality is generally used to refer to a soil's capacity to perform its production and environment - related functions, to produce healthy and nutritious crops, resist erosion and reduce the impact of environmental stresses on plants, soil biota, human beings and animals. Soil quality and its importance in agricultural sustainability have been well recognized (Smith *et al.*, 1993). *Thotapalli* major irrigation project proposed to supply irrigation water to an ayacut area of 73,580 ha in Srikakulam and Vizianagaram districts of North Coastal Andhra Pradesh. Necessity is always agreed for soil quality database on ayacut area of the proposed irrigation project. However, so far no efforts made to study quality indices of these soils. Keeping the above in view, the study was carried out during the year 2018 on soil quality indicators of Thotapalli irrigation project ayacut area of North Coastal Andhra Pradesh. The investigation has been conducted to assess the quality of soils of Thotapalli reservoir ayacut to maximize irrigation use efficiency and achieve sustainable crop production. Twenty-two soil quality indicators were assessed in the laboratory and soil quality indexes of SQI and RSQI were computed.

The study area comprises parts of Srikakulam and Vizianagaram districts of the North Coastal region of Andhra Pradesh under Thotapalli reservoir located between 18° 12' 820" to 18° 32' 876" N latitude and

83° 29' 889" to 83° 37' 727" E longitude. A reconnaissance soil survey was conducted in the ayacut area of *Thotapalli* major irrigation project from April to June, 2018 using toposheets of 1: 50,000 scale as per the procedure outlined by AIS&LUS (1970). Auger bores, mini pits, road cuts of 15 profiles located on uplands and plains were studied. Soil correlation exercise resulted in six typical profiles *i.e.* four in uplands and two in plains identified for the study. Devarapalli, patikivalasa and amity pedons were moderate to well drained, Gujjangivalasa pedon is well drained and Gangada and Maddivalasa were poorly drained. The land slope of Gangada and Maddivalasa pedons was 0-1% and Devarapalli, patikivalasa, Gujjangivalasa and amity pedons were 1% - 3%. Soil bulk density, soil texture and hydraulic conductivity were estimated by adopting standard methods outlined by Jalota *et al.* (1998). Soil reaction (pH) and soluble salt concentration (EC), organic carbon content, available nitrogen, available phosphorus, available potassium, calcium carbonate and cation exchange capacity (CEC) in soil samples were estimated by adopting procedure outlined by Jackson (1973). The available zinc, copper, iron and manganese in soils were extracted by DTPA and measured by using atomic absorption spectrophotometer (Lindsay and Norvell, 1978). Microbial biomass

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was estimated by fumigation extraction technique (Sparling and West, 1988).

Enzymatic activity was also determined by using the standard procedures; Urease ( $\mu\text{g NH}_4^+$  released  $\text{g}^{-1}$  soil  $\text{h}^{-1}$ ), acid phosphatase and alkaline phosphatase ( $\mu\text{g}$  of p- nitrophenol released  $\text{g}^{-1}$  soil  $\text{h}^{-1}$ ) as described by (Tabatabai and Bremner, 1972); and dehydrogenase (mg of TPF produced  $\text{g}^{-1}$  soil  $\text{day}^{-1}$ ) as described by Casida *et al.* (1964).

### Assessment of soil quality index

The soil quality was assessed by calculating the soil quality index suggested by Singh, (2007) and Maheswara Prasad and Prabhu Prasadini (2014) using the data set of 22 indicators (Table 1). Each indicator was assigned weightage on the basis of existing soil conditions. The sum of all the weights was normalized to 100%. Each indicator was divided into four (4) classes (I-most suitable for plant growth, II-suitable for plant growth with slight limitations, III-more serious limitations than class II, and IV- severe limitations for plant growth). Marks were allotted as 4,3,2,1 to the respective class. Quantitative evaluation of soil quality by introducing the concept of relative soil quality index was adopted (Karlen and Stott, 1994). The relative soil quality index (RSQI) was worked out by combining 22 indicators selected for the study. The equation was  $\text{RSQI} = (\text{SQI} / \text{SQI}_m) \times 100$ ; wherein, SQI = Soil Quality Index and  $\text{SQI}_m$  = Maximum value of SQI. Wang and Fang, (1978) reported that the maximum value of SQI for soil is 400 and minimum value is 100. SQI was calculated as  $\text{SQI} = \sum W_i l_i$ ; where  $W_i$  = Weight of the indicators and  $l_i$  = marks of the indicator classes.

SQI of every indicator was calculated separately by multiplying the weight of indicators with marks

allotted to each class (Table 1). The summation of all indicators was considered as SQI. The normalized RSQI is 100, however, the real soil will have lower values which directly indicate their deviation from the optimal soil. Based - on the RSQI values, the soils were further classified into five classes from best to that with serious limitations *i.e.*, I (90–100), II (80-90), III (70-80), IV (60-70) and V (< 60).

The soil quality parameters were evaluated quantitatively for six soil pedons (representative soils). Results indicated variations in soil depth, soil texture, bulk density, hydraulic conductivity, soil pH, CEC, organic carbon, available nutrients such as phosphorous, potassium, zinc and soil enzyme activities such as microbial biomass, acid phosphatase and alkaline phosphatases (Table 2). However, there was not much variability in slope, EC, available nitrogen, copper, manganese, Urease and dehydrogenase. Wang and Gong (1996) also reported such variations in soil quality indicators in soils of South China.

Soil quality evaluation using data showed that RSQI values ranged from 67.8 in soils of Gujjangivalasa pedon corresponding to soil quality class of IV (severe limitations for plant growth) to 86.8 in Devarapalli pedon, corresponding to soil quality class II (slight limitations for plant growth). Other soils of Patikivalas pedon qualified for quality class of III with RSQI value of 71.3, soils of Gangadaa pedon in class III with RSQI value of 72.5, soils of Amity pedon in class II with RSQI value of 82.5 and soils of Maddivalasa pedon in class II with RSQI value of 82.

The poor quality soils of Gujjangivalasa pedon characterized by coarse texture, low CEC, acidic pH, low organic carbon, low available N,  $\text{P}_2\text{O}_5$ , Zn, microbial

**Table 1. Criteria of Soil quality indicators, weightages and classes for the evaluation of soil quality**

Soil Quality Indicator	Weightage	Class I	Class II	Class III	Class IV
1. Soil Depth (cm)	13	>100	80-100	50-80	<50
2. Slope (%)	9	0-5	5-10	10-20	>20
3. Soil texture	11	Loam	sl or sc	Sand or clay	grit
4. Bulk density (g cm <sup>-3</sup> )	4	< 1.4	1.5	1.6	> 1.6
5. Hydraulic conductivity (cm h <sup>-1</sup> )	3	> 0.30	0.25-0.3	0.2-0.25	< 0.2
6. pH	5	5.5-7.0	7.1-8.0	8.0-8.5	8.5-9.0
7. EC (dS m <sup>-1</sup> )	4	< 0.4	0.4-0.5	0.5-0.6	> 0.6
8. CEC (c mol (p+) kg <sup>-1</sup> )	5	> 25	15-25	05-15	< 5
9. OC (mg kg <sup>-1</sup> )	8	> 20	10-20	05-10	< 05
10. N (kg ha <sup>-1</sup> )	4	> 400	300-400	200-300	< 200
11. P <sub>2</sub> O <sub>5</sub> (kg ha <sup>-1</sup> )	4	> 45	25-45	15-25	< 15
12. K <sub>2</sub> O (kg ha <sup>-1</sup> )	3	> 250	200-250	100-200	< 100
13. CaCO <sub>3</sub> (%)	3	< 0.5	0.5-1.0	1.0-1.5	> 1.5
14. Zn (mg kg <sup>-1</sup> )	5	> 0.6	0.5-0.6	0.45-0.5	< 0.45
15. Cu(mg kg <sup>-1</sup> )	2	> 0.2	0.10-0.2	0.05-0.10	< 0.05
16. Fe(mg kg <sup>-1</sup> )	4	>4.0	3-4	2-3	1-2
17. Mn(mg kg <sup>-1</sup> )	2	< 3	2-3	1-2	< 1
18. Micro biomass (µg <sup>-1</sup> g <sup>-1</sup> soil)	3	> 150	100-150	75-100	< 75
19. Urease (µg NH <sub>4</sub> <sup>+</sup> -N g <sup>-1</sup> soil h <sup>-1</sup> )	2	> 2	1.5-2	1-1.5	<1
20. Acid Phosphatase (P-nitro phenol µg g <sup>-1</sup> soil h <sup>-1</sup> )	2	> 150	100-150	75-100	< 75
21. Alkaline Phosphatase (P-nitro phenol µg g <sup>-1</sup> soil h <sup>-1</sup> )	2	> 150	100-150	75-100	< 75
22. Dehydrogenase (µg <sup>-1</sup> g <sup>-1</sup> soil 24 h <sup>-1</sup> )	2	> 15	12-15	10-12	< 10
Score for each class		4	3	2	1

**Class I:** Most suitable plant growth, **Class II:** Suitable for Plant growth with less limitation, **Class III:** Suitable for plant growth with serious limitation, **Class IV:** Suitable for plant growth with more severe limitation

**Table 2. Soil quality indicators, their weightages and classes for the evaluation of soil quality**

Soil Quality Indicator	Pedon 1	Pedon 2	Pedon 3	Pedon 4	Pedon 5	Pedon 6
1. Soil depth (cm)	115+ (52)	91 (39)	78 (39)	85 (39)	80 (39)	125+ (52)
2. Slope %	1-2 (36)	2-5 (36)	2-5 (36)	1-2 (36)	1-2 (36)	1-2 (36)
3. Soil texture	SI (33)	SI (33)	Scl (33)	Sc (33)	Scl (33)	C (22)
4. Bulk density (g cm <sup>-3</sup> )	1.42 (12)	1.48 (12)	1.42 (12)	1.37 (16)	1.40 (12)	1.33 (16)
5. Hydraulic conductivity (cm h <sup>-1</sup> )	0.48 (12)	0.85 (12)	0.35 (12)	0.16 (3)	0.39 (12)	0.12 (3)
6. pH	6.23 (20)	4.87 (10)	7.38 (15)	7.88 (15)	6.53 (20)	7. 50 (15)
7. EC (dS m <sup>-1</sup> )	0.23 (16)	0.21 (16)	0.29 (16)	0.49 (16)	0.34 (16)	0.48 (12)
8. CEC (c mol (p+) kg <sup>-1</sup> )	13.5 (10)	8.40 (5)	15.3 (15)	25.35 (20)	16.8 (10)	29.1 (20)
9. OC (mg kg <sup>-1</sup> )	5.3 (16)	3.8 (8)	3.3 (8)	4.5 (8)	5.1 (16)	6.2 (16)
10. N (kg ha <sup>-1</sup> )	194 (4)	140 (4)	171 (4)	186 (4)	157 (4)	219 (8)
11. P <sub>2</sub> O <sub>5</sub> (kg ha <sup>-1</sup> )	48.3 (16)	18.0 (8)	16.8 (8)	18.0 (8)	32.0 (16)	22.6 (8)
12. K <sub>2</sub> O (kg ha <sup>-1</sup> )	488 (12)	227 (9)	207 (9)	344 (12)	575 (12)	379 (12)
13. CaCO <sub>3</sub> (%)	Traces (12)	Traces (12)	1.3 (6)	3.15 (3)	Traces (12)	traces(12)
14. Zn (mg kg <sup>-1</sup> )	0.66 (20)	0.34 (5)	0.38 (5)	0.31 (5)	0.75 (20)	0.93 (20)
15. Cu(mg kg <sup>-1</sup> )	2.56 (8)	1.87 (8)	1.87 (8)	1.53 (8)	2.34 (8)	2.56 (8)
16. Fe(mg kg <sup>-1</sup> )	7.68 (16)	7.92 (16)	4.66 (16)	4.12 (16)	9.54 (16)	7.37 (16)
17. Mn(mg kg <sup>-1</sup> )	22.13 (8)	15.64 (8)	18.69 (8)	13.04 (8)	14.90 (8)	12.66 (8)
18. Micro biomass (µg <sup>-1</sup> g <sup>-1</sup> soil)	203.4 (20)	94.8 (10)	140.6 (15)	132.9 (20)	243.5 (20)	281.2 (20)
19. Urease (µg NH <sub>4</sub> <sup>+</sup> -N g <sup>-1</sup> soil h <sup>-1</sup> )	49.7 (8)	36.5 (8)	45.8 (8)	52.9 (8)	49.7 (8)	61.8 (8)
20. Acid Phosphatase (P-nitro phenol µg g <sup>-1</sup> soil h <sup>-1</sup> )	66.5 (4)	62.7 (2)	58.1 (2)	50.5 (2)	70.8 (2)	69.3 (4)
21. Alakaline Phosphatase (P-nitro phenol µg g <sup>-1</sup> soil h <sup>-1</sup> )	71.8 (4)	55.1 (2)	69.5 (2)	75.3 (2)	65.9 (2)	75.3 (4)
22. Dehydrogenase (µg g <sup>-1</sup> soil 24 h <sup>-1</sup> )	27.1 (8)	22.5 (8)	25.8 (8)	31.7 (8)	29.4 (8)	34.0 (8)

Figures in parentheses are SQL values of each parameter

**Table 3. Soil quality indices of Thotapalli irrigation project ayacut area**

Soil Pedon	SQI	RSQI	CLASS	Suitability for plant growth	Management options for sustainable crop production
Devarapalli	347	86.8	II	Suitable for plant growth with slight limitations	Green manuring, integrated nutrient management (INM), soil test based fertilizer management
Gujjangivalasa	271	67.8	IV	Suitable for plant growth with severe limitations	Addition of tank silt and judicious application of organic matter, INM, soil test based fertilizer management
Patikavalasa	285	71.3	III	Suitable for plant growth with moderate limitations	Green manuring, INM, soil test based fertilizer management
Gangada	290	72.5	III	Suitable for plant growth with moderate limitations	Provision of drainage, Green manuring, INM, soil test based fertilizer management
Amity	330	82.5	II	Suitable for plant growth with slight limitations	Green manuring and INM, soil test based fertilizer management
Maddivalasa	328	82.0	II	Suitable for plant growth with slight limitations	Provision of drainage, INM, soil test based fertilizer management

biomass and phosphatase activities. These soil characters needs intense soil management including addition of tank silt, judicious addition of organic matter, integrated nutrient management by following soil test data (Table 3). Soils of Patikivalasa and Gangada pedons had moderate limitations for plant growth, hence, require careful soil management practices. However, soils of Amity and Maddivalasa pedons had slight limitations for plant growth, hence, require moderate management such as integrated nutrient management and provision of drainage.

Soil quality evaluation of proposed ayacut area under Thotapalli irrigation project showed the range of RSQI values ranging from 67.8 to 86.8 and soil quality classes between IV and II. Lowest RSQI values of 67.8 in soils of Gujjangivalasa pedon corresponding to soil quality class of IV (severe limitations for plant growth) and highest RSQI value of 86.8 in soils of

Devarapalli pedon, corresponding to soil quality class II (slight limitations for plant growth). Other soils of Patikivalas pedon qualified for quality class of III with RSQI value of 71.3, soils of Gangada pedon in class III with RSQI value of 72.5, soils of Amity pedon in class II with RSQI value of 82.5 and soils of Maddivalasa pedon in class II with RSQI value of 82. The study has produced useful information about soil quality, with a scope to prepare soil and crop management plans for different soils of the Thotapalli irrigation project ayacut area for improving soil quality and sustainable productivity.

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## Research Note

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# ADOPTION BEHAVIOUR OF KRISHNA DISTRICT FARMERS TOWARDS SOIL HEALTH CARDS

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Soil is the basic component required for farming as soil provides nutrients to the plant. Testing of the soil answers for poor performance owing to the nutrient requirement of crops and solutions to overcome the same. Soil testing helps to recommend chemical fertilizers judiciously in combination with organic manures and biofertilizers and hence, balanced nutrition to crops. The scheme of Soil Health Card (SHC) is started and promoted by the Government of India from the year 2015 and has the provision for providing SHCs to the farmers once in three years for their agricultural land holding and contains crucial information on macro nutrients, micronutrients, secondary nutrients and physical parameters. Soil Health Cards provide information and calculate the use of major fertilizers and also make farmers aware of the absent nutrients, which could be added to balance the soil health.

Perception is defined for this study as – an individual's current assessment of SHC information and recommendations. High perception about SHC scheme can lead to the adoption of soil testing practice once in every three years by the farmers. Keeping the above aspects in view, the study was conducted during 2016-17 with the specific objectives of studying the personal, socio-economic characteristics of the farmers and to find out the perception and adoption levels of 209 farmers of Krishna district regarding the utility of SHCs information and recommendations.

The study was carried out in Krishna district of Andhra Pradesh purposively with *ex-post facto* research design by adopting random sampling procedure. The research study was conducted in seven mandals viz., Bapulapadu, Vuyyuru, Nuzividu, Penuganchiprolu, Nandigama, Vastavai and Jaggaiahpetta making up a sample of 209 SHC holders. The data was collected during 2016-17, through pre-tested interview schedule, which was coded, tabulated, analysed and interpreted. Data was measured by coding 3 = Agree; 2 = Undecided and 1 = Disagree for questions related to perception.

Nearly sixty percent (57.90%) of the farmers belonged to middle age, followed by old age (24.9%) and young (17.2%) age. More than half (53.6%) of the farmers were having high school education followed by Primary school (20.10%) and 15.8 % are uneducated, a small portion of them having intermediate/diploma (6.2%) and graduation (4.2%).

Almost all of the respondents (98.6%) considered farming as their occupation and most (86.6%) of the farmers belonged to forward caste followed by an equal proportion (6.7%) belonging to backward castes and SC/ST category of caste (6.7%). Nearly half (48.8%) of the farmers had greater than 20 years of farming experience followed by 11 years to 20 years (32.1%) and 19.1% were having less than 10 years of farming experience. It

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**Table 1. Farmers' perception to individual questions regarding Soil Health Cards information**

n=209

S. No.	Perception Question	Agree		Undecided		Disagree	
		f	%	f	%	f	%
1	The results given in SHC are reliable	130	62.2	78	37.3	1	0.5
2	The results given in SHC are useful to increase yields	115	55.0	91	43.5	3	1.4
3	The SHCs were delivered in time	109	52.2	42	20.1	58	27.8
4	The results given in SHC are useful to reduce cost of cultivation	110	52.6	93	44.5	6	2.9
5	SHC helps in selecting right crop suitable to the soils	119	56.9	79	37.8	11	5.3
6	Information provided in SHC helps to sustain soil fertility	139	66.5	65	31.1	5	2.4
7	Information provided in SHC is simple to understand	125	59.8	60	28.7	24	11.5
8	Information provided in SHC is simple to adopt	115	55.0	67	32.1	27	12.9
9	Micronutrients management is possible with SHC information	104	49.8	94	45	11	5.3
10	Problematic soils were easily diagnosed with SHC information	124	59.3	69	33	16	7.7
11	Reclamation of problematic soils is possible with SHC information	116	55.5	75	35.9	18	8.6

**Table 2. Farmers' adoption of fertilizers and micronutrients based on SHC recommendations**

n=209

S. No.	Adoption Question	Yes		No	
		f	%	f	%
1	Recommended organic manures as per SHC results are adopted	55	26.3	154	73.7
2	Recommended Nitrogen as per SHC results is adopted	96	45.9	113	54.1
3	Recommended Phosphorous as per SHC results is adopted	86	41.1	123	58.9
4	Recommended Potash as per SHC results is adopted	84	40.2	125	59.8
5	Recommended Micro nutrients as per SHC results is adopted	54	25.8	155	74.2
6	Recommended Gypsum/Lime as per SHC results is adopted	63	30.1	146	69.9

could be concluded that the majority of farmers had good farming experience. Two-fifths (41.1%) of the farmers had more than 3 ha of landholding followed by one ha to two ha (38.8%) and less than one ha (20.1%) landholding, respectively.

Nearly half (48.8%) of the respondents were having an annual income of above one lakh rupees followed by 27.3% having an annual income between Rs.50,000 and one lakh rupees and nearly one-fourth (23.9%) of respondents were having an annual income upto Rs.50,000. Nearly 2/3<sup>rd</sup> of the respondents belonged to medium (64.59%) category followed by high (18.66%) category and a scanty (16.75%) percentage of them fall under low category of source of information. About 90% of the respondents were having family size up to five members and 9.50% were having more than five members in their family. About 82.8% of the respondents belong to the nuclear family and 17.2% of the respondents were having Joint families. Regarding social participation, a great deal (88.5%) of the farmers did not have any kind of membership, while nearly 11.5% were holding membership in at least one organisation.

Most of the respondents (84.69%) were having high extension contact followed by medium (8.13%) and low (7.18%) extension contact respectively, with ANGRAU extension scientists including DAATTC/KVK scientists, Department of Agriculture Officials for want of timely agricultural advisories. This might be due to the fact that the immediate and long term needs of farmers would force them to have regular contact with scientists of DAATTC/KVK, ARS and extension workers. These results draw support from the findings of Tamboli *et al.* (2012).

On the whole, more than half (52.15%) of the respondents had a 'high level of perception' regarding soil health cards information, followed by medium (25.84%) level of perception information and 22.01% of the farmers had a low level of perception regarding SHCs information. The high level of perception of farmers about SHCs provided information might be due to their good extension contacts and as the majority of the farmers were having education upto high school level. The high level was also due to the fact that the Department of Agriculture (DoA) of the Govt. of A.P. is the major institute promoting testing of the soil for soil fertility management among farmers through SHC scheme. The Dept. of Agriculture officials test the soils of farmers and delivers Soil Health Cards free of cost to the farmers. The Agricultural Officers and MPEO's have to approach the farmers as it was compulsory to deliver the Soil Health Cards.

Overall, nearly half of respondents (46.4%) belonged to the 'medium adoption' category, while 39.2% belonged to 'low category of adoption' followed by 14.4 per cent of the respondents belonged to the 'high adoption' category. The level of adoption of recommended doses of major fertilizers (NPK) by observing the information provided in SHC was just above forty percent (45.9% for N; 41.1% for P and 40.2% for K) of the respondents as only the progressive farmers are aware of soil health management in Krishna district and they also witnessed the advantage of fertilizers application based on the SHC recommendation. These results were supported by the findings of Raghavendra and Theodore (2016) who studied SHC adoption behaviour of Bhuchetana project beneficiaries (farmers) in

Kurnool district.

A perusal at the data in the Table 1 indicate that 66.5 % of the farmers agreed with the statement 'Information provided in SHC helps to sustain soil fertility' followed by 'The results given in SHC are reliable' (62.2%), 'Information provided in SHC was simple to understand' (59.8%), Problematic soils were easily diagnosed with SHC' (59.3%), 'SHC helps in selecting right crop suitable to the soils' (56.5%), 'Reclamation of problematic soils with SHC' (55.5%), 'The results given in SHC are useful to increase yields' (52.6%), 'Information provided in SHC was simple to adopt' (55%), 'The SHC were given in time' (52.2%), 'The results given in SHC are useful to reduce cost of cultivation' (52.2%) and 'Micro nutrient management is possible with SHC' (49.8%). These results were similar with the findings of Patel and Chauhan (2012) who studied attitude of farmers towards SHCs in Anand District of Gujarat. The results are also in line with Raghavendra and Theodore (2015) study who reported knowledge level of farmers about SHC recommendations in Kurnool district.

Majority of the respondents (74.2%) have not-adopted recommended micronutrients as per SHC results, followed by recommended organic manures as per SHC results (73.7%), recommended gypsum/ lime as per SHC results (69.9%), recommended use of Potash as per SHC results (59.8%), recommended Phosphorous as per SHC results (58.9%) and recommended Nitrogen as per SHC results (54.1%)

(Table 2).

On the whole, the Krishna district farmers had high (52.15 %) to medium (25.84 %) perception regarding SHCs information. Overall, the farmers had medium (46.4%) to low (39.2 %) adoption concerning recommendation of fertilizers and micronutrients as specified in SHCs. More than 50% of the farmers did not adopt recommended fertilizers, micronutrients and organic manures specified in the SHCs, even though the farmers have medium to high perception regarding information in SHCs.

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## Research Note

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# AMELIORATION OF PHYSIOLOGICAL AND MORPHOLOGICAL SEED QUALITIES OF GREEN GRAM THROUGH PRE-SOWING SEED TREATMENT WITH BIOFERTILIZERS

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Greengram (*Vigna radiata* (L.) Wilczek) is the third most main pulse crop of India. Greengram being mainly grown as rain-fed crop, experiences drought at critical growth stages, highly sensitivity to abiotic stresses, susceptible to a wide range of diseases and insect pests leading to instability in the production of the pulse crop. Biofertilizers are microbial inoculants of selective microorganisms, can assist in improving soil fertility via accelerating organic nitrogen fixation from the atmosphere, solubilization of the insoluble nutrients already available in the soil, decomposing plant residues, stimulating plant growth and production. The seed inoculation with *Rhizobium*, phosphate solubilizing microorganism and VAM increase the nodulation, increase the phosphate availability through mineralization, renders inorganic phosphorus compound very much available to plants by secreting organic acids.

Good quality seed acts as a catalyst for realizing the potential of all other agricultural inputs. Establishment of seedling depends largely on the germination and vigour of seeds used for sowing. sound and proven technology, scientific management practices leads to quality seed production and higher productivity. With this information, an experiment was carried out to study the effect of pre-sowing bio-

inoculation of green gram seed with various bio-fertilizers on physiological and morphological seed quality characteristics.

Genetically pure and physically cleaned seed of green gram (*Vigna radiata* L.) cv. KM2 obtained from Tamilnadu Rice Research Institute, Aduthurai served as a basic material for this study conducted during *Kharif*, 2014. After manual cleaning and grading using BSS 8 X 8 sieves, seed was inoculated with biofertilizers like *Rhizobium*, Phosphate solubilizing bacteria and VAM @ 600 g ha<sup>-1</sup> of seeds either individually or in combinations as detailed: T<sub>0</sub>—Control (untreated dry seed); T<sub>1</sub>. *Rhizobium*; T<sub>2</sub>. Phosphate solubilizing bacteria; T<sub>3</sub>. VAM ; T<sub>4</sub> - *Rhizobium* + Phosphate solubilizing bacteria; T<sub>5</sub>. *Rhizobium* + VAM; T<sub>6</sub> – Phosphate solubilizing bacteria + VAM; T<sub>7</sub>. *Rhizobium* + Phosphate solubilizing bacteria + VAM. Pelleting was completed by using gum arabica @ 10% as adhesive. After pelleting, seeds were dried under shade separately to bring back to their original moisture content and used for sowing. The design adopted was Completely Randomized Design with seven(7) treatments along with dry seed (control) and replicated four times. The above-treated seeds along with control were tested for the following seed quality traits such as speed of germination (Maguire, 1962),

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Germination (%), ISTA, 2013). Accumulated Speed of Germination (Bradbeer, 1988), Mean daily germination (Scott *et al.*, 1984), Germination value (Djavanshir and Pourbeik, 1976), Emergence index (Scott *et al.*, 1984), Root length (cm), Shoot length (cm), Dry matter production (g 10 seedlings<sup>-1</sup>), Vigour index I (Abdul-Baki and Anderson, 1973) and Vigour index II (Abdul-Baki and Anderson, 1973). The data from the experiment was analyzed statistically adopting the technique described by Panse and Sukhatme (1985). Wherever necessary, the per cent values were converted to angular (arcsine) values, earlier than carrying out the statistical analysis.

Seed inoculation with biofertilizers *viz.*, *Rhizobium*, Phosphate solubilizing micro organism and VAM individually and in combination significantly influenced all the parameters under study except germination. All the pre-sowing seed treatments using *Rhizobium* either independently or in combination caused pronounced improvement in all the characters. The physiological seed quality parameters such as germination per cent (95%), speed of germination (15.56), accumulated speed of germination (55.75), mean daily germination (11.83), emergence index (3.01) and germination value (1840.83) were maximum upon triple inoculation of green gram seeds with biofertilizers (T<sub>7</sub>) followed by dual inoculation with *Rhizobium* and VAM (T<sub>5</sub>) (Table 1). The seedling characters such as root length (14.52 cm) and shoot length (21.07cm) used to be found high when compared to untreated seeds (10.72 cm and 15.47 cm, respectively, Table 2). Enhancement of the

metabolic activity in germinating seeds which resulted in early and higher germination per cent and other related germination indices, was due to the higher synthesis of growth-promoting hormones (IAA, GA<sub>3</sub> and related auxins) with the help of the microorganisms existing in biofertilizer such as PSB, N<sub>2</sub> fixers and VAM which in turn increases the synthesis of hydrolytic enzymes and with the help of these enzymes, storage compounds are converted to transferable ones (sucrose and glucose) and transferred to embryo (Sedghi *et al.*, 2008). The lowest value was observed in control (T<sub>0</sub>) might be due to the low osmotic potential of the medium which prevents the uptake of water essential for mobilization of nutrient required for germination.

Higher dry matter production (0.2163) and vigour index (3368.65 and 20.48, respectively) were also recorded in T<sub>7</sub> (triple inoculation with biofertilizers) in contrast to control (0.1600, 2183.06 and 13.34, respectively) and other treatments (Table 2). The higher seedling vigour in T<sub>7</sub> (triple inoculation with biofertilizers) might be due to the improved oxygen uptake and increased hydrolyzing enzymes activity and efficiency of metabolizing nutrients from the cotyledons to the embryonic axis which was reduced in control (Krishna *et al.*, 2008). During metabolism, the bacteria excrete organic acids (citric acid, malic acid, etc.,) as well, thus, helping nutrient uptake at a later stage of growth (Anand and Kamaraj, 2017). Moreover, root exudation and plasticity of root cell membrane may probably have influenced the growth of VAM through PSB inoculation.

**Table 1. Effect of pre-sowing seed treatment using various biofertilizers on physiological attributes of green gram seed**

Treatment	Speed of Germination	Germination (%)	Accumulated Speed of Germination	Mean daily germination	Emergence Index	Germination value
T <sub>0</sub>	13.16	83 (65.91)	46.89	10.33	2.75	1361.11
T <sub>1</sub>	15.09	91(72.90)	54.06	11.33	2.89	1722.16
T <sub>2</sub>	14.11	89(71.01)	50.49	11.08	2.85	1564.17
T <sub>3</sub>	14.67	89(71.01)	52.51	11.17	2.92	1638.33
T <sub>4</sub>	15.14	93(74.32)	54.21	11.58	2.97	1753.75
T <sub>5</sub>	15.22	93(75.07)	54.50	11.67	3.00	1776.11
T <sub>6</sub>	14.66	91(72.90)	52.43	11.33	2.95	1662.78
T <sub>7</sub>	15.56	95(76.70)	55.75	11.83	3.01	1840.83
Mean	14.70	91(72.90)	52.61	11.29	2.92	1664.91
SED	0.1262	0.9058 (0.8759)	0.4584	0.1235	0.0394	31.8101
CD (P=0.05)	0.2575	NS	0.9352	0.2519	0.0804	64.8925

**Note:** Figures in parentheses indicate angular arcsine values; NS-Non-Significant

**Table 2. Effect of pre-sowing seed treatment using various biofertilizers on seedling growth of green gram**

Treatment	Root length (cm)	Shoot length (cm)	Dry matter production (g 10 seedlings <sup>-1</sup> )	Seedling vigour Index I	Seedling vigour Index II
T <sub>0</sub>	10.72	15.47	0.1600	2183.06	13.34
T <sub>1</sub>	12.67	17.60	0.1833	2765.60	16.75
T <sub>2</sub>	12.35	16.87	0.1750	2590.72	15.52
T <sub>3</sub>	12.51	17.37	0.1827	2674.16	16.31
T <sub>4</sub>	12.88	18.57	0.1900	2913.34	17.61
T <sub>5</sub>	13.85	20.43	0.2080	3195.88	19.41
T <sub>6</sub>	13.11	18.13	0.1873	2833.37	16.98
T <sub>7</sub>	14.52	21.07	0.2163	3368.65	20.48
Mean	12.83	18.19	0.1878	2815.60	17.05
SED	0.2046	0.2997	0.0036	50.9954	0.3982
CD (P=0.05)	0.4173	0.6114	0.0074	104.0306	0.8123

The experiment revealed the promising effect of triple inoculation (Rhizobium, PSB and VAM fungus) of green gram seeds in improving the seed and seedling quality parameters. Pre-sowing seed treatment with biofertilizers improved the physiological and morphological seed and seedling quality traits. The effect was noticed to be more with all the treatments involving Rhizobium either independently or in combination of triple inoculation with Rhizobium, PSB and VAM was noticed to be the best for seed quality amelioration in green gram. Hence, triple inoculation could be recommended for farmers to increase their productivity.

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## Research Note

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# SUSTAINABILITY INDEX AS AN AID FOR DETERMINATION OF GENOTYPIC STABILITY IN RICE IN SOUTHERN ZONE OF ANDHRA PRADESH

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Rice (*Oryza sativa* L.) has a special significant position as a source of food. It is recognized as staple food for millions of people across the world and is expected to contribute towards food security in the world. With an alarming increase in the population throughout the world, the demand for rice will continue to increase in near future. Therefore, rice breeders across the world aim at increasing the grain yield of rice. The yield of improved inbred rice varieties in favourable conditions has reached a plateau. Hence, varietal adaptability to environmental fluctuations is gaining much importance especially in decreased farm holdings and resource-poor farmer conditions. This lays a heavy emphasis on developing technologies while keeping the sustainability of small farmer and his resources as the top priority. Information on genotype x environment interaction leads to successful evaluation of stable genotype, which could be used for general cultivation.

Yield is a complex quantitative character and is greatly influenced by environmental factors hence selection for superior genotype based on yield *per se* at a single location in a year may not be very effective. In subsistence agricultural system, yield *per se* may be less important than reaching a certain yield level (Fox *et al.*, 1997). Therefore, the development of varieties and hybrids with stable

performance is gaining ground to achieve sustainability in agricultural production. To achieve this, the first concept is to select the genotype with the smallest deviation from its production potential. The use of sustainability index in terms of varietal stability indicates the stability of a variety over the years. In rice, phenotypic stability has been studied by various workers (Nurmalina, 2008; Baber *et al.*, 2009; Koli and Prakash, 2013). However, the information on the use of sustainability index for assessment of varietal stability is lacking in rice. Hence, the investigation was undertaken to determine the sustainability index of eleven rice genotypes evaluated for four consecutive years (2013-2016) at Agricultural Research Station, Nellore in both *Kharif* and *Rabi* seasons consisting of six advanced lines (NLR 3415, NLR 3412, NLR 3408, NLR 3407, NLR 3410 and NLR 3414) and five released varieties (NLR 34449, NLR 33892, NLR 40024, NLR 30491 and NLR 3041). The experiment was carried out in a randomized complete block design (RCBD) and was replicated thrice. Twenty-five days old seedlings were transplanted in 12 m<sup>2</sup> plot using single seedling per hill at a spacing of 15cm×15 cm. Fertilizers were applied @ 120:60:40 kg ha<sup>-1</sup> N, P and K, respectively. Plant protection measures were taken as and when required. Single border rows were used to minimize

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the border effects. The grain yield ( $t\ ha^{-1}$ ) data was collected at 14% moisture level. The four years data on each variety was used for the estimation of sustainability index as per the formula mentioned by other researchers (Singh and Agarawal, 2003; Gangwar *et al.*, 2004 and Tuteja, 2006).

**Sustainability Index =**

$$\frac{\text{Average Performance} - \text{Standard Deviation}}{\text{Best performance}} \times 100$$

The values of sustainability index were divided into five groups viz., very low (up to 0- 45%), low (46%- 60 %), moderate (61%-75%), high (76%-90%) and very high (above 90%).

The mean yield performance over the years, best performance and the sustainability index values of the eleven genotypes were furnished in Table 1. The yield differences were found to be significant over the years, indicating genetic difference among the varieties studied. To draw a meaningful conclusion, the yield and sustainability index were classified into four groups as

Grain yield ( $t\ ha^{-1}$ ) Best performance	Sustainability Index	Remarks
High	High	Desirable
High	Low	Location specific
Low	High	Undesirable
Low	Low	Undesirable

The high mean performance regarding mean grain yield was recorded by NLR 3412 ( $7.04\ t\ ha^{-1}$ ) followed by NLR 3407 ( $6.96\ t\ ha^{-1}$ ) and NLR 40024 ( $6.56\ t\ ha^{-1}$ ). Even though the culture NLR 3412 has medium slender grain type it performed better with

respect the grain yield compared to NLR 3407 which is a long slender grain culture. Whereas, NLR 40024 is a medium slender grain type which ranks third among the genotypes. In general, high sustainability index indicates little inference of the environmental factors on the genotype (Verma *et al.*, 2013).

In the study, NLR 3414 recorded highest stability index of 85% followed by NLR 34449 which recorded about 83% indicating the stable performance of the two rice cultures over the years tested. NLR 3407 (BP: $8.46\ t\ ha^{-1}$  and SI:72%, respectively) and NLR 3412 (BP: $8.64\ t\ ha^{-1}$  and SI:67%) recorded highest grain yield coupled with high sustainability index, indicating the best performance of this variety and it could be taken as the indication of proximity between the best performance and the average performance over the years. This explains the good stable performance of these cultures over the years. The genotypes viz., NLR 3415 (BP: $7.41\ t\ ha^{-1}$  and SI:79%), NLR 3410 (BP: $7.38\ t\ ha^{-1}$  and SI:73%) and NLR 40024 (BP: $7.88\ t\ ha^{-1}$  and SI:72%) also recorded high mean grain yield as well as sustainability index indicating the stable performance of the genotypes over the years.

The cultures NLR 30491 and NLR 3408 although recorded high yield of  $8.01\ t\ ha^{-1}$  and  $8.45\ t\ ha^{-1}$ , respectively, its sustainability index was moderate indicating its inconsistent performance over the years. These cultures gave the highest performance during the years 2013-14 and 2014-15, thus, it was adaptable to that specific situation only. The yield performance and sustainability index of remaining genotypes were moderate to average indicating their unstable performance over the years. Rice cultures viz., NLR 3410, NLR 40024, NLR 3415 and NLR 3412

**Table 1. Estimation of sustainability index (%) for eleven genotypes of rice**

S. No	Genotype	Grain yield (t ha <sup>-1</sup> )					Standard deviation (ó)	Best performance (t ha <sup>-1</sup> )	Sustainability Index	
		2016-2017	2015-2016	2014-2015	2013-2014	Mean			(%)	Score
1	NLR 3415	5.79	6.63	7.42	6.37	6.55	0.67	7.42	79	H
2	NLR 3412	6.40	6.39	8.47	6.92	7.04	0.98	8.47	72	H
3	NLR 3408	6.41	3.98	8.46	6.47	6.33	1.84	8.46	53	M
4	NLR 3410	5.79	5.34	7.38	6.51	6.26	0.89	7.38	73	H
5	NLR 3414	5.89	6.16	7.00	6.94	6.50	0.56	7.00	85	VH
6	NLR 3407	5.97	6.39	8.65	6.82	6.96	1.18	8.65	67	H
7	NLR 34449	4.88	5.42	5.55	6.00	5.46	0.46	6.00	83	VH
8	NLR 40024	6.38	5.73	7.88	6.27	6.56	0.92	7.88	72	H
9	NLR 30491	5.16	3.85	7.19	8.01	6.05	1.90	8.01	52	M
10	NLR 33892	6.33	3.35	5.98	4.73	5.10	1.35	6.33	59	M
11	NLR 3041	4.45	2.85	2.69	4.24	3.56	0.91	4.45	59	M

**Note :** VH: Very High; H: High; M: Medium

<b>Sustainability Index</b>	Very high	NLR 3414	NLR 34449	
	High	NLR 3412 NLR 3407 NLR 40024 NLR 3415 NLR 3410		
	Medium	NLR 3408 NLR 30491	NLR 3041 NLR 33892	
	Low			
		High	Medium	Low
		<b>Grain yield</b>		

**Fig. 1. Grouping of genotypes as per their best performance and sustainability indices**

were found to be most suitable and is suggested that these genotypes can be used as parents in the future breeding programme for evolving genotypes with high sustainability of grain yield.

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## Research Note

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# IMPACT OF URBAN COMPOST USAGE ON SOIL PROPERTIES

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Efficient utilization of energy and natural resources have generated an interest in the utilization of organic wastes rather than disposal to landfills. Composting of urban waste or municipal solid waste is seen as a method of diverting organic waste materials from landfills creating a product at relatively low cost, which is suitable for agricultural purposes. In this context, an attempt was made to explore the prospects of urban compost utilization in agriculture by studying its effect on soil physico-chemical properties and nutrient status.

A laboratory soil column study was conducted as described by Rambabu Naik *et al.* (2017) aiming at the evaluation of the soil application of urban compost collected from 'Integrated Municipal Solid Waste Management Project' in Jawaharnagar, Telangana State during 2012-13. The treatments imposed were : T<sub>1</sub> - Control, T<sub>2</sub> - Urban compost @ 20 t ha<sup>-1</sup>, T<sub>3</sub> - Urban compost @ 40 t ha<sup>-1</sup>, T<sub>4</sub> - T<sub>2</sub> + FYM @ 10 t ha<sup>-1</sup>, T<sub>5</sub> - T<sub>3</sub> + FYM @ 10 t ha<sup>-1</sup>, T<sub>6</sub> - T<sub>2</sub> + Humic acid @ 20 kg ha<sup>-1</sup>, T<sub>7</sub> - T<sub>3</sub> + Humic acid @ 20 kg ha<sup>-1</sup>, T<sub>8</sub> - T<sub>2</sub> + Biochar @ 5 t ha<sup>-1</sup> and T<sub>9</sub> - T<sub>3</sub> + Biochar @ 5 t ha<sup>-1</sup>, mixing the amendments only in the top 0-15cm soil in the column. The urban compost, FYM, humic acid, biochar and soil samples were analysed as per standard procedures (Tandon, 1999). Soil pH and electrical conductivity (EC) is 7.76 and 0.83 dS m<sup>-1</sup>, respectively and organic carbon (OC) was 0.56%. The soil contained 164 kg ha<sup>-1</sup>, 20.8 kg ha<sup>-1</sup> and 453 kg ha<sup>-1</sup> of available N, P and K. The urban compost used was neutral in reaction (pH

of 7.37), non-saline (EC 0.56 dS m<sup>-1</sup>) with OC of 23.46%. Total N, P and K contents were 1.2 %, 1.2% and 0.45%, respectively. FYM had pH of 6.65, EC of 1.12 dS m<sup>-1</sup>, OC of 17.3%, and total N, P, K of 0.85%, 0.27% and 0.46 %, respectively. Biochar and humic acid had pH and EC (dS m<sup>-1</sup>) of 8.2 and 1.28, 4.87 and 0.034, respectively. Cation exchange capacity (c mol (p) kg<sup>-1</sup>) and total negative charges estimated were 49 and 2.6, 86 and 2.98 in biochar and humic acid, respectively. Impact of urban compost on soil properties was studied, by analysing the residual soil *i.e.*, left after ninth leaching event at 0-15 cm, 15 cm-30 cm and 30 cm-45 cm depth for pH, EC, organic carbon, available nitrogen, phosphorus and potassium (Table 1).

Application of urban compost to the soil of 0-15 cm increased pH of the layer (Table 1). Such a trend of increase in pH was reported by Jalil Ahmed Khan *et al.* (2007) in Lahore, Pakistan with the application of urban compost @ 5 t ha<sup>-1</sup>. When urban compost @ 20 t ha<sup>-1</sup> integrated with FYM there was a significant reduction in soil pH to 7.07. Though biochar recorded an increase in the soil pH, to 7.29 and 7.32, the increase was non-significant. While, in 15-30 cm and 30-45 cm layers there was no significant effect on pH with the application of urban compost either alone or in combination with FYM/ humic acid/ biochar. The electrical conductivity of the control (soil alone) was 0.20 dS m<sup>-1</sup>, which was significantly increased to 0.26 dS m<sup>-1</sup> with the application of urban compost either alone @ 40 t ha<sup>-1</sup> or in a combination of FYM/

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biochar. Broadly, EC was higher in the surface layer and decreased with depth. The organic carbon content of the soil was found to decrease with depth and was not affected significantly by the treatments. This could be due to higher organic carbon additions through the organic sources to the surface layer. Similar results were reported by Jalil Ahmed Khan *et al.* (2007) and Gabriela Civeira (2010).

Nutrient status in terms of available N, P and K was significantly affected by the treatments studied (Table 1). Nitrogen values recorded in 0-15 cm, in all the treatments receiving urban compost @20 or 40 t ha<sup>-1</sup> alone and each of their combination with other organics were at par. A significant difference was found in N availability at 15-30 cm depth between the control and the treatments receiving organics. Available N at 30-45 cm depth was significantly higher when urban compost @ 40 t ha<sup>-1</sup> was applied alone or on conjunctive use with FYM at both levels of urban compost. Significantly lower available N of 123 kg ha<sup>-1</sup> and 125 kg ha<sup>-1</sup> (in 15-30 cm and 30-45cm) was observed with the combination of humic acid and urban compost @ 20 t ha<sup>-1</sup>. While, urban compost at a lower level of 20 t ha<sup>-1</sup> either alone or in combination was found to record significantly lower available N. Specifically it was true when the integration was with humic acid or biochar which might be due to their high CEC and binding with NH<sub>4</sub><sup>+</sup> making it temporarily unavailable. Data on available P showed that control soil recorded significantly lower available P in all the soil depths among all the treatments. Available P in the surface layer in the control was 17.9 kg ha<sup>-1</sup>, was on par with the treatment receiving urban compost @20 t ha<sup>-1</sup>, which in turn was on par with urban compost @ 40 t ha<sup>-1</sup>. Highest available P of 53.5 kg ha<sup>-1</sup> was recorded with the application of urban compost @ 40 t ha<sup>-1</sup> and humic acid @20 kg ha<sup>-1</sup>. In 15-30 cm layer, the available P in the control showed a higher value than surface layer, which could be due to the leaching loss of phosphates because of

negative adsorption of phosphates to the negatively charged soil colloids. While, the soil when treated with urban compost either alone or in combination with FYM, humic acid or biochar, the available P in 15-30 cm layer was lower than the surface layer due to the adsorption of phosphate with a bridging cation and binding in the surface. However, with urban compost at a higher level when applied along with biochar, the available P in the second layer was marginally higher. Similarly, in the third layer, urban compost @ 40 t ha<sup>-1</sup> together with biochar when applied to soil showed a significantly higher available P of 51.2 kg ha<sup>-1</sup>. This could be justified with the reports of Giusquiani *et al.* (1988). They found increased soil P availability with the addition of Municipal Solid Waste compost and decreased soil P retention with increasing compost application which was attributed to competition between organic ligands and phosphate for sites on metallic oxides as well as the formation of phosphohumic complexes which could increase P mobility and result in higher P in subsoil layers. Similar reports of high soil P with MSW compost were given by Orhan Yuksel (2004). Available K was significantly influenced by the treatments. Broadly, the treatments receiving humic acid or biochar at both the levels of urban compost recorded lower available K. This could be because of K<sup>+</sup> on the adsorption sites of humic acid and biochar. The results were in agreement with the findings of Soheil Roghanian *et al.* (2012).

The option to utilize urban compost in agricultural soils instead of taking to landfill as it contained organic carbon and more than one essential nutrient, can be considered after confirmation studies in the field with crops. High available soil P recorded on the addition of urban compost alone and also in combination with FYM/biochar/ humic acid suggests its application for low P soils in particular. The surface chemistry and adsorption studies will give an insight into the integrated use of urban compost for improved soil nutrient status.

**Table 1. Soil properties as influenced by Urban compost and its conjunctive use with FYM, Humic acid and Biochar**

Treat- ment	pH			EC (dS m <sup>-1</sup> )			OC(%)			N (kg ha <sup>-1</sup> )			P (kg ha <sup>-1</sup> )			K (kg ha <sup>-1</sup> )		
	0-15*	15-30*	30-45*	0-15	15-30	30-45	0-15	15-30	30-45	0-15	15-30	30-45	0-15	15-30	30-45	0-15	15-30	30-45
T <sub>1</sub>	7.22	7.27	7.12	0.20	0.21	0.21	0.55	0.53	0.53	157	148	148	17.9	23.6	18.3	514	579	652
T <sub>2</sub>	7.23	7.23	7.01	0.23	0.22	0.22	0.60	0.57	0.51	169	168	161	22.3	22.9	22.4	540	594	670
T <sub>3</sub>	7.29	7.26	7.06	0.26	0.23	0.27	0.62	0.57	0.55	177	173	172	26.6	27.5	23.9	557	627	650
T <sub>4</sub>	7.07	7.00	7.03	0.24	0.21	0.19	0.66	0.50	0.50	179	180	179	38.8	32.1	37.1	545	657	661
T <sub>5</sub>	7.18	7.14	7.14	0.26	0.23	0.20	0.65	0.51	0.51	181	135	193	52.4	37.7	37.3	594	693	654
T <sub>6</sub>	7.14	7.04	7.01	0.20	0.22	0.20	0.65	0.62	0.55	168	123	125	49.3	31.3	36.2	458	526	315
T <sub>7</sub>	7.16	7.09	7.05	0.19	0.20	0.21	0.67	0.58	0.57	177	176	147	53.5	34.7	37.4	415	543	477
T <sub>8</sub>	7.29	7.23	7.15	0.25	0.24	0.21	0.59	0.57	0.58	162	137	141	44.7	37.0	39.3	474	477	424
T <sub>9</sub>	7.32	7.19	7.20	0.26	0.22	0.21	0.61	0.58	0.58	171	129	151	42.6	43.0	51.2	422	530	473
Mean	7.21	7.16	7.09	0.23	0.22	0.21	0.62	0.56	0.54	171.2	152.1	157.4	38.7	32.2	33.7	502	581	553
CD(5%)	0.135	NS	NS	0.046	NS	0.032	NS	NS	NS	13.6	14.4	13.2	7.8	4.1	7.51	76	53	139
SE(m)	0.045	0.066	0.099	0.015	0.011	0.011	0.034	0.042	0.038	4.56	4.81	4.43	2.6	1.4	2.5	25	17	46

\*Depth in cm

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## Research Note

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# PERCEPTION OF FARMERS TOWARDS FARMERS' FAIR ORGANIZED IN GBPUA&T, PANTNAGAR

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In Uttarakhand, 'Farmers' Fair' was organized by GovindBallabh Pant University of Agriculture & Technology, Pantnagar, twice in a year mainly to benefit the farming community. This is also called "KrishiKumbh" as its main purpose is to uplift the rural population by displaying valuable products, innovative ideas and techniques to achieve its objectives in a most efficient manner (Sharma and Hasan, 2012). Various firms selling Chemical Fertilizers, Micro nutrients and Bio-fertilizers, Tractors, Farm Machinery and Tools Pumps, Motors, Sprayer Seed, Planting Materials Pesticides, Bio-pesticides, Veterinary Medicines, Animal Feed, Additives Food & Beverages Herbal Products firms also demonstrate their products, organize exhibitions in the farmers' fair. Publication Houses, Banks and Financial Institutions, Government/Non-Government organizations, Academic and Research Institutions are also part of Farmers fair. Thus, we can say that Farmer's fair is a single window approach practiced by the University.

Perception towards farmers' fair has been reported as an important factor in adoption of new technologies and ideas. The study was conducted during 2017-18 with the objectives of (1) Studying the socio-economic condition of the farmers. (2) To study the perception of Farmers towards farmers' fair activities.

A total of 100 farmers who visited farmers' fair were selected through purposive sampling method. The farmers were interviewed during farmers' Fair organized by GBPUA&T, Pantnagar. Group discussions were also organized to study the usefulness of farmer's fair. Independent variables were age, caste, occupation, income and Perception of farmers towards farmers' fair was taken as the dependent variable. For measuring the perception of farmers towards farmers' fair, three point scale was used. Responses to each statement was recorded as Agree, Undecided, Disagree. Interview schedule and perception scale were modified after pre testing on non sample.

### Socio-economic characteristics of farmers

More than half of the farmers (65%) fall in middle age group followed by old age group (25%) and young age (10%). Majority of the respondents (43%) were from Other Backward Castes category followed by Schedule Caste and Schedule Tribe categories (42%) and OC (15%), respectively.

More than half of farmers (54%) were engaged in farming as main occupation followed by Agriculture and Dairying (40%). Only 6% farmers were engaged in Service sector. Majority of respondents (58%) belonged to high income group followed by middle income group (29%) and low income group (13%).

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**Information sources about Farmers fair:** Majority of respondents (88%) reported that they get the farmers' fair information from newspaper followed by Mobile phone (78%) and Television (15%).

**Participation of farmers in the activities of Farmers' fair:** Majority of respondents (98 %) reported that they have participated in 'Kishan Gosthi' followed by 'Kavi Sammelan' (89%) and cultural programme (36%) and quiz competition (21%). Thus, it can be inferred that farmers were more interested in 'Kishan Gosthi programme' held in Gandhi Hall.

#### **Perception of Farmers towards Farmers' fair**

The operational definition of perception refers to the degree of agreement, indecisiveness or disagreement towards 'Farmers Fair' concept and activities as responded by the farmers.

It is recorded that 56% of the farmers agreed with the statement 'My Knowledge regarding improved scientific technology has been increased due to farmers' fair followed by 'My economic condition has improved due to advised obtained from farmer's fair' (49%), 'To reap the fruits of innovations farmers fair should be organized every year' (69%), 'Farmers fair has played a significant role in increasing per unit production of major crop of Uttarakhand' (71%), "Farmers fair has helped us to get loan from the bank" (60%), "Farmers fair is well through practical approach for boosting the agricultural production" (54%) and "Farmers fair has helped farmers to get improved seeds, fertilizers and pesticides in time" (69%). The agree response is anticipated, because various private and Government firms demonstrate various new technologies related to farming. *Kisan Gosthi* and farmers meetings are also organized in farmers' fair. Thus, Farmers knowledge was enhanced

due to above programmes organized in farmers fair. Progressive farmers apply all demonstrated technologies in their field and get benefit from the technologies. Farmers get knowledge, information and education from the farmers' fair. Various banks such as PNB, SBI, HDFC, UCO and Nainital Banks provide knowledge regarding credit facilities available for farmers. Farmers can practically use the new equipments related to farming and animal husbandry in farmers fair and subsequently they can buy the products or technology on loan. Also, farmers are getting benefits from the farmers fair through farmer-scientist interaction, demonstration of new technologies, exhibition etc.

#### **Overall perception of farmers towards 'Farmers Fair' activities**

Majority (53%) of the respondents had high level of perception regarding Farmers' Fair, followed by medium level (35%) of perception and 12% of them had low level of perception regarding Farmers' Fair. The high level of perception of farmers Farmers' Fair might be due to the demonstration of new technologies, seeds, high yielding varieties and also due to the fact that majority of the farmers were getting benefits from the farmers' fair. The high level of perception was also due to the fact that GBPUA&T, Pantnagar is organizing Farmers' Fair twice in every year so that farmers get benefits from the newly innovated technologies in every year.

On the basis of above findings, it can be concluded that the respondents had medium (35%) to high perception level (53%) regarding Farmers Fair. This is an ICTs era (Sharma and Singh, 2018). Thus, there is an urgent need to modernize farmers fair. In Uttarakhand state, many farmers were unaware about

**Table 1. Perception of Farmers towards Farmers Fair concept and activities**

**N=100**

S. No.	Category	Agree		Undecided		Disagree	
		f	%	f	%	f	%
1.	My knowledge regarding improved scientific technology has been increased due to 'Farmers Fair' discussions	56	56	35	35	9	9
2.	My economic condition has improved due to advisories obtained from 'Farmers Fair'	49	49	41	41	10	10
3.	To reap the fruits of innovations 'Farmers Fair' should be organized every year	69	69	31	31	–	–
4.	'Farmers Fair' has played a significant role in increasing per unit production of major crop of Uttarakhand	71	71	20	20	9	9
5.	'Farmers Fair' has helped us to get loan from the bank	60	60	34	34	6	6
6.	'Farmers Fair' is well through practical approach for boosting the agricultural production	54	54	46	46	–	–
7.	'Farmers Fair' has helped us procure improved varieties of seeds, fertilizers and pesticides in time	69	69	31	31	–	–

hill-specific technologies. Thus, there is an urgent need to provide hill-specific information to farming community through Farmers fair.

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