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EFFECT OF TILLAGE AND METHODS OF FERTILIZER APPLICATION ON YIELD AND ECONOMICS OF HORSEGRAM

S.D.RAUT, U.V. MAHADKAR, S.S.NITAVE, V.A. RAJEMAHADIK AND G.B. SHENDAGE
Department of Agronomy, College of Agriculture,
Dr. B. S. Konkan *Krishi Vidyapeeth*, Dapoli, Ratnagiri -415 712

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ABSTRACT

An experiment was conducted at Agronomy Farm of Dr. B.S.K.K.V., Dapoli during *rabi* season 2012-2013 to study the effort of tillage and methods of fertilizer application on yield and economics of horsegram.The field experiment was laid out in a split plot design with three replications. The main plot treatments comprised four tillage conditions - Minimum tillage with drilling(S_1), Conventional tillage with drilling (S_2), Conventional tillage with dibbling (S_3) and Zero tillage (dibbling) (S_4) and sub plot treatments comprised four methods of fertilizer application absolute control (F_1), 100% RDF (Soil application) (F_2), 25% RDF (Foliar application) (F_3) and 50% RDF (Foliar application) (F_4). The results revealed that tillage treatments conventional tillage with dibbling and conventional tillage with drillingwas found significantly superior to rest of the treatments but at par with each other and recorded higher grain and straw yield, total cost of cultivation, gross income, net returns and B:C ratio obtained from different treatments. Among the methods of fertilizer application *viz.,* 100% RDF (Soil application) and 50% RDF (Foliar application) were found significantly superior over remaining treatments but statistically identical with each other in respect of seed yield, total cost of cultivation, gross income, net returns and B:C ratio. It can be concluded that horsegram crop should be grown in conventional tillage condition by dibbling method along with soil application of 100 per cent recommended dose of fertilizer at sowing time, to obtain higher grain and straw yield, net returns and B:C ratio.

INTRODUCTION

In *Konkan* region of Maharashtra, horsegram is mainly grown in *Rabi* season in rice field after harvest of *Kharif* rice both on residual moisture as well as under irrigation. Horsegram is one of under-exploited grain legumes, which has great potential in sustainable agriculture. Hence, there is scope to enhance the productivity of horsegram by proper agronomic practices such as tillage and fertilizer management. Tillage is an important aspect in crop production, as tillage accounts 30 per cent of cost of production. Considering the high cost of tillage, there is a need to plan suitable tillage system for profitable crop production. Fertilizers are applied by different methods to make the nutrients easily available to crops, to reduce the fertilizer losses and for easy application. Basal dose of fertilizer application has a significant importance in the vegetative growth and in maintain yield characteristics. For optimum growth of the plant, the concentration of nutrients in the soil solution should be maintained at the critical value below which the growth of plant decreased (Mengel and Kirby,1982).The present investigation was, therefore, undertaken to study the effect of different tillage conditions and effect of different methods of fertilizer application on yield and economics of horsegram.

MATERIAL AND METHODS

Field experiment was conducted in Agronomy Department Farm, College of Agriculture, Dapoli, Ratnagiri district during *rabi* season 2012-2013. The field experiment was laid out in a split plot design. The main plot treatments comprised four tillage conditions - Minimum tillage with drilling(S_1), Conventional tillage with drilling (S_2), Conventional tillage with dibbling (S_3) and Zero tillage (dibbling) (S_4).

E-mail: santoshraut0227@gmail.com

Sub plot treatments comprised four methods of fertilizer application- absolute control (F_1), 100% RDF (Soil application) (F_2), 25% RDF (Foliar application) (F_3) and 50% RDF (Foliar application) (F_4). Thus, there were in all sixteen treatment combinations replicated thrice. The gross plot size was 4.0 m x 3.0 m and net plot size was 3.6 m x 2.4 m, respectively. The soil of the experimental plot was sandy clay loam in texture, medium in available nitrogen (294.2 kg ha^{-1}), low in phosphorus (13.2 kg ha^{-1}), medium in available potassium (164.6 kg ha^{-1}), medium in organic carbon (0.96%) and slightly acidic in reaction. The preparatory tillage operations carried out as per the main treatments. Sowing of horsegram was done on 5^{th} December, 2012 by using the seed rate of 20 kg ha^{-1}. The sowing of treated seeds was done as per treatments. The quantity of fertilizer dose for each plot was calculated and applied through soil and foliar application as per the treatments.100% RDF was applied through soil as basal dose. Foliar applications of fertilizers were started from 24 days after sowing. Total eleven spays were applied at the interval of four days during the experimentation. Crop was harvested at physiological maturity and data on grain and straw yield was recorded. The economics of growing horsegram was worked out by considering the prevailing market rates for different inputs and produces. The gross returns (Rs.ha^{-1}) was worked out on the basis of grain and straw yield of horse gram for each treatment, considering the prices prevailing in the market during the year 2013.The cost of cultivation (Rs.ha^{-1}) of each treatment was calculated considering the current charges of agricultural operations and market prices of inputs. The net returns (Rs.ha^{-1}) for individual treatment were worked out by deducting the total cost of cultivation of each treatment from gross returns of respective treatment. The benefit - cost ratio of each treatment was calculated by dividing the gross returns by the cost of cultivation of respective treatment.

RESULTS AND DISCUSSION

Effect of tillage conditions on grain and straw yield (q ha^{-1})

Data furnished in Table 1 reveals that various tillage conditions significantly influenced the grain yield and straw yield (q ha^{-1}) of horsegram. The tillage treatment S_3 recorded higher grain yield (9.72 q ha^{-1}) and straw yield (19.99 q ha^{-1}) followed by treatment S_2 which was at par with each other and significantly superior over S_1 and S_4 in that descending order of significance. However, significantly the lowest grain and straw yield was recorded in treatment S_4 *i.e.* zero tillage over rest of treatment and similar results have been reported by Chendge(2012).

Effect of methods of fertilizer application on grain and straw yield (q ha^{-1})

It was revealed from the data presented in Table 1 that the method of fertilizer application F_2 recorded maximum grain yield (10.05 q ha^{-1}) and straw yield (20.04 q ha^{-1}) followed by treatment F_4 which were at par with each other and significantly superior over all remaining treatments *viz.*, F_3 and F_1. Treatment F_3 has also recorded significantly higher grain and straw yield over F_1. However, F_1 recorded significantly lowest grain and straw yield (q ha-^{1}).These results

Table1. Effect of tillage conditions and fertilizer application methods on grain and straw yield and economics of horsegram as influenced by different treatments

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Total cost (Rs. ha^{-1})	Gross income (Rs. ha^{-1})	Net income (Rs. ha^{-1})	B:C ratio
Tillage conditions						
S_1- Minimum tillage	7.05	15.38	28378.97	37916.53	9537.56	1.31
S_2-Conventional tillage with drilling	9.11	18.56	32391.09	48789.23	16398.14	1.47
S_3- Conventional tillage dibbling	9.72	19.99	33842.12	52083.40	18241.29	1.52
S_{4-} Zero tillage	5.63	12.79	25609.07	30405.09	4796.03	1.17
F. test	Significant	Significant	-	-	-	-
S.Em. ±	0.28	0.50	-	-	-	-
C.D. at 5%	0.96	1.74	-	-	-	-
Methods of fertilizer application						
F_1- Control	5.18	11.80	24471.62	27939.71	3468.09	1.12
F_2-100% RDF (Soil)	10.05	20.04	32675.46	53732.76	21057.30	1.62
F_3- 25% RDF(Foliar)	7.39	15.55	30543.32	39679.32	9136.00	1.28
F_4-50% RDF (Foliar)	8.89	19.33	32530.84	47842.47	15311.62	1.46
F. test	Significant	Significant	-	-	-	-
S.Em. ±	0.46	0.78	-	-	-	-
C.D. at 5%	1.33	2.29	-	-	-	-
Interaction effect						
F. test	N.S	N.S	-	-	-	-
S.Em. ±	0.91	1.57	-	-	-	-
C.D. at 5%	-	-	-	-	-	=
General mean	7.88	16.68	-	-	-	-

Selling price: Grain- Rs.5000 q ha^{-1} and Straw- Rs.175 q ha^{-1}

are in line with those reported by Raghuwanshi *et al.* (1993) and Muhammad Hamayun *et al.* (2011).

Effect of tillage on economics of horsegram

The total cost, gross income, net returns and B: C ratio obtained from different treatments is presented in Table 1. Various tillage conditions significantly increased the total cost, gross income, net returns and benefit- cost ratio. Among the different tillage conditions treatment S_3 (conventional tillage with dibbling) gave significantly higher cost of cultivation (Rs.33842 ha^{-1})followed by treatment S_2 which was at par with each other and significantly superior to rest of the treatments *viz.*, S_1 (Rs.38417 ha^{-1}) and S_4 (Rs.25609 ha^{-1}). Treatment S_1 was found significantly superior to treatment S_4. Treatment S_4 recorded significantly lower cost of cultivation. Similar trends followed in respect of gross income, net returns and B:C ratio. The treatment S_3 recorded significantly more gross returns (Rs.52083 ha^{-1}) and net returns (Rs.36613 ha^{-1}) over the rest of the treatments except S_2 which was at par to former treatment. It was followed by treatment S_1 (Table 1). However, treatment S_4 recorded significantly the lowest gross income and net income, respectively. B:C ratio was found maximum with the treatment S_2 (1.52) followed by treatment S_2 (1.47), S_1 (1.31) and the lowest B: C ratio was recorded by treatment S_4 (1.17) *i.e.*, zero tillage. The increased net returns and benefit- cost ratio were mainly due to increased grain yield and straw yield under treatment S_3 (conventional tillage with dibbling) which was significantly superior over S_4 (zero tillage) treatment. Similar results were also reported by Billore *et al.*(2009) and Chendge (2012).

Effect of methods of fertilizer application on economics of horsegram

Data furnished in Table 1 revealed that total cost of cultivation, gross income, net returns and benefit-cost ratio significantly influenced due to different methods of fertilizer application. Cost of cultivation was found significantly maximum with treatment F_2 (Rs. 32675 ha^{-1}) followed by treatments F_4 (Rs.32530 ha^{-1}) which was at par with each other but found significantly superior over F_3 (Rs.30543 ha^{-1}) and F_1 (Rs.24471 ha^{-1}). Treatment F_1 recorded significantly the lowest cost of cultivation over rest of the treatments. Similar trends followed in case of gross income, net return and benefit to cost ratio. Treatment F_2 gave the highest gross returns(Rs.53732 ha^{-1}) as well as net returns(Rs.21057 ha^{-1}) followed by treatment F_4 which was at par with each other but found significantly superior over rest of treatments. *Vise* F_3 and F_1, respectively. However, F_1 recorded significantly lowest gross income as well as net returns over rest of treatment. The treatment F_2 recorded the highest B: C ratio(1.62) followed by treatment F_4(1.46), F_3 (1.28) and the lowest B: C ratio was recorded by treatment F_1 (1.12). This is might be due increasing yield in above treatment. The above observations are in accordance with Sagare *et al.*(1986).

CONCLUSION

From the results of the present investigation, it can be concluded that horsegram crop should be grown in conventional tillage condition by dibbling method along with soil application of 100 per cent recommended dose of fertilizer at sowing time, to obtain higher yield, net returns and B: C ratio.

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GENETIC DIVERSITY BASED ON CLUSTER AND PRINCIPAL COMPONENT ANALYSIS FOR YIELD, YIELD COMPONENTS AND QUALITY TRAITS IN PEANUT STEM NECROSIS TOLERANT GROUNDNUT (*Arachis hypogaea* L.) GENOTYPES

P. DHARANI NIVEDITHA, M. SUDHARANI, A. PRASANNA RAJESH, P.J. NIRMALA
Department of Genetics and Plant Breeding, Agricultural College, Acharya N.G Ranga Agricultural University, Mahanandi- 518502

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ABSTRACT

The present research work was carried out to excavate diverse parents and to determine selection parameters for Peanut Stem Necrosis tolerance in groundnut. It was carried out to estimate genetic diversity by principal component analysis(PCA) for fifteen yield, yield components and quality traits in fifty groundnut genotypes at Agricultural Research Station, Kadiri during *kharif,* 2015. First five principal components (PC1, PC2, PC3, PC4 and PC5) have Eigen values greater than one and accounted for 71.46 per cent of total variability and account with values of 23.39%, 18.20%, 12.22%, 10.01% and 7.64%, respectively. PC1 has positive association with haulm yield plant^{-1}, shelling per cent, kernel yield, number of filled pods plant^{-1}, oil content, SCMR at 60 DAS, pod yield plant^{-1}, total pods plant^{-1}, days to 50 per cent flowering and protein content. PC2 is positively associated with harvest index, days to 50 per cent flowering, shelling per cent and plant height.

INTRODUCTION

Groundnut *(Arachis hypogaea L.)* is an important oil and protein producing legume crop. It belongs to family Fabaceae and sub family Faboideae (Janila *et al.,* 2016). India is the largest grower (44.46 lakh ha) and second producer (71.81 lakh tones) after China with an average yield of 1615 kg ha^{-1} (Annual report 2014-15, Directorate of Groundnut Reasearch, Junagadh). Andhra Pradesh occupies third place in production in India. The productivity of Andhra Pradesh is very low against Indian productivity of 1615 kg ha^{-1} and world productivity of 1676 kg ha^{-1}. The low productivity can be attributed to factors *viz.,* erratic rainfall, incidence of pests and diseases in addition to cultivation of low yielding varieties. Many biotic stresses are limiting the productivity of groundnut and peanut stem necrosis is an important one among them. It was initially observed as an epidemic resulting in complete death of young groundnut plants during the *kharif*, 2000 in Anantapur district of Andhra Pradesh, where the crop was grown in 0.7 million hectares. The disease affected nearly 2.25 lakh ha and the crop losses were estimated to exceed three billion rupees (Reddy *et al.*, 2002). Keeping these in view, high yielding groundnut varieties with improved performance are being developed.

Enormous breeding practices resulted in reducing genetic diversity of elite groundnut germplasm and reveals the problems associated with biotic stresses, abiotic stresses and adaptation. Information on genetic diversity in elite germplasm is essential to identify the promising lines for trait of interest (Ali *et al.*, 2008). Selection of genetically divergent parents is mandatory for exploitation of transgressive segregation (Joshi *et al.*, 2004). Vast genetic distance among parents is essential for securing useful heterosis in progeny. Principal Component Analysis (PCA) is the more frequently used method to screen out gentically divergent parents for developing high yielding and disease tolerant groundnut.

E-mail: prathakotadharani12@gmail.com

MATERIAL AND METHODS

The material for the present study comprised of 50 groundnut genotypes showing tolerance to PSND, grown in a randomised block design with two replications at Agricultural Research Station, Kadiri during *kharif*, 2015. Each treatment was sown in two rows of 5 m length by adopting a spacing of 30 cm X 10 cm. Observations were recorded on randomly chosen five competitive plants for all characters *viz*., days to 50 per cent flowering, plant height (cm), number of filled pods plant^{-1}, total pods plant^{-1}, number of seeds pod^{-1}, sound mature kernel per cent, haulm yield plant^{-1} (g), pod yield plant^{-1} (g), kernel yield plant^{-1} (g), shelling per cent, harvest index per cent, 100 kernel weight , SPAD Chlorophyll Meter Reading at 60 days after sowing, oil content and protein content. The character days to 50 per cent flowering was recorded on per plot basis. Principal Component Analysis is a multivariate statistical method which attempts to describe the total variation in a multivariate sample with fewer variables than in the original data set (John and Wichern, 2003).

RESULTS AND DISCUSSION

PCA reveals major contributor of the total variation at each distinct point. Generally, the sum of Eigen values is equal to the number of variables. The Eigen value is often used to determine the number of major principal components to be explained. First five principle components (PC1, PC2, PC3, PC4 and PC5) have Eigen values greater than one and accounted for 71.46 per cent of total variability and account with values of PC1 (23.39%), PC2 (18.20%), PC3 (12.22%), PC4(10.01%) and PC5 (7.64%), respectively. Eigen values, percent of variation and cumulative variation explained for fifty genotypes in groundnut in Table 1.

PC1 has major positive association with haulm yield plant^{-1} (0.48) followed by shelling percentage (0.41), kernel yield (0.36), number of filled pods plant^{-1} (0.33), oil content (0.32), SCMR at 60 DAS (0.23), pod yield plant^{-1} (0.23), total pods plant^{-1} (0.22),

Table 1. Eigen values, percent of variation and cumulative variation explained for fifty genotypes in groundnut

Canonical root	Value of canonical root	Percent of variation accounted for	Cumulative total variation accounted for
Z_1	3.51	23.39	23.39
Z_2	2.73	18.20	41.59
Z_3	1.83	12.22	53.81
Z_4	1.50	10.01	63.82
Z_5	1.15	7.64	71.46
Z_6	0.91	6.07	77.53

days to 50 per cent flowering (0.14) and protein content (0.07). All the remaining characters *viz.,* plant height, number of seeds pod^{-1}, sound mature kernel per cent, harvest index and 100 kernel weight contributed negatively to the diversity (Table 2).

Number of filled pods plant^{-1} contributed maximum to the total genetic diversity in PC2 (0.38) and harvest index (0.37), days to 50 per cent flowering (0.35), shelling per cent (0.32) and plant height (0.23) were in the decreasing order of their contribution. All the remaining characters contributed negatively to the diversity.

Total pods plant^{-1} contributed maximum (0.41) to the total genetic diversity in PC3, followed by number of seeds pod^{-1} (0.27), 100 kernel weight (0.22), SCMR at 60 DAS (0.20), shelling percentage (0.007), days to 50 per cent flowering (0.003) and protein content (0.01). The remaining characters contributed

Table 2. Canonical vectors for fifteen characters in groundnut

S.No	Character	Z_1	Z_2	Z_3	Z_4	Z_5
1.	Days to 50% flowering	0.14	0.35	0.03	0.41	0.08
2.	Plant height (cm)	-0.06	0.23	-0.31	-0.34	0.09
3.	No of filled (mature) pods plant^{-1}	0.33	0.38	-0.01	-0.21	0.15
4.	Total pods plant^{-1}	0.22	-0.08	0.41	-0.26	-0.19
5.	No of seeds pod^{-1}	-0.08	0.01	0.27	-0.58	0.26
6.	Sound mature kernels (%)	-0.20	-0.28	-0.42	-0.15	0.04
7.	Haulm yield plant^{-1} (g)	0.48	-0.07	-0.03	-0.07	0.02
8.	Pod yield plant^{-1} (g)	0.23	-0.17	-0.51	-0.21	0.10
9.	Kernel yield plant^{-1} (g)	0.36	-0.16	-0.33	0.25	-0.23
10.	Shelling percentage (%)	0.41	0.32	0.07	-0.01	-0.12
11.	Harvest index (%)	-0.18	0.37	-0.11	0.00	-0.34
12.	100 kernel weight (g)	-0.05	-0.35	0.22	0.20	-0.12
13.	SPAD Chlorophyll meter reading (SCMR) at 60 DAS	0.23	-0.36	0.20	-0.01	0.08
14.	Oil content (%)	0.32	-0.21	-0.02	-0.12	-0.07
15.	Protein content (%)	0.07	0.01	0.01	0.29	0.80

negatively to the diversity. In PC4, days to 50 per cent flowering (0.41) contributed maximum to the diversity followed by protein content (0.29), kernel yield plant^{-1} (0.25) and 100 kernel weight (0.20). In PC5, protein content (0.80) contributed positively to the diversity followed by number of seeds pod^{-1} (0.26), number of filled pods plant^{-1} (0.15), pod yield plant^{-1} (0.10), plant height (0.09), days to 50 per cent flowering (0.08) and SCMR at 60 DAS (0.08).

Among all the PCs, PC1 has higher yield potential and having positive association with haulm yield plant^{-1}, shelling percentage , kernel yield, number of filled pods plant^{-1}, oil content, SCMR at 60 DAS, pod yield plant^{-1}, total pods plant^{-1}, days to 50 per cent flowering and protein content than the remaining clusters. Proportional contribution of fifteen yield, yield components and quality traits for first three PCs revealed grouping pattern of groundnut genotypes.

The PCs identified above formed the basis for clustering. For the purpose of clustering, agglomerative hierarchical clustering method *i.e.,* ward's method was followed to group the entries into different clusters based on Euclidean distance. The ward's method of clustering can be applied for classification due to its several advantages over other procedures (Seber, 1984).

The genotypes were grouped into eight clusters. The means of the clusters for all the fifteen characters revealed that cluster I contained five genotypes and recorded highest average values for days to 50 per cent flowering, plant height, sound mature kernel per cent, shelling per cent and protein content compared to the mean value. Cluster II contained seven genotypes and recorded highest values for number of filled pods plant^{-1}, total pods plant^{-1}, sound mature kernel per cent, shelling per cent and harvest index.

Similarly, cluster III contained eight genotypes and recorded highest values for plant height, number of filled pods plant^{-1}, total pods plant^{-1}, sound mature kernel per cent and harvest index. Cluster IV contained seven genotypes and recorded highest values for days to 50 per cent flowering, plant height, seeds pod^{-1}, sound mature kernel per cent, 100 kernel weight, oil content and protein content. Similarly, cluster V contained three genotypes and recorded highest values for number of filled pods plant^{-1}, total pods plant^{-1}, sound mature kernel per cent, haulm yield plant^{-1}, pod yield plant^{-1}, kernel yield plant^{-1}, shelling per cent, harvest index, 100 kernel weight, SCMR at 60 DAS and protein content.

Cluster VI contained four genotypes and recorded highest values for number of filled pods plant^{-1}, total pods plant^{-1}, seeds pod^{-1}, haulm yield plant^{-1}, pod yield plant^{-1}, kernel yield plant^{-1}, harvest index, 100 kernel weight and oil content. Cluster VII contained nine genotypes and recorded highest values for days to 50 per cent flowering, plant height, total pods plant^{-1}, shelling per cent, 100 kernel weight and SCMR at 60 DAS. Similarly, cluster VIII contained seven genotypes and recorded highest values for days to 50 per cent flowering, plant height, sound mature kernel per cent, haulm yield plant^{-1}, pod yield plant^{-1}, 100 kernel weight and SCMR at 60 DAS. The grouping of genotypes into different clusters is presented in Table 3.

Table 3. Cluster composition of fifty groundnut genotypes based on Tocher's method

Cluster number	No. of genotypes	Genotypes
I	5	03 x 427-082, 03 x 427-094, 03 x 427-088, 03 x 427-107 and 03 x 397-031
II	7	03 x 427-086, Harithandra, K6, Anantha, JL-24, 03 x 398-067 and K9
III	8	03 x 427-091, 04 x 479-002, 04 x 479-005, 03 x 461-019, K1811, K 1799, K 1809 and K 1800
IV	7	03 x 482-036, K 1735, K 1576, K 1535, K 1650, 03 x 485-024-01 and 04 x 481-023
V	3	K 1715, K 1725 and 04 x 479-012
VI	4	K 1501, K 1717, 04 x 477-031 and K 1641
VII	9	03 x 427-109, K 1621, K 1577, K 1574, 03 x 485-001, 04 x 477-021-2, 04 x 480-007, K 1647 and 04 x 481-005
VIII	7	04 x 477-018, 04 x 477-021-1, 04 x 477-010, K 1643, K 1563, 04 x 477-030 and 04 x 477-024- 1

Table 4. Average inter and intra cluster distances for the groundnut genotypes

	Cluster I	Cluster II	Cluster III	Cluster IV	Cluster V	Cluster VI	Cluster VII	Cluster VIII
Cluster I	91.15	171.97	221.02	263.52	460.58	279.29	332.09	501.06
Cluster II		120.99	269.12	332.66	482.62	265.21	315.64	495.65
Cluster III			92.92	150.61	188.77	183.13	233.64	285.16
Cluster IV				106.07	185.13	199.12	172.45	187.14
Cluster V					71.95	166.34	244.96	210.72
Cluster VI						84.96	158.17	240.72
Cluster VII							112.83	166.93
Cluster VIII								147.49

CONCLUSION

The intra and inter cluster Eucledian distant values in Table 4 and Fig.2 revealed maximum intra cluster distance for cluster VIII (147.49) and minimum intra cluster distance for cluster V (71.95). The maximum inter cluster distance was observed between the clusters I and VII (501.06) and minimum inter cluster distance was observed between clusters III and IV (150.61). The selection of parents from these divergent clusters was found to be rewarding. Thus, the genetic divergence studies could be helpful to select diverse parents and strengthen breeding programmes of India.

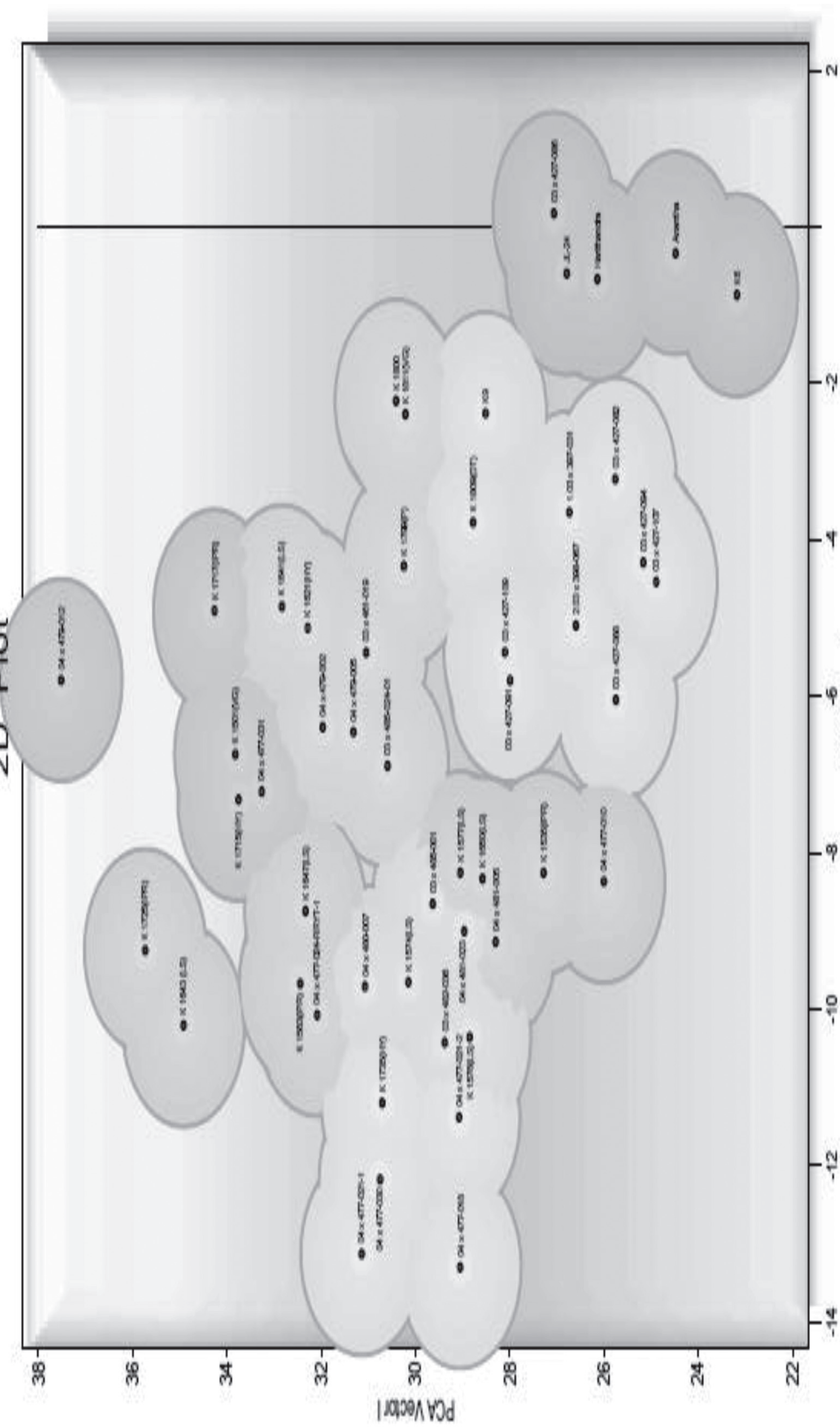

Fig. 1. Two dimensional picture of vectors in Principal Component Analysis (PCA)

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RICE- WEED ECOSYSTEM UNDER MECHANIZED SYSTEM OF RICE INTENSIFICATION (MSRI) IN NORTH COASTAL A.P.

G. PRIYANKA AND K.V. RAMANA MURTHY

Department of Agronomy, Agricultural College, Acharya N.G. Ranga Agricultural University, Naira-532 185

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ABSTRACT

An experiment was conducted at the Agricultural College, Naira during *Kharif*, 2014 to study the correlation and regression of the grain yield of rice on certain weed and crop parameters in rice under mechanized system of rice intensification. The results revealed that the grain yield was highly negatively correlated with all the weed parameters, while the correlation was significantly positive with weed control efficiency (WCE) and weed management index (WMI). The correlation coefficient between grain yield and all crop parameters were significantly positive except with test weight, while it was significantly negative with weed index. The regression analysis indicated that there was a negative linear relationship between grain yield and dry weight of all the three groups of weeds as well as with weed density both at 50 DAP and harvest. The grain yield was reduced by 190 kg ha^{-1} with unit increase of weed dry weight per m^{-2} at 50 DAP.

INTRODUCTION

Rice is the "Global Grain" in 89 nations with an annual production of 518 million tonnes. It plays a pivotal role in Indian economy with an area of 39.47 million hectares with an annual production of 87.83 million tones and productivity of 2284 kg ha^{-1}. In Andhra Pradesh rice is grown in an area of 40.06 lakh hectares in *kharif* and *rabi* with a production of 12.88 million tonnes and productivity of 3217 kg ha^{-1} (Ministry of Agriculture, Govt. of India, 2011-2012).Improving the productivity of rice is one the major challenge that India is facing today. However, low cost and energy saving approach the mechanized system of rice intensification (MSRI)has been recently developed. Mechanization combined with improved crop management results in yields of 6.5 t ha^{-1}, indicating a yield gap of more than 3 t ha^{-1}.

Among several factors responsible for low productivity of rice, weed competition is one of the most important. When rice fields are not flooded continuously and plants are widely spaced as recommended under SRI, weeds get a better chance to grow. Weeds when left uncontrolled reduced the grain yield of transplanted rice by 62.6% (Singh *et al.*, 2005). However, the information on the extent of reduction in grain yield due to different group of weeds in this fragile ecosystem is not available. Therefore, the present study was taken up to find out these losses.

MATERIAL AND METHODS

A field experiment was conducted during *Kharif,* 2014 at the Agricultural College, Naira, Andhra Pradesh which is situated at 18.24^0 N latitude, 83.84^0 E longitude and at an altitude of 27 m above mean sea level. The experimental soil was sandy clay loam in texturewith a pH of 6.6 and EC of 0.20 dSm^{-1}, low in organic carbon(0.32%), available nitrogen (183 kg ha^{-1}) and available phosphorus (54 kg ha^{-1}) and medium in available potassium(259 kg ha^{-1}). A total of 816.9 mm rainfall was received in 40 rainy days during the cropping period.

The experiment was laid out in randomized block design with three replications and ten weed management practices*viz.*,T_1- Weedy check, T_2-

E-mail: priyanka.golla153@gmail.com

Hand weeding at 20 and 40 DAP, T_3- Oxadiargyl @ 100 g *a.i* ha^{-1} as pre-emergence sand mix application (SMA), T_4- Running power weeder at 20 and 40 DAP, T_5- Orthosulfamuron @100 g *a.i* ha^{-1} as pre-emergence SMA, T_6- Orthosulfamuron @100 g *a.i* ha^{-1} as post-emergence SMA at 20-25 DAP, T_7- Oxadiargyl @ 100 g *a.i* ha^{-1} as pre-emergence sand mix application (T_3) followed by Running power weeder at 20 and 40 DAP (T_4), T_8- Oxadiargyl @ 100 g *a.i* ha^{-1} as pre-emergence sand mix application (T_3) followed by Orthosulfamuron @100 g *a.i* ha^{-1} as post-emergence SMA at 20-25 DAP, T_9- Orthosulfamuron @100 g *a.i* ha^{-1} as pre-emergence SMA (T_5) followed by Running power weeder at 20 and 40 DAP (T_4) and T_{10}- Orthosulfamuron @100 g *a.i* ha^{-1} as pre-emergence SMA (T_5) followed byOrthosulfamuron @100 g *a.i* ha^{-1} as post-emergence SMA at 20-25 DAP(T_6).

For the weed management Oxadiargyl and Orthosulfamuron as pre-emergence herbicides were applied uniformly at one day after transplanting (DAT) by mixing with sand @ 50 kg ha^{-1}. Post-emergence herbicides were applied uniformly by spraying as per treatment by using a spray volume of 500 l of water per hectare at 22 DAT. Hand weeding was done at 20 and 40 DAT and weeding with power weeder and combinational treatments of power weeder were done by manual labour at 20 and 40 DAT, respectively.

Transplantation was done by using Yanmar transplanter with 14 days aged seedlings by adopting 30 cm × 14 cm. The variety Pushyami (MTU-1075) with fertilizer dose of 120-60-40 kg N, P_2O_5 and K_2O ha^{-1} was applied uniformly to all the experimental plots. Nitrogen was applied in three equal splits, one each at basal, active tillering and panicle initiation. All the other cultural practices were followed as per the recommended package of practices.

For the growth parameters, yield attributes and yield, five plants from destructive sampling area *i.e.* third outermost row in border were cut randomly at harvest and the plants were shade dried and then oven dried at 60°C till a constant weight was obtained. The number of filled grains and 1000 grain weight from ten randomly tagged panicles were counted, averaged and expressed as number of filled grains panicle^{-1}. Grain yield and straw yield of rice from the net plot was weighed and expressed in kg ha^{-1}.

For the weed parameters, all the weeds present in a quadrate of 0.5 m X 0.5 m (0.25 m^2) area, selected at random in the sampling area kept for destructive sampling were picked up and separated as grasses, sedges and broad leaved weeds. After sun drying, the samples were oven dried at 60° C to a constant weight. The dry weight of weeds were recorded group wise *i.e.*, grasses, sedges and broad leaved weeds. The total dry weight was arrived by adding all three groups. The dry weight was expressed in g m^{-2}.

The data were computerized and correlation and regression analysis between grain yield and various weed and crop parameters were calculated by following the standard procedure given by Gomez and Gomez (1984).Weed Management Index (WMI) was calculated by using the formula suggested by Devasenapathy *et al.* (2008).

$$\text{WMI} = \frac{\text{\% of crop yield over control}}{\text{\% of control of weeds}}$$

RESULTS AND DISCUSSION

The study revealed that all the crop parameters except test weight were significantly and positively correlated with grain yield, while all the weed parameters except weed control efficiency(WCE) at 50 DAP and WCE at harvest and weed management indexwere negatively correlated with grain yield (Table 1, Fig. 1 and 3). The correlation coefficient values are worked out between the grain yield and the dry weight of all the three groups of weeds at 50 DAP (grasses, sedges and broad leaved weeds) and total weed dry weight at 50 DAP and at harvest. It was observed that a strong negative correlation was recorded between the grain yield and dry weight of all groups of weeds and total weed dry weight at all stages, clearly indicating that exploitive ability of weeds in rice under mechanized system of rice intensification. Similar results were reported by Patra *et al.* (2011) in transplanted rice. A comparatively strong negative relationship was detected between the grain yield and density of all groups of weeds at 50 DAP and total weed density at 50 DAP and at harvest. The significantly high positive correlation between grain yield and weed control efficiency (WCE) at 50 DAP and WCE and weed management index at harvest. A very strongly negative correlation between grain yield and weed index reflects the pronounced effect of these three parameters on grain yield and the reliability of these indices for evaluation of the impact of weed control treatments on grain yield of rice. Similar results were also made in maize weed ecosystem by Parmeet Singh *et al.* (2007).

The regression analysis (Table 1) revealed that the reduction in grain yield could be predicted to the extent of 190.28 kg ha^{-1} with increase of one gram of weed dry weight m^{-2} at 50 DAS. The predictions pertaining to the reduction in grain yield due to the dry weight of individual group of weeds, it was in the order of 255.61, 342.87 and 534.08 at 50 DAP for grasses, sedges and broad leaved weeds, respectively.

The correlation of grain yield with dry matter accumulation of weeds revealed that a highest negative correlation (-0.968) was observed at harvest followed by -0.953 at 50 DAT. The correlation coefficient of different crop parameters with grain yield indicated that the weed index has highest negative correlation (-0.996) and filled grains panicle^{-1} (Fig. 2) has greatest positive correlation (0.981) followed by panicle length (0.977) and total number of tillers at harvest m^{-2} (0.974). Similar results were recorded by Jacob *et al.* (2005) and Hashem Aminpanah (2014).

Among the different crop parameters, a linear positive increase in grain yield was predicted with total and productive tillers m^{2}, about 13.21 and 11.09 kg ha^{-1}respectively with an increase of one unit of each of these parameters. As regards weed control efficiency at 50 DAP and at harvest, the regression equation predicted a linear increase in grain yield by 19.57 and 19.75 kg ha ^{1} with every one percent increase of this parameter, while in case of weed index, the relationship was negative and could be predicted by a loss of 64.15 kg ha^{--1} in grain yield with an escalation of every unit of this index. Similar findings were reported by Ramana *et al.* (2008).Thus, it is concluded that by controlling weed population at critical stages, it reduces weed dry matter accumulation and increases weed control efficiency and weed management index which in turn increases yield attributes and consequently grain yield of rice under mechanized system of rice intensification.

Table 1. Correlation and regression of rice yield on weed and crop parameters under mechanized system of rice intensification

S. No	Character	Correlation Coefficient (r)	Y=a+bx
I)	**Grain yield (kg ha^{-1}) Vs** **Weed parameters**		
1	Dry matterof grasses (g m^{-2}) at 50 DAP	-0.961**	Y=5646.15-255.61 X
2	Dry matterof sedges (g m^{-2}) at 50 DAP	-0.904**	Y=5545.38-342.87X
3	Dry matterof BLW (g m^{-2}) at 50 DAP	-0.954**	Y=5715.39-534.08X
4	Total Weed Dry matter (g m^{-2}) at 50 DAP	-0.953**	Y=5588.95-190.28X
5	Total Weed Dry matter (g m^{-2}) at Harvest	-0.968**	Y=5499.24-101.30X
6	Density of grasses (No.m^{-2}) at 50 DAP	-0.941**	Y=6502.88-484.77X
7	Density of sedges (No.m^{-2}) at 50 DAP	-0.974**	Y=5553.42-187.73X
8	Density of BLW (No.m^{-2}) at 50 DAP	-0.963**	Y=5554.24-139.59X
9	Total Weed density (No.m^{-2}) at 50 DAP	-0.97**	Y=5670.88-113.42X
10	Total Weed density (No.m^{-2}) at Harvest	-0.881**	Y=6562.53-225.81X
11	Weed Control Efficiency (%) at 50 DAP	0.933**	Y=3268.07+19.57X
12	Weed Control Efficiency (%) at Harvest	0.958**	Y=3247.81+19.75X
13	Weed Index (%)	-0.996**	Y=5541.71-64.15X
14	Weed Management Index	0.993**	Y= -1817.41+7178.15X
II) Crop parameters			
15	Plant height(cm) at 50 DAP	0.961**	Y=1230.83+51.39X
16	Plant height (cm) at Harvest	0.902**	Y= 523.24+48.83X
17	Total no. of tillers (m^{-2}) at 50 DAP	0.921**	Y=1149.61+12.70X
18	Total no.of tillers (m^{-2}) at Harvest	0.974**	Y=1985.71+13.21X
19	Plant dry matter production(kg ha^{-1}) at 50 DAP	0.906**	Y=2631.81+0.66X
20	Plant dry matter production (kg ha^{-1})at Harvest	0.921**	Y=2307.02+0.26X
21	Productive tillers (m^{-2})	0.956**	Y=2903.97+11.09X
22	Filled grains panicle^{-1}	0.981**	Y=1969.98+22.16X
23	Panicle length (cm)	0.977**	Y= -155.58+252.98X
24	Test weight (g)	0.511	Y=-4818.63+471.86X
25	Straw yield (kg ha^{-1})	0.879**	Y=1352.71+0.64X

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CORRELATION AND PATH ANALYSIS IN GROUNDNUT(*Arachis hypogaea* L.) UNDER ORGANIC AND CONVENTIONAL FERTILIZER MANAGEMENTS

M. MANJUBHARGAVI, M. SHANTHI PRIYA, D. MOHAN REDDY AND B. RAVINDRA REDDY
Department of Genetics and Plant Breeding, S.V. Agricultural College,
Acharya N.G. Ranga Agricultural University, Tirupati-517502

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ABSTRACT

Correlation and path analysis was conducted in 44 genotypes of groundnut with two fertilizer managements *viz.,* organic and conventional. The association analysis in both the managements indicated significant positive association of pod yield plant^{-1}, mature pods plant^{-1}, number of pods plant^{-1}, primary branches plant^{-1}, days to 50% flowering, harvest index, 100 seed weight, shelling percentage and protein content with kernel yield per plant under both the managements, indicating the possibility for simultaneous selection of these characters towards the improvement of kernel yield. Path analysis revealed high positive direct effects of pod yield plant^{-1} and shelling percentage under both organic and conventional fertilizer managements and significant positive correlation of other traits with kernel yield was due to positive indirect effect *via* these traits. Hence, selection would be more effective through these traits to improve kernel yield under both the environments.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is important oilseed crop of the world. It is a segmental allotetraploid (2n=40), self-pollinating annual legume and it is grown throughout the tropical, sub-tropical and warm temperate regions of the world. The production of oilseed crops was much higher after 1980's and it brought yellow revolution in oilseed crops in India. However, our traditional agro system suffered a great setback, especially owing to the indiscriminate use of fertilizers that created the problem of serious environmental consequences. Organic agriculture is continuously growing in more than 160 countries. There is a growing demand for the varieties suitable to organic and / or low input farming. The constraint in organic farming is the lack of suitable varieties specifically bred for optimal production in organically managed systems (Dawson *et al.,* 2011).

As per Murphy *et al.* (2007), with crop cultivars bred in and adapted to the unique conditions inherent in organic systems, organic agriculture will be better able to realize its full potential as a high-yielding alternative to conventional agriculture. In some circumstances varieties that perform well in organic systems have different yield rankings under conventional management. Hence, it would be a challenge for the breeders to develop cultivar for that condition. Hence, there is essential need to encourage breeding programmes, designed in concert with organic farming. The phenotypic and genotypic correlation co-efficient was estimated using the method suggested by Johnson *et al.* (1955). Path coefficient analysis, a statistical method developed by Wright (1921) permits a thorough understanding of contribution of various characters by partitioning the correlation coefficient into components of direct and indirect effects.

MATERIAL AND METHODS

The material for the present investigation comprised of fourty- four genotypes of groundnut evaluated in two separate contiguous trials that differ only in fertilizers managements using a randomized

E-mail:manjubhargavimotupalli@gmail.com

block design with three replications, during *kharif*, 2014 at dryland farm of S.V. Agricultural College, Tirupati. Each genotype was sown in single row of 3 m length adopting recommended spacing of 30 cm × 10 cm. In organic fertilizer management trial, FYM at the rate of 20 t ha^{-1} at the time of field preparation and at fifteen days interval Jeevamrutha was applied. The seed of groundnut was treated with bijamrutha. No inorganic chemicals were used. In order to encounter biotic stresses biopesticides (neemasthram, bramhastram, Gobanam) were used.

In conventional fertilizer management trial, FYM at the rate of 10 t ha^{-1} at the time of field preparation and recommended dose of chemical fertilizers at the rate of 20 kg N, 40 kg P_2O_5 and 40 kg K_2O per hectare in the form of urea, single super phosphate and murate of potash were used. Seed treatment was done with Bavistin at the rate of 3 g kg^{-1}. The crop was raised with protective irrigation and 500 kg of gypsum ha^{-1} was applied at peak flowering stage. Cultural practices such as weeding and irrigation were followed in common for both trials to maintain good crop growth apart from need based plant protection measures adopted during the crop season for controlling diseases and pests.

The biometrical observations were recorded for days to 50% flowering, plant height, primary branches $plant^{-1}$, number of pods $plant^{-1}$, pod yield $plant^{-1}$, mature pods $plant^{-1}$, kernel yield $plant^{-1}$, shelling percentage, harvest index, 100 seed weight, oil content and protein content for five randomly selected plants per genotype per replication. Path coefficient analysis was carried out as suggested by Dewey and Lu (1959).

RESULTS AND DISCUSSION

Analysis of variance carried out in respect of twelve quantitative characters revealed highly significant differences among the genotypes for all the characters under both the fertilizer managements except shelling percentage, which showed non-significant difference under organic fertilizer management and significance at 5% under conventional fertilizer management. The data on all the twelve characters was subjected to statistical analysis. Estimation of correlation coefficients at phenotypic and genotypic levels under both organic and conventional fertilizer managements were presented in Tables 1 and 2.

The results indicated that the genotypic correlation coefficients were higher in magnitude than the corresponding phenotypic correlation coefficients in general, indicating that though there exists an intrinsic association between the characters studied, the environment and genotype × environment interaction played a major role in determining these associations between the characters. Under organic fertilizer management, kernel yield $plant^{-1}$ showed highly significant and positive correlation with pod yield $plant^{-1}$ ($r_p = 0.927^{**}$, $r_g = 0.978$), followed by mature pods $plant^{-1}$ ($r_p = 0.622^{**}$, $r_g = 0.784$), number of pods $plant^{-1}$ ($r_p = 0.576^{**}$, $r_g = 0.730$), harvest index ($r_p = 0.575^{**}$, $r_g = 0.704$), 100-seed weight ($r_p = 0.297^{**}$, $r_g = 0.312$), shelling percentage ($r_p = 0.396^{**}$, $r_g = 0.334$), days to 50 % flowering ($r_p = 0.352^{**}$, $r_g = 0.471$), primary branches $plant^{-1}$ ($r_p = 0.289^{**}$, $r_g = 0.336$) and protein content ($r_p = 0.271^{**}$, $r_g = 0.390$). It exhibited significant negative correlation with oil content ($r_p = -0.382^{**}$, $r_g =$

Table 1. Genotypic (r_g) and Phenotypic (r_p) correlation coefficients among kernel yield plant^{-1} and its components in groundnut under organic management

S.No	Character		PH (cm)	PBP	NPP	MPP	SP (%)	HI (%)	100SW (%)	Oil (%)	Protein (%)	PYP (g)	KYP (g)
1	DFF	r_g	-0.139	0.411	0.540	0.438	0.177	0.292	-0.144	-0.287	0.002	0.442	0.471
		r_p	-0.191*	0.252**	0.217*	0.173**	0.053	0.253**	0.058	-0.228**	-0.003	0.357**	0.352**
2	PH	r_g		-0.601	-0.202	-0.025	0.006	-0.171	0.201	-0.080	0.371	0.083	0.065
		r_p		-0.468**	-0.116	-0.027	0.004	-0.189	0.138	-0.061	0.333**	-0.048	-0.051
3	PBP	r_g			0.521	0.325	-0.359	0.096	-0.294	-0.073	-0.071	0.395	0.336
		r_p			0.421**	0.310**	-0.176*	0.087	-0.103	-0.052	-0.047	0.368**	0.289**
4	NPP	r_g				0.977	-0.135	0.308	-0.284	-0.341	0.208	0.813	0.730
		r_p				0.947**	-0.120	0.215*	-0.262**	-0.224**	0.143	0.687**	0.576**
5	MPP	r_g					0.038	0.376	-0.166	-0.361	0.285	0.833	0.784
		r_p					-0.086	0.247**	-0.179*	-0.238**	0.196*	0.728**	0.622**
6	SP	r_g						0.957	0.648	-0.196	-0.170	0.147	0.334
		r_p						0.441**	0.347**	-0.074	-0.066	0.040	0.396**
7	HI	r_g							0.545	-0.415	-0.071	0.520	0.704
		r_p							0.372**	-0.308**	-0.045	0.458**	0.575**
8	100SW	r_g								-0.254	0.282	0.312	0.431
		r_p								-0.161	0.195*	0.297**	0.404**
9	Oil%	r_g									-0.381	-0.528	-0.552
		r_p									-0.381**	-0.382**	-0.382**
10	Protein%	r_g										0.456	0.390
		r_p										0.333**	0.271**
11	PYP	r_g											0.978
		r_p											0.927**

*Significant at 5% level; ** Significant at 1 % level. DF : Days to 50% flowering; PH : Plant height (cm); PBP : Primary branches plant^{-1}; NPP : Total number of pods plant^{-1}; PYP : Pod yield plant^{-1} (g); MPP :Number of mature pods plant^{-1}; KYP : Kernel yield plant^{-1} (g); SP : Shelling percentage(%); HI : Harvest index; 100SW : 100 seed weight (g); Oil%: oil content (%); Protein %: protein content (%)

Table 2. Genotypic (r_g) and Phenotypic (r_p) correlation coefficients among kernel yield plant^{-1} and its components in groundnut under conventional fertilizer management

S.No	character		PH (cm)	PBP	NPP	MPP	SP (%)	HI (%)	100SW (g)	Oil (%)	Protein (%)	PYP (g)	KYP (g)
1	DFF	r_g	0.129	0.397	0.122	0.194	0.203	0.275	0.200	-0.290	0.158	0.512	0.535
		r_p	0.037	0.187*	0.006	0.003	0.128	0.116	0.135	-0.215*	0.120	0.180*	0.224**
2	PH	r_g		-0.391	-0.433	-0.296	0.462	-0.262	0.130	0.163	0.196	-0.174	-0.064
		r_p		-0.310**	-0.123	0.004	0.113	-0.228**	0.089	0.133	0.170	-0.023	0.021
3	PBP	r_g			0.823	0.800	-0.494	-0.118	-0.264	-0.030	-0.052	0.420	0.332
		r_p			0.475**	0.406**	-0.174*	-0.051	-0.187*	-0.014	-0.075	0.298**	0.234**
4	NPP	r_g				0.977	-0.704	0.077	-0.520	-0.112	-0.257	0.333	0.204
		r_p				0.946**	-0.229**	0.022	-0.321**	-0.069	-0.170	0.416**	0.313**
5	MPP	r_g					-0.582	0.230	-0.545	-0.258	-0.206	0.451	0.342
		r_p					-0.152	0.046	-0.285**	-0.131	-0.108	0.432**	0.353**
6	SP	r_g						0.527	0.443	-0.457	0.349	0.151	0.308
		r_p						0.330**	0.303**	-0.179*	0.138	0.034	0.361**
7	HI	r_g							0.416	-0.510	-0.045	0.601	0.653
		r_p							0.273**	-0.333**	-0.030	0.412**	0.493**
8	100SW	r_g								-0.255	0.426	0.622	0.660
		r_p				s				-0.206*	0.357**	0.458**	0.518**
9	Oil%	r_g									-0.146	-0.417	-0.473
		r_p									-0.142	-0.302**	-0.328**
10	Protein%	r_g										0.210	0.280
		r_p										0.145	0.189*
11	PYP	r_g											0.987
		r_p											0.938**

* Significant at 5% level; ** Significant at 1 % level DF : Days to 50% flowering; PH : Plant height (cm); PBP : Primary branches plant^{-1}; NPP : Total number of pods plant^{-1}; PYP : Pod yield plant^{-1} (g); MPP :Number of mature pods plant^{-1}; KYP : Kernel yield plant^{-1} (g); SP : Shelling percentage(%); HI : Harvest index; 100SW : 100 seed weight (g); Oil%: oil content (%); Protein %: protein content (%)

-0.552), at both phenotypic and genotypic levels, indicating that increase in these traits would result in an increase in the kernel yield.

Under conventional fertilizer management the trait kernel yield plant^{-1} showed highly significant and positive correlation with pod yield plant^{-1} (r_p = 0.938**, r_g = 0.987), followed by 100-seed weight (r_p=0.518**, r_g = 0.660), harvest index (r_p = 0.493**, r_g = 0.653), shelling percentage (r_p = 0.361**, r_g = 0.308), mature pods plant^{-1} (r_p = 0.353**, r_g = 0.342), total number of pods plant^{-1} (r_p = 0.313**, r_g = 0.204), primary branches plant^{-1} (r_p = 0.234**, r_g = 0.332), days to 50 % flowering (r_p = 0.224*, r_g = 0.535) and protein content (r_p = 0.189**, r_g = 0.280) at both phenotypic and genotypic levels, showing that increase in these traits would result in increase in the kernel yield. It exhibited significant negative correlation with oil content (r_p = -0.382**, r_g = -0.552). Kernel yield plant^{-1} exhibited non significant negative correlation with plant height (r_p = -0.051, r_g = 0.065).

Significant positive association of kernel yield plant^{-1}, with pod yield plant^{-1} has been observed in the present investigation was also reported by Kumar *et al*. (2012), Rao *et al*. (2014), John *et al*. (2008) and Narasimhulu *et al*. (2012). Results of significant and positive correlation of kernel yield plant^{-1} with days to 50% flowering was reported by Mahalakshmi *et al*. (2005); with total number of pods plant^{-1} by Mahalakshmi *et al*. (2005), John *et al*. (2009), Rao *et al*. (2014); with mature pods plant^{-1} by John *et al*. (2007) and John *et al*. (2008). On the contrary, significant negative correlation of primary branches plant^{-1} with kernel yield plant^{-1} was reported by John *et al*. (2009) and Pavankumar *et al*. (2014).

Significant and positive association of kernel yield plant^{-1} with harvest index was reported by John *et al*. (2008); with 100 seed weight and shelling percentage by Mahalakshmi *et al*. (2005) and with protein content by Pavankumar *et al*. (2014). Significant negative correlation of kernel yield plant^{-1} with oil content was reported by Lakshmidevamma *et al*. (2004). Non significant negative correlation of kernel yield plant^{-1} with plant height was reported by John *et al*. (2005).

Identification of important yield components and information about the association with yield and also with each other are necessary in developing efficient breeding strategy for evolving improved genotypes in any crop species. Under both fertilizer managements, significant and positive correlation was observed for days to 50 % flowering with pod yield plant^{-1} and primary branches plant^{-1}; primary branches plant^{-1} with number of pods plant^{-1}, mature pods plant^{-1} and pod yield plant^{-1}; number of pods plant^{-1} with mature pods plant^{-1} and pod yield plant^{-1}; mature pods plant^{-1} with pod yield plant^{-1}; Shelling percentage with harvest index and 100 seed weight; harvest index with 100 seed weight and 100 seed weight with protein content. Whereas, under organic fertilizer management significant and positive association was observed for days to 50% flowering with number of pods plant^{-1}, mature pods plant^{-1} and harvest index; plant height with protein content; number of pods plant^{-1} with harvest index; mature pods plant^{-1} with harvest index and protein content.

Hence, these characters could be emphasized during selection process to bring about improvement in the yield potential as well as quality of groundnut cultivars under organic and conventional fertilizer management. Selection of easily observable traits among these would ultimately enhance the mean performance of all concerned inter dependent characters and hence would be helpful in order to get improved pod yield under organic and conventional fertilizer management. Oil content displayed a significant negative association with kernel yield under both organic and conventional fertilizer managements. Hence, judicious selection programme might be formulated by repeated intermating to break the negative correlation between oil content and kernel yield plant^{-1} for simultaneous improvement of these characters under organic and conventional fertilizer management.

Path coefficient analysis was conducted using kernel yield plant^{-1} as dependent variable and ten characters *viz.,* days to 50% flowering, primary branches plant^{-1}, total number of pods plant^{-1}, mature pods plant^{-1}, shelling percentage, harvest index, 100 seed weight, oil content, protein content and pod yield plant^{-1} which exhibited significant correlation with kernel yield as independent variables under both organic and conventional fertilizer managements and the results are presented in Table 3.

Under organic fertilizer management the traits pod yield plant^{-1} (0.9225) and shelling percentage recorded high positive direct effect (0.3608) on kernel yield plant^{-1}. On the other hand mature pods plant^{-1} (-0.0310), protein content (-0.0151) oil content (-0.0150), harvest index (-0.0110) and days to 50 % flowering (-0.0004) recorded negligible negative direct effect on kernel yield plant^{-1}. The traits primary branches plant^{-1} (0.0191), total number of pods plant^{-1} (0.0110) and 100 seed weight (0.0090) displayed negligible positive direct effect on kernel yield plant^{-1}. The characters *viz.,* days to 50 % flowering (0.3297), primary branches plant^{-1} (0.3391), total number of pods plant^{-1} (0.6335), number of mature pods plant^{-1} (0.6712), harvest index (0.4221) and protein content (0.3068) recorded high positive indirect effect through pod yield plant^{-1} on kernel yield plant^{-1}. 100 seed weight (0.2741) displayed moderate positive indirect effect through pod yield plant^{-1}. Harvest index (0.1591) and 100 seed weight (0.1252) displayed low positive indirect effect through shelling percentage. Oil content (-0.3525) has recorded high negative indirect effect through pod yield plant^{-1}.

High direct effect of pod yield plant^{-1} on kernel yield plant^{-1} was reported by Lakshmidevamma *et al.* (2004) and Pavankumar *et al.* (2014). Similar to the present findings, Pavankumar *et al.* (2014) reported the negligible negative direct effect of days to 50% flowering on kernel yield plant^{-1}. Contrary to the present results, low negative indirect effect of primary branches plant^{-1} through pod yield plant^{-1} and shelling percentage was reported by Pavankumar *et al.* (2014). High indirect positive effect of number of mature pods plant^{-1} through pod yield plant^{-1} on kernel yield plant^{-1} and negligible negative direct effect of protein content and its moderate positive indirect effect through pod yield plant^{-1} on kernel yield plant^{-1} was reported by Pavankumar *et al.* (2014). High positive direct effect of shelling percentage on kernel yield plant^{-1} was reported by Durgarani *et al.* (1987) and Pavankumar *et al.* (2014). High positive indirect effect of harvest index through pod yield plant^{-1} was reported by Lakshmidevamma *et al.* (2004) and Pavankumar

Table 3. Phenotypic (P) path coefficient analysis for kernel yield plant^{-1} and its components in groundnut under organic and conventional fertilizer management

S. No	Char -acter	DFF(O)	DFF(I)	PBP(O)	PBP(I)	NPP(O)	NPP(I)	MPP(O)	MPP(I)	SP(O)	SP(I)	HI(O)	HI(I)	100SW (g) (O)	100SW (g) (I)	Oil% (O)	oil%	Protein % (O)	Protein %	PYP (g) (O)	PYP (g)	r_p KYP (g) (O)	r_p KYP (g)
1	DFF	**-0.0004**	**0.0140**	0.0048	0.0031	0.0024	-0.0001	-0.0054	0.0000	0.0192	0.0422	-0.0028	0.0014	0.0005	-0.0013	0.0034	-0.0037	0.0000	0.0017	0.3297	0.1664	0.352**	0.224**
2	PBP	-0.0001	0.0026	**0.0191**	**0.0166**	0.0046	-0.0066	-0.0096	0.0043	-0.0634	-0.0574	-0.0010	-0.0006	-0.0009	0.0018	0.0008	-0.0003	0.0007	-0.0010	0.3391	0.2750	0.289**	0.234**
3	NPP	-0.0001	0.0001	0.0080	0.0079	**0.0110**	**-0.0140**	-0.0293	0.0101	-0.0433	-0.0753	-0.0024	0.0003	-0.0023	0.0031	0.0033	-0.0012	-0.0022	-0.0024	0.6335	0.3840	0.576**	0.313**
4	MPP	-0.0001	0.0000	0.0059	0.0068	0.0104	-0.0132	**-0.0310**	**0.0107**	-0.0311	-0.0499	-0.0027	0.0005	-0.0016	0.0027	0.0036	-0.0023	-0.0029	-0.0015	0.6712	0.3989	0.622**	0.353**
5	SP	0.0000	0.0018	-0.0034	-0.0029	-0.0013	0.0032	0.0027	-0.0016	**0.3608**	**0.3293**	-0.0048	0.0038	0.0031	-0.0029	0.0011	-0.0031	0.0010	0.0019	0.0367	0.0313	0.396**	0.361**
6	HI	-0.0001	0.0016	0.0017	-0.0008	0.0024	-0.0003	-0.0076	0.0005	0.1591	0.1088	**-0.0110**	**0.0116**	0.0033	-0.0026	0.0046	-0.0058	0.0007	-0.0004	0.4221	0.3805	0.575**	0.493**
7	100SW	0.0000	0.0019	-0.0020	-0.0031	-0.0029	0.0045	0.0056	-0.0030	0.1252	0.0998	-0.0041	0.0032	**0.0090**	**-0.0095**	0.0024	-0.0036	-0.0029	0.0049	0.2741	0.4226	0.404**	0.518**
8	oil%	0.0001	-0.0030	-0.0010	-0.0002	-0.0025	0.0010	0.0074	-0.0014	-0.0265	-0.0591	0.0034	-0.0039	-0.0014	0.0020	**-0.0150**	**0.0174**	0.0057	-0.0020	-0.3525	-0.2785	-0.382**	-0.328**
9	Protein %	0.0000	0.0017	-0.0009	-0.0013	0.0016	0.0024	-0.0061	-0.0012	-0.0240	0.0456	0.0005	-0.0004	0.0017	-0.0034	0.0057	-0.0025	**-0.0151**	**0.0138**	0.3068	0.1338	0.270**	0.189*
10	PYP	-0.0001	0.0025	0.0070	0.0050	0.0076	-0.0058	-0.0225	0.0046	0.0144	0.0112	-0.0050	0.0048	0.0027	-0.0043	0.0057	-0.0053	-0.0050	0.0020	**0.9225**	**0.9229**	0.927**	0.938**

O: Organic management, I: Conventional fertilizer management
Residual effect of organic (Phenotypic): 0.010, Residual Effect of conventional (Phenotypic): 0.0118
Bold: Direct effects; Normal: Indirect effects * Significant at 5% level; ** Significant at 1 % level
DF : Days to 50% flowering; PH : Plant height (cm); PBP : Primary branches plant^{-1}; NPP : Total number of pods plant^{-1}; PYP : Pod yield plant^{-1} (g); MPP :Number of mature pods plant^{-1}; KYP : Kernel yield plant^{-1} (g); SP : Shelling percentage(%); HI : Harvest index; 100SW : 100 seed weight (g);Oil%: oil content (%); Protein %: protein content (%)

et al. (2014). Durgarani *et al*. (1987) and Pavankumar *et al*. (2014) reported the low positive indirect effect of harvest index through shelling percentage.

Under conventional fertilizer management the traits pod yield plant^{-1} (0.9229) and shelling percentage (0.3293) exhibited high positive direct effects on kernel yield plant^{-1}. The direct effects of the traits oil content (0.0174), primary branches plant^{-1} (0.0166), days to 50 % flowering (0.0140), protein content (0.0138), harvest index (0.0116) and mature pods plant^{-1} (0.0107) were negligible and positive on kernel yield plant^{-1}.The traits total number of pods plant^{-1} (-0.0140) and 100 seed weight (-0.0095) displayed negligible negative direct effect on kernel yield plant^{-1}. Days to 50 % flowering (0.1664) and protein content (0.1338) exhibited low positive indirect effect through pod yield plant^{-1}. Primary branches plant^{-1} (0.2750) recorded moderate positive indirect effect through pod yield plant^{-1}. The traits total number of pods plant^{-1} (0.3840), number of mature pods plant^{-1} (0.3989), harvest index (0.3805) and 100 seed weight (0.4226) displayed high positive indirect effect through pod yield plant^{-1}. Oil content (-0.2785) has recorded moderate negative indirect effect through pod yield plant^{-1}. Harvest index (0.1088) showed low positive indirect effect through shelling percentage. The highest positive direct effect on kernel yield plant^{-1} was recorded by pod yield plant^{-1} followed by shelling percentage. Positive direct effects of these traits on kernel yield plant^{-1} and significant and positive association of other traits *viz.,* days to 50% flowering, primary branches plant^{-1}, number of pods plant^{-1}, number of mature pods plant^{-1}, harvest index, 100 seed weight and protein content due to indirect effect via pod yield plant^{-1} and shelling percentage indicated that direct selection for these traits *viz.,* pod yield plant^{-1} and shelling percentage will be rewarding for yield improvement.

CONCLUSIONS

In conclusion, based on over all path analysis studies, the traits pod yield plant^{-1} and shelling percentage recorded high positive direct effect under both the fertilizer managements. The above result indicated that by keeping the other traits constant, selection for them results in an increased kernel yield. Besides their positive direct effects on kernel yield, the significant positive correlation of other traits with kernel yield plant^{-1} was due to positive indirect effects via these traits. Hence, it could be inferred that pod yield plant^{-1} and shelling percentage were the major contributing characters in groundnut under both organic and conventional fertilizer managements. Therefore, these traits should be given due consideration for indirect selection to improve kernel yield to obtain superior genotypes under both the environments.

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SUPPLEMENTATION OF NITROGEN AND POTASSIUM NUTRIENTS THROUGH FOLIAR NUTRITION TO BIDI TOBACCO (*Nicotiana tabacum* L.)

K. PRABHAKAR, P. PULLI BAI , P. MUNIRATHNAM, J. MANJUNATH, T. RAGHAVENDHRA, Y. PADMALATHA AND B. GOPAL REDDY
Regional Agricultural Research Station, Acharya N.G.Ranga Agricultural University, Nandyala - 518 002

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ABSTRACT

Field experiment was conducted for two *kharif* seasons (2014 – 15 and 2015 – 16) at Regional Agricultural Research Station, Nandyal to study the response of bidi tobacco to supplemental nitrogen (N) and potassium (K) nutrients through foliar application. The treatments consisted of ten treatment combinations from three sources of nutrients *(i.e.* potassium nitrate (KNO_3), ammonium sulphate + sulphate of potash and urea + sulphate of potash) and three intervals of foliar sprays at 45 days after sowing (DAT), 60 DAT, 45 and 60 DAT. The experiment was laid out in a RBD design and replicated thrice. Foliar nutrition of 2.5% potassium nitrate twice at 45 and 60 DAT recorded significantly higher cured leaf yield (1783 kg ha^{-1}) but at par with foliar nutrition of 2.5% Ammonium sulphate + sulphate of potash twice at 45 and 60 DAT (1743 kg ha^{-1}). Control treatment (without foliar nutrition) recorded significantly lower cured leaf yield of 1520 kg ha^{-1}. Foliar nutrition of N and K recorded positive effect on content of nitrogen and potassium in cured leaf. The quality parameters *viz.,* nicotine, reducing sugars and chlorides in cured leaf were not altered by the foliar nutrition of N and K compared to control. However, higher net returns were recorded with foliar nutrition of 2.5% ammonium sulphate + sulphate of potash twice at 45 and 60 DAT (Rs. 80169/- per ha) followed by application of 2.5% potassium nitrate (KNO_3) (Rs. 69645/- ha^{-1}) whereas without foliar spray treatment recorded the lowest net returns of Rs. 67550/- ha^{-1}.

INTRODUCTION

Tobacco (*Nicotiana tabacum* L.) is the most important non-food crop cultivated in more than 100 countries. It is one of the most important commercial crops of India, valued for its leaf containing nicotine. It is grown over an area of 1.22 lakh ha with production of 185 million kg in Gujarat, Karnataka, Maharastra and Andhra Pradesh (Lakshminarayana, 1990). The role of potassium (K) and nitrogen (N) nutrients is important in crop production. A deficiency of either one or both of these nutrients causes yield loss. They play a key role in controlling important quality parameters such as leaf colour, texture, hygroscopic properties, combustibility, sugar and alkaloid contents. Balanced N-K fertilization enhances tobacco growth and improves the uptake of both nutrients, which in turn reduces the nitrate losses during and after the cropping season.

In Andhra Pradesh, bidi tobacco is commercially cultivated under rainfed black soils in late rainy season *i.e.* September (2nd fortnight) month. Usually, farmers apply recommended fertilizer dose in two splits *i.e.* one at basal and another as top dressing at 30 days after sowing (DAT). Several studies were conducted earlier on nutrient management to improve the cured leaf yields and found less response. However, in present day agriculture, foliar fertilization is very frequently practiced in agriculture and also recommended as an integrated plant production component because it is environmental friendly and helps to achieve high productivity with good quality. Foliar fertilization should be done under conditions of decreased nutrient availability in soil, dry topsoil and decreased root activity during the reproductive stage (Wójcik, 2004). However, the efficiency of foliar fertilization depends

E-mail:kprabhakar7714@gmail.com

on nutrient mobility within a plant. For nutrients which are phloem mobile, the efficiency of this measure is particularly successful. According to Doring and Gericke (1986) and Tukey and Marczyñski (1984), a combined soil and foliar fertilization should be recommended in crop production to increase both crop productivity and yield quality. Hence, the present study was conducted to study the response of bidi tobacco to foliar nutrition of nitrogen and potassium and also to find out the effective source and time of application.

MATERIAL AND METHODS

A field experiment was conducted at Regional Agricultural Research Station, Nandyal under rainfed conditions during *kharif* 2014-15 and 2015-16. The soil of experimental site was medium deep black, low in organic carbon (0.36 %), high in available P_2O_5 (45kg ha^{-1}) and available K_2O (536 kg ha^{-1}). The experiment comprised of ten treatments, *viz.*, (T1) Control (No foliar nutrition), (T2) 2.5% Potassium nitrate (KNO_3) at 45 DAT, (T3) 2.5% KNO_3 at 60 DAT, (T4) 2.5% KNO_3 at 45 and 60 DAT, (T5) 2.5% Ammonium Sulphate (A.S) + Sulphate of potash (SOP) at 45 DAT, (T6) 2.5% A.S +SOP at 60 DAT, (T7) 2.5% A.S +SOP at 45 and 60 DAT, (T8) 2.5% Urea +SOP at 45 DAT, (T9) 2.5% Urea +SOP at 60 DAT and (T10) 2.5% Urea +SOP at 45 and 60 DAT. The experiment was carried out in randomized block design (RBD) with three replications. The row-to-row and plant to plant spacing was 75 cm x 75 cm. Crop management practices such as land preparation, N, P and K fertilizer application, weed control, intercultivation, need based plant protection, de suckering and sun curing were followed as recommended for local area. The nursery was raised during 2nd FN of July and healthy seedlings were transplanted at 45 days during 2nd FN of September. For foliar nutrition, 2.5% potassium nitrate, 2.5% ammonium sulphate + sulphate of potash and 2.5% urea + sulphate of potash were prepared at spraying time and sprayed at 45 and 60 DAT using of 500 litres of spray fluid per hectare by using a hand operated knapsack sprayer.

The experiment was conducted under rainfed condition. A total rainfall of 644 mm and 732 mm of was received during crop season (July to December) during 2014 and 2015, respectively. Rainfall distribution was highly erratic coupled with prolonged dry spells in the month of August followed by continuous and heavy rainfall in the month of September during both the years. The data were recorded on ten randomly selected plants of each treatment in all replications for plant height, leaf length, leaf width, leaf thickness and leaf area.

Dry matter partitioning, green leaf yield and cured leaf yield at harvest were recorded. Leaf quality parameters such as spangle score, nicotine percentage and reducing sugars percentage were also recorded at harvest. Complete leaf analysis was taken up and estimated for nitrogen, phosphorus and potassium content in cured leaf. The data was subjected to statistical analysis by following standard procedures.

RESULTS AND DISCUSSION

Growth characters

Foliar nutrition did not significantly influence the plant height, leaf length and leaf width. However, leaf area and leaf thickness were significantly higher with foliar nutrition of 2.5% KNO_3 at 45 and 60 DAT

Table 1. Plant growth characters of of bidi tobacco as influenced by foliar nutrition of Nitrogen and Potassium (Pooled data of 2014-15 and 2015-16)

Treatment	Leaf length (cm)	Leaf width (cm)	Leaf Area (m^2)	Leaf thickness (mg cm^{-2})	Stem dry weight (g $plant^{-1}$)	Leaf dry weight (g $plant^{-1}$)
Control (No foliar nutrition)	36.7	18.4	1.34	3.19	75.2 (46.2)	87.5 (53.7)
2.5% KNO3 at 45 DAT	39.7	17.4	1.38	3.21	77.0 (47.1)	86.3 (52.8)
2.5% KNO3 at 60 DAT	44.2	20.5	1.32	3.19	72.0 (45.7)	85.3 (54.2)
2.5% KNO3 at 45 and 60 DAT	33.2	14.1	1.60	4.06	87.1 (48.3)	102.9 (57.1)
2.5% A.S +SOP at 45 DAT	38.5	18.6	1.34	3.26	82.0 (50.5)	80.2 (49.4)
2.5% A.S +SOP at 60 DAT	30.6	14.8	1.36	3.43	83.9 (51.4)	79.3 (48.5)
2.5% A.S +SOP at 45 and 60 DAT	37.3	17.0	1.58	3.90	86.9 (47.5)	95.9 (52.4)
2.5% Urea +SOP at 45 DAT	37.1	15.6	1.32	3.35	79.5 (50.0)	79.3 (49.9)
2.5% Urea +SOP at 60 DAT	36.4	17.6	1.37	3.39	85.7 (50.9)	82.6 (49.0)
2.5% Urea +SOP at 45 and 60 DAT	38.4	18.2	1.32	3.36	71.3 (45.9)	84.9 (54.7)
S.Em±	2.7	1.5	0.03	0.07	2.2	1.7
C.D. at 5 %	NS	NS	0.12	0.20	6.6	5.3
CV	12.8	15.2	3.7	3.4	4.8	3.6

Figures in parentheses indicates the percentage of dry matter contributed to total weight

Table 2. Economic yield and economics of bidi tobacco as influenced by foliar nutrition of Nitrogen and Potassium (Pooled data of 2014-15 and 2015-16)

Treatment	Green leaf yield (kg ha -1)	Cured leaf yield (kg ha -1)	Gross returns (Rs/ha)	Cost of cultivation (Rs/ha)	Net returns (Rs/ha)
Control (No foliar nutrition)	7099	1520	98800	31250	67550
2.5% KNO3at 45 DAT	7663	1533	99645	38750	60895
2.5% KNO3at 60 DAT	7605	1521	98865	38750	60115
2.5% KNO3at 45 and 60 DAT	9205	1783	115895	46250	69645
2.5% A.S +SOP at 45 DAT	7125	1425	92625	32188	60437
2.5% A.S +SOP at 60 DAT	7714	1542	100230	32188	68042
2.5% A.S +SOP at 45 and 60 DAT	9009	1743	113295	33126	80169
2.5% Urea +SOP at 45 DAT	6956	1391	90415	32073	58342
2.5% Urea +SOP at 60 DAT	6812	1362	88530	32073	56467
2.5% Urea +SOP at 45 and 60 DAT	7730	1546	100490	33156	67334
S.Em±	421	84	-	-	-
C.D. at 5 %	1261	175	-	-	-
CV	9.4	9.4	-	-	-

Table 3. Nutrient content in cured leaf of bidi tobacco as influenced by foliar nutrition of Nitrogen and Potassium sources at different intervals (Pooled data of 2014-15 and 2015-16)

Treatment	Nitrogen (%)	Phosphorus (%)	Potassium (%)
Control (No foliar nutrition)	1.48	0.34	3.42
2.5% KNO3at 45 DAT	1.50	0.37	3.67
2.5% KNO3at 60 DAT	1.53	0.37	3.64
2.5% KNO3at 45 and 60 DAT	1.63	0.37	4.40
2.5% A.S +SOP at 45 DAT	1.46	0.37	3.12
2.5% A.S +SOP at 60 DAT	1.46	0.35	3.26
2.5% A.S +SOP at 45 and 60 DAT	1.61	0.42	4.36
2.5% Urea +SOP at 45 DAT	1.41	0.39	3.07
2.5% Urea +SOP at 60 DAT	1.40	0.36	3.37
2.5% Urea +SOP at 45 and 60 DAT	1.49	0.39	3.26
S.Em±	0.02	0.03	0.05
C.D at 5 %	0.07	NS	0.16
CV (%)	2.9	11.6	2.9

(1.60 m^2 and 4.06 mg cm^2, respectively) which was at par with foliar nutrition of 2.5% A.S +SOP at 45 and 60 DAT (1.58 m^2 and 3.90 mg cm^2). Leaf area is an important factor determining the dry matter production of a crop and subsequently the yield. Govindan and Thirumurugan (2000) reported that the growth parameters *viz.,* LAI in green gram were significantly higher with the foliar spray of KNO_3 (%) or KCl (1%) and their combinations. Similar results were also reported from ICAR-CTRI Rajahmundry (Damodar Reddy, 2014) which revealed that the application of N and K through foliar sprays improved the leaf area in FCV tobacco. Dry weight of single plant was significantly higher with foliar spray of 2.5% KNO_3 at 45 and 60 DAT(87.1g $plant^{-1}$) which was on par with 2.5% A.S +SOP at 45 and 60 DAT (86.9 g $plant^{-1}$). Similarly, leaf dry weight was significantly higher with 2.5% KNO_3 at 45 and 60 DAT (102.9 g $plant^{-1}$) which was on par with 2.5% A.S +SOP at 45 and 60 DAT (95.9 g $plant^{-1}$). This is in conformity with the findings of Jayarani Reddy *et al.* (2004) where in foliar application of NAA 20 ppm + KNO_3 0.5 percent significantly increased the dry matter production in redgram.

Nutrient content in cured leaf

Results given in Table 4 revealed that foliar nutrition had positive effect in accumulation of nitrogen and potassium in bidi tobacco leaf compared to control. Higher content of nitrogen (1.63%) and potassium (4.4%) in leaf was recorded with 2.5% KNO_3 at 45 and 60 DAT which was on par with 2.5% A.S + SOP at 45 and 60 DAT (1.61 and 4.36% of N and K, respectively). Phosphorus content did not differ with control treatment. Marchand (2010) opined that spraying of potassium salts on the leaves of plants with low K status but adequately supplied with other nutrients would be expected to promote sucrose (and K) transport in phloem from shoot to roots. Energy would thus be provided to further root growth thereby enhancing K acquisition from the soil in a K pump-like action. Both foliar applied and any enhanced K uptake would also favour growth by improving water status, photosynthetic activity, protein synthesis, etc. Higher concentration of K in the cured leaf was due to the foliar nutrition of N and K either through potassium nitrate or ammonium sulphate + SOP application compared to control (Damodar Reddy, 2015).

Economic yield

A significant increase in green leaf (9205kg ha^{-1}) and cured leaf yield (1783kg ha^{-1}) were recorded with foliar nutrition of 2.5% KNO_3 at 45 and 60 DAT which was on par with 2.5% A.S + SOP at 45 and 60 DAT (9009 and1743 kg ha^{-1} respectively). Foliar nutrition through 2.5% Urea + SOP at 45 and 60 DAT recorded cured leaf yield of 1546 kg ha^{-1} which was at par with control (1520 kg ha^{-1}). However, foliar nutrition twice with KNO_3 or ammonium sulphate + sulphate of potash was found significantly superior to single spray. However, foliar nutrition with Urea + sulphate of potash either two spray or one spray did not bring any significant impact on economic yield of tobacco. For foliar nutrition, potassium nitrate and ammonium sulphate are superior to Urea which might be due to low salt index (Steve Curley, 1994). The results confirmed that increased N and K concentration in the foliar spray solution and increases N and K concentration in the leaves, which in turn increase yields. Moreover, leaf area and leaf thickness also contributed for increase in cured leaf yield. The similar results were reported by Marchand(2010) where foliar nutrition of SOP increased the concentration of leaf K content and increased tobacco leaf yield. Experimental results on foliar nutrition on FCV tobacco by All India Net work project on Tobacco (AINPT) indicated that the foliar application of N and K at 45 and 55 DAT @ 2.5% concentration increased the cured leaf productivity by 13-14% and there was no difference between the two sources potassium nitrate or ammonium sulphate + SOP (Damodar Reddy, 2015). Hence, foliar nutrition of potassium nitrate or ammonium sulphate + SOP twice at 45 and 60 DAT could increase the cured leaf yield of bidi tobacco by 16-17%.

Economics

The economic evaluation of the study (Table 3) revealed that the highest net profit of Rs.80169/- per ha was obtained with foliar nutrition of 2.5% ammonium sulphate+ SOP at 45 and 60 DAT. Though 2.5% KNO_3 at 45 and 60 DAT recorded maximum net returns Rs. 69645/- per ha which is a marginal benefit over control (Rs. 67550/- per ha) due to high cost of potassium nitrate chemical contributed to increase in cost of cultivation and thus low net profit compared to 2.5% ammonium sulphate+ SOP at 45 and 60 DAT.

CONCLUSIONS

Bidi tobacco yields could be increased by 16% through supplementation of nitrogen and potassium through foliar nutrition of potassium nitrate or ammonium sulphate + SOP twice at 45 and 60 DAT. Cured leaf quality parameters such as spangle score, nicotine%, reducing sugars and chlorides were slightly altered by foliar nutrition and observed with the acceptable range. Leaf nitrogen and potassium content were increased with foliar nutrition of 2.5% KNO_3 alone and or 2.5% A.S +SOP at 45 and 60. However, maximum net returns per hectare were recorded with foliar nutrition of 2.5% A.S +SOP at 45 and 60 DAT.

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INFLUENCE OF VARIETIES AND FERTILIZATION ON GROWTH AND YIELD OF SWEET SORGHUM GROWN AS MAIN AND RATOON CROPS

M. GANGA DEVI, S. TIRUMALA REDDY AND S.M. MUNEENDRA NAIDU
Department of Agronomy, S.V. Agricultural College,
Acharya N.G. Ranga Agricultural University, Tirupati -517 502

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ABSTRACT

A field experiment was conducted at S.V. Agricultural College, Tirupati of Acharya N.G. Ranga Agricultural University during *kharif* and *rabi* seasons of 2010 and 2011. The experiment was laid out in a split-split plot design and replicated thrice. The results revealed that all the growth parameters *viz.,* plant height, leaf area and dry matter production and yield parametres stalk yield and grain yield of sweet sorghum grown as main crop were recorded highest with variety SPV-422 followed by Madhura hybrid with application of 100-80-80 kg ha^{-1} N, P_2O_5 and K_2O. The ratoon crop of sweet sorghum also followed same trend and recorded highest yield with application of 125 per cent of the nitrogen applied to main crop than the other treatments tested in this study.

INTRODUCTION

Sweet sorghum (*Sorghum bicolor* (L.) Moench) originated in tropical Africa and later spread to the near and far east. Sweet sorghum can be grown in regions ranging from 21°S to 47°N latitude and hence it is considered as the sugarcane of the temperate zone. The crop has a sweet and juicy stem because it can store considerable amount of sugar. Thus, recently sweet sorghum has been developed as a dual purpose crop for grain as well as for biomass production. It also exhibits quick growth rate and rapid sugar accumulation. Being a C_4 plant, sweet sorghum has a high photosynthetic potential producing 30 to 35 tonnes of millable cane along with 1.5 to 2.5 tonnes of grain ha^{-1}, accumulating dry matter at a rate of 50 gm day^{-1}.

Because of a faster growth rate, early maturity (90-120 days) and higher quantities of readily available fermentable sugar content, sweet sorghum has frequently been suggested as a good source of ethanol production (Prasad *et al.*,2006).Inadequate supply of nitrogen to sweet sorghum results in lower stalk yield and grain yield per unit area while excessive application results in poor juice quality. As is the case with nitrogen, phosphorus and potassium are also fundamental to sweet sorghum for synthesis and translocation of carbohydrates and proteins and accumulation of sucrose rather than reducing sugars. To maximize the yields of sweet sorghum using ratoon cropping systems, the role of management factors must be fully understood. However, it is not known whether the ratoon crop is capable of producing sugars, biomass and grain yield as that of the main crop.

MATERIAL AND METHODS

Field experiments were conducted at College farm, Tirupati of Acharya N.G. Ranga Agricultural University both during *kharif* and *rabi* seasons of 2010 and 2011 which is geographically situated at 13.5°N latitude, 79.5°E longitude and at an altitude of 182.9 m above the mean sea level in the Southern Agroclimatic Zone (Zone IV) of Andhra Pradesh. The

E-mail : devimadu@gmail.com

soils were sandy clay loam in texture, low in organic carbon and available nitrogen and medium in available phosphorus and potassium with soil pH of 7.2. The experiment was laid out in a split-split plot design and replicated thrice. Three genotypes *viz.,* SPV-422, ICSV-700 and Madhura hybrid were assigned to main plots and four fertilizer levels *viz.,* 60-40-40, 80-60-60, 100-80-80 and 120-100-100 kg ha^{-1} of N, P_2O_5 and K_2O were allotted to sub plots for main crop during *kharif* seasons, while three nitrogen levels *viz.,*100 per cent, 125 per cent and 150 per cent of nitrogen applied to main crop were allotted to sub-sub plots in the ratoon crop. The main plot is 13.5 m x 20.0 m, sub-plot is13.5 m x 5.0 m and sub-sub plot is of 4.5 m x 5.0 m. Healthy sweet sorghum seeds, treated with carbendazim @ 3 g kg^{-1} of seed to prevent seed borne diseases were used for sowing.The seeds were dibbled @ 2 to 3 seeds $hill^{-1}$ using a seed rate of 8-10 kg ha^{-1} with inter and intra row spacing of 45 cm x 20 cm, respectively. Pre-emergence spray of atrazine @ 1 kg $acre^{-1}$ was done on the next day after sowing for weed control. Four graded fertilizer levels of nitrogen, phosphorus and potassium *viz.,* 60-40-40, 80-60-60, 100-80-80 and 120-100-100 kg ha^{-1} were applied to sub plots during *kharif* for the main crop while three levels *viz.,* 100 per cent, 125 per cent and 150 per cent of the nitrogen applied to main crop were allotted to sub-sub plots during *rabi* season for the ratoon crop. In all the treatment combinations, while the nitrogen was applied in 2 equal splits at sowing and at 25 DAS, entire quantity of phosphorus and potassium was applied as a basal dose at the time of sowing. Inter-cultivation with a blade harrow was also done along with the second hoeing at 45 DAS followed by earthing up of ridges on both sides of the crop. Growth and yield attributes were recorded at different growth stages. Sweet sorghum stalks were cut at 4-5 cm above the ground level at physiological maturity and later ear heads were cut and separated. The stripped stalks of sweet sorghum were weighed immediately after harvesting, after separating the leaves from stem, in each net plot and the stripped stalk yield was expressed in t ha^{-1}. The panicles were air dried, threshed, cleaned and the grain was weighed and expressed as grain yield in kg ha^{-1}. The data recorded on various growth parameters, yield attributes, yield, quality, economics and nutrient uptake during the course of investigation were statistically analysed following the analysis of variance procedure as suggested by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Growth parameters

All the growth parameters *viz.,* plant height, leaf area and dry matter production of sweet sorghum as main crop (Table 1) were recorded highest values with the variety SPV-422 (V_1) which was, however, comparable with Madhura hybrid (V_3) and both these were significantly superior to ICSV-700 (V_2) which resulted in lowest growth parameters. This might be due to differences in their genetic characters and leaf area, and number of green leaves and better partitioning of assimilates Latha and Sharanappa (2010). All the growth parameters have significantly differed among them with the graded levels of

Table 1. Growth parameters of sweet sorghum as main crop influenced by different treatments

Treatment	Plant height (cm)	Leaf area (cm^2)	DMP (g $plant^{-1}$)
Main plots (Varieties)			
V_1 - SPV-422	310.7	3056.92	133.32
V_2 - ICSV-700	256.7	2466.83	111.13
V_3 - Madhura	307.8	2974.25	131.31
S.Em±	3.8	24.50	0.64
CD at 5 %	14.8	96.17	2.51
Sub-plots (Fertilizer levels – N, P_2O_5 and K_2O kg ha^{-1})			
F_1 - 60-40-40	263.4	2691.00	118.18
F_2 - 80-60-60	279.8	2778.78	122.41
F_3 - 100-80-80	307.3	2902.78	129.71
F_4 - 120-100-100	316.2	2958.11	130.71
S.Em±	3.2	27.86	0.24
CD at 5 %	9.5	82.78	0.72
Interaction	NS	NS	Significant

fertilizers tried, and recorded highest with the highest fertilizer level of 120-100-100 kg ha^{-1} N, P_2O_5 and K_2O (F_4), which was significantly superior to other three levels.The next level was 100-80-80 kg ha^{-1} N, P_2O_5 and K_2O (F_3) fb 80-60-60 kg ha^{-1} N, P_2O_5 and K_2O (F_2). The lowest values recorded with 60-40-40 kg ha^{-1} N, P_2O_5 and K_2O (F_1) which was significantly inferior to the other higher fertilizer levels.

The pooled analysis on growth parameters of ratoon crop (Table 2) showed that the variety SPV-422 (V_1) recorded highest values closely followed by Madhura hybrid (V_3). Both these were at par with each other but significantly superior to ICSV-700 (V_2). Among the fertilizers application of 120-100-100 kg ha^{-1} N, P_2O_5 and K_2O (F_4) and 100-80-80 kg ha^{-1} N, P_2O_5 and K_2O (F_3) was comparable with each other and both these were significantly superior to the other lower fertilizer levels. They were followed by 80-60-60 kg ha^{-1} N, P_2O_5 and K_2O (F_2) which was superior to 60-40-40 kg ha^{-1} N, P_2O_5 and K_2O (F_1) and the later (F_1) produced significantly inferior values. With regard to different nitrogen levels tried, growth parameters of ratoon sweet sorghum increased with increasing levels of nitrogen and recorded highest with 150% of nitrogen *i.e.,* 150 kg N ha^{-1} (N_3) followed by 125% of nitrogen i.e. 125 kg N ha^{-1} (N_2). Both these were on par with each other but significantly superior to 100% of nitrogen *i.e.,* 100 kg N ha^{-1} (N_1) which produced the lowest growth parameters during both the years. This might be due to development of relatively longer internodes, probably as a result of greater cell division and cell enlargement in nitrogen treated plots as explained by Silli *et al*. (2001). At all the stages of observation, the tallest plants were noticed with the

Table 2. Growth parameters of sweet sorghum as ratoon crop influenced by different treatments

Treatment	Plant height (cm)	Leaf area (cm^2)	DMP (g $plant^{-1}$)
Main plots (Varieties)			
V_1 - SPV-422	140.4	578.65	82.95
V_2 - ICSV-700	116.9	432.04	70.57
V_3 - Madhura	135.9	570.37	79.78
S.Em±	0.8	3.09	1.24
CD at 5 %	5.7	14.01	5.60
Sub-plots (Fertilizer levels – N, P_2O_5 and K_2O kg ha^{-1})			
F_1 - 60-40-40	109.7	465.73	62.28
F_2 - 80-60-60	127.7	498.60	78.54
F_3 - 100-80-80	142.4	566.39	83.96
F_4 - 120-100-100	144.6	577.36	85.28
S.Em±	0.8	3.53	0.39
CD at 5 %	2.7	12.13	1.33
Sub-Sub plots (Nitrogen levels)			
N_1 – 100% N	127.1	513.32	73.84
N_2 – 125% N	132.6	529.24	79.07
N_3 – 150% N	133.5	538.49	80.39
S.Em±	0.7	4.01	0.52
CD at 5 %	1.8	11.40	1.48
Interaction	NS	NS	Significant

variety SPV-422 (V_1) which was, however, comparable with Madhura hybrid (V_3) and both these were significantly superior to ICSV-700 (V_2) which produced plants of the shortest stature. The differences in the plant height among the cultivars might be due to differences in their genetic characters and internodal length. At all the stages, plants of the tallest stature were observed with the highest fertilizer level of 120-100-100 kg ha^{-1} N, P_2O_5 and K_2O (F_4) which was, however, comparable with the fertilizer level of 100-80-80 kg ha^{-1} N, P_2O_5 and K_2O (F_3) and both these were significantly superior to other lower fertilizer levels tried, *i.e.,* 80-60-60 kg ha^{-1} (F_2) and 60-40-40 kg ha^{-1} of N, P_2O_5 and K_2O (F_1).

Stripped Stalk Yield (t ha^{-1}) :

Statistical analysis of pooled data of main crop of sweet sorghum (Table 3) revealed that the highest stripped stalk yield was recorded with the variety SPV-422 (V_1) which was, however, comparable with Madhura hybrid (V_3). Both these genotypes were significantly superior to the variety ICSV-700 (V_2), which resulted in significantly lowest stripped stalk yield. The highest stripped stalk yield with SPV-422 (V_1) could be attributed to an increase in the plant height and more importantly dry matter accumulation in stem. Among the fertilizer levels tried, the highest fertilizer level of 120-100-100 kg ha^{-1} N, P_2O_5 and K_2O (F_4) resulted in the highest stripped stalk yield followed by 100-80-80 kg ha^{-1} N, P_2O_5 and K_2O (F_3) which were on par with each other. Both these were significantly superior to 80-60-60 kg ha^{-1} N, P_2O_5 and K_2O (F_2) and 60-40-40 kg ha^{-1} N, P_2O_5 and K_2O (F_1) with significant disparity between the later (F_2 and F_1) treatments and lowest was with F_1. This could be attributed to the better vegetative growth which, in turn, enhanced the dry matter production Silli *et al.* (2001). The interaction effect of the variety SPV-422 with a fertilizer level of either 120-100-100 kg ha^{-1} N, P_2O_5 and K_2O (V_1F_4) or 100-80-80 kg ha^{-1} N, P_2O_5 and K_2O (V_1F_3) are comparable and recorded significantly higher stalk yield and significantly the lowest stripped stalk yield was recorded with the genotype ICSV-700 coupled with the fertilizer level of 60-40-40 kg ha^{-1} N, P_2O_5 and K_2O (V_2F_1).

Table 3. Effect of varieties and fertilizer levels on stripped stalk yield (t ha^{-1}) of main crop of sweet sorghum

Treatment	V_1- SPV-422	V_2- ICSV-700	V_3- Madhura	**Mean**
F_1 - 60-40-40	46.3	39.0	46.9	44.1
F_2 - 80-60-60	49.7	40.4	49.5	46.5
F_3 - 100-80-80	52.6	45.6	53.8	50.7
F_4 - 120-100-100	53.5	47.4	52.8	51.2
Mean	**50.5**	**43.1**	**50.7**	
	S.Em±		**CD @ 5%**	
V	0.19		0.74	
F	0.23		0.69	
F at V	0.41		1.20	
V at F	0.38		1.22	

The pooled data analysis revealed that the highest stripped stalk yield of ratoon crop (Table 4) was recorded with the varietySPV-422 (V_1) which, however, was comparable to Madhura hybrid (V_3) and distinctly superior to the other variety ICSV-700 (V_2). Stripped stalk yield increased marginally with application of fertilizers from F_1 (60-40-40 kg ha^{-1} N, P_2O_5 and K_2O) to F_3 (100-80-80 kg ha^{-1} N, P_2O_5 and

Table 4. Effect of varieties, fertilizer levels and nitrogen levels on stripped stalk yield (kg ha^{-1}) of ratoon sweet sorghum at harvest

Treatment		Pooled			
		V_1- SPV-422	V_2- ICSV-700	V_3- Madhura	**Mean**
F_1	N_1 – 100% N	2879.5	1130.5	2847.5	2285.8
	N_2 – 125% N	3180.8	1150.8	2886.8	2406.2
	N_3 – 150% N	3248.2	1160.2	3117.2	2508.5
	Mean	**3102.8**	**1147.2**	**2950.5**	
F_2	N_1 – 100% N	3377.8	1170.2	3309.7	2619.2
	N_2 – 125% N	3520.3	1176.8	3519.0	2738.7
	N_3 – 150% N	3557.2	1184.7	3627.7	2789.8
	Mean	**3485.1**	**1177.2**	**3485.4**	
F_3	N_1 – 100% N	3809.7	1190.3	3759.0	2919.7
	N_2 – 125% N	3955.8	1192.5	3876.2	3008.2
	N_3 – 150% N	4037.0	1194.2	3950.3	3060.5
	Mean	**3934.2**	**1192.3**	**3861.8**	
F_4	N_1 – 100% N	3961.3	964.5	3982.7	2969.5
	N_2 – 125% N	4111.8	966.3	4158.5	3078.9
	N_3 – 150% N	4183.3	969.8	4167.0	3106.7
	Mean	**4085.5**	**966.9**	**4102.7**	
		S.Em±		**CD @ 5%**	
V		11.9		54.2	
F		17.8		61.2	
N		27.3		77.5	
V at F		29.3		97.0	
F at V		30.9		101.5	

K_2O) where after it decreased significantly with the highest fertilizer level of 120-100-100 kg ha^{-1} N, P_2O_5 and K_2O (F_4). Among the nitrogen management, application of 150% nitrogen (N_3) resulted in the highest quantity of stripped stalk yield which, in turn, was at par with 125% nitrogen (N_2). Both these were significantly superior to 100% nitrogen (N_1) which resulted in the lowest stripped stalk yield Silli *et al.* (2001). With respect to interaction effects, only the varieties and fertilizer levels exhibited discernible effects while the others failed to exert any significant interaction effects. The combination of the Madhura hybrid and the fertilizer level of 120-100-100 kg ha^{-1} N, P_2O_5 and K_2O (V_3F_4) resulted in marginally higher stripped stalk yield.

Grain Yield (kg ha^{-1})

The pooled data analysis revealed (Table 5) that the highest grain yield of main crop was recorded with the variety SPV-422 (V_1) which was, however, at par with Madhura hybrid (V_3) and significantly superior to ICSV-700 (V_2).The variety SPV-422 (V_1) was consistently superior to ICSV-700 (V_2) in terms of plant height, leaf area and dry matter production. The better partitioning of the available photosynthates and efficiency of translocation towards sink resulting in the highest grain yield with the variety SPV-422 (Latha and Sharanappa , 2010). The highest grain yield was recorded with 100-80-80 kg ha^{-1} N, P_2O_5 and K_2O (F_3) which was at par with F_4 but distinctly superior to other two lower fertilizer levels (F_1 and F_2) tried. Significantly lowest grain yield was recorded with the lowest level of 60-40-40 kg ha^{-1} N, P_2O_5 and K_2O (F_1). This might be due to sufficiency of nutrients at this level which resulted in efficient translocation of accumulated assimilates to reproductive organs resulting in higher grain yield. Above or below this level, most of the accumulated assimilates might have been utilized for dry matter production and less

Table 5. Effect of varieties and fertilizer levels on grain yield (kg ha^{-1}) of main crop of sweet sorghum at harvest

Treatment	V_1- SPV-422	V_2- ICSV-700	V_3- Madhura	**Mean**
F_1 - 60-40-40	764	375	675	605
F_2 - 80-60-60	789	402	756	649
F_3 - 100-80-80	852	482	870	735
F_4 - 120-100-100	845	482	834	721
Mean	**813**	**435**	**784**	
	S.Em±		**CD @ 5%**	
V	10		38	
F	6		17	
F at V	10		30	
V at F	17		33	

quantity of assimilates were translocated to reproductive organs. With respect to interaction effects combination of either SPV-422 or Madhura genotypes along with the application of a fertilizer level of 100-80-80 kg ha^{-1} N, P_2O_5 and K_2O (V_1F_3 and V_3F_3) resulted in the highest grain yield (Fig.1) Turgut *et al*. (2005).

The pooled data analysis revealed (Table 6) that the highest grains yield of ratoon sweet sorghum crop was recorded with SPV-422 (V_1), which in turn

Table 6. Effect of varieties, fertilizer levels and nitrogen levels on grain yield (kg ha^{-1}) of ratoon sweet sorghum at harvest

Treatment					
		V_1- SPV-422	V_2- ICSV-700	V_3- Madhura	**Mean**
F_1	N_1 – 100% N	221	206	237	221
	N_2 – 125% N	246	223	250	240
	N_3 – 150% N	240	214	245	233
	Mean	**235**	**214**	**244**	
F_2	N_1 – 100% N	267	238	256	253
	N_2 – 125% N	298	259	276	278
	N_3 – 150% N	287	253	266	269
	Mean	**284**	**250**	**266**	
F_3	N_1 – 100% N	333	275	326	311
	N_2 – 125% N	350	290	342	327
	N_3 – 150% N	347	288	336	324
	Mean	**343**	**285**	**335**	
F_4	N_1 – 100% N	325	271	297	297
	N_2 – 125% N	352	285	334	324
	N_3 – 150% N	344	315	323	327
	Mean	**340**	**290**	**318**	

	S.Em±	**CD @ 5%**
V	3	12
F	2	6
N	2	5
V at F	4	12
F at V	3	10

was at par with Madhura hybrid (V_3). Both these were significantly superior to the variety ICSV-700 (V_2). With regard to fertilizer levels, 100-80-80 kg ha^{-1} N, P_2O_5 and K_2O (F_3) resulted in the highest grain yield after which a decreased grain yield was noticed with 120-100-100 kg ha^{-1} N, P_2O_5 and K_2O (F_4). Both these were significantly superior to the lower fertilizer levels of 80-60-60 kg ha^{-1} N, P_2O_5 and K_2O (F_2) and 60-40-40 kg ha^{-1} N, P_2O_5 and K_2O (F_1) with significant disparity between them and significantly least grain yield was recorded with the lowest fertilizer level (F_1). With respect to nitrogen levels tried, the highest grain yield was recorded with 125% N (N_2), after which, there was a declining trend with 150% N (N_3). Both of them were on par with each other but significantly superior to 100% N *i.e.,* 100 kg N ha^{-1} (N_1) which registered the lowest grain yield. With respect to interaction the variety SPV-422 along with the application of a fertilizer level of 100-80-80 kg ha^{-1} N, P_2O_5 and K_2O (V_1F_3) resulted in higher grain yield which was comparable to Madhura hybrid with the same fertilizer level of 100-80-80 kg ha^{-1} N, P_2O_5 and K_2O (V_3F_3).

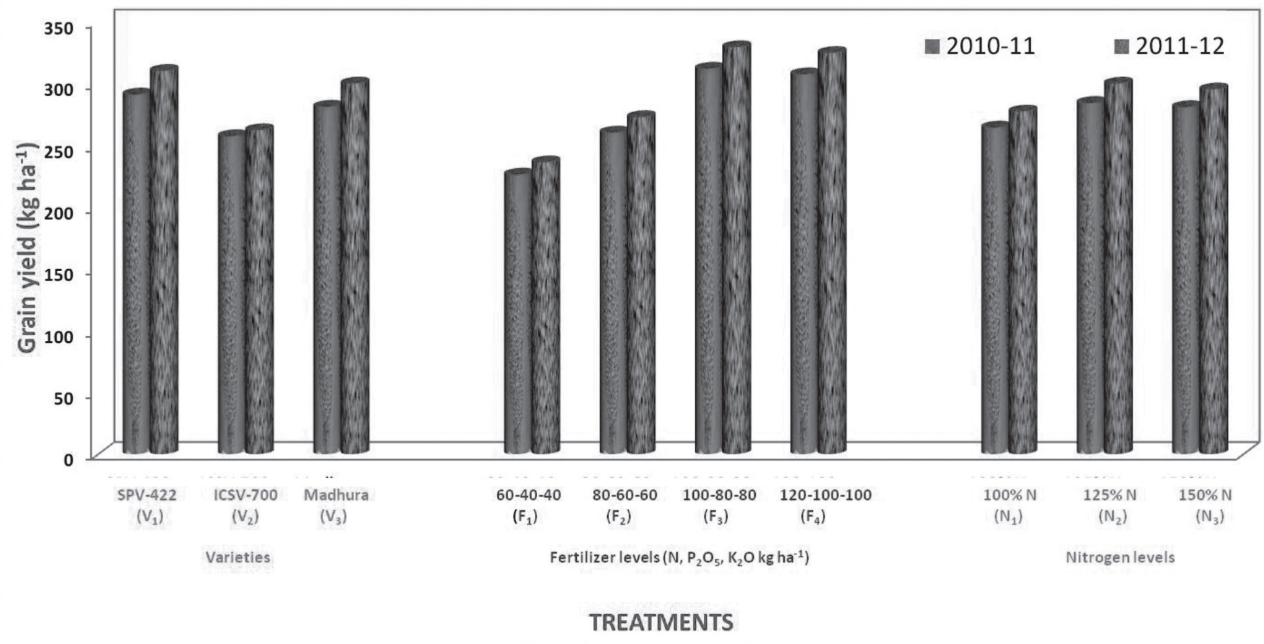

Fig.1. Effect of different treatments on grain yield (kg ha^{-1}) of Main & Ratoon crops

CONCLUSION

Sweet sorghum variety SPV-422 is performing better as main and ratoon crop (in terms of yield) at fertilizer level of 100-80-80 kg ha^{-1} N, P_2O_5 and K_2O and 125% nitrogen applied to main crop.

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INFLUENCE OF GREEN MANURE AND POTASSIUM ON GROWTH, YIELD AND ECONOMICS OF RICE (*Oryza sativa.* L)

D.V. SUJATHA, P. KAVITHA, M.V.S. NAIDU AND P. UMA MAHESWARI
Department of Soil Science and Agricultural Chemistry, Agricultural College,
Acharya N.G. Ranga Agricultural University, Mahanandi – 518 502

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ABSTRACT

A field experiment was conducted in rice during *Kharif*, 2015 at Agricultural College Farm, Mahanandi to study the influence of different levels of potassium either alone or in combination with green manure on plant height, yield, yield attributes and economics of rice. The results revealed that plant height, yield and yield attributes were increased with increasing levels of potassium up to 120 kg K_2O ha^{-1}. However, there was no statistical difference between three levels of K (40, 80 and 120 kg K_2O ha^{-1}) in increasing plant height, yield and yield attributes. Application of green manure *in situ* (GM) in combination with K recorded higher values of above mentioned parameters than when applied alone. The higher plant height, yield and yield attributes were obtained with GM+120 kg K_2O ha^{-1} which was on a par with GM+80 kg K_2O ha^{-1} and GM+40 kg K_2O ha^{-1}. However, the highest gross returns, net returns and B: C ratios were recorded with GM+120 kg K_2O ha^{-1} followed by GM+80 kg K_2O ha^{-1} and GM+40 kg K_2O ha^{-1}.

INTRODUCTION

Rice is an important food crop in the world. It is the staple food in South-East Asia and at present more than half of the world's population depends on this crop. It is also one of the most important cereals in India and occupies second position in cultivation after wheat. Rice is one of the major field crops in Kurnool district, cultivated in an area of 91,568 ha (Department of Agriculture, 2014). Incorporation of *dhaincha* at flowering stage before transplanting of rice is followed by most of the farmers in major rice growing areas of Kurnool district. The available potassium content was increased by the incorporation of *dhaincha* (Singh *et al.,* 2009 and Singh *et al.,* 2006). The soils of Agricultural College Farm, Mahanandi were high in available K and K supplying power of rice growing soils of canal ayacut in Kurnool district is low as indicated by PBC^K. Hence, judicious application of potassic fertilizer is required for better crop production were reported by Prasad (2014) and Swamanna (2015). Though much work has been reported on green manure in combination with N and P in rice crop but no investigation has been carried out in green manure along with K nutrition in rice crop. Hence, the present investigation was carried out to study the yield, yield attributes and economics of rice as influenced by different levels of potassium in combination with green manure.

MATERIAL AND METHODS

A field experiment was conducted at Agricultural College Farm, Mahanandi in Kurnool district of Andhra Pradesh during *Kharif*, 2015. The soils of experimental field was sandy loam with soil pH 7.97, EC 0.33 dSm^{-1}, organic carbon 0.55%, low in available N (239 kg ha^{-1}), high in P_2O_5 (82 kg ha^{-1}) and K_2O (1075 kg ha^{-1}), respectively. The eight treatments consisted of 0, 40, 80 and 120 kg K_2O ha^{-1} alone and in combinations with green manure. The treatment details are given in Table 1, which were laid out in randomized block design and replicated thrice. Nitrogen in the form of urea was applied in three equal splits as basal, at tillering and at panicle

E-mail : sujathadwaram42@gmail.com

initiation stages. Phosphorus in the form of single super phosphate was applied as during puddling. Potassium in the form of Muriate of Potash (MoP) was applied in two equal splits as basal and at panicle initiation stage as per the treatments. Green manure (*dhaincha*) was grown in the treatments T5, T6, T7 and T8 ploughed *in situ* at flowering before transplanting. The content of N, P and K in green manure was 3.5 percent, 0.3 percent and 1 percent, respectively. Plant height (cm) of the rice was measured from the base of the plant to the tip of the top most leaf and was recorded at tillering, panicle initiation and at maturity stages from five randomly labeled plants in each plot. Number of tillers and productive tillers were counted at harvest stage in an area one square meter in each plot. Length from the last node to the tip of panicles was recorded randomly for 10 panicles and expressed in cm. Number of grains and filled grains on the randomly selected panicle was counted and expressed as number of grains and number of filled grains panicle^{-1}. Thousand filled grains were counted from selected samples for each treatment from a composite sample drawn from the net plot yield and weighed as grams for 1000 grains. The grain from each net plot was cleaned and sun dried until constant weight was recorded and expressed in kg ha^{-1}. The yield from sample plants from net plot was added to the net plot yield. The straw from each net plot was allowed to dry in the field until a constant weight obtained and the final weight was recorded and expressed in kg ha^{-1}. Gross returns, net returns and benefit cost ratio were calculated for each treatment by considering prevailing input costs and output prices.

The data obtained from experiment were subjected to statistical analysis as per the procedures out lined by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

Plant height

The results showed that there was an increase in plant height with increase in age of crop from tillering to harvest in all the treatments. The rate of increase was more from transplanting to tillering than from panicle initiation to harvest (Table 1).Plant height increased with increasing level of K up to 120 kg K_2O ha^{-1} (T4) at all the stages of crop growth. However, significant difference in plant height was recorded at 80 kg K_2O ha^{-1} (T3) and 120 kg K_2O ha^{-1} (T4). Plant height recorded with K (40, 80 and 120 kg K_2O ha^{-1}) was on a par at all the stages of crop growth. Plant height increased with addition of K fertilizer was also reported by Fageria and Oliveira (2014), Kanthi *et al.* (2014) and Fageria (2015).

Application of green manure in combination with potassium recorded higher plant height than when applied alone at all the stages of crop growth. The highest plant height was observed in GM +120 kg K_2O ha^{-1} (T8) (57 cm at tillering, 71.20 cm at panicle initiation stage and 84.30+ cm at harvest stage). However at panicle initiation stage, it was on a par with GM + 80 kg K_2O ha^{-1}(T7) and at harvesting stage it was on par with GM+40 kg K_2O ha^{-1} (T6) and GM +80 kg K_2O ha^{-1}(T7). At tillering stage all the treatments were equally effective in increasing plant height except control (T1) and 40 kg K_2O ha^{-1}(T2). Green manure in combination with K fertilizers had significantly enhanced the plant height, which might

Table 1. Plant height, Yield attributes as influenced by different levels of potassium and green manure

Treatments	Plant height (cm)			No. of tillers m^{-2}	No. of productive tillers m^{-2}	No. of grains $panicle^{-1}$	Filled grains $panicle^{-1}$	Test weight (g)	Panicle length (cm)
	Tillering stage	P.I stage	Harvesting stage						
T1: 0% RDK (Control)	46.20	57.87	72.07	455	411	133	124	14.03	18.9
T2: 50% RDK (40 kg K_2O ha^{-1})	47.43	61.40	74.37	477	444	153	142	14.53	19.1
T3:100% RDK (80 kg K_2O ha^{-1})	51.62	63.93	76.33	500	455	154	141	14.73	19.1
T4:150% RDK (120 kg K_2O ha^{-1})	52.60	64.67	77.60	522	500	155	145	15.04	19.6
T5:GM (*dhaincha)in situ* only	53.33	65.67	78.33	555	489	152	144	14.89	19.5
T6:GM+ 40 kg K_2O ha^{-1}	54.00	67.00	80.53	577	533	153	146	15.67	19.4
T7:GM+ 80 kg K_2O ha^{-1}	55.80	68.27	81.20	622	544	156	147	15.74	19.4
T8:GM+ 120 kg K_2O ha^{-1}	57.00	71.20	84.30	733	677	158	149	15.86	19.7
SE(m) ±	1.77	1.20	1.23	9.85	13.03	1.4	1.8	0.17	0.3
CD at 5 %	5.41	3.69	3.77	31	40	4.13	5.51	0.53	NS
CV %	5.86	3.21	2.73	3.07	4.45	1.54	2.20	1.99	2.08

*P.I – Panicle Initiation

be due to prevalence of better soil physical conditions and increased availability of nutrients which enhanced the uptake of nutrients, resulting in improved the plant height. Similar results were reported by Reddy and Reddy (1979) in maize-soybean cropping system and Bhoite (2005) in rice – wheat cropping system.

Green manure *in situ* only (T5) was also found advantageous in producing taller plants than fertilizer treatments. This was due to greater availability and steady release of nutrient from green manure, which might have helped in cell multiplication and enlargement leading to substantial increase in plant height. Similar results were reported by Karmakar *et al*. (2011).

Yield attributes

Similar to yield, yield attributes *i.e*, number of tillers m^{-2}, number of productive tiller m^{-2}, numbers of grains $panicle^{-1}$, filled grains $panicle^{-1}$, test weight were significantly increased with increase in K fertilizer application and also due to green manure incorporation. Green manure in combination with K fertilizer treatment recorded higher yield parameters than when applied alone. (Table 1). The highest number of tillers m^{-2}, number of productive tiller m^{-2}, numbers of grains $panicle^{-1}$, filled grains $panicle^{-1}$, test weight was observed by the treatment T8 (G.M + 120 kg K_2O ha^{-1}) but which were on par with T_6 (G.M + 40 kg K_2O ha^{-1}) and T7 (G.M + 80 kg K_2O ha^{-1}). Among K levels the highest number of tillers m^{-2}, number of productive tiller m^{-2}, numbers of grains $panicle^{-1}$, filled grains $panicle^{-1}$, test weight was recorded at 120 kg K_2O ha^{-1} might be due to the application of potash at active growth stages resulted in adequate potash supply which increased plant photosynthesis rate, activation of starch synthesis and then conversion of soluble sugars into starch which is a vital step in the grain filling process. These results were in accordance with findings of Ramos *et al*. (1999) and also positive response of potassium application on number of grains per panicle in rice crop was reported by Manzoor *et al*. (2008).

Green manure *in situ* alone also recorded higher number of tillers m^{-2} than K fertilizer treatments alone. The lowest number of tillers m^{-2}, number of productive tiller m^{-2}, number of grains $panicle^{-1}$, filled grains $panicle^{-1}$ and test weight was observed with control (T1). The maximum test weight due to combined application of organics and in organics may be attributed to steady supply of nutrients which enhanced the dry matter production and translocation of photosynthates to grain resulted bold seeds which in turn increased the test weight (Puste *et al.,* 1996). Panicle length recorded was similar in different treatments.

Yield

All the treatments recorded significantly higher grain and straw yield than control except T2 (40 kg K_2O ha^{-1}) (Table 2). Grain and straw yield increased with increasing levels of K up to 120 kg K_2O ha^{-1}. However, there was no statistical difference between the three levels of K (40, 80 and 120 kg K_2O ha^{-1}) in increasing grain and straw yield. The increased grain and straw yield by the application of K fertilizer was due to the continuous supply of K during crop growth period which might be due to increased total no of tillers, dry mater accumulation, effective tillers, number and weight of filled grains and fertilizer use efficiency. These findings were in close conformity with those of Meena *et al.* (2003) and Surekha *et al.* (2003).

Table 2. Yield and Economics as influenced by different levels of potassium and green manure

Treatments	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Cost of cultivation (Rs ha^{-1})	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C ratio
T1. 0% RDK (Control)	5008	6173	42208	123109	80900	1.92
T2. 50% RDK (40 kg K_2O ha^{-1})	5281	6716	42528	130331	87803	2.06
T3. 100% RDK (80 kg K_2O ha^{-1})	5433	7664	42847	135977	93131	2.17
T4. 150% RDK (120 kg K_2O ha^{-1})	5517	7830	43166	138182	95016	2.20
T5. GM (*dhaincha)in situ* only	5493	8979	42958	140548	97590	2.27
T6. GM+ 40 kg K_2O ha^{-1}	5552	9617	43278	143403	100124	2.31
T7. GM+ 80 kg K_2O ha^{-1}	5671	10403	43597	147934	104337	2.39
T8. GM+ 120 kg K_2O ha^{-1}	5748	10931	43916	151992	108076	2.44

Application of green manure in combination with K recorded higher grain and straw yield than when applied alone. The highest grain and straw yield were obtained with T8 (GM + 120 kg K_2O ha^{-1}), but which were on par with T7 (GM + 80 kg K_2O ha^{-1}) and T6 (GM + 40 kg K_2O ha^{-1}) .Green manure in combinations with K fertilizers increased the grain yield due to long stature of plants, higher number of tillers m^{-2}, higher dry matter production and decomposition of succulent green manure crop, which favoured for release of nutrients and their continuous availability in soil for sustaining higher grain and straw yield of rice. Highest grain yield with green manure along with NPK fertilizers in rice was also reported by Sharma *et al.* (2001) and Singh *et al.* (2002). Green manure in combinations with K fertilizers increased the straw yield due to the highest plant height and dry matter accumulation. This might be due to immediate release of nutrients through inorganic sources and later by mineralization of nutrients through green manure leading to steady supply of nutrients. Similar findings were reported by Sharma *et al.* (2001) and Patra *et al.* (2000).

Economics

All the treatments showed higher gross returns, net returns and B:C ratio when compared to control.(Table 2). Green manure either alone or in combination with K fertilizer showed higher gross returns, net returns and B:C ratio. Among all the treatments the highest gross returns (Rs 1,51,992/-), net returns (Rs 1,08,076/-) and B:C ratio (2.44) were observed with T8 (GM +120 kg K_2O ha^{-1}) followed by T7 (GM + 80 kg K_2O ha^{-1}) and T6 (GM +40 kg K_2O ha^{-1}). Highest gross returns, net returns and B:C ratio were due to higher grain yield associated with the treatment T8 (GM +120kg K_2O ha^{-1}). Green manuring *in situ* only (T5) also showed higher gross returns, net returns and B:C ratio when compared to K treatments alone. Among K levels, the highest gross returns, net returns and B:C ratio were recorded at 150% RDK (120 kg K_2O ha^{-1}) followed by 100% RDK (80 kg K_2O ha^{-1}) .

CONCLUSION

The higher grain yield, straw yield, yield attributes and economics were obtained with incorporation of green manure as *dhaincha* (GM) + 120 kg K_2O ha^{-1} and was on par a with GM + 80 kg K_2O ha^{-1} and GM + 40 kg K_2O ha^{-1}. Hence, the incorporation of green manure (*dhaincha*) at flowering stage before transplanting along with 40 kg K_2O ha^{-1} may be recommended for rice crop.

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GENETIC CHARACTERIZATION OF PROMISING PROSOMILLET LINES USING CLUSTER AND PRINCIPAL COMPONENT ANALYSES

B.V REDDY, CVCM REDDY, PVRM REDDY AND B. GOPAL REDDY
Regional Agricultural Research Station, Acharya N.G. Ranga Agricultural University, Nandyala – 518 503

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ABSTRACT

Prosomillet is important rainfed crop among small millets for which this study was taken to characterize 18 promising prosomillet genotypes using multivariate analysis. High variability observed for most of the characters indicated the scope of improvement of these characters by direct selection. Phenotypic correlation between grain yield and panicle length was highly significant and positively associated. Similarly, fodder yield was also highly significant and positively associated with days to maturity and negatively associated to grain yield. The principal component analysis revealed that the first five components with eigen value >0.40 contributed about 95.47% of total variability. The characters including grain yield, fodder yield, days to maturity, panicle length, number of tillers plant^{-1}, plant height and days to 50% flowering were the most important traits contributing for the overall variability. Cluster analysis grouped 18 genotypes into three different clusters through multivariate hierarchical clustering. Cluster I, II and III formed distinct clusters and genotypes DHP2181, GPUP 23, TNPM 230, DhPrMV 2769, DhPrMV 2164, DhPrMV 2721, DHP 2780, GPUP 24, TNPM 228, TNAU 145, DhPrMV 2710 and TNAU 151 found to be more distinct. Recombination breeding using these parents provides segregants with rare combination of traits of interest towards maximizing grain and fodder yield potential.

INTRODUCTION

Prosomillet (*Panicum milliceum* L.) is an important small millet crop traditionally cultivated in rainfed regions of India and has the ability to produce better yields under multiple stresses such as drought, soil acidity and land marginality (Reddy and Reddy, 2012). Moreover, it has high nutritional value, weaning properties and excellent storage qualities (Seetharama *et al.*, 1986). Promising lines serve as a valuable source of useful genes and provides scope for building up a basic population of wide genetic variability. Therefore, knowledge of sound genetic diversity is essential for undertaking any recombination breeding program.

Multivariate statistical techniques which simultaneously analyze multiple measurements on each line under investigation are widely used in analysis of genetic diversity irrespective of whether it is morphological, biochemical or molecular marker-based and subsequently, classification of promising lines into groups on the basis of dissimilarity basis. Multivariate analysis has been used frequently for genetic diversity analysis in many crops such as proso millet (Reddy and Reddy, 2012) and rice (Gana *et al.,* 2013). Among the multivariate techniques, principal component analysis (PCA) and cluster analysis had been shown to be very useful in selecting genotypes for breeding program that meet the objective of a plant breeder (Mohammadi and Prasanna, 2003). PCA may be used to reveal patterns and eliminate redundancy in data sets (Adams, 1995) as morphological and physiological variations routinely occur in crop species. Cluster analysis is commonly used to study genetic diversity and for forming core subset for grouping accessions with similar characteristic into one homogenous category. Clustering is also used to summarize information on relationships between objects by grouping similar units so that the relationship may be

E-mail : cvcmreddy@yahoo.com

easily understood and communicated. This study was undertaken to analyse prosomillet genotypes by means of morphological and yield traits to understand the association of various characters, Principal Component Analysis(PCA) and cluster analysis which would enable to classify the best lines into distinct groups on the basis of their genetic diversity.

MATERIAL AND METHODS

This study was conducted to evaluate 18prosomillet promising lines includes 4 checks from different geographical regions across India pooled under All India Coordinated Small Millets Improvement Project (AICSMIP) for evaluation at Regional Agricultural Research Station, Nandyal, Andhra Pradesh during two seasons in the year 2014. For evaluation and characterization these 14 promising lines and 4 check varieties GPUP 21, TNAU 145, TNAU 151 and Local were grown in randomized complete block design during *kharif*, 2014. Each line was grown in ten rows of 3 m length with a spacing of 30 cm x 10 cm. Observations were recorded from five randomly selected plants in each accession for seven quantitative characters such as days to 50% flowering, plant height (cm), number of tillers plant^{-1}, panicle length (cm), days to maturity, grain yield (kg ha^{-1}), fodder yield (kg ha^{-1}). Days to 50% flowering was noted on basis of the flowering 50% of the plants in 10 rows. The major descriptive statistics such as mean, range, standard deviation and coefficient of variation were worked out by adopting the standard methods (Panse and Sukhatme, 1964). Phenotypic correlation coefficients were calculated using the formula as suggested by Johnson *et al*. (1955). The principal component analysis was computed inJMP software package (Version 13, SAS Institute Inc., 2016).As suggested by Johnson and Wichern (1988), principal components with eigen values less than one was considered. Mean values of 18 genotypes for seven yield traits were subjected to multivariate hierarchical cluster analysis computed using JMP software package (Version 13, SAS Institute Inc., 2016).

RESULTS AND DISCUSSION

Days to 50% flowering exhibited the 13 days range among genotypes where the genotype GPUP 24 (34 days) had the earliest and TNAU 145 (47 days) had the latest values. Similarly, plant height got 60.6 cm range where genotype DhPrMV 2710 (81.30 cm) had the shortest and TNAU 145 (142.00 cm) had the tallest value. Number of tillers per plant had range of five tillers where genotype DHP 2181 (8) had the lowest and GPUP 23, TNPM 230, DhPrMV 2161and DhPrMV 2721 (13) had the highest value. Panicle length had also wide range *i.e.,* 11.8 cm where genotype DHP 2780 (23.3 cm) was observed the smallest and genotype TNAU 145 (35.1 cm) was observed the longest. In case of days to maturity, 11 days range was observed among genotypes, DhPrMV 2721 and TNPM 228 (67 days) were recorded as the earliest maturing and genotype DhPrMV 2769 (78) was the latest maturing one. For grain yield, TNAU 151 (1611 kg ha^{-1}) is lowest and DHP 2181 (3232 kg ha^{-1}) is highest. TNAU 151 (3703 kg ha^{-1}) yielded minimum fodder while maximum was from DHP 2780 (8023 kg ha^{-1}). Similar results on wide range of variations for plant height and grain yield per plant, panicle lengthand plant height and productive tillers (Prasada Rao *et al.,* 1994) were reported earlier. Such diversity within the prosomillet genotypes tested would provide ample opportunities for future genetic improvement of the crop through direct selection from the accessions and/or following traits recombination through intraspecific hybridization for desirable traits. The range, mean, standard deviation and coefficient of variation for 7 quantitative traits in 18prosomillet genotypes are presented in Table 1.

Table 1. Patterns of genetic variability for 7 quantitative traits in 18 proso millet genotypes

Characters	Mean±SEm	Maximum	Minimum	Range	SD	CV (%)
Days to 50% Flowering	40.33±0.78	47	34	13	3.34	8.28
Plant Height (cm)	105.11±3.68	141.9	81.3	60.6	15.63	14.82
No of Tillers Plant^{-1}	13±0.40	13	8	5	1.71	15.40
Panicle Length (cm)	35.1±0.71	35.1	23.3	11.8	3.03	11.15
Days to Maturity	72.4±0.78	78	67	11	3.32	4.59
Grain yield(kg ha^{-1})	2505±121.08	3232	1611	1621	513.70	20.52
Fodder yield (kg ha^{-1})	5935±289.50	8023	3703	4320	1228.26	20.69

The coefficient of variation was found high (> 20%) in fodder yield (20.69%) and grain yield (20.52%); Medium (10-20%) was observed in number of tillers plant^{-1} (15.40%), plant height (14.82%) and panicle length (11.15%); low (< 10 %) was observed in days to 50% flowering (8.28%) and days to maturity (4.59%). Hence, there is scope for selecting high yielding potential genotypes.

Grain yield is a complex character influenced by a large number of other component characters. Knowledge on the association between yield and other biometrical traits and also among component traits helps in improving the efficiency of selection. The correlation between characters may exist due to various reasons such as pleiotropy, genetic linkage and association of loci or blocks of loci governing variability for different characters located on same chromosome. It has been generally accepted that correlation between different characters represents a coordination of physiological processes which is often achieved through gene linkages.

The association of all morphological traits was estimated by correlation analysis (Table 2). Among the 7 morphological and yield traits studied, days to 50% flowering (0.44*), plant height (0.14**), number of tillers plant^{-1} (0.24*), panicle length (0.79**), days to maturity (0.103**), fodder yield (-0.433**) had * significant correlations with grain yield at P = 0.01 level.** significant at P=0.01. Earlier workers have also reported significant positive association of grain yield per plant with days to flowering, panicle length, flag leaf blade length and 1000-grain weight (Reddy and Reddy, 2012). Maximum positive correlation observed for most of the characters with grain yield plant^{-1} indicated that all these characters could be simultaneously improved and it also suggested that

Table 2. Phenotypic correlation coefficients for different traits in 18 proso millet genotypes

Characters	DFF	DM	PH	NTPP	PL	GY	FY
DFF	1.00						
DM	.678**	1					
PH	.539*	.230*	1				
NTPP	-.408*	-.309*	-.481*	1			
PL	.511*	.340*	.781**	-.351*	1		
GY	.44*	.103**	.14**	.24*	.79**	1	
FY	.004*	.71**	.307*	.300*	-.503*	-.433**	1.00

* Significant at *P* = 0.05 ** Significant at *P* = 0.01
DFF = Days to 50% flowering, PH = Plant height (cm), NTPP = No of tillers plant $^{-1}$, PL = Panicle length (cm), DM = Days to maturity, GY = Grain yield(kg ha^{-1}), FY = Fodder yield (kg ha^{-1})

increase in any one of them would lead to improvement of other character. Grain yield plant^{-1} which was positively correlated with plant height, indicating that prosomillet growth at vegetative stage is also important and crucial for the physiological process that determines the output of its performance in terms of yield and other physiological attributes that contributes to its development. Scrutiny on correlation among component characters revealed that strong associations among desirable component characters are present especially with days to flowering and number of tillers plant^{-1}. Hence, selection criteria should consider all these characters for the improvement of grain yield in prosomillet.

Significant negative correlation observed for fodder yield (-0.433) with grain yield indicated increase in one character would lead to decrease in another character. Negative association for fodder yield with grain yield plant^{-1} was beneficial association because wider flag leaf sheath width may pose problem and require more energy for complete emergence of the panicle which will result in reduced thousand grain weight and grain yield per plant. Similarly, fodder yield having negative and significant correlation with grain yield per plant was reported by Reddy and Reddy(2012) in prosomillet.

The principal component analysis is a technique which identifies plant traits that contribute most of the observed variation within set of genotypes. This tool has a practical application in the selection of best genotypes for breeding purpose. The results of PCA revealed that the first 5 components with eigen value of greater than 0.40 contributed about 95.47% of total variability in 18 genotypes involving all seven quantitative traits studied (Table 3). The importance of traits towards the PC could be seen from the corresponding eigen values which are presented in Table 4. The first principal component accounted for 43.83% of the total variation in the population. Days to 50% flowering

Table 3. Principal components showing the Eigen values, proportion of variation and total variation across axis

Principal component	Eigen value	Variation (%)	Total variation explained across axis
1	3.06	43.83	43.83
2	1.42	20.30	64.13
3	1.02	14.63	78.77
4	0.72	10.32	89.10
5	0.44	6.37	95.47

(0.84) contributed more to the variation followed by plant height (0.81), number of tillers plant^{-1} (0.75), panicle length (0.62) and days to maturity (-0.19), grain yield (-0.51) and fodder yield (-0.63) had the highest loadings in PC1 indicating their significant importance for these components. These traits had the largest participation in the divergence and carried the largest portion of its variability. Second principal component contributed 20.30% of the total variation. Characters that contributed to the second component include Days to maturity (0.77), grain yield (0.70), number of tillers plant^{-1} (0.40), panicle length (0.24) and plant height (0.06). Only two days to 50% flowering and fodder yield contributed negative to the second component. The third principal component accounted for 14.63% of the total variation in the population. Panicle length contributed the highest (0.62) followed by number of tillers plant^{-1} (0.36), fodder yield (0.32) and grain yield (0.15) while days to 50% flowering, plant height and days to maturity contributed negative variation. Likewise, the fourth principal component contributed 10.32% of the total variation. The major characters that contributed highly to the variation include fodder yield (0.57),days to maturity and plant height (0.32);grain yield (0.31) and number of tillers plant^{-1} (0.14)contributed least to the variation. Fifth principal component contributed 6.37% of the total variation. The major characters that contributed highly to the variation include days to maturity (0.37), fodder yield (0.29), panicle length (0.27); days to 50% flowering (0.17) contributed least to the variation. Similar findings with regard to grain yield plant^{-1}, plant height, days to flowering and productive tillers plant^{-1} were reported by Reddy *et al.*(2015). The traits such as grain yield plant^{-1} and plant height as earlier reported by KhavariKhorasani *et al.,* (2011) in maize and days to maturity was reported by Azad *et al.* (2012) in maize. Principal component analysis in this study confirmed the first principal components contributed maximum number of characters towards genetic diversity and these traits could be effectively used for further breeding programs to create more variability. Characters with high variability are expected to provide high level of transgressive segregation in breeding populations. This is important for breeders to investigate high yielding, early maturing and dwarf varieties through conventional breeding. Several authors indicated that different morphological traits for the different crops have contribution for the overall variability (Negash *et al.,* 2005; Assefa *et al.,* 2003).The biplot between principal components 1 and 2 show 3 groups among the characters studied (Fig.1). The cluster I had one trait in the group (number of tillers plant^{-1}), cluster II had 2 characters in another group (grain yield and fodder yield) and in cluster III 4 characters in group (days to 50% flowering, days to maturity, plant height and panicle length).

Based on cluster analysis, 18 genotypes were separated into 3 clusters (Fig. 2) through multiple hierarchical using similarity coefficient matrix (Table 5). The clustering pattern could be utilized in choosing the diverse genotypes which were likely to generate the highest possible variability for various economic characters. Cluster 1 was the largest comprising of 11 genotypes followed by cluster II with two

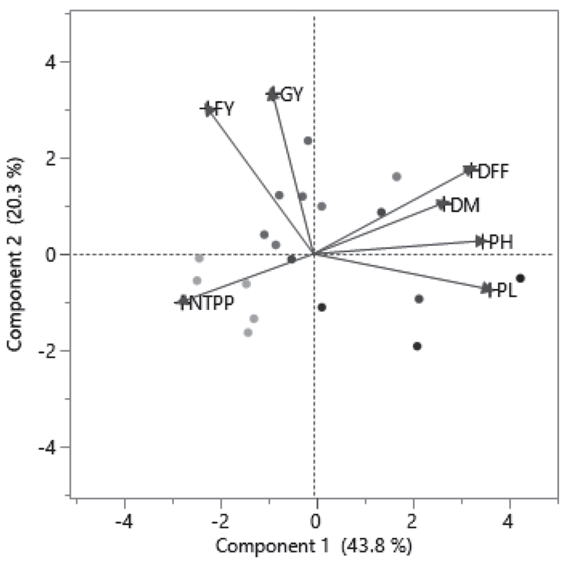

Fig. 1. Biplot between PCs 1 and 2 showing contribution of various traits in variability of 18 prosomillet genotypes based on 7 quantitative characters

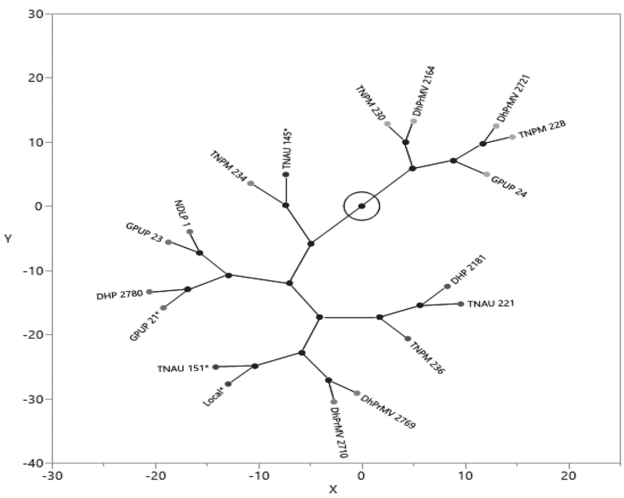

Fig. 2. Constellation plot showing the grouping of the 18 prosomillet genotypes studied

genotypes, cluster III with five genotypes (Table 6). The mean, maximum, minimum and range values of characters for each clusterclearly indicating the dissimilarities among them (Table 7). The genotypes namely DHP2181, GPUP 23, TNPM 230, DhPrMV 2769, DhPrMV 2164, DhPrMV 2721, DHP 2780, GPUP 24, TNPM 228, TNAU 145, DhPrMV 2710 and TNAU 151 formed diverse in clusters. Hybridization using genotypes belonging to I, II and III clusters might be used for exploitation of hybrid vigor. The random pattern of distribution of accessions into various clusters from different eco-geographic regions revealed that there was no association between genetic diversity and geographic diversity. The nature of selection forces operating under one eco-geographical region seemed to be similar to that of other regions since the accessions from different geographical regions were grouped together into same clusters. This could be due to the similarity of conditions under which the types were bred and domesticated in different localities.

Table 5. Cluster analysis of various traits in of 18 prosomillet genotypes based on 7 quantitative characters

Cluster	Count	Days to 50% flowering	Plant height (cm)	No of tillers Plant^{-1}	Panicle length (cm)	Days to maturity	Grain yield (kg ha^{-1})	Fodder yield (kg ha^{-1})
I	11	41.45	102.50	10.77	26.85	74.43	2409.48	5747.33
II	2	44.5	137.9	10	33.4	75	2554.5	5832.00
III	5	36.20	96.28	12.60	26.12	68.40	2434.00	6060.80

Table 6. Constituents of 3 clusters in 18 prosomillet genotypes based on 7 quantitative characters

Clusters	Number of genotypes	Constituent accessions
I	11	DHP 2181, TNAU 221, TNPM 236,DhPrMV 2769, DhPrMV 2710, Local, TNAU 151, GPUP21, DHP2780, GPUP23, NDLP1
II	2	TNPM 234 , TNAU145
III	5	TNPM230, DhPrMV 2164, DhPrMV2721, TNPM228, GPUP24

Table 7. Cluster membership, mean, maximum, minimum and range of 18 prosomillet genotypes based on 7 quantitative characters of each cluster

Cluster	Parameter	Days To 50% flowering	Plant height (cm)	No of tillers Plant^{-1}	Panicle length (cm)	Days to maturity	Grain yield (kg ha^{-1})	Fodder yield (kg ha^{-1})
Cluster1	Mean	41.45	103.81	10.6	26.64	73.81	2523.90	5896.72
	Max	43	119.8	13	31.1	78	3232	8023
	Min	39	81.3	8	23.3	70	1611	4196
	Range	4	38.5	5	7.8	8	1621	3827
Cluster 2	Mean	44.5	137.9	10	33.4	75	2554.5	5382
	Max	47	141.9	10	35.1	76	3008	7344
	Min	42	133.9	10	31.7	74	2101	4320
	Range	5	8	0	3.4	2	907	3024
Cluster 3	Mean	36.2	96.28	12.6	26.12	68.4	2434	6060.8
	Max	39	110.5	13	27.9	70	3114	6789
	Min	34	85.2	12	24.9	67	2135	5246
	Range	5	25.3	1	3	3	979	1543

CONCLUSIONS

Promising line evaluation and characterization is important for plant breeders and multivariate statistical analysis provides a means for estimating diversity of yield attributing traits between the lines. These tools are useful for the evaluation of potential breeding value of improved lines. However, this study suggests the need for breeders to exploit lines from distinct groupings for the development of improved varieties. Principal component analysis indicated that there was genetic variation for all traits within the lines used in this study. Intercrossing between genotypes of diverse clusters would generate a broad spectrum of variability for effective selection in the segregating generations for the development of high yielding cultivars. The genotypes DHP2181, GPUP 23, TNPM 230, DhPrMV 2769, DhPrMV 2164, DhPrMV 2721, DHP 2780, GPUP 24, TNPM 228, TNAU 145, DhPrMV 2710 and TNAU 151 formed divergent clusters. Thus, crosses among the genotypes would exhibit high heterosis and may produce new recombinants with desired characters.

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YIELD, ECONOMICS AND QUALITY PARAMETERS OF BABY CORN AS INFLUENCED BY PLANT DENSITIES AND LEVELS OF NITROGEN

M. VENKATA LAKSHMI, B VENKATESWARLU, P. V. N. PRASAD AND P. PRASUNA RANI
Department of Agronomy, Agricultural College,
Acharya N.G. Ranga Agricultural University, Bapatla – 522 101

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ABSTRACT

Baby corn (*Zea mays* L.) is grown for vegetable purpose and it is not a separate type of corn. Baby corn can be consumed raw or used as an ingredient in wide variety of dishes in many cuisines across the globe. A field experiment was conducted during *kharif,* 2014 on sandy loam soils of the Agricultural College Farm, Bapatla. The treatments consisted of four levels of nitrogen in Factor – A (N_1= 60, N_2= 120, N_3= 180 and N_4= 240 kg N ha^{-1}) and four plant densities (P_1: 2,22,222, P_2: 1,48,148, P_3: 1,11,111 and P_4: 1,66,666 plants ha^{-1}) in Factor – B. Results of the experiment showed that applying 240 kg N ha^{-1} registered the highest (12024 kg ha^{-1}) cob with husk yield which was statistically comparable (11771 kg ha^{-1}) with 180 kg N ha^{-1}. The highest crude protein in ear (13.8 per cent), crude fibre (33.3 per cent) and ash content (14.3 per cent) were registered by 1,11,111 plants ha^{-1}. Crude protein (15.67 per cent), Crude fibre (32.52 per cent) and ash contents (15.67 per cent) increased significantly with increasing levels of nitrogen up to 240 kg ha^{-1}. Benefit cost ratio registered with different treatment combinations indicated 1.2 the lowest with 60 kg N ha^{-1} along with 2,22,222 plants ha^{-1} and 3.1 the highest with 240 kg N ha^{-1} along with 1,66,666 plants ha^{-1}. The treatment with 180 kg N ha^{-1}along with 1,66,666 plants ha^{-1} too registered 3.1 cost benefit ratio.

INTRODUCTION

Baby corn (*Zea mays* L.) is grown almost throughout the world is an off shoot of maize which is cultivated for its young, fresh, finger like green ears, harvested at the time of silk emergence and before pollination and fertilization (Ramachandrappa, 2004). Baby corn being one of the most important dual purpose crops is grown widely round the year for baby corn as well as green fodder in India. It has an edge over other cultivated fodder crops due to its higher production potential, wider adaptability, fast growing nature, succulent, palatable, excellent fodder quality, freedom from toxicants proving safer to fed animals at any stage of crop growth. It is a low calorie vegetable having higher fibre content without cholesterol, rich in vitamin B and C, potassium and carotenoids. Baby corn grows well in a wide range of soil types but it thrives best in loose soil, which drains well. Baby corn production, being a recent development, has proved an enormously successful venture in countries such as Thailand and Taiwan. Attention is now being paid to explore its potential in India, for earning foreign exchange besides higher economic returns to the farmers. The present study was, therefore, designed to find out how the yield and quality parameters of baby corn are influenced by plant densities and nitrogen levels.

MATERIAL AND METHODS

The field experiment was conducted at the Agricultural College Farm, Bapatla of the Acharya N. G. Ranga Agricultural University during *Kharif*, 2014. The experimental soil was sandy loam in texture, neutral in reaction (pH 7.0), medium in organic carbon (0.52%), very low in available nitrogen (189 kg ha^{-1}) medium in available phosphorus (28 kg ha^{-1}) and high in available potassium (324 kg ha^{-1}). Treatments consisted of four levels of nitrogen in Factor – A (N_1= 60 kg N ha^{-1}, N_2= 120 kg N ha^{-1}, N_3= 180 kg N ha^{-1}

E-mail: mamidi.venkatalakshmi@gmail.com

and N_4= 240 kg N ha^{-1}) and four plant densities (P_1: 2,22,222 plants ha^{-1}, P_2: 1,48,148 plants ha^{-1}, P_3: 1,11,111 plants ha^{-1} and P_4: 1,66,666 plants ha^{-1}) in Factor – B. The nitrogen content in the fodder and ear at harvest was multiplied with factor 6.25 to get crude protein content (Doubetz and Wells, 1968). The crude fibre content in fodder at harvest was estimated by acid-alkali digestion method (Madhadevan, 1965). The total ash content in fodder at harvest was estimated by dry ashing method (Piper, 1966). The cobs from net area of each plot were harvested separately, weighed and recorded as young cob yield (kg ha^{-1}).

RESULTS AND DISCUSSION

Cob Yield with Husk (kg ha^{-1})

The data pertaining to cob yield with husk (kg ha^{-1}) of baby corn was significantly influenced by plant densities, nitrogen levels and their interaction too (Table 1a).With increase in nitrogen levels there was a significant increase in baby corn yield up to 180 kg N ha^{-1} only. Applying 240 kg N ha^{-1} registered the highest 12024 kg ha^{-1} cob with husk yield which was statistically comparable with 11771.0 kg ha^{-1} with 180 kg N ha^{-1}. 1,66,666 plants ha^{-1} with 12,596 kg ha^{-1} and 1,48,148 plants ha^{-1} with 11,647 kg ha^{-1} were statistically comparable and significantly superior over other two densities tried. Among the combinations significantly the lowest and the highest cob with husk yield were resulted with 1,11,111 plants ha^{-1} along with 60 kg N ha^{-1} (6223 kg ha^{-1}) and 1,66,666 plants ha^{-1} along with 240 kg N ha^{-1} (15100 kg ha^{-1}), respectively. This might be due to taller plants, higher dry matter, increased ear length, higher ear weight at high levels of nitrogen could be the reason for higher yields. Similar reports of higher yield at higher nitrogen levels was earlier reported Singh *et al.* (2012).

At all the nitrogen levels 1,11,111 plants ha^{-1} registered the lowest cob along with husk yield (7448 kg ha^{-1}) and 1,66,666 plants ha^{-1} recorded the highest yield (11647 kg ha^{-1}). At all nitrogen levels (Table 1b), population of 1,48,148 plants ha^{-1} and 1,66,666 plants ha^{-1} have recorded comparable yield (11647 kg ha^{-1} and12596 kg ha^{-1}). At all the population levels, with increase in the nitrogen level, there was an increase in the cob along with husk yield. This might be due to taller plants, higher dry matter, increased ear length, higher ear weight at high levels of nitrogen and lower population levels. At higher plant density (2,22,222 plants ha^{-1}) there was increased competition for light, space, nutrients, and moisture between plants and created a stress environment for plant growth which was evident from the poor yield attributes *viz.,* thin, and shorter cobs, and lesser weight of cob. Thus, plant density above a critical population has a negative effect on yield. Similar results were also reported by Xue *et al.* (2002), Ashok Kumar (2009) and Lal Shankar *et al.* (2013).

Crude Protein Content (%)

Data pertaining to crude protein per cent in baby corn at harvest (in both fodder and ear) are presented in Table 1. In fodder and ear, crude protein content (%) increased significantly from 60 kg N ha^{-1} to 180 kg N ha^{-1} only. The highest crude protein in fodder and ear 10.9 per cent and 12.1 per cent, respectively was registered by applying 240 kg N ha^{-1} but it was statistically comparable with 180 kg N ha^{-1}.

Table 1a. Cob yield with husk (kg ha^{-1}), Crude protein (%), Crude fibre (%) and ash content (%) of baby corn as influenced by plant densities and levels of nitrogen

Treatment	Cob yield with husk (kg ha^{-1})	Crude protein in Fodder (%)	Crude protein in Ear (%)	Crude fibre (%)	Ash content (%)
N_1 - 60	7492.0	5.1	10.3	24.3	8.3
N_2 - 120	10069.0	8.2	11.6	27.8	11.3
N_3 - 180	11771.0	10.4	12.0	31.4	14.7
N_4 - 240	12024.0	10.9	12.1	32.5	15.7
S.Em±	336.8	0.34	0.42	0.38	0.46
CD @ 5%	988.0	1.0	1.2	1.10	1.40
P_1 - 2,22,222 plants ha^{-1}	9665.0	8.7	10.4	25.2	10.3
P_2 - 1,48,148 plants ha^{-1}	11647.0	9.6	10.1	29.0	13.0
P_3 - 1,11,111 plants ha^{-1}	7448.0	11.0	13.8	33.3	14.3
P_4 -1,66,666 plants ha^{-1}	12596.0	9.7	11.7	28.4	12.4
S.Em±	336.8	0.34	0.42	0.38	0.46
CD @ 5%	988.0	1.0	1.2	1.1	1.4
Interaction (N X P)					
S.Em±	476.3	0.48	0.59	0.55	0.66
CD @ 5%	1397	NS	1.75	NS	NS
CV (%)	7.9	8.5	8.9	3.2	9.2

Table 1b. Interaction effect of baby corn yield with husk (kg ha^{-1}) as influenced by plant densities and levels of nitrogen

Treatment	N_1-60	N_2-120	N_3-180	N_4-240	Mean
P_1 (2,22,222 Plants ha^{-1})	7163	10384	10415	10698	9665
P_2 (1,48,148 Plants ha^{-1})	7871	11221	13502	13994	11647
P_3 (1,11,111 Plants ha^{-1})	6223	7087	8179	8305	7448
P_4 (1,66,666 Plants ha^{-1})	8711	11585	14987	15100	12596
Mean	7492	10069	11771	12024	10069
	S.Em±	CD @ 5 %)	CV (%)		
N	336.8	988			
P	336.8	988	7.9		
N x P	476.3	1397			

Significantly the lowest crude protein content 5.1 per cent in fodder and 10.3 per cent in ear was recorded by applying 60 kg N ha^{-1}. This might be due to high nitrogen concentration in plant and high dry matter production. Further, nitrogen in corn plant is also strongly associated with the metabolism of protein. Similar results were also reported by Neylon and Kung (2003), Morshed *et al.* (2008), Almodares and Hadi (2009), Ibrahim (2009) and Khalid *et al.* (2010).

Crude protein content in fodder (11.0 per cent) and ear (13.8 per cent) was the highest at a population level of 1,11,111 plants ha^{-1} and the lowest crude protein content in fodder (8.7 per cent) and in ear (10.4 per cent) was registered at a plant density of 2,22,222 plants ha^{-1}. In fodder, 9.6 per cent and 9.7 per cent crude protein registered in 1,48,148 and 1,66,666 plants ha^{-1} were statistically comparable with one another. The highest crude protein at lower plant population could be due to better availability and utilization of all natural resources for plants. When all the resources were efficiently utilized, there was better growth which might have resulted in higher synthesis of dry matter. It might have resulted in higher synthesis of aminoacids and ultimately in more proteins. These results are in agreement with the findings of Banerjee *et al.* (2004), Kunjir (2004) and Gosavi and Bhagat (2009).

Crude Fibre Content (%)

With each increment in nitrogen level up to 180 kg N ha^{-1} there was a gradual and significant increase in the crude fibre content. The highest crude fibre content was recorded with 240 kg N ha^{-1} (32.5 per cent) however it was on par with 180 kg N ha^{-1} (31.4 percent) and it was significantly superior over 60 and 120 kg N ha^{-1} (24.3 and 27.8 percent). Significantly the lowest crude fibre content was recorded with 60 kg N ha^{-1} (24.3 per cent). Similar findings were also reported by Ayub *et al.* (2003) and Hani *et al.* (2006).

Significantly the highest crude fibre content was found with 1,11,111 plants ha^{-1} (33.3 per cent) which was significantly superior over 1,48,148 plants ha^{-1} and 1,66,666 plants ha^{-1} (29 and 28.4 per cent). The lowest crude fibre content was found with 2,22,222 plants ha^{-1} (25.2 per cent). This might due to the reason that at closer spacing, there are higher number of plants per unit area which create competition among the plants for resources. Similar findings were also reported by Ayub *et al.* (2003) and Hani *et al.* (2006)

Ash Content (%)

There was a significant increment in ash content with each increment in nitrogen levels. The highest ash content was registered at 240 kg N ha^{-1} (15.7 per cent) which was significantly superior over 60 and 120 kg N ha^{-1} only. The lowest ash content was recorded with the application of 60 kg N ha^{-1} with 8.3 per cent. Increase in ash contents (%) may be due to increase in growth parameters and also dry matter production. The increase in ash contents with increased nitrogen levels was also reported by Ayub *et al.* (2007), Nadeem *et al.* (2009) and Iqbal *et al.* (2009).

Significantly highest ash content (14.3 per cent) was recorded with a plant density of 1,11,111 plants ha^{-1}. Significantly lowest ash content (10.3 per cent) was observed in 2,22,222 plants ha^{-1}. Total ash content registered with 1,48,148 plants ha^{-1} and 1,66,666 plants ha^{-1} were statistically comparable. At lower plant density, lower was the interplant competition resulting in better utilization of light, water and minerals. This was reflected in higher per plant drymatter reflecting higher absorption and accumulation of all essential plant nutrients and higher total ash content. Higher plant densities resulted in higher interplant competition for resources and resulted in lower drymatter and lower ash contents. These results are supported by the earlier reports of Iqbal *et al.* (2009).

Economics

Cost of cultivation for each treatment was calculated by taking into account all inputs used and the data in Table 2 indicate that the gross returns ranged between Rs 81200 to Rs 1,69,443 and net returns from Rs 45,149 to 1,28,115 and benefit cost ratio from 1.2 to 3.1. Gross returns are lower at 60 kg N ha^{-1} and as the nitrogen dose increased, there was an increase in gross returns too. The highest gross returns of Rs 1,69,443 was recorded at 240 kg N ha^{-1} along with 1,66,666 plants ha^{-1}. The net return ranged from Rs 45,149 in 60 kg N ha^{-1} along with 1,11,111 plants ha^{-1} to Rs 1,28,115 with 240 kg N ha^{-1} along

Table 2. Cost of cultivation, Gross returns, Net returns and B:C ratio of baby corn as influenced by plant densities and levels of nitrogen

Treatments	Cost of cultivation (Rs)	Gross returns (Rs)	Net returns (Rs)	B : C (Rs)
N_1 P_1	42151	92217	50066	1.2
N_1 P_2	38101	92278	54178	1.4
N_1 P_3	36051	81200	45149	1.3
N_1 P_4	39131	101275	62144	1.6
N_2 P_1	42881	123508	80626	1.9
N_2 P_2	38831	126902	88070	2.3
N_2 P_3	36781	85803	49022	1.3
N_2 P_4	39861	130017	90155	2.3
N_3 P_1	43618	126153	82535	1.9
N_3 P_2	39568	152525	112957	2.9
N_3 P_3	37518	96792	59275	1.6
N_3 P_4	40598	168030	127432	3.1
N_4 P_1	44348	129983	85634	1.9
N_4 P_2	40298	157609	117311	2.9
N_4 P_3	38248	97716	59468	1.6
N_4 P_4	41328	169443	128115	3.1

with 1,66,666 plants ha^{-1}. At all the nitrogen levels, 1,11,111 plants ha^{-1} recorded the lowest net returns and 1,66,666 plants ha^{-1} registered the highest net returns. The data also indicated that the net returns registered in the treatment combination of 180 kg N ha^{-1} with 1,66,666 plants ha^{-1} (Rs 1,27,432) was more or less equal to Rs 1,28,115/- registered with 240 kg N ha^{-1} along with 1,66,666 plants ha^{-1}.

Benefit-cost ratio registered with different treatment combinations indicated 1.2 the lowest with 60 kg N ha^{-1} along with 2,22,222 plants ha^{-1} and 3.1 with 240 kg N ha^{-1} along with 1,66,666 plants ha^{-1}. The treatment with 180 kg N ha^{-1}along with 1,66,666 plants ha^{-1} also registered 3.1 benefit-cost ratio. As there was an increase in the nitrogen level, there was also an increase in the cost of cultivation. Similar was the case with planting densities. With increase in the plant density, there was further increase in the cost of cultivation. The treatment combination in which the net returns were higher due to increased yield, their benefit-cost ratios were also higher and the treatment combinations, where the yields were lower and the net returns were also lower, the benefit-cost ratios were also lower. Similar findings were reported earlier by Kheibari *et al.* (2012), Lal Shankar *et al.* (2013) and Sanjiv kumar *et al*. (2014).

CONCLUSIONS

Applying 240 kg N ha^{-1} registered the highest (12024 kg ha^{-1}) cob with husk yield which was statistically comparable (11711 kg ha^{-1}) with 180 kg N ha^{-1}. 1,66,666 plants ha^{-1} with 12,596 kg ha^{-1} and 1,48,148 plants ha^{-1} with 11,647 kg ha^{-1} were statistically comparable and significantly superior to other two densities tried. Application of 240 kg N ha^{-1} recorded significantly higher crude protein content in fodder and ear (10.9 and 12 percent) at harvest over the other treatments. The highest crude fibre content (33.3 per cent) and ash content (14.3 per cent) were registered by 1,11,111 plants ha^{-1}. Crude fibre and ash contents increased significantly with increasing levels of nitrogen up to 240 kg ha^{-1}. The highest crude fibre (32.52 per cent) and ash content (15.67 per cent) was noticed with the application of 240 kg N ha^{-1}. With increase in nitrogen levels there was a significant increase in baby corn yield up to 180 kg N ha^{-1} only. Benefit cost ratio registered with different treatment combinations indicated 1.2 the lowest with 60 kg N ha^{-1} along with 2,22,222 plants ha^{-1} and 3.1 the highest with 240 kg N ha^{-1} along with 1,66,666 plants ha^{-1}. The treatment with 180 kg N ha^{-1}along with 1,66,666 plants ha^{-1} too registered 3.1 benefit-cost ratio.

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DRYMATTER PARTITIONING AND GRAIN YIELD POTENTIAL OF MAIZE-CHICKPEA SEQUENCE AS INFLUENCED BY SOWING TIME AND NITROGEN LEVELS

M. RATNAM, B. VENKATESWARLU, E. NARAYANA, T.C.M NAIDU AND A. LALITHA KUMARI
Regional Agricultural Research Station, Lam, Guntur-522 034

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ABSTRACT

A field experiment was conducted on clay soils of Regional Agricultural Research Station, Lam, Guntur during *kharif* and *rabi* of 2013-14 & 2014-15 to find out the influence of sowing windows and nitrogen levels on drymatter partitioning and yield potential of maize-chickpea sequence under rainfed agro-climatic condition of Krishna zone. Sowing time and nitrogen levels were significantly influenced the drymatter accumulation at all growth stages and yield of preceding maize and succeeding chickpea under of maize-chickpea sequence. Higher drymatter accumulation and yield of preceding maize was recorded when maize sown on the 2[nd] FN of June with 200 % RDN and the more drymatter partitioning and grain yield of succeeding chickpea was recorded when preceding maize sown on 1[st] FN of July with 200 % RDN followed by 100 % RDN applied to succeeding chickpea during both the years of the experimentation.

INTRODUCTION

Maize in *kharif* and chickpea in *rabi* is one of the crop sequences in India in both irrigated and rainfed areas. This sequence occupies 5.4 lakh hectares and contributes 0.65 % of total food grain production of the country (Annual Report, 1996). Maize crop in this sequence removes lot of nutrients (148 kg N, 62 kg P_2O_5 and 133 kg K_2O ha^{-1}) and addition of nutrients to soil is often less than the removal (Annual Report, 2004). The succeeding chickpea builds up the soil nitrogen symbiotically and its leaf senescence character also improves the soil organic matter. The maize-chickpea sequence profitable than sole cropping and also helps in soil fertility maintenance on long run in Krishna zone of Andhra Pradesh.

Both the crops together require comparatively shorter period with secured income to the farmer and sustains to the soil health. Among the maize based cropping systems, maize-chickpea is one which was recently introduced due to the changing scenario of natural resource base. Therefore, introduction of maize-chickpea in rainfed conditions of Krishna zone may sustain the economy of the rainfed farmers of the Krishna zone. The yield of maize and chickpea mainly depends on the major agronomic practices like time of sowing and nitrogen supply. These are key factors in deciding grain yield which intern depends on drymatter partitioning of these crops. The information on sowing time and nitrogen management in and around the Krishna zone is megre. Therefore, the present study was conducted and the results were presented and discussed in the following sub heads.

MATERIAL AND METHODS

A field experiment was conducted at Regional Agricultural Research Station, Lam Farm located at Guntur (Latitude:$16^0 18^1$, Longitude: $80^0 29^1$, Altitude:33 m.a.m.s.l). The climate is sub-tropical with mean annual rainfall of 950 mm. The soil of experimental field was clay loam in texture, neutral to slightly alkaline in reaction (pH 7.8 to 8.2). Low in available N

E-mail : mekala1968@gmail.com

(204 kg ha^{-1}), high in P_2O_5 (96.5 kg ha^{-1}) and K_2O (886.5 kg ha^{-1}) and medium in organic carbon (0.51%), respectively. The experiment was conducted for two successive *kharif* and *rabi* of 2013-14 and 2014-15 in Krishna agro-climatic zone of Andhra Pradesh. The experiment consisting of three sowing windows as main plots treatments *viz.*, 2nd FN of June, 1st FN of July and 2nd FN of July, three nitrogen levels as sub-plot treatments *viz.,* 100 %, 150 % and 200 % RDN applied to preceding maize and four N levels as sub-sub plot treatments viz., 0, 50 %, 75 % and 100 % RDN to succeeding chickpea. All treatments were randomly allocated and replicated thrice in a split plot design for *kharif* crop and double split designs for *rabi* crop was adopted for both years of the experimentation. Each main plot divided in required size of three sub plots and each sub-plot again divided in to four sub-sub plots of required size. Recommended dose of N for maize was applied in three splits ($^1/_2$ at sowing, ¼ at knee high stage and ¼ at teaselling stage, respectively) to preceding maize and entire dose of N (*kharif* 200 kg N ha^{-1}, *rabi* 20 kg N ha^{-1})was applied at the time of sowing to succeeding chickpea. A popular and non lodging medium duration maize variety P-3396 and popular desi chickpea JG-11 were used in both the year of study. The data pertaining to soil, weather and yield attributes and yield was collected during crop growth period. Statistical analysis for drymatter partitioning and yield parameters were done following the analysis of variance technique for split and double split design as suggested by Gomez and Gomez (1984). Statistical significance was tested by applying F-test at 0.05 level of probability and critical difference (CD) were calculated for those parameters.

RESULTS AND DISCUSSION

Effect of sowing windows and N levels on maize

Drymatter partitioning and grain yield of maize were affected significantly due to sowing time during both the years of study (Table 1). The maximum drymatter partitioning at different growth stages and the highest kernel yield was recorded with the crop sown on 2nd FN of June. It might be due to the better performance of early sown maize crop congenial climatic conditions at the early stages of crop growth making it to utilize all the inputs and natural resources very effectively. Adequate soil moisture that makes higher availability of nutrients in the soil, longer sunshine hours per day resulting in more photosynthetic activity, efficient translocation to sink might have resulted in the more drymatter accumulation in the early sown maize crop. Similar reports were also given by Maryam *et al.* (2013) and Sreerekha *et al.* (2015).

The three nitrogen levels tried were found significant on drymatter partitioning and kernel yield of maize. Nitrogen applied at 200 % RDN significantly recorded more drymatter partitioning and more kernel yield over 100 % RDN but it was on a par with 150 % RDN. The increased drymatter production with more nitrogen application might be due to the fact that nitrogen fertilization made the plants more efficient in photosynthetic activity, enhancing the carbohydrate metabolism and ultimately the increasing drymatter accumulation. Taller plants with more number of leaves with higher dose of nitrogen might have resulted in the higher drymatter accumulation. The dwarf plants with little number of

Table1. Drymatter partitioning and yield response of maize as influenced by sowing time and nitrogen levels

Treatments / Main Plots / Sowing windows (A)	Drymatter partitioning (g m^{-2})						Yield (q ha^{-1})	
	30 DAS		60 DAS		Harvest			
	2013	2014	2013	2014	2013	2014	2013	2014
2nd FN of June	71.00	63.00	1009.20	994.20	2094.11	1894.11	95.52	94.87
1st FN of July	35.29	29.84	801.27	786.27	1920.89	1720.89	93.48	92.83
2nd FN of July	33.38	28.17	518.29	503.20	1637.67	1437.67	77.71	77.06
SEm ±	1.66	1.89	23.33	20.16	52.78	74.71	3.19	3.18
CD (@ 5%)	6.52	7.42	91.59	79.16	207.23	207.42	12.52	12.50
C V %	10.70	14.10	9.02	7.95	8.40	9.41	10.76	10.84
Sub-plots: N Levels (B)								
100 % RDN	37.21	32.21	583.09	568.09	1606.7	1406.78	81.40	80.75
150 % RDN	46.64	41.66	764.16	749.16	1936.11	1736.11	91.35	90.70
200 % RDN	55.81	47.14	981.51	966.42	2109.78	1909.78	93.96	93.31
SEm ±	1.69	1.99	27.99	21.59	68.06	96.23	2.61	2.61
CD @ (5 %)	5.21	6.16	86.27	66.54	209.70	210.00	8.05	8.10
C V (%)	10.74	14.87	10.82	8.51	10.83	12.12	8.82	8.88
Interaction (AxB)	NS		NS		NS		NS	

leaves at lower dose of nitrogen could be the reason for lower drymatter values at lower nitrogen levels. These results are in conformation with findings of Wasnik *et al.* (2012), Ayub *et al.* (2013), Prathyusha and Hemalatha (2013), Leela Rani *et al.* (2012), Maryam *et al.* (2013) and Sreerekha *et al.* (2015).

Effect of sowing windows and N levels on succeeding chickpea

Drymatter partitioning at different growth stages and grain yield of succeeding chickpea was significantly influenced by sowing time and nitrogen levels applied to preceding maize and nitrogen levels applied to succeeding chickpea during both the years of study (Table 2). Significantly the highest drymatter partitioning of succeeding chickpea in both the years of study was recorded when its preceding maize was applied with 200% RDN. Applications of higher doses of nitrogen to the previous crop lead to higher residual nitrogen to the succeeding crop. This might be the reason for the significant accumulation of drymatter in succeeding chickpea. These findings are in conformity with those of Nawale *et al.* (2009), Thomas *et al.* (2010).

Interaction effect between sowing windows and nitrogen levels of preceding maize and nitrogen levels applied to succeeding chickpea was found to be non significant on drymatter partitioning and yield of succeeding chickpea.

Table 2. Drymatter partitioning and yield response of chickpea as influenced by sowing time and nitrogen levels

Treatments	Drymatter partitioning (g m^{-2})						Grain yield q ha^{-1}	
Main Plots	30 DAS		60 DAS		Harvest			
Maize sowing windows (A)	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
2nd FN of June	8.27	7.86	116.11	116.10	193.59	183.84	13.39	13.25
1st FN of July	9.59	9.63	125.10	125.11	294.99	287.57	17.43	17.42
2nd FN of July	8.56	8.49	121.90	121.91	272.18	265.02	15.50	15.39
SEm ±	0.06	0.37	1.28	1.31	11.25	8.79	0.09	0.11
CD (@ 5 %)	0.25	1.14	5.01	5.01	38.26	34.43	0.28	0.34
CV (%)	4.43	20.0	6.36	6.40	5.30	20.44	2.72	3.34
Sub-Plots: Nitrogen Levels applied to maize (B)								
100% RDN	8.62	8.29	114.94	114.90	194.97	198.81	14.05	13.99
150% RDN	8.78	8.66	118.19	118.20	237.89	217.01	14.77	14.72
200% RDN	9.03	8.99	129.38	129.40	327.89	320.61	17.49	17.35
SEm ±	0.10	0.21	1.06	1.10	21.19	6.98	0.13	0.25
CD (@ 5 %)	0.30	0.62	3.27	3.30	64.28	21.49	0.38	0.76
CV (%)	6.71	13.97	5.28	5.30	3.73	17.00	4.80	9.70
Sub-Sub plots: Nitrogen Levels applied to chickpea (C)								
0 % RDN	8.59	8.21	119.91	120.01	224.88	215.60	1224	12.20
50 % RDN	8.69	8.56	119.95	120.05	249.49	240.95	1462	14.48
75 % RDN	8.82	8.79	119.94	120.04	265.82	257.87	1637	16.29
100 % RDN	9.13	9.04	123.53	123.54	274.16	267.47	1852	18.45
SEm ±	0.18	0.24	1.01	1.20	13.63	13.72	0.16	0.27
CD @ (5 %)	0.50	0.68	2.86	2.90	41.08	45.04	0.49	0.82
CV (%)	10.57	14.43	4.35	4.40	6.71	6.95	5.90	9.81
Interaction (AxBxC)	NS							

CONCLUSION

Sowing maize during 1st FN of July with 200 % RDN followed at 100 % RDN to succeeding chickpea was found to be the best in terms of drymatter partitioning and yield of maize-chickpea sequence

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EVALUATION OF PACKAGING METHOD AND MATERIAL FOR SHELF LIFE ENHANCEMENT OF SWEET ORANGE

M.V. VENKATESH, S. VISHNU VARDHAN AND R. LAKSHMIPATHY
Post Harvest Technology Centre, Acharya N.G. Ranga Agricultural University, Bapatla -522 101

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ABSTRACT

Polyolefin and PVC shrink films were evaluated for individual and tray wrapping of carbendazim (1000 ppm) treated and hot water treated sweet orange fruits to extend the shelf life at ambient (29-38°C, 67-74%) and refrigerated (5-7°C) storage conditions. Different physico-chemical and microbial properties of wrapped fruits were studied until quality deterioration was observed. Wrapping reduced weight loss during 49 days of ambient storage, 75 days of refrigerated storage with post-storage holding period of one week. Polyolefin shrink wrapped fruits had significantly lower weight loss compared with other treatments. Juice content significantly dropped in tray wrapped fruits under both the storage conditions. Fruit firmness decreased in all the treatments during the storage period. Acidity and Ascorbic acid content declined with non-significant differences among the treatments. Reducing sugar content increased significantly in all treatments. PVC shrink wrapped fruits recorded lowest value for reducing sugar content in ambient storage condition and polyolefin shrink wrapped fruits recorded lowest value under refrigerated condition. There was no spoilage in any treatment stored under refrigerated condition up to 75 days except PVC tray wrapped fruits after 70 days. The surface microbial load showed a gradual raise in number of colonies during the storage period in samples stored under ambient condition. PVC tray wrapped fruits recorded higher scores for all sensory attributes analyzed and acceptable for 75 days of refrigerate storage.

INTRODUCTION

The production of sweet oranges seems to be largely favoured by the sub-tropical or dry arid conditions, prevailing during a good part of year with distinct summer and winter seasons and a low rainfall like that found in different districts of Andhra Pradesh. Andhra Pradesh is the leading producer of citrus fruits (23.80%) and occupies first (46.78%) in overall production of sweet oranges produced in the country next to Maharashtra (Kumar *et al*., 2011). During the peak harvesting period, in the absence of cold chains and processing units farmers have to sell off their produce at lower prices in local markets, leading to glut and post harvest losses. The limited shelf life of the fruit poses the problem of decay and reduced juice content. Prolonging the storage life can help transportation of fruits to long distance cities, even during hot summer months, when citrus fruits are in great demand. Film wrapping of mandarins has been very promising with respect to controlling water loss and spread decay, retention of fruit shape without adverse effect on flavour and colour development (Ladaniya *et al.,* 1997). This technique provides an alternative to the wax coating. The film also provided protection from dust and thus resulted in hygienic, attractive and very handy consumer pack for retail outlets most suitable for tropical Indian marketing conditions. Several researchers reported on the usefulness of shrink wrapping in citrus fruits. However, reports on shrink wrapping particularly in sweet oranges are not available. The objective of this investigation was to examine the shelf life of individually shrink wrapped sweet oranges using different packaging materials stored under both ambient and refrigerated condition.

MATERIAL AND METHODS

Freshly harvested, fully matured, uniform sized and disease free sweet oranges were selected for

E-mail : vishnuvardhans@yahoo.com

the study during the year 2013. The freshly harvested fruits were washed under tap water followed by dipping of fruits in a 1000 ppm solution of carbendazim to reduce microbial load. Later, the fruits were heat treated as a pre storage treatment by hot water (53°C) dip for 3 minutes.

Treated fruits were subjected for individual shrink wrapping and tray wrapping. A sealer was used to loosely pack the films around the fruits before wrapping in heat shrink tunnel. The polyolefin shrink film (25 microns) and PVC cling film were shrink wrapped around the fruit individually and as tray over wrap. For shrink wrapping fruits sealed in the film were then passed through a heat shrink tunnel on a moving belt at 145°C for 10 seconds with belt speed of 6 cm/s to form a tight wrap on the fruit surface. Sealing of the package for tray wrapping was achieved by placing the tray over the heater pad of tray wrapping machine. After wrapping, the trays were passed through heat shrink tunnel at 125°C for 5 seconds with moving belt speed of 12 cm/s to achieve perfect sealing. The wrapped fruits were separated into different lots of same size and stored under both ambient condition and refrigerated condition. Samples of fruits stored under ambient condition were tested every week and fruits stored under refrigerated condition were tested for every 15 days to examine changes in physiological loss of weight, firmness (Fruit firmness meter, Make: Optics Technology; Range : 0-20 kg), juice content, TSS, titrable acidity, ascorbic acid content, reducing sugars, total phenol content (Ranganna, 2010), surface microbial load and sensory quality of packed fruits.

RESULTS AND DISCUSSION

The physico-chemical and microbial properties of samples stored under ambient condition and refrigerated condition were shown in Table 1 and 2.

Physiological loss of weight (%)

The weight loss was significantly less in polyolefin shrink wrapped fruits as compared to other treatments under both storage conditions. Under ambient condition fruits packed with polyolefin recorded lowest loss of weight during the storage period with 7.06% weight loss followed by polyolefin tray wrapped fruits (13.30%). PVC shrink wrapped samples (22.24%) recorded highest loss of weight during the storage period. PVC tray wrapped fruits recorded 17.01% weight loss after 49 days. The reduction in weight loss in fruits may be attributed to higher evapo-transpiration and respiration rates due to metabolic activities (Singh and Sharma, 2011). The higher weight loss in PVC wrapped fruits can be due to its higher permeability rate.

Under refrigerated conditions fruits packed with polyolefin shrink wrapping significantly recorded lowest weight loss of 6.56% followed by PVC tray wrapped fruits (6.84%) during the storage period. Polyolefin tray wrapped samples recorded highest loss of weight (24.94%) during the storage period. PVC shrink wrapped fruits recorded 13.36% weight loss by the end of 75 days of refrigerated storage. Loss of weight was higher in ambient storage condition to that stored under refrigerated condition.

Juice content (%)

Juice content of the fruits was reduced significantly with the increase in duration of storage

Table 1. Physico-chemical evaluation of packed and stored sweet oranges under ambient condition

Parameter	Polyolefin Shrink Wrapping		PVC Shrink Wrapping		Polyolefin Tray Wrapping		PVC Tray Wrapping		SEM ±		CD @5%	
	7 DAS	49 DAS	7 DAS	49 DAS	7 DAS	49 DAS	7 DAS	49 DAS	7 DAS	49 DAS	7 DAS	49 DAS
PLW (%)	0.24	7.06	1.01	22.24	0.97	13.30	2.31	17.01	-	-	-	-
Firmness (kg)	12.12	9.84	16.62	9.56	13.20	9.73	16.87	9.79	0.13	0.28	0.43	0.96
Juice content (%)	37.22	28.96	38.71	25.19	37.26	25.45	38.39	24.44	0.05	0.88	2.10	2.71
TSS (%)	7.64	10.48	8.24	10.48	7.64	10.75	8.10	10.75	0.20	0.19	0.64	0.58
Ascorbic Acid Content (mg 100 g^{-1})	39.61	27.11	42.15	29.39	43.57	27.31	43.69	28.60	0.63	0.64	2.05	2.10
Acidity (%)	0.93	0.59	0.86	0.56	0.87	0.57	0.93	0.52	0.01	0.02	0.04	0.05
Phenols (mg 100g^{-1})	17.15	17.58	17.32	17.92	17.32	17.67	17.32	17.67	0.15	0.15	0.49	0.49
Reducing Sugars (%)	2.04	2.85	1.88	2.77	2.04	2.85	1.94	2.79	0.03	0.03	0.10	0.11
Decay%	0.00	10.00	0.00	3.33	6.67	13.33	0.00	13.33	-	-	-	-
Surface bacterial load (cfu cm^{-2})	14207	22496	1916	8515	3585	13021	14120	22065	71	69	232	225
Surface fungal load (cfu cm^{-2})	500	1417	33	1067	50	1600	850	1467	26	32	86	153

Treated sweet oranges were stored upto 49 days Under ambient conditions

Table 2. Physico-chemical evaluation of packed and stored sweet oranges under refrigerated condition

Parameter	Polyolefin Shrink Wrapping		PVC Shrink Wrapping		Polyolefin Tray Wrapping		PVC Tray Wrapping		SEM ±		CD @5%	
	7 DAS	75 DAS	7 DAS	75 DAS	7 DAS	75 DAS	7 DAS	75 DAS	7 DAS	75DAS	7 DAS	75 DAS
PLW (%)	0.23	6.56	0.35	13.36	0.34	24.94	0.76	6.84	-	-	-	-
Firmness (kg)	14.27	8.86	11.38	6.17	11.34	6.02	13.42	7.95	0.27	0.28	0.84	0.96
Juice content (%)	46.93	37.80	48.18	34.74	41.93	29.98	41.17	34.69	0.88	0.94	2.71	3.03
TSS (%)	7.87	10.44	8.47	10.27	7.67	10.27	8.17	10.44	0.21	0.19	0.64	0.58
Ascorbic Acid Content (mg 100g $^{-1}$)	35.56	30.58	38.22	31.60	39.47	30.33	39.10	31.63	0.49	1.96	1.51	2.34
Acidity (%)	0.87	0.36	0.96	0.48	0.91	0.42	0.87	0.41	0.02	0.04	0.05	0.15
Phenols (mg 100g $^{-1}$)	17.11	17.37	17.12	17.37	17.08	17.49	17.11	17.49	0.20	0.13	0.62	0.39
Reducing Sugars (%)	1.77	2.06	1.83	2.15	2.13	2.35	2.18	2.41	0.03	0.06	0.10	0.17
Decay%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.33	-	-	-	-
Surface bacterial load (cfu cm $^{-2}$)	6504	8351	1737	3629	8641	11498	19459	21323	30	62	92	178
Surface fungal load (cfu cm $^{-2}$)	0.00	137	0.00	186	6.67	394	0.00	196	15	52	47	158

period in all the treatments. Under ambient storage condition, control fruits spoiled after 21 days with decrease in juice content from 46.25% to 34.38%. Fruits packed with polyolefin shrink wrapping significantly recorded highest juice content of 28.96% followed by polyolefin tray wrapped fruits (25.45%) by the end of the storage period. PVC tray wrapped fruits (24.44%) recorded significantly lower juice content than the other samples followed by PVC shrink wrapped fruits (25.19%). A similar reduction in juice content in kinnow mandarins was reported by Jawandha *et al.* (2009) which might be due to increased transpiration and respiration losses in sealed fruits.

Under refrigerated storage conditions juice content decreased in all the treatments during the storage. Fruits packed with polyolefin shrink wrapping significantly recorded highest juice content of 37.80%. Juice content of PVC shrink wrapped fruits (34.74%) was on par with that of polyolefin shrink wrapped fruits by the end of 75 days. Polyolefin tray wrapped fruits (29.98%) recorded significantly lower juice content than the other samples. PVC tray wrapped fruits recorded 34.69% of juice content by the end of storage period. Juice content was found high in refrigerated samples than in samples stored under ambient condition which can be attributed to higher temperature and lower RH (29-38°C, 67-74%).

Fruit firmness (kg)

Fruit firmness significantly declined during the storage period under both storage conditions. Under ambient storage condition firmness declined with non-significant differences among the treatments. Fruits packed with polyolefin shrink wrapping significantly recorded highest firmness of 9.84 kg by the end of storage period of 49 days. All the packaging treatments stored at ambient condition were on par during the entire storage period. Softening of fruits is caused either by breakdown of insoluble protopectin into soluble pectin or by cellular disintegration leading to increased membrane permeability (Mahajan *et al.*, 2005).

Under refrigerated condition fruits packed with polyolefin shrink wrapping significantly recorded highest firmness of 8.86 kg by the end of storage period of 75 days. Firmness of fruits packed with polyolefin shrink wrapping and fruits packed with PVC tray wrapping (7.95%) were on par. Polyolefin tray wrapped fruits recorded firmness of 6.02 kg which is significantly lower than the other samples followed by PVC shrink wrapped fruits (6.17%).

TSS

TSS slightly increased in all the treatments up to 49 and 75 days. Total soluble solids, at time zero was 7.77% which gradually increased in all the treatments. Tray wrapped fruits stored at ambient condition significantly recorded highest TSS (10.75%) compared to other samples. All the treatments stored at ambient condition were on par during the storage period. The analysis of total soluble solids as advancement of storage duration reveals a general tendency of increase in soluble solids as the fruits advance in ripening and senescence.

TSS of the samples stored under refrigerated condition increased with non-significant difference among the treatments up to 75 days. Polyolefin shrink wrapped and PVC tray wrapped fruits recorded highest TSS compared to other treatments. TSS of fruits stored in ambient storage condition was higher than fruits stored in refrigerated condition which might be due to higher temperature and higher transpiration losses. The increase in TSS during storage may be probably due to increased hydrolysis of polysaccharides to into mono and disaccharides, as well as concentration of juice due to dehydration. Similar results were reported by Jawandha *et al.* (2009) for kinnow mandarin.

Titrable acidity

Under ambient condition, maximum acidity retention after 49 days of storage was observed in fruits packed with polyolefin shrink wrapping (0.59%). The acidity of fruits declined throughout the storage period. PVC tray wrapped fruits significantly recorded lowest acidity retention (0.52%) during the storage period. All the treatments were on par during the storage period.Under refrigerated condition fruits packed with PVC shrink wrapping significantly recorded highest acidity of 0.48% by the end of storage period of 75 days. All the treatments were on par with non-significant differences among the treatments during the storage period. Decline of acidity may be due to higher utilization of organic acids in metabolic activities, which reduced the level of acidity with the progress in storage period.

Ascorbic acid content (mg 100g^{-1})

Vitamin C retention is of prime importance in post harvest handling of citrus fruits as it is rapidly lost during extended storage of citrus fruits. Ascorbic acid content of fruits followed a declining trend during storage. Fruits packed with PVC shrink wrapping significantly recorded highest ascorbic acid content of 29.39 mg 100g^{-1} followed by PVC shrink wrapped fruits 28.60 mg 100g^{-1}. All the treatments were on par during the storage period. Under refrigerated storage fruits packed by PVC tray wrapping significantly recorded highest ascorbic acid content of 31.63 mg 100g^{-1}. All the treatments were on par during the storage period of 75 days. Polyolefin tray wrapped fruits recorded lowest value of 30.33 mg 100g^{-1} compared to other treatments. The decrease in ascorbic acid during storage may be due to inversion of ascorbic acid into dehydro ascorbic acid (Mahajan *et al.*, 2005).

Reducing sugars

The reducing sugars content increased significantly and progressively throughout the storage period. Fruits packed with polyolefin shrink wrapping and polyolefin tray wrapped recorded highest reducing sugar content of 2.85%. All the packaging treatments stored at ambient condition were on par. Similar increase in reducing sugars has also been shown by the other workers (Ghorai 1998; Ram *et al.*, 2004). The increase in reducing sugars could be due to the hydrolysis of sucrose during storage.Under refrigerated condition PVC tray wrapping samples significantly recorded highest reducing sugars content of 2.41%. PVC tray wrapping, polyolefin tray wrapping and coconut oil coated were on par. Fruits treated with polyolefin shrink wrapping significantly recorded lowest value of 2.06% compared to other treatments.

Phenol content

The phenol content in juice showed increasing trend throughout the storage period. The change in phenol content was observed almost similar in all the treatments. Higher phenol content of 17.92 mg 100g^{-1} was observed in PVC shrink wrapped fruits followed by tray wrapped fruits with 17.67 mg $100g^{-1}$. All the treatments stored at ambient condition were on par. The increase in phenol content of juice tissue was likely to be influenced by increased synthesis of anthocyanin and carotenoids which are of polyphenol in nature (Ram *et al.*, 2004).Under refrigerated conditions higher phenol content was observed in tray wrapped fruits. All the treatments stored at refrigerated condition were on par.

Surface bacterial load

Under ambient condition polyolefin shrink wrapped fruits significantly recorded highest bacterial load of 22496 cfu cm^{-2} followed by PVC tray wrapped fruits recorded 22065 cfu cm^{-2}. PVC shrink wrapped fruits significantly recorded lowest value of 8515 cfu cm^{-2} followed by polyolefin tray wrapped fruits with 13021 cfu cm^{-2}. Increased bacterial load might be due to weakening of the defense system against microbial attack (Jawandha *et al.*, 2009).

Under refrigerated condition PVC shrink wrapped fruits significantly recorded the lowest bacterial load of 3629 cfu cm^{-2} followed by polyolefin shrink wrapped fruits with bacterial load of 8351 cfu cm^{-2}. PVC tray wrapped fruits significantly recorded highest bacterial load of 21323 cfu cm^{-2} followed by polyolefin tray wrapped fruits with 11498 cfu cm^{-2}.

Surface fungal load

Under ambient condition PVC shrink wrapped fruits significantly recorded lowest fungal load of 1067 cfu/cm^2 followed by polyolefin shrink wrapped fruits with fungal load of 1417 cfu cm^{-2}. Polyolefin tray wrapped fruits significantly recorded highest fungal load of 1600 cfu cm^{-2}. Increased fungal load during the storage period might be due to weakening of the defence system against microbial attack (Jawandha *et al.*, 2009).Under refrigerated condition polyolefin shrink wrapped fruits recorded lowest fungal load of 137 cfu cm^{-2} followed by PVC shrink wrapped fruits with fungal load of 186 cfu cm^{-2}. Polyolefin tray wrapped samples recorded highest fungal load of 394 cfu cm^{-2}. All the treatments recorded lower values for fungal load under refrigerated storage.

% Decay

Under ambient condition tray wrapped fruits recorded highest decay of 13.33 %. PVC shrink wrapped fruits recorded lowest decay of fruits (3.33%) during the storage period followed by polyolefin shrink wrapped fruits with 10% decay. There was no decay observed in all packaging treatments stored under refrigerated condition up to 60 days. Decay of 3.33% was found in PVC tray wrapped fruits after 70 days of refrigerated storage. Increase in decay of fruits was attributed due to increase of microbial load and due to rapid senescence of fruits.

Organoleptic Evaluation

Sensory evaluation was performed by an untrained panel randomly selected from college of agricultural engineering, Bapatla. Evaluation of sensory attributes was performed at regular interval of 10 days for ambient treatments (Table 3) and 15 days for refrigerated treatments (Table 4). Samples were rated using 9 point hedonic scale where 9 represent like extremely and 1 represent dislike extremely, respectively. Taste, flavour and visual quality decreased with increased duration of storage.

Table 3. Organoleptic evaluation of packed and stored sweet oranges under ambient condition

Treatment	Visual Quality					Taste					Flavour					Overall Acceptability				
	Interval (DAS)					Interval (DAS)					Interval (DAS)					Interval (DAS)				
	10	20	30	40	50	10	20	30	40	50	10	20	30	40	50	10	20	30	40	50
T1	8.72	7.84	7.12	6.80	6.72	7.42	7.18	6.83	6.28	6.14	7.52	7.14	6.72	6.23	6.10	7.83	7.80	6.74	6.26	6.18
T2	8.58	7.80	6.99	6.53	6.18	7.30	6.89	6.23	5.78	5.60	7.70	7.58	6.18	5.72	5.72	7.60	7.26	6.08	5.44	5.36
T3	8.53	7.26	6.18	5.82	5.74	7.43	7.04	6.73	6.14	6.02	7.70	7.44	6.80	6.09	6.00	7.48	6.84	6.08	5.68	5.48
T4	8.58	8.50	7.80	7.26	7.08	7.58	7.50	7.12	6.54	6.26	7.83	7.52	7.18	6.20	6.08	7.73	7.43	6.86	6.48	6.22

T1- Polyolefin Shrink Wrapping;
T2- PVC Shrink Wrapping;
T3- Polyolefin Tray Wrapping;
T4- PVC Tray Wrapping
DAS - Days of Storage

Table 4. Organoleptic evaluation of packed and stored sweet oranges under refrigerated condition (Visual quality and taste)

Treatment	Visual Quality					Taste					Flavour					Overall Acceptability				
	Interval (DAS)					Interval (DAS)					Interval (DAS)					Interval (DAS)				
	15	30	45	60	75	15	30	45	60	75	15	30	45	60	75	15	30	45	60	75
T1	8.63	8.54	7.86	7.37	6.88	7.25	7.10	6.83	6.80	6.02	7.38	7.38	6.72	6.26	6.07	7.56	7.26	6.74	6.23	6.00
T2	8.58	8.34	7.40	7.22	6.65	7.13	6.89	6.47	6.16	5.63	7.88	7.35	6.83	6.04	5.56	7.47	7.13	6.97	5.44	5.13
T3	8.42	8.06	7.23	6.84	5.67	7.63	7.00	6.73	6.27	5.97	8.13	7.44	6.80	6.17	5.82	7.56	7.34	6.62	6.34	5.64
T4	8.25	8.47	7.80	7.19	6.92	7.50	7.50	7.13	6.83	6.38	7.89	7.52	7.06	6.38	6.18	7.78	7.49	7.22	6.80	6.36

T1- Polyolefin Shrink Wrapping;
T2- PVC Shrink Wrapping;
T3- Polyolefin Tray Wrapping;
T4- PVC Tray Wrapping
DAS - Days of Storage

CONCLUSIONS

Carbendazim (1000 ppm) dip treated and hot water dip (53°C, 6 min) as a pre-treatment were chosen along with packaging for enhancement of storage life of sweet oranges. The different packaging treatments adopted were shrink wrapping of 25 micron size of individual fruits and tray wrapping of multiple fruits under both ambient and refrigerated storage conditions. Of all the treatments, polyolefin shrink wrapped fruits retained higher values for various physico-chemical parameters studied and was rated best under both the storage conditions. Shelf life of sweet oranges was extended to 50 days under ambient storage condition (67-74% RH, 29-38°C) and shelf life was enhanced up to 75 days under refrigerated conditions (5-7°C).

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KNOWLEDGE LEVEL OF RURAL PEOPLE ON *GRAM SABHA* OF DANTIWADA TALUKA OF GUJARAT

SIMPLE JAIN
Department of Home Science Extension and Communication Management,
ASPEE College of Home Science and Nutrition, Sardarkrushinagar Dantiwada Agricultural University,
Gujarat- 385506

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ABSTRACT

Gram Sabha is a constitutional body of all the adult members of a village, irrespective of their caste, class, gender and political leanings and affiliations and represents their needs and aspirations. It establishes the supremacy of the people at the grassroot level of democracy. However, this constitutional body is not functioning properly due to lack of knowledge amongst the members and poor participation in the *Gram Sabha*. Therefore, the present study was undertaken to assess the knowledge level of rural people about the *Gram Sabha*. The present study was conducted in three blocks of Dantiwada taluka, district Banaskantha, Gujarat. One village from each block was selected randomly. A sample of 20 women and 20 men were randomly selected from each village. Thus, the total sample of the study was 120 respondents which included 60 women and 60 men. Findings of the study showed that 44.2 per cent respondents had excellent knowledge and 32.5 per cent respondents had less knowledge about *Gram Sabha*. Majority of the respondents had good knowledge on *Gram Sabha* whereas men had comparatively more knowledge (0.98) than women (0.17).

INTRODUCTION

Gram Sabha is an institutional embodiment of the ideal of decentralised participatory democracy at the grassroot level. It is a body of all adult members of a village who have the right to vote.

The effective functioning of the *Gram Sabha* would also make *Gram Panchayat* transparent and directly accountable to the people (Dwarakanath, 2013).It is a means to solve people's problems, fulfill their felt needs, to decide on how to use the available resources optimally in ways desired by its members, to benefit the poorest in the village through direct democratic and participatory planning. The role of *Gram Sabha* is vital in bringing good governance in the local self government. However, the studies and previous literatures show that most *Gram Sabha*s are not functioning as expected and the main reasons are general lack of knowledge about *Gram Sabha* and low participation, unavailability of information and ignorance about its powers, functions and importance, lack of awareness amongst the elected representatives of PRIs, poor information dissemination regarding *Gram Sabha* meeting and ritualistic conduct of the meeting (Hazara, 2013 and Prabhakar Reddy, 2014). The effectiveness of this constitutional body largely depends upon the understanding, ownership and participation of villagers, for which the elementary requirement is the knowledge of *Gram Sabha*. Therefore, the present study was undertaken to assess the knowledge level of rural people on *Gram Sabha*.

MATERIAL AND METHODS

The present study was conducted in three blocks namely Nadotra Brahmanwas, Naddotra Thakurwas and Dangiya of Dantiwada taluka. One village from each Block was selected on random basis. A sample of 20 women and 20 men were selected randomly from each village. Thus, the total sample of the study was 120 respondents which included 60 women and 60 men. Personal interview

E-mail : simplejain2@gmail.com

technique was used for collecting data. A structured interview schedule was developed to assess the knowledge level of rural people about functioning of *Gram Sabha*, procedure of organisation of *Gram Sabha* meeting, role of elected representatives and government officials in *Gram Sabha*, reporting and budget information. The interview was conducted in local dialect at the residence of the respondents. Appropriate statistical tests were used to arrive at conclusion which included frequency, percentage, mean and Z test.

RESULTS AND DISCUSSION

I. Demographic profile of the respondents

Majority of the respondents (58.3%) belonged to middle age group (31-45 years) and had education up to secondary level (26.7 per cent). Around 49 per cent respondents' belonged to general caste included Brahmin, Jain and Rajput and 45.8 per cent respondents belonged to backward caste. 70.8 per cent of the respondents belonged to joint families. Agriculture is the main occupation of most of the respondents (72.5%). Almost all the respondents (98.3%) had exposure to one or more media *i.e.*, mobile, TV, internet, newspaper and radio.

II. Knowledge of respondents about *Gram Sabha*

Knowledge is one of the most important components in the understanding and acceptance of an idea and its practice. Hence, efforts were made to know how far rural people were aware of the *Gram Sabha*, its importance and organisational structure. The broad areas covered in the study were namely-primary awareness, communication, functioning and organisation procedure of *Gram Sabha*, role of elected representatives and government officials in *Gram Sabha*, reporting and resolutions taken in *Gram Sabha* and budget information; knowledge of the respondents was judged in these areas. The existing knowledge of the respondents is described in detail in the subsequent sub-sections.

Primary Awareness about *Gram Sabha*

Primary awareness about *Gram Sabha* included concept and membership of *Gram Sabha*, notice, venue, time and quorum of *Gram Sabha* meeting.

Data in Table 1 show that all the men and 91.7 per cent women had heard about *Gram Sabha*. Similarly, cent percent men and 88.3 percent women were aware about the venue for the *Gram Sabha* meeting. Findings further show that most of the men had knowledge about the concept (80.0%), time schedule (83.3%) and social audit system (83.3%) of *Gram Sabha*. Only 38.3 per cent men knew about the required quorum for holding the *Gram Sabha* meeting. It is evident from the results that only 25 per cent of men and 6.7 per cent of women had knowledge about membership of *Gram Sabha*. Regarding primary awareness of *Gram Sabha* it is concluded that women had less knowledge than their counterpart. The findings are in line with the Veeresha (2009) who revealed that only one woman, out of 7 women was unaware about *Gram Sabha* whereas, all the 10 men were aware about the *Gram Sabha*.

Knowledge about means of Publicity for *Gram Sabha* meetings

Findings presented in Table 2 regarding means of publicity prior to the *Gram Sabha* meeting clearly depict that personal communication (70.8%) was used by elected representatives and villagers for

Table1. Distribution of respondents according to primary awareness about *Gram Sabha*

S. No.	Aspects	f (%) Men (n=60)	f (%) Women (n=60)	f (%) Total (n=120)
1.	Know the term Gram Sabha	60 (100.0)	55 (91.7)	115 (95.8)
2.	Concept of Gram Sabha	48 (80.0)	35 (58.3)	83 (69.2)
3.	Members of Gram Sabha	15 (25.0)	5 (8.3)	20 (16.7)
4.	Notice of Gram Sabha meetings	45 (75.0)	22 (36.7)	67 (55.8)
5.	Venue of Gram Sabha meetings	60 (100.0)	53 (88.3)	113 (94.2)
6.	Time of Gram Sabha meetings	50 (83.3)	22 (36.7)	72 (60.0)
7.	No. of mandated meetings in a year	55 (91.7)	23 (38.3)	78 (65.0)
8.	Quorum required for Gram Sabha meeting	23 (38.3)	4 (6.7)	27 (22.5)
9.	Organisation of social audit by Gram Sabha	50 (83.3)	9 (15.0)	59 (49.2)

Note: Figures in parenthesis indicate percentage

giving information about *Gram Sabha* meetings. Traditional methods *i.e.* "dhol bajana" (use of drum for attention and dissemination of information) and mike are used sparsely, thus, only 20.8 per cent respondents were aware about these method. It was observed that women as well as men respondents had less knowledge about use of posters, social media and electronic media for providing information about *Gram Sabha* meetings. It is worth mentioning that 15.8 % women were aware of social media such as Whatsapp, mobile SMS. Only 8.3 per cent women had knowledge about electronic media such as advertisement on TV and local channels compared to 40% men respondents.

Table 2. Distribution of respondents according to knowledge about means of publicity for *Gram Sabha* meetings **n=120**

S. No.	Aspects	f (%) Men (n=60)	f (%) Women (n=60)	f (%) Total (n=120)
1.	Personal communication	55 (91.7)	30 (50.0)	85 (70.8)
2.	Traditional method	14 (23.3)	11 (18.3)	25 (20.8)
3.	Displaying Notice	40 (66.7)	20 (33.3)	60 (50.0)
4.	Poster	18 (30.0)	13 (21.7)	31 (25.8)
5.	Social media/ mobile	19 (31.7)	9 (15.8)	28(23.3)
6.	Electronic media	24 (40.0)	5 (8.3)	29 (24.2)

Note: Figures in parenthesis indicate percentage

Knowledge about preparation prior to *Gram Sabha* meeting

Circulation of the agenda in advance is a pre-requisite for all *Gram Sabha* meetings and about 54 per cent respondents were aware of it. Gender wise data show that 86.7 per cent men and 21.7 per cent women had knowledge of this preparatory act. The reason for less knowledge among women might be due to their lack of interest in *Gram Sabha*. Almost 97 per cent men respondents and 31.7 per cent women respondents had knowledge of the Chairperson of the *Gram Sabha* meeting.

Table 3. Distribution of respondents according to knowledge about preparation for *Gram Sabha* meetings

S. No.	Aspects	f (%) Men (n=60)	f (%) Women (n=60)	f (%) Total (n=120)
1.	Advance circulation of agenda for Gram Sabha meeting	52 (86.7)	13(21.7)	65 (54.2)
2.	Chairperson in Gram Sabha meeting	58 (96.7)	19 (31.7)	77 (64.2)

Note: Figures in parenthesis indicate percentage

Knowledge about procedure of *Gram Sabha* meeting

Proper and systematic organization is necessary for a successful *Gram Sabha* meeting. Data presented in Table 4 regarding knowledge on organization of *Gram Sabha* meeting show that cent per cent men knew that signature of participants are essential at the beginning of meeting. Only 33.3 per cent women respondents knew this fact because of their fewer participation in *Gram Sabha* meetings. However, only 8.3 per cent men knew that action taken report of previous meeting is mandatory in the

Table 4. Distribution of respondents according to knowledge about procedure of *Gram Sabha* meeting

S. No.	Aspects	f (%) Men (n=60)	f (%) Women (n=60)	f (%) Total (n=120)
1.	Signature of participants	60 (100.0)	20 (33.3)	80 (66.7)
2.	Reading of action taken report of previous meeting	5 (8.3)	0 (0.0)	5 (4.2)
3.	Sharing of agenda	58 (96.7)	13 (21.7)	71 (59.2)
4.	Provision of basic facility	46 (76.7)	15 (25.0)	61 (50.8)

Note: Figures in parenthesis indicate percentage next *Gram Sabha* meeting; not a single women respondent was aware of this fact. Agenda should be shared with the members of *Gram Sabha* at the beginning of the meeting and most of the men respondents (96.7%) were aware about this process. Nearly 51 per cent respondents had knowledge that basic facilities like light, water and sanitation should be arranged for the meeting. It was observed that only one fourth women respondents (25%) knew this as against three fourth men respondents.

Knowledge about reason of organising *Gram Sabha* meeting

Gram Sabha meetings are organized on various issues such as overall development of village, social audit, conflict resolution, solving social issues, registration of essential documents, etc. Perusal of Table 5 depicts that all the men knew that village development issues are raised during *Gram Sabha*, similarly 98.3 men respondents had knowledge about preparation of birth/death related documents during *Gram Sabha* meetings. Most of the men (91.7%) knew that beneficiaries for various developmental schemes are selected in *Gram Sabha* meeting but they were unaware of the procedure and other formalities for selection of beneficiaries. A possible reason for lack of knowledge of the procedure could be that the beneficiaries of various schemes were generally not selected through the *Gram Sabha* meetings in these villages. Almost one-tenth of the respondents (9.2%) had knowledge that *Gram Sabha* is a platform for solving social issues too. Around 40 per cent respondents knew about the social audit done by the *Gram Sabha*. Overall picture shows that more than 70% men respondents were aware about the main reasons for organising *Gram Sabha* meetings whereas less number of women respondents had knowledge in this regard.

Findings are supported by the results of Dhavaleshwar and Ali (2012) that 84.70% respondents had opined that *Gram Sabha* is the best platform to discuss the rural development activities.

Table 5. Distribution of respondents according to knowledge about reason of organising *Gram Sabha* meeting **n=120**

S. No.	Aspects	f (%) Men (n=60)	f (%) Women (n=60)	f (%) Total (n=120)
1.	Development of Village	60 (100.0)	20 (33.3)	80 (66.7)
2.	Preparation of Annual Plan for Panchayat	48 (80.0)	9 (15.0)	57 (47.5)
3.	Social Audit	42 (70.0)	5 (8.3)	47 (39.2)
4.	Solving social issues	7 (11.7)	4 (6.7)	11 (9.2)
5.	Selection of beneficiaries for developmental schemes	55 (91.7)	19 (31.7)	74 (61.7)
6.	Accounting for birth, death, etc	59 (98.3)	27 (45.0)	86 (71.7)

Note : Figures in parenthesis indicate percentage

Knowledge about the Role of Elected Representatives and Government Officials

It is clearly evident from Table 6 that 59.2 per cent respondents had knowledge about the role of sarpanch, similarly 51.7 per cent knew about the role of Ward Panch. Respondents said that sarpanch is responsible to organsize and preside over the *Gram Sabha* meeting and subsequently discuss suggestions and resolutions of *Gram Sabha* in the *Gram Panchayat* meeting. When asked about the role of the Ward Panch, respondents said that the Ward Panchs should raise the issues of their Wards and seek solutions in *Gram Sabha* meetings.

Table 6. Distribution of respondents according to knowledge about role of elected representatives and Government officials n=120

S. No.	Aspects	f (%) Men (n=60)	f (%) Women (n=60)	f (%) Total (n=120)
1.	Sarpanch	51 (85.0)	20 (33.3)	71 (59.2)
2.	Ward Panch	46 (76.7)	16 (26.7)	62 (51.7)
1.	Secretary	50 (83.3)	18 (30.0)	68 (56.7)
2.	Block Development Officer	50(83.3)	11 (18.3)	61 (50.8)
3.	Others (Aanganwadi Workers/ Teachers/ ASHA Sahyogini / Auxiliary Nurse Midwife)	15 (25.0)	6 (10.0)	21 (17.5)

Note: Figures in parenthesis indicate percentage

Role of Government officials is important in the proper conduct of *Gram Sabha* meeting. Roles of secretary and Block Development Officer were known to more than 50 per cent respondents (56.7 % and 50.8%); most of them were men respondents (83.3%). In an informal discussion respondents said that secretary has to manage works from giving information about the *Gram Sabha* meeting to recording details of the meeting and coordinating with the Sarpanch and Ward Members for considering the resolutions of *Gram Sabha* in Gram Panchayat meetings. It is revealed from Table 6 that only 17 per cent respondents had knowledge regarding role of other Government officials *viz.,* aaganwadi workers, ASHA sahyogini, school teacher and Auxiliary Nurse Midwife (ANM).

Knowledge about Reporting and Resolutions

A large section of the respondents (66.7 %) said that they knew the language of the report. Interestingly, 100% men respondents had knowledge of it. They opined that Gujarati is used for writing minutes and other information. Majority of men respondents (76.7%) compared to very few women (18.3%) claimed that minutes are recorded in writing during *Gram Sabha* meeting. Data further reveals that 66.7% men respondents and only 20 per cent women respondents had knowledge of the process of approval of resolution in the meeting. Similar results were reported by Dhavaleshwar and Ali (2012).

Table 7. Distribution of respondents according to knowledge about reporting and resolution

S. No.	Aspects	f (%) Men (n=60)	f (%) Women (n=60)	f (%) Total (n=120)
1.	Writing of minutes of Gram Sabha meetings	46 (76.7)	11 (18.3)	57 (47.5)
2.	Reporting language	60 (100.0)	20 (33.3)	80 (66.7)
3.	Reading of minutes	30 (50.0)	7 (11.7)	37 (30.8)
4.	Resolution approval process	40 (66.7)	12 (20.0)	52 (43.3)

Note: Figures in parenthesis indicate percentage

Knowledge about Budget

Fund allocation and expenditure is most essential for any development programme; budget is required to materialise the Annual Plan. Knowledge of budget, allocations and expenditure with reference to preparation of annual plan was tested. Table 8 shows that 71 per cent respondents were aware about information sharing regarding fund allocation and expenditure in *Gram Sabha*. The similar trend was observed in case of both men and women. Although, the respondents have knowledge that presentation of fund allocation and expenditure is mandatory in *Gram Sabha* meeting, in practice, such information had not been shared in most of the *Gram Sabha* meetings.

Table 8. Distribution of Respondents according to Knowledge about Budget

n=120

S. No.	Particulars	f (%) Men (n=60)	f (%) Women (n=60)	f (%) Total (n=120)
1.	Fund allocation presentation	55 (91.7)	16 (26.7)	71 (59.2)
2.	Fund expenditure presentation	55 (91.7)	16 (26.7)	71 (59.2)

Note: Figures in parenthesis indicate percentage

Overall knowledge of the respondents about *Gram Sabha*

To get an overview of the knowledge, the respondents were grouped under three categories namely poor, good and excellent on the basis of scores obtained by them. It is evident from Table 9 that 44.2 per cent respondents had excellent knowledge and 32.5 per cent respondents had less knowledge on *Gram Sabha*. Overall, it has been concluded that respondents had good knowledge about *Gram Sabha*.

Table 9. Distribution of the respondents in various knowledge categories

n= 120

Knowledge Category	f (%) Men (n=60)	f (%) Women (n=60)	f (%) Total (n=120)
Poor (0 – 13)	0 (0.0)	39 (65.0)	39 (32.5)
Good (14 – 26)	20 (68.3)	8 (13.3)	28 (23.3)
Excellent (27-39)	40 (66.7)	13 (21.7)	53 (44.2)

Note: Figures in parenthesis indicate percentage

Difference in knowledge of men and women about *Gram Sabha*

To measure the respondents' knowledge of *Gram Sabha*, nine different aspects of *Gram Sabha* meeting were studied. An examination of data presented in Table 10 indicate that calculated 'Z' value was greater than its tabulated value at 5% level of significance for all the nine aspects of knowledge of *Gram Sabha*. It leads to a conclusion that there had been highly significant difference in level of knowledge of *Gram Sabha* between men and women of selected villages.

Table 10. Significance of difference regarding knowledge of men and women about *Gram Sabha*

Aspects	Mean		Z value
	Men n=60	Women n=60	
Knowledge about			
1. Primary Awareness about Gram Sabha	0.80	0.65	1.851^{NS}
2. Publicity means of Gram Sabha meetings	1.87	1.70	1.225^{NS}
3. Preparation of Gram Sabha meeting	7.10	3.53	9.703**
4. procedure of Gram Sabha Meeting	2.83	1.63	3.560**
5. Reason of organising Gram Sabha Meeting	1.83	0.53	11.020**
6. Role of elected representatives	2.82	0.80	11.964**
7. Role of government officials	4.52	1.40	11.790**
8. Reporting and resolution	1.62	0.60	7.771**
9. Budget	1.92	0.58	8.132**
Overall knowledge about Gram Sabha	**0.98**	**0.17**	**4.565****

** Value significant at 5% level of significant NS= Non Significant

Thus, it can be inferred from analysed mean values that men had higher knowledge (0.98) than women (0.17). Mean of different publicity medium of *Gram Sabha* meetings (1.87, 1.70) shows that knowledge amongst both genders was in nearby range and there was no significant difference in knowledge between them. However, high mean difference was calculated on the aspects related to the knowledge of the role of elected representatives (2.82, 0.80), role of government officials (4.52, 1.40) and reason for organising *Gram Sabha* meeting (1.83, 0.53). It is observed from calculated data that men and women had knowledge of *Gram Sabha* but the level of knowledge vary significantly, and that men had higher knowledge than women in all nine aspects of knowledge; but for the two aspects of primary awareness about *Gram Sabha* and publicity means used for *Gram Sabha* the difference is very little and non-significant. The lesser knowledge amongst women about *Gram Sabha* meeting was due to lack of interest and participation in *Gram Sabha* meeting. Women are still not allowed by their community to participate and speak in meetings.

CONCLUSIONS

The knowledge profile of the respondents shows that there was significant difference in the knowledge level between men and women. Men exhibited higher knowledge than the women in all aspects; however, women are almost at par with men in primary awareness on *Gram Sabha* and in the knowledge of publicity medium used for *Gram Sabha* meeting. Further, men have above average knowledge on almost all the aspects of *Gram Sabha* whereas women had poor knowledge on all the aspects of *Gram Sabha*. The study presents an urgent need for capacity building and handholding programmes at the grassroot levels to ensure better participation of people in *Gram Sabha* so as to strengthen the local self governance system.

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A STUDY OF THE DETERMINANTS OF PERCEPTION ON THE GIRL CHILD IN *ANDHRA, TELANGANA* AND *RAYALASEEMA* REGIONS

BILQUIS AND K.MAYURI

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ABSTRACT

The decline in child sex ratio (0-6 years) from 945 in 1991 to 927 in 2001 and further to 914 females per 1,000 males in 2011, the lowest since independence is cause for alarm, and serious policy re-think. This is despite legal provisions, incentive-based schemes, and media messages. This artificial alteration of our demographic landscape has implications for not only gender justice and equality but also social violence, human development and democracy. The present study (2013-14)focused on finding out the determinants of the perception on the girl child in the three regions of united Andhra Pradesh state. Sample consisted of 345men and women, 115 from each region were selected. The perception scores of the participants were related with the selected independent variables such as age, gender, education, social desirability, values and satisfaction with life using step down regression to find out the important determinants in each region. The findings revealed that number of years of education, social desirability and the values like self enhancement and conservation were found to be important determinants that influence the perception of the people on the girl child.

INTRODUCTION

It is a travesty that a nation that aspires to be a world power has no social respect for its women. Various social, economic and demographic indicators provide evidence of a gender bias as well as deep-rooted prejudice and discrimination against women and girl children. The issue of the survival of the girl child is a critical one, and needs systematic effort in mobilizing the community. The status of the girl child in any society depends on the perception of people on the girl child. The highly positive perception towards girl child depicts a girl child friendly society and records less number of female feticides and infanticides. This perception is influenced by several personal, social and cultural determinants. Hence, the present study was taken up with the objective-determinants of perception on the girl child of Andhra region, Telangana region and Rayalaseema region respondents.

MATERIAL AND METHODS

Sampling procedure

The study was taken up in the Rayalaseema, Andhra and Telangana regions of united Andhra Pradesh state during the year 2013-14. As the study aimed at exploring the various social and cultural factors responsible for the declining sex ratio, all the three regions of the state are selected. Sample for the study was selected from the three villages from each region which have the lowest girl child sex ratio (as per the 2011 census of Government of India). were selected randomly for the study thus making a total of 345 respondents (21-60 years). 115 respondents from each region were selected from which 60 were male and 55 were female.The dependent variable of the study was perception on the girl child. The independent variables include age gender, education, religion,region, life satisfaction,value orientation and social desirability.

E-mail : bilquisbasha@gmail.com

Data collection and measuring instruments

S.No	VARIABLES	MEASURING TOOL
INDEPENDENT		
1	Age	General information schedule developed for the study by the researcher.
2	Gender	
3	Education	
4	Region	
5	Religion	
6	Life satisfaction	Edward Diener's life satisfaction scale (1985)
7	Social desirability	Social desirability scale by Douglas P Crown and David Marlowe, 1964
8	Value orientation	The ESS Human values scale By Shalom H.Schwartz, 2006
DEPENDENT		
1	Perception on the girl child	A Interview schedule was developed for the study by the investigator

A detailed schedule for studying perceptions on the social and cultural factors responsible for declining sex ratio in united Andhra Pradesh state was developed for the present study which included 53 questions divided into ten sections to understand the individual's perception about declining sex ratio, marriage related practices, abortion related practices, sex determination, girl child, female foeticide and infanticide. Questionnaire was developed by using attitude scale format for selected aspects with Likert five point rating scale. The developed schedule was pretested and revised before using for the main study. The important determinants among the independent variables that influence the perception of people on the girl child were found by using the step down regression analysis.

RESULTS AND DISCUSSION

In order to find out the influence of seven variables on the general perceptions on the girl child, step down regression analysis was carried out for the respondents of the Andhra region. Thirty- seven percent variation in the in the responses to the general perception of girl child was caused by seven variables namely education, social desirability, openness to change, self transcendence, self enhancement, conservation and satisfaction with life. However from these seven variables education and social desirability were highly significant at 0.01 level and self enhancement and conservation were significant at 0.05 level. For the Andhra region respondents' openness to change, self transcendence and satisfaction with life did not operate to a significant level in determining the perceptions on girl child issues.

Education level of the respondents, social approval motive, sensuous gratification for one self (hedonism), acceptance of their culture and traditions, achievement motivation and holding the power with authority and wealth were the variables that determined the perceptions on girl child by the Andhra region respondents.

Table 1. Determinants of perception on the girl child of *Andhra* region respondents through step down regression

Variable	Regression coefficient	Error	t value	Significant 't'
Education	1.7096	0.3856	2.798	0.00903**
Social desirability	0.7859	0.2704	2.906	0.00694**
Openness to change	-0.317	0.177	-1.791	0.08376
Self transcendence	-2.8869	2.3096	-1.25	0.22203
Self enhancement	1.0804	0.4467	2.419	0.02258*
Conservation	-0.456	0.204	-2.235	0.03385*
Satisfaction with life	-2.7714	2.2139	-1.252	0.22064

** 0.01 , * 0.05
Residual standard error : 3.659
Multiple R squared : 0.3784, Adjusted R-squared : 0.5944
F- statistic : 6.716 , p-value – 2.601 e-05

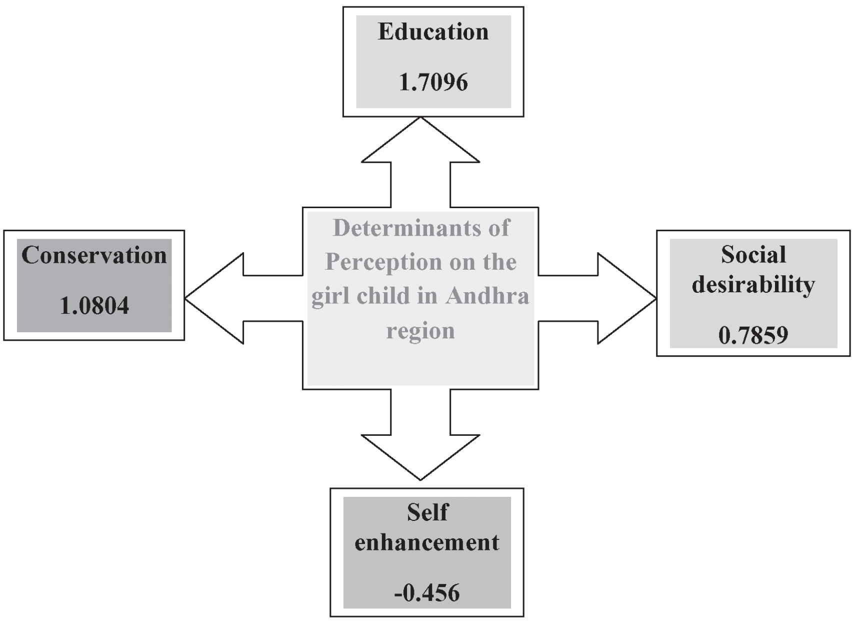

Fig. 1. Determinants of perception on the girl child of *Andhra* region respondents through step down regression

Table 2. Determinants of perception on the girl child of *Rayalaseema* region respondents through step down regression

Variable	Regression coefficient	Error	t value	Significant 't'
Education	-3.61352	1.30103	-2.777	.005749**
Social desirability	-4.4661	1.3023	-3.43	.00067**
Openness to change	-0.14162	.07789	-1.818	.06982
Self transcendence	-0.0421	.02241	-1.874	.06173
Self enhancement	-5.9643	1.9558	-3.049	.002452**
Conservation	-4.2491	1.2903	-3.293	.001083**
Satisfaction with life	-4.2736	1.9067	-2.241	0.0334*

** 0.01; Residual standard error : 5.5843
Multiple R squared : 0.4704, Adjusted R-squared : 0.2351
F- statistic : 1.999 , p-value – .066

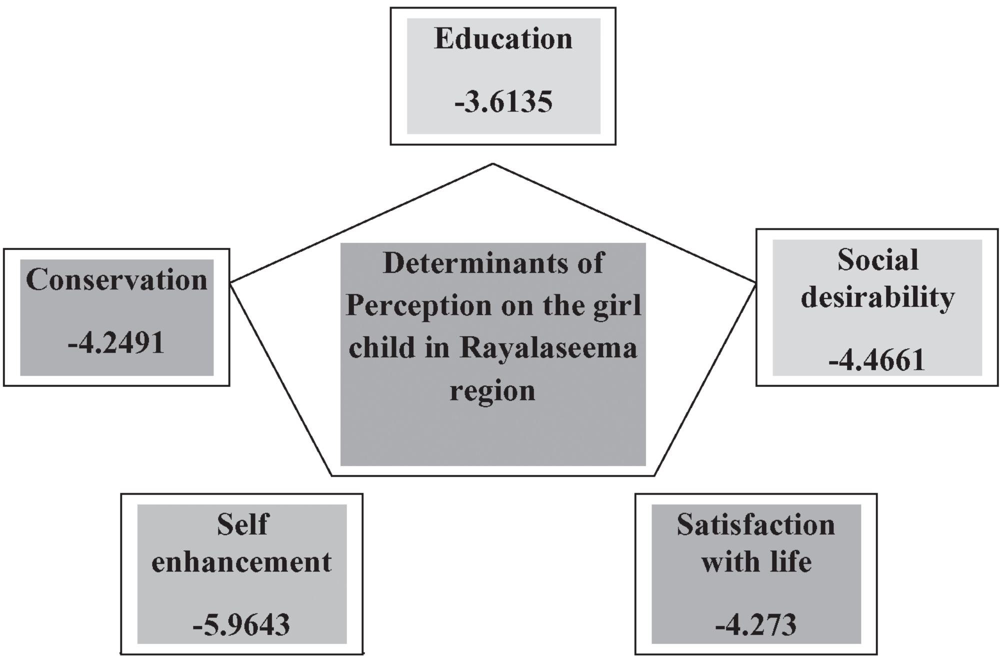

Fig. 2. Determinants of perception on the girl child of *Rayalaseema* region respondents through step down regression

The step down regression analysis carried out to determine the significant variables that contribute to the perception on the girl child for the Rayalseema region respondents revealed that among the seven variables, five variables were found to be significant. Education, social desirability, self enhancement, conservation variables were highly significant at 0.01 level whereas satisfaction with life was significant at 0.05 level.The number of years of education, social approval motive, acceptance of their culture and traditions, sensuous gratification of oneself, social status and prestige, achievement as a competence related goal, satisfaction with life were the variables that determined response to general perception on girl child in the Rayalaseema region. Lower the scores on these variables more conservative were the responses and higher the scores on these variables more liberal were the responses to the perception items on the girl child.

Table 3. Determinants of perception on the girl child of *Telangana* region respondents through Step down regression

Variable	Regression coefficient	Error	t value	Significant 't'
Education	2.27324	0.10442	2.622	0.009094**
Social desirability	-4.2491	1.2903	-3.293	0.001083**
Openness to change	-0.14162	0.07789	-1.818	0.069826
Self transcendence	-4.4627	1.3200	-3.38	0.000799***
Self enhancement	-0.04214	0.02249	-1.874	0.069826
Conservation	-5.25424	1.33472	-3.937	0.000982***
Satisfaction with life	-3.1662	1.5725	-2.238	0.02708*

***0.001 ,** 0.01
Residual standard error : 3.203
Multiple R squared : 0.5882, Adjusted R-squared : 0.3576
F- statistic :2.551 , p-value – 0.01994

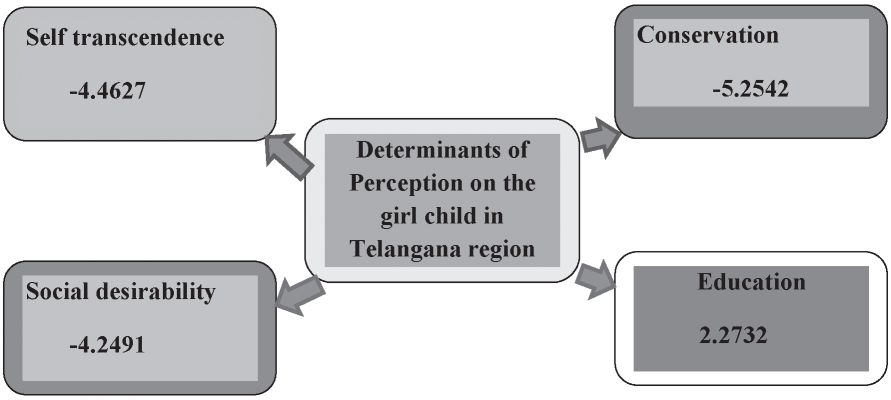

Fig . 3. Determinants of perception on the girl child of *Telangana* region respondents through Step down regression

In order to find out the influence of seven variables on the general perceptions on the girl child, step down regression analysis was carried out for the respondents of the Telangana region. Fifty-eight percent variation in the responses to the general perception of girl child was caused by seven variables namely education, social desirability, openness to change, self transcendence, self enhancement, conservation and satisfaction with life. However from these seven variables self transcendence and conservation were highly significant at 0.001 level and education and social desirability were significant at 0.01 level. Satisfaction with life was significant at 0.05 level. For the Telangana region respondents openness to change, self enhancement did not operate to a significant level in determining the perceptions on girl child issues.The tribal respondents of Telangana region hold the values of universalism, benevolence and respect their culture and traditions. Hence, these values were highly significant in determining the perceptions on girl child. Education and social desirability were also found to be significant determinants that influence the perceptions of Telanagana region people.

The values of social justice, a sense of equality, helpfulness, number of years of education and a strong social approval motive were the variables that determined response to general perception on girl child in the Telangana region. Higher the scores on these variables less conservative were the responses and more liberal were the responses to the perception items on the girl child.

Table 4. Determinants of perception on the girl child of Andhra Pradesh (three regions) respondents through step down regression

Model		Sum of Squares	df	Mean Square	F
1	Regression	463.917	7	66.274	1.973
	Residual	11283.514	336	33.582	
	Total	11747.430	343		
2	Regression	463.017	6	77.170	2.305
	Residual	11284.413	337	33.485	
	Total	11747.430	343		
3	Regression	461.723	5	92.345	2.766
	Residual	11285.707	338	33.390	
	Total	11747.430	343		
4	Regression	439.042	4	109.761	3.290
	Residual	11308.388	339	33.358	
	Total	11747.430	343		
5	Regression	413.519	3	137.840	4.135
	Residual	11333.911	340	33.335	
	Total	11747.430	343		
6	Regression	346.533	2	173.266	5.182
	Residual	11400.898	341	33.434	
	Total	11747.430	343		

CONCLUSIONS

From the above results it can be concluded that in all the three regions of Andhra Pradesh people valued conservative ideas and are giving importance to the cultural aspects. In all the three regions educated participants had positive and better perceptions on the girl child than the uneducated participants. High social desirability of the persons also influenced the responses in all the three regions. However, the Rayalaseema region respondents were found to be more satisfied with their lives compared to Telanagana and Andhra regions and had better perceptions on girl child. Over all, people who value self enhancement, conservation and self transcendence are more satisfied with their lives influencing the positive perception on the girl child.

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INFLUENCE OF PLANTATION AGE ON PRODUCTION PERFORMANCE OF OIL PALM IN ANDHRA PRADESH

P. MADHAVI LATHA, M. KALPANA AND K. MANORAMA
Horticultural Research Station, Dr.Y.S.R. Horticultural University, Vijayarai - 534475

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ABSTRACT

Oil palm being a perennial plantation crop with high vegetable oil yielding potential is expected to show varied yield potential at different stages of life cycle, with increase in age of the plantation yield increase up to 25 to 30 years. The yield recorded in 5 years old plantation was 93.93 kg of fresh fruit bunch yield (FFB) per palm per year with (13.97 t ha^{-1}) a deviation of 25.53 kg. In 9 years old plantation, the yield recorded was 178.92 kg of fresh fruit bunch yield (FFB) per palm per year (26.33 t ha^{-1}) with a yield deviation of 50.62 kg, it was 48 percent more yield than that of 5 years old palms and 16 percent less than to 24 years old palms. In 24 years old palms the average yield recorded was 215.35 kg of fresh fruit bunch yield (FFB) per palm per year (31.80 t ha^{-1}) with a deviation of 70.38 kg. Among 18 palms studied in each of three age groups, 66.66 per cent of palms recorded 50 to 100 kg of FFB per palm per year at 5 years age of plantation. In 9 year old palms 66.66 percent of palms recorded 150 to 250 kg of FFB per palm per year where as in 24 years old palms, 33.33 percent of palms recorded 200 to 250 kg of FFB per palm per year and 33.33 percent of palms recorded more than 250 kg. Regarding per hectare yield in 5 years old plantation 50 percent of palms recorded 10 to 15 t ha^{-1} of FFB, while in 9 years old plantation 78 percent of palms recorded more than 20 t ha^{-1} and in 24 years old plantation 66 percent of palms recorded more than 30 t ha^{-1} of FFB yield per year. This data reflects that up to 24 years, oil palm produces stable yield of more than 30 t ha^{-1} with increase in age of the palms, though there is reduction in number of bunches, improvement in average bunch weight contributes to the increase in yield per palm and per hectare.

INTRODUCTION

Oil palm has recently expanded dramatically in South East Asia (Wick *et al*., 2011). In Andhra Pradesh oil palm is one of the most suitable perennial and potential vegetable oil yielding plantation crop (Rethinam and Chadda, 1992). Being a long duration perennial crop the existing oil palm plantation needs to be maintained there in field for 25 to 30 years. Land and water are highly precious and costly natural resources, in view of this, farmers aim to get highly economic and retainable benefits per unit area per unit period. In oil palm plantation, age is one of the criteria for field management because height of the palm which create more difficulty in manual harvesting (Mohd Basri Wahid *et al.,* 2004). Aged plantations demand nearly 10 percent increase in production cost, and so farmers obviously expect more FFB yield and also stabilized economic returns in aged plantations. Production potential of oil palm with Tenera crosses vary widely within the crosses and also with age. In Andhra Pradesh nearly 25-30 years old existing oil palm plantations are there in farmer fields. Production potential in oil palm increases with increase in age of the palm from 4^{th} year to 12^{th} year, and from 12^{th} year the plantation comes to yield stabilization (Rethinam, 1998). However, much information is not available about the yielding pattern of oil palm at different ages under irrigated conditions. Hence, the present study was carried out in the existing plantations of Horticultural Research Station located at Vijayarai, West Godavari district of Andhra Pradesh.

MATERIAL AND METHODS

In the present study, three different age groups of Tenera oil palm crosses were studied. The age groups included were 5 years old, 9 years old

E-mail : madhavi_akp@yahoo.co.in

and 24 years old. In each age group 18 palms were taken for yield estimation as sample size. Yield attribute and yield data was collected at every 12 to 14 days interval for the year 2014-15 and 2015-16 with recorded average annual rainfall of 828.3 and 841.3 mm in each year at Horticultural Research Station, Vijayarai, West Godavari district, Andhra Pradesh.

RESULTS AND DISCUSSION

Production performance of oil palm varied much with increase in age of the plantation. Yield attributing characters recorded like number of bunches per palm and average bunch weight varied widely within the age group palms and also among the three age groups. Number of bunches recorded was maximum in 9th year old plantation (13.72 ± 3.81) where 5 years old palms recorded (11.56±3.09) and 24 years old palms recorded (9.39±2.81) average number of bunches per palm per year(Table 1).The range of bunch number in 3 different age groups, 5 years old palms recorded 6 to 17 bunches, 9 years old palms recorded 7 to 22 bunches and in 24 years old palms recorded 4 to 14 bunches per palm in a year. Average bunch weight recorded was 8.40±1.76 kg in 5 years old palms, 13.47±2.45 kg in 9 years old palms and 23.70±5.31 kg in 24 years old palms. Average bunch weight increases with increase in age of the palms. Average bunch weight in 5 years old palms ranges from 4.64 to 11.43 kg, in 9 years old palms 6.15 to 16.97 kg and in 24 years old palms it ranged from 15.50 to 35.09 kg(Table 1).

In similar lines to yield attributes, yield per palm and yield ha^{-1} also varied widely within the same age group palms and also among the 3 different age groups. Yield of oil palm(FFB) recorded in 9 years old oil palms was 178.92±50.62 kg per palm with 26.33 t ha^{-1} which was 48 per cent higher than 5 year old plantation palms, where 5 years old palms recorded 93.93±25.53 kg per palm with 13.97 t ha^{-1} FFB yield(Table 2).In 24 years old plantation the average yield recorded was 215.35±70.38 kg per palm with 31.80 t ha^{-1} FFB yield which was 16 per cent more than 9 years old plantation yield (Table 2). The average FFB per palm yield recorded in a year in 3 age groups were 49.9 to 165.9 kg in 5 years old palms, 92.30 to 78.92 kg in 9 years old palms and 62 kg to 348.50 kg of FFB yield per palm per year in 24 years old palms. The average FFB Yield recorded per hectare was 13.97, 26.33 and 31.80 t ha^{-1} per year in 5, 9 and 24 years old palms. Oil Palm breeders estimate potential yields of 18 t ha^{-1}(Corley and Tinker, 2003).

Among 18 palms studied in three age groups, In 5 year old palms 66.66 per cent of palms recorded 50 to 100 kg of FFB per palm per year. In 9 year old palms 33.33 per cent of palms recorded 150 to 200 kg of FFB per palm per year and 33.33 per cent of palms recorded 200 to 250 kg of FFB per palm per year (Table 3). While in 24 years old palms 33.33 per cent of palms recorded 200 to 250 kg of FFB per palm per year and 33.33 per cent of palms recorded higher than 250 kg of FFB per palm per year. (Table 3).

Table 1. Yield attributing parameters in 3 different age plantations of oil palm

Treatment	No. of bunches palm^{-1}			Average bunch weight (kg)		
	Age of palms			Age of palms		
	5 years	9 years	24 years	5 years	9 years	24 years
Palm-1	14	22	12	8.76	11.12	21.05
Palm-2	15	12	7	11.06	16.97	20.64
Palm-3	17	15	13	8.35	15.31	21.20
Palm-4	12	13	5	6.54	13.55	21.26
Palm-5	17	11	4	7.64	15.64	15.50
Palm-6	13	12	7	9.11	14.36	24.09
Palm-7	13	15	7	4.99	13.35	31.33
Palm-8	12	12	9	8.27	13.81	29.51
Palm-9	12	15	13	7.95	9.97	26.81
Palm-10	11	7	11	7.17	15.24	21.64
Palm-11	6	15	11	8.32	6.15	19.81
Palm-12	12	12	11	4.64	13.42	24.68
Palm-13	9	20	14	9.44	13.92	16.34
Palm-14	9	16	9	6.92	14.89	17.72
Palm-15	10	9	8	9.38	15.48	35.09
Palm-16	7	18	11	11.43	11.72	21.78
Palm-17	11	9	9	7.84	11.46	23.87
Palm-18	8	14	8	10.26	12.63	22.84
Average	11.56	13.72	9.39	8.40	13.47	23.70
Max	17	22	14	11.43	16.97	35.09
Min	6	7	4	4.64	6.15	15.50
SDEV	3.09	3.81	2.81	1.76	2.45	5.31

Table 2. Yield of oil palm in 3 different age plantations

Treatment	Yield per palm (kg)			Yield (t ha^{-1})		
	Age of palms			Age of palms		
	5 years	9 years	24 years	5 years	9 years	24 years
Palm-1	122.7	244.6	252.6	17.55	34.98	36.12
Palm-2	165.9	203.6	144.5	23.72	29.11	20.66
Palm-3	142	229.7	275.56	20.31	32.85	39.41
Palm-4	78.5	176.1	106.3	11.23	25.18	15.20
Palm-5	129.9	172	62	18.58	24.60	8.87
Palm-6	118.4	172.3	168.6	16.93	24.64	24.11
Palm-7	64.9	200.2	219.3	9.28	28.63	31.36
Palm-8	99.2	165.7	265.6	14.19	23.70	37.98
Palm-9	95.4	149.6	348.5	13.64	21.39	49.84
Palm-10	78.9	106.7	238	11.28	15.26	34.03
Palm-11	49.9	92.3	217.9	7.14	13.20	31.16
Palm-12	55.7	161	271.5	7.97	23.02	38.82
Palm-13	85	278.3	228.7	12.16	39.80	32.70
Palm-14	62.3	238.3	159.5	8.91	34.08	22.81
Palm-15	93.8	139.3	280.7	13.41	19.92	40.14
Palm-16	80	210.9	239.6	11.44	30.16	34.26
Palm-17	86.2	103.1	214.8	12.33	14.74	30.72
Palm-18	82.1	176.8	182.7	11.74	25.28	26.13
Average	93.93	178.92	215.35	13.97	26.33	31.80
Max	165.9	278.30	348.50	23.72	39.80	49.84
Min	49.9	92.30	62.00	7.14	13.20	8.87
SDEV	25.53	50.62	70.38	4.44	7.26	9.85

Table 3. Yield per palm ranging in different percentages

FFB Yield per palm per year (kg)	AGE GROUP					
	5 years		9 years		24 years	
	No. of palms out of 18 palms within yield range	Percentage of palms in yield range	No. of palms out of 18 palms within yield range	Percentage of palms in yield range	No. of palms out of 18 palms within yield range	Percentage of palms in yield range
< 50	1	5.5	0	0.00	0	0.00
50 – 100	12	66.66	1	5.5	1	5.5
100 – 150	4	22.22	4	22.22	2	11.11
150 - 200	1	5.5	6	33.33	3	16.6
200 – 250	0	0.00	6	33.33	6	33.33
> 250	0	0.00	1	5.5	6	33.33

Table 4. Yield per hectare ranging in different percentages

FFB yield ($t\ ha^{-1}$)	AGE GROUP					
	5 years		9 years		24 years	
	No. of palms out of 18 palms within yield range	Percentage of palms in yield range	No. of palms out of 18 palms within yield range	Percentage of palms in yield range	No. of palms out of 18 palms within yield range	Percentage of palms in yield range
< 10	4	22.22	0	----	1	5.5
10 – 15	9	50	2	11.11	0	----
15 – 20	3	16.66	2	11.11	1	5.5
20 – 25	1	5.5	5	27.77	3	16.66
25 – 30	0	0	4	22.22	1	5.5
> 30	0	0	5	27.77	12	66.66

The per hectare yield of FFB range between 10 to 15 t ha^{-1} in 50 percent of 5 years old palms, while in 9 years old palms 78 percent of palms recorded more than 20 t ha^{-1} FFB yield(Table 4) and in 24 years old plantation 66 percent of palms recorded more than 30 t ha^{-1} of FFB yield per year. A realistic value for palm oil yield potential in favorable environments averaged over the economic life of planting after canopy closer is around 10-11 t ha^{-1} (Breure,2003). This data reflects that up to 24 years oil palm produces stable yield of more than 30 t ha^{-1} with increase in age of the palms sex ratio decreases so that number of bunches decreases per palm but average bunch weight increases drastically which contribute to the increase in yield per palm and per hectare (Rethinam, 1998).

CONCLUSIONS

This paper reviews that variability in yield among palms varies with increase in age of plantations. There is need to effort to narrow the gap between commercial yield and potential yield in oil palm with good planting material and good management practices. Need of the hour in our country is to produce huge quantities of vegetable oils to support the domestic demands of growing Indian population, which can be supported by cultivating oil palm with high oil yield per unit area of land.

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CLIMATE RESILIENT TECHNOLOGY ADAPTATION AND EXPECTED COST OF UNCERTAINTY UNDER NAGARJUNA SAGAR PROJECT, KRISHNA RIVER BASIN

M. CHANDRASEKHAR REDDY, D. VISHNU SHANKAR RAO, G. RAGHUNADHA REDDY, K. GURAVA REDDY AND V. SREENIVASA RAO

Department of Agricultural Economics, Acharya N.G Ranga Agricultural University, Bapatla -522 101

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ABSTRACT

Policy makers are figuring out on the upscaling of the adaptation technologies with the changing climate. Adaptation strategies followed by the farmers is very low and had ranged from 6-30 percent only. This is mainly due to the lack of awareness about the actual cost associated with adaption and non-adaptation strategies. Hence, the present papers address the cost of adaptation for rice using joint probability distribution of rainfall and crop prices. The cost of adaptation varied from Rs.3520 to Rs.646 ha^{-1} for the adaptation of direct seeding of rice, modified system of rice intensification and alternate wetting and drying of rice, whereas, the expected cost for not using the se technologies range from Rs.1900 to Rs.12423 ha^{-1}. It was found out from the study that promotion of adaptation technologies itself minimize the income losses to the farmers to a large extent.

INTRODUCTION

Agricultural production vary and often faces uncertainty due to regional variation in rainfall, temperature and other weather parameters besides soils, crop yields, cropping systems and management practices (Palanisami *et al.,* 2011). The crop losses may increase further, if the predicted climate change increases the climate variability. Simulation models on crop growth also indicated that yield of some crops in tropical regions would decrease generally even with a minimal increase in temperature under dryland agriculture (Prasad Rao *et al.,* 2008). In order to strengthen the climate forecasts, researchers are also developing ex-ante type climate change forecasts by innovative approaches to assess the uncertainty of the climate impacts (Immerzeel, 2008). Kavi Kumar and Parikh (2001) and Sanghi and Mendelsohn (2008) have estimated that under moderate climate change scenarios, there could be about a 9% decline in farm-level net revenues in India. A one-degree increase in temperature may reduce yields of wheat, soybean, mustard, groundnut and potato by 3-7% (Kavi Kumar *et al.,* 2010). The yield losses are likely to be substantially higher with the long-term climate change scenarios (Nagothu *et al.,* 2012). Such climate-forecast tools and scenarios can help evaluate sector-specific, incremental changes in risk over the next few decades (Wilby *et al.,* 2009). The clear message from these studies is that climate change will affect crop production and income and therefore appropriate adaptation measures are necessary at the farm level to cope up with such situations.

Adaptations are adjustments or interventions which take place in order to manage the losses or take advantage of the opportunities presented by a changing climate. Adaptation occurs at two levels: i) farm-level adaptation which mainly focuses on farming-related interventions or adjustments and are related to short-term periods and influenced by seasonal climate variations and local agricultural cycles; ii) the regional- or national-level adaptation which focuses on the agricultural production at macro level, linking domestic and international policy (Bradshaw *et al.,* 2004).The assessment of farm-level

E-mail : csreddy9315@gmail.com

adaptation strategies is important in providing information necessary to the implementing agencies and government for formulating the needed policies. The adaptation strategies include physical investment in creating farm structure as well as management technologies such as improved crop and water management practices, several of which have been already examined by the researchers.

The question is how best farmers can follow up with the adaptation measures to cope with the climate change impacts. Nhemachena and Hassan (2007) had studied the farm-level adaptation strategies in Southern Africa such as using different varieties, planting different crops in different planting dates, diversifying from farm to non-farm activities, increasing number of irrigations and adopting soil conservation techniques. But, many farmers do not want to invest on such technologies due to inadequate know-how on the technologies, lack of financial support, poor climate-change forecasts and high cost of the technologies (Clements *et al.,* 2011). Further, adoption level of the technologies is influenced by the occurrence of various climate events such as variation in rainfall during different periods (Palanisami *et al.,* 2011). In general, farmers see only the actual benefits (which are comparatively small) due to the technology adoption from their past experiences but do not foresee the expected costs (which are comparatively high) for not following the adaptation strategies. Exposing the farmers to the actual cost of adaptation as well as to the expected income associated with adaptation measures may motivate them towards better adaptation measures. Therefore, the main question that needs to be addressed is how to estimate the actual cost of adaptation and the expected cost by not using the adaptation technologies given the occurrence of the climate events (such as variation in rainfall and variations in crop prices). Hence, the present study focused on this aim through a survey cross- section of farmers in a delta region.

MATERIAL AND METHODS

Study area

The Krishna river basin that covers both Andhra Pradesh and Telangana was selected for the study due to logistic advantages of the researcher. The Nagarjuna Sagar Project (NSP) in the Krishna River Basin was selected purposively, which has left and right canals covering both the states. NSP left canal covers Nalgonda and Khammam districts of Telangana and part of Krishna district from Andhra Pradesh with 4.20 lakh ha. The right canal covers Guntur and Prakasam districts with 4.75 lakh ha as command area. The technologies prevalent in the selected study locations were surveyed and analyzed in detail for their adoption level. Since the technologies are mostly related to the irrigated rice situations, the technologies followed in the project area are considered to address the climate change adaptations by the farmers. An earlier study conducted by Palanisami *et al.* (2012) in the region had also identified similar technologies to address the climate change adaptations in rice. Among the various technologies the Modified system of rice intensification, Direct seeding of rice (DSR) and Alternate wetting and drying (AWD) area were considered for this study.

Study sample

The farmers adopting the above farm-level technologies in the project locations/districts were enumerated and formed as the sample for the study. The sample farmers (300) surveyed from the five districts varied in technology adoption. The analysis was carried out for the farmers adopting Modified System Rice Intensification (70 number), DSR (120 farmers) and AWD (110 farmers) comparing the cost values with their conventional practice.

Data

Data relating to socioeconomic aspects of farm households (such as age, gender, education, experience in farming), farm size, irrigation sources, water supplies, crop pattern, crop yield, cost of crop cultivation, and cost and returns of different climate adaptation technologies being practiced in the study area were collected from farmers through the survey method using a pretested questionnaire during 2014-15. Further, data relating to the occurrence of different rainfall events and price changes in a 10-year period were also collected from the published sources in the project area and using this, the probability of occurrence of rainfall as surplus, normal, deficit and failure were worked out. Similarly, the probability of occurrence of high, medium and low crop prices was worked out using the time series on crop prices.

Tools of analysis

Tools of decision analysis falling under the gamut of decision theory can be used to analyze economics of different interventions (Kanti Swarup *et al.,*2012; Taha, 2010). The tendency of the farmers to adopt the interventions can be explained through the additional income generated by adopting them. For example, in the case of mechanised transplantation, famers prefer to have the transplantor mainly to minimize the labour scarcity and avoid the delayed transplantation and crop damages due to rainfall and cold weather in the lateral stages of the crop. Hence, incorporating the behaviour of the rainfall and prices in crop production is important to maximize the income of the farmers. In this situation, for example, farmers' current mechanisation behaviour (X_1) is induced by labour and rainfall distribution and can be described by a probability distribution as stated in Table 1.

Table 1. Probability distribution of adaptation strategies of farmers due to climate and Labour

S.No.	Farmers' adaptation strategy	Probability
1	Transplantation method and irrigation to crops(X_{11})	p_1
2	Adopt to Mechanisation and water management practice (X_{12})	p_2

The next uncertain factor is the fluctuations in price of the crops. In cases of normal and surplus rainfall periods, when crop production is more, prices may comparatively decrease. The situation may reverse in below-normal rainfall periods when prices will be high due to reduction in production of crops. Therefore, the price of the crop (X_2) has three levels: low (X_{21}), normal (X_{22}) and high (X_{23}). The probability of their occurrence as low, medium and high was calculated using 10-year time series, and calculated values were used in the estimation of the joint probabilities.

Table 2. Probability distribution of price of crop

S.No.	Crop price level	Probability
1	Low (X_{21})	q_1
2	Normal (X_{22})	q_2
3	High (X_{23})	q_3

The probability distribution of X_2 can be stated as given in Table 2. Since the irrigation behaviour and price levels are independent, their joint probabilities are given by the product of separate probabilities (Palanisami *et al.,* 2012):

$$p(X_{ij}) = p_{ij} = p(X_1 = X_{1i}, X_2 = X_{2j}) = p(X_1 = X_{1i})p(X_2 = X_{2j}) = p_i q_j \; i = 1,2; j = 1,2,3 \qquad (1)$$

There are six combinations of irrigation strategies and price levels. Each combination (X_{1i}, X_{2j}) can be called as a *'state of nature'* because the farmer has no control over either rainfall or price level. The probability distribution of the state of nature is given by equation (1).

Farmers have different technology options to adopt such as MSRI, AWD and DSR. In the language of decision analysis, each technology is called an *'alternative strategy'* or simply '*strategy.'* For each technology adopted, the net return can be computed for each state of nature and then using the joint probabilities, the Expected Monetary Value (EMV) for each technology can be worked out as follows:

$$EMV_T = \sum_{i=1}^{i=4}\sum_{j=1}^{j=3}(R_{ij} - r_{ij})p_{ij} \qquad (2)$$

where, R_{ij} and r_{ij} are respectively the returns with and without technology T when the state of nature is (X_{1i}, X_{2j}). Normally, $R_{ij} \geq r_{ij}$, because the farmer derives extra benefit due to application of technology and in the language of decision analysis, the difference $R_{ij} - r_{ij}$ is called *'payoff'* corresponding to the state of nature (X_{1i}, X_{2j}). The expected monetary value is defined as the weighted sum of the net benefits where the weights are the corresponding (joint) probabilities. Equation (2) can be rewritten as

$$EMV_T = \sum_{i=1}^{i=4}\sum_{j=1}^{j=3} R_{ij}p_{ij} - \sum_{i=1}^{i=4}\sum_{j=1}^{j=3} r_{ij}p_{ij} \qquad (3)$$

The first term gives the expected gross return with technology and the second term refers to the expected gross return without applying the technology. Thus, the expected monetary value is the difference between expected gross return with and without technology. This is the expected net profit (or benefit) for adopting technology *T*.

Further, the farmer can choose that technology for which EMV_T is maximum and this is referred to as the *optimum technology*. EMV is based on '*Imperfect Information'* because the farmer is not aware of what the state of nature will be, and so, it is called *expected value under uncertainty.* Decision theory analysis further helps us compute the Expected Opportunity Loss (EOL) or Expected Value of Perfect Information (EVPI) which is the difference between the expected value with perfect information (about state of nature) and the expected value with current information. In other words, EVPI is the maximum amount a decision maker should pay for additional information that gives a perfect signal as to the state of nature.

In order to identify the most ideal situation for decision making, the exact outcome of the state of nature should be known. For example, let there be k alternative technologies (hereafter we shall call them as *strategies*) and n states of nature whose probability distribution is $p_i, i = 1,2,..n.$

Let $P_{ij}, i = 1,2,...n; j = 1,2,...k$ be the payoff when the state of nature is i and the farmer selects strategy j.]

$$EMV_j = \sum_{i=1}^{n} p_i P_{ij},\ j = 1,2,...k \qquad (5)$$

Then the optimal strategy for the farmer will be to select that strategy for which *EMV* is maximum. So the expected monetary value is given by

$$EMV = \underset{j}{Max}\{EMV_j, j = 1,2,..k\} \qquad (6)$$

This is the expected value under imperfect information. If the predicted state of nature is i, then the farmer will select that strategy which will correspond to maximum of the payoffs given in the i^{th} row. If R_i is the maximum payoff corresponding to the state of nature predicted, then

$$R_i = \underset{j}{Max}\{P_{ij}, j = 1,2,..k\},\ i = 1,2,...n \qquad (7)$$

Then the expected payoff to the farmer *with* perfect information is

$$EPwPI = \sum_{i=1}^{n} p_i R_i \qquad (8)$$

This is the maximum payoff the farmer can achieve. From equation (7), for each $i,\ R_i \geq P_{ij}, j = 1,2,..n$ and hence,

$$\sum_{i=1}^{i=n} p_i R_i \geq \sum_{i=1}^{i=n} p_i P_{ij} \quad \text{That is}$$

$$EPwPI \geq EMV_j, j = 1,2...n \qquad (9)$$

This shows that the expected payoff with perfect information is always greater than the expected monetary value for any strategy j and from equation (6), it can be easily seen that.

$$EPwPI \geq EMV \qquad (10)$$

Now consider the difference, $EPwPI - EMV_j$. This represents the opportunity loss corresponding to the strategy j and we shall denote it by EOL_j and this loss will be a minimum when the farmer adopts the optimal strategy. The *Expected Value of Perfect Information* is the difference between expected payoff with perfect information and expected payoff with imperfect information. That is,

$$EVPI = EPwPI - EMV = \underset{j}{Min}\ \{EPwPI - EOLj, j=1,2,..k\} \qquad (11)$$

The $EVPI$ is also known as the Expected Opportunity Loss (EOL) for not adopting the best decision. The above methodology can be represented in the form of a Flow Chart as shown in Figure 2. The expected monetary value of a technology, EMV_T given in equation (3) can also be interpreted as the net loss the farmer will incur if he is not adopting technology T. Since this measure is based on uncertainties in the state of nature, we shall term it as *Expected Cost of Uncertainty 1* (or $ECU1$). The difference $EPwPI - ECU1$ will be termed as *Expected Cost of Uncertainty 2* (or $ECU2$). It can be easily seen that for optimal technology, $ECU1$

will have a maximum value and $ECU2$ will have a minimum value. Further, $EVPI$ is the minimum value of $ECU2$. Finally, the sum of $ECU1$ and $ECU2$ will always be equal to $EPwPI$

RESULTS AND DISCUSSION

Data related to the summary of costs and returns and input use for MSRI, AWD and DSR are shown in Table 3. The technologies adopted were able to reduce the seed rate in MSRI and DSR practices by 93% and 49 % respectively. The days for transplantation were reduced by 58 % for MSRI and 100% for DSR. In MSRI, seedlings are transplanted within 15-18 days of sowing. The labour days were also decreased excepted in case of AWD, where it has increased by seven days. The yields are also increased in all the methods except in case of DSR. In contrast, Kakumanu *et al.*, (2016) has shown that the yield has increased in DSR and cost of cultivation is less than the current practice. In the present study also the cost was reduced by Rs.4300/ ha^{-1} and gross margin is higher than the current practice with 14% deviation.The adaptation measures are able to reduce the seed rate, labour and days for transplantation in Modified System of Rice Intensification and DSR. Water use can be reduced in all the methods compared to the traditional methods (Mahender Kumar *et al.*, 2014; Rejesus *et al.,* 2011).

The additional cost due to the adaptation practice was also provided to estimate the cost of adaptation.

Table 3. Cost and returns of the adaptation technologies

S. No.	NSP, Krishna Basin (per ha)					% Deviation from current management practice		
	Particulars (1)	MSRI (2)	AWD (3)	DSR (4)	Current practice (5)	MSRI (6)	AWD (7)	DSR (8)
1	Seed rate (kg)	5	70	35	69	-93	1.4	-49
2	Days to transplant	17	30	0	30	-58	0	-100
3	Labor use (days)	10	35	2	28	-64	25	-93
4	Yield (kg)	6,100	5,700	4,753	5,002	22	14	-5
5	Operating cost (Rs)	38,778	36,024	31,246	35,546	9	1	-12
6	Gross return (Rs)	65,054	52,621	47,003	49,399	32	7	-5
7	Gross margin (Rs)	26,276	16,597	15,757	13,853	89	20	14
8	Additional cost (Rs)*	3,232	478	-4300	-	-	-	-

* Additional cost includes annualized capital cost and operation and maintenance cost.

The adaptation costs are the costs associated with the implementation of the agriculture and water management technologies by the farmers, as these technologies are already available but not practiced by all the farmers. The adaptation cost of these technologies includes both additional investment made (due to the technology over the traditional practices) plus the transaction cost (in terms of time and other expenses in getting the technology or practices in place). The additional investment and the transaction cost could vary among the technologies and affect the technology adoption level. It is seen from Table 4 that the transaction cost is comparatively higher for MSRI due to its high management intensity. The cost of adaptation is thus ranging from Rs.3,520 ha^{-1} for DSR to Rs. 646 ha^{-1} for AWD.

Table 4. Adaptation cost of the technologies in rice production

Technologies	Additional cost of the technology (Rs. ha^{-1})	Transaction cost (Rs. ha^{-1})	Adaptation cost (Rs. ha^{-1})
NSP, Krishna Basin			
i. Modified system of rice intensification	3,232	1,163	4,395
ii. Alternate wetting and drying (AWD)	478	168	646
iii. Direct seeding of rice (DSR)	-4,300	780	-3,520

An earlier study by researchers has indicated that farmers' adaptation levels are comparatively low (Palanisami *et al.,* 2012).In case of NSP under Krishna basin, the level of adoption of the technologies had ranged from 6-8% indicating the importance of upscaling the technologies as well as identifying the constraints in their adoption. The adaptation rate specified under NSP was achieved based on the discussion with farmers and agricultural department officials in the district as there is no specified data base on the technology adaptation in the irrigation project area.

The adaptation varies among the technologies, probably due to the preference of farmers in adopting a technology/practice available to them and the costs of adaptation. The technologies are less costly as they involve mostly the managerial inputs. However, other factors such as farmers' poor knowledge in handling it, lack of skilled laborers in doing the crop operations, poor water control from canal systems, high transaction costs, etc., also constrain the adoption of the technology. It is important to see how the non-adaptation will cost the farmers. The expected cost of uncertainty-1 (*ECU 1*) which is the profit foregone for non-adaptation of the technologies will be a clear indication of the farmers' decision making behavior which will vary according to the type of technology and the occurrence of uncertain events such as erratic rainfall pattern and varying crop prices. In the study area, the *ECU1* for Modified System of Rice Intensification was calculated with the probability of using traditional transplanting methods at 0.8 and adopting the technologies (Modified System of Rice Intensification, AWD and DSR) at 0.2. The probability of low, normal and high output prices was arrived at 0.3, 0.4 and 0.3, respectively, based on the time series on prices which were used to compute the joint probabilities Table (6). Using equations (2) and (3) the expected cost of uncertainty 1, *ECU1* were computed (refer chapter 3 for equations). The *ECU1*for the three technologies under NSP of Krishna river basin range from Rs.1900 to Rs.12423 ha^{-1}(Table 5). In all the cases, the cost of uncertainty is higher than the cost of adaptation indicating that farmers are incurring more losses for their non-adoption of the technologies (Fig. 1). The possible reason might be that the costs of adaptation are more or less known before the crop season and they are related to the technology costs alone, whereas cost of uncertainty is unknown prior to the season due to the interplay of both the rainfall and price events and they are related to both adaptation costs and other crop production costs.

Table 5. Expected cost of uncertainty-1(*ECU1*) for non-adaptation of the technologies

S. No.	Technologies	Gross margin without technology (Rs ha^{-1})	Expected gross margin with technology (Rs ha^{-1})	Expected Monitory value (or) Expected cost of uncertainty I (*ECU1*) (Rs ha^{-1})
1	Modified system of rice intensification	13,853	26,276	12,423 (89.6)
2	Alternate wetting and drying (AWD)	13,853	16,597	2,744 (19.8)
3	Direct seeding of rice (DSR)	13,853	15,757	1,904 (13.7)

As the cost of uncertainty-1 reflects the non-adaptation cost of the technology, it is interesting to examine whether the farmers who have adopted the technologies are also maximizing their crop income through these technologies. In this context, a comparision of the various adaptation practices was made in order to get an idea of the farmers' optimal decision making. Given the technologies that are adopted, the expected cost (reduction in revenue) for not adopting them at the level that gives the maximum income (optimal decisions) can be referred to as cost of uncertainty-2 (*ECU2*). In the case of the

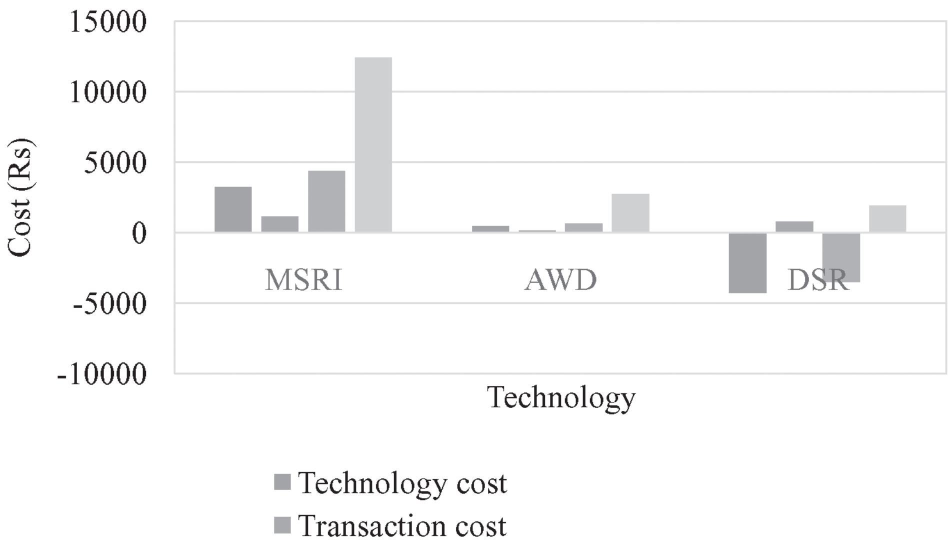

Fig. 1. Technology adaptation cost and expected cost of uncertainty

management strategies, the optimal decisions and the EVPI were analyzed using equations (5) to (8) and (11) are given in Table 6.

The *ECU2* for AWD is high, when compared with other technologies. The present adoption of MSRI in the study area has maximum returns, *ECU2* is zero. Hence, it is important to see how best farmers' adoption of the technologies is close to the optimum decision making so that the cost of uncertainty could be minimized. Given the *ECU1* and *ECU2*, it is important to focus on *ECU1* as it is directly addressing the technology adaptation.

Table 6. Expected cost of uncertainty-2 (*ECU2*) for non-adaptation of the technologies

Event	Joint Probability	Krishna Basin			
		MSRI	AWD	DSR	OPTD
1	0.24	6,000	3,900	4,926	6,000
2	0.32	7,400	3,750	6,167	7,400
3	0.24	6,900	3,750	6,197	6,900
4	0.06	6,500	5,050	5,230	6,500
5	0.08	7,650	5,300	6,300	7,650
6	0.06	8,500	6,000	6,450	8,500
	EMV (ECU1)	12,423	2,744	1,904	12,423*
	ECU2	0**	9,679	10,519	--

Note: Values shown under each practice is the difference between net income with and without adoption under different market prices of high, medium and low probabilities;
OPTD = optimum decision; * denotes EPwPI; ** denotes EVPI;
other notations are as in the text; JP=joint probability.

CONCLUSIONS

The impact of climate change is fully acknowledged by several studies in recent years. Even though technologies/improved practices such as modified system of rice intensification, alternate wetting and drying and direct seeding of rice are available to the farmers, their adoption level is very low. High cost of the technologies as well as lack of awareness and technical skills on the adaptation technologies are the key constraints in the better adoption of the adaptation technologies. Poor water control at the system level also contributed to the poor adoption of technologies such as SRI and AWD. As a result, the expected cost for not adopting the adaptation technologies in rice is significantly high compared to actual cost of the adaptations in the river basins. Hence, the results give a strong message for promoting the technology adaptation to address the climate change impacts in agriculture.

In order to speed up the technology spread, policy interventions in terms of supplying the machinery for transplanting, water regulation in the canals, capacity-building programs and monitoring the technology adaptation in the fields through stakeholder participation are highly warranted. Further, the study has given an idea of the cost associated with the technology adoption and the investment needed for technology transfer programs at macro level. The policymakers can plan the technology transfer program and investment priorities accordingly.

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RELATIONSHIP BETWEEN PROFILE OF THE FARMERS AND EXTENT OF ADAPTATION MEASURES IN COMBATING CLIMATE VARIABILITY

B. KRANTHI KUMARI, S.V. PRASAD, P.V. SATHYA GOPAL AND G. MOHAN NAIDU
Department of Agricultural Extension, S.V. Agricultural College, Tirupati-517 502

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ABSTRACT

The study revealed that majority of the respondents had medium (45.83%) level of adaptation followed by low (30.00%) and high (24.17%) levels of adaptation. The relationship between the profile and their extent of adaptation measures indicated that computed r-value of education, farming experience, achievement motivation, social participation, mass media exposure and preparedness for adaptation showed positively significant. While age, gender, farm size, family size, family income, extension contact and credit and subsidy orientation showed non-significant with the extent of adaptation measures in combating climate variability.

INTRODUCTION

Climate is the primary determinant of agricultural productivity. Climate change refers to any change in climate over time, whether due to natural variability and the result of human activity (IPCC, 2007). Climate change is central in development policies and practices. Conservation agriculture appears to be potentially contributing in addressing the challenge of adapting agricultural practices to climate change (FAO, 2011). Adaptation to climate change refers to adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderates harm or exploits beneficial opportunities (IPCC, 2001). Adaptation in agriculture is how perception of climate change is translated into agricultural decision making process. Hence, the present investigation made an attempt to study various factors that are responsible for the adaptation of the farmers to climate variability in Kurnool district of Andhra Pradesh.

MATERIAL AND METHODS

A study was conducted with *ex-post-facto* research design to find out the relationship between selected profile characteristics of farmers with their extent of adaptation measures in Kurnool district which was purposively selected for the study as it is in scarce rainfall zone which is very much prone to climate change. One mandal from each revenue division of Kurnool district *viz.,* Nandyal, Kurnool and Adoni were selected randomly. Three mandals *viz.,* Banaganapalle mandal from Nandyal revenue division; Orvakallu mandal from Kurnool revenue division and Emmiganuru mandal from Adoni revenue division were randomly selected for the study.

From each of the three selected mandals, two villages were selected for the study *viz.,* Yagantipalle and Yerragudi from Banaganapalle mandal; Ussenapurum and Orvakallu from Orvakallu mandal; Banavasi and Siraladoddi from Emmiganuru mandal. Thus, a total of six villages were selected by following random sampling procedure. 120 respondents were selected with 20 farmers from each village through simple random sampling procedure. Keeping the objectives of the study in view, interview schedule was developed. This was administered to sample respondents through personal investigation. The data obtained was coded, classified and tabulated.

E-mail : kranthi200860.bommu@gmail.com

RESULTS AND DISCUSSION

It is evident from the Table 1 that majority of the respondents had medium (45.83%) level of adaptation followed by low (30.00%) and high (24.17%) levels of adaptation.

An attempt has been made to find out the association between independent variables and dependent variables through correlation coefficient (r) values. The results are presented in Table 2.The r values in Table 2 indicated that education (0.317), farming experience (0.233), achievement motivation (0.333), social participation (0.244), mass media exposure (0.377) and preparedness for adaptation (0.395) were positively correlated with the extent of

Table 1. Distribution of the respondents according to their level of adaptation on climate variability N=120

S.No.	Category	Frequency	Percentage
1.	Low level of adaptation	36	30.00
2.	Medium level of adaptation	55	45.83
3.	High level of adaptation	29	24.17
	Total	**120**	**100.00**

Table 2. Relationship between the selected independent variables and extent of adaptation measures in combating climate variability

N=120

S.No.	Variable	Independent variables	Correlation coefficients (r values)
1.	X_1	Age	-0.142^{NS}
2.	X_2	Gender	0.067^{NS}
3.	X_3	Education	0.317**
4.	X_4	Farm size	0.178^{NS}
5.	X_5	Farming experience	0.233**
6.	X_6	Family size	-0.032^{NS}
7.	X_7	Family income	-0.101^{NS}
8.	X_8	Achievement motivation	0.333**
9.	X_9	Extension contact	0.114^{NS}
10.	X_{10}	Social participation	0.244**
11.	X_{11}	Mass media exposure	0.377**
12.	X_{12}	Credit and subsidy orientation	0.160^{NS}
13.	X_{13}	Preparedness for adaptation	0.395**

* : Significant at 0.05 level of probability
** : Significant at 0.01 level of probability
NS : Non- Significant

adaptation measures in combating climate variability. The r values of age (-0.142), gender (0.067), farm size (0.178), family size (-0.032), family income (-0.101), extension contact (0.114) and credit and subsidy orientation (0.160) were non-significant with the extent of adaptation measures in combating climate variability.

Higher level of education is believed to be associated with access to information on improved technologies, climate information and productivity consequences. Farmers with higher levels of education are more likely to adopt better, to climate change using various methods because a farmer who has more years of education is more likely to adopt improved methods and expected to be more efficient to understand and obtain new technologies than less educated people. This is in conformity with the findings of Debalke (2013). Highly experienced farmers are more likely to have more information and knowledge on changes in climatic conditions and crop management practices. Experienced farmers have high skills in farming techniques and management and are able to spread risk when facing climate variability.Experienced farmers are usually leaders and progressive farmers in rural communities and these can be targeted in promoting adaptation management to other farmers who do not have such experience and are not yet adapting to changing climatic conditions.

It could be inferred that farmers with more achievement motivation will search for correct choices for combating climate variability in comparison to other farmers. Their decision making will also be better about modalities of task performance in combating climate variability. Hence, this trend was noticed. Social participation plays a significant role in information exchange about climate change among the farmers through peer communication. High social participation enables the farmers to have more and better contacts with formal and informal sources which in turn might have lead to willingness to adopt recommended practices to minimize the impact of climate variability.

Mass media plays a vital role in influencing the attention of the farmers on new technologies. Mass media *i.e.,* radio, television and newspaper were major sources of awareness of effects of climate change and adaptive measures to cope with the effects of climate change. This is in conformity with finding of Luka and Yahaya (2012). Farmers with high level of preparedness for adaptation to changes are likely to perceive more about the prevailing climate situations. Preparedness for adaptation helps the farmers to face the adverse impacts of climate change. For example famers who had acquired information about the climate change or who had taken insurance are more adapted to agriculture. The above findings could be explained as the higher the education, farming experience, achievement motivation, social participation, mass media exposure and preparedness for adaptation, the higher would be the extent of adaptation measures in combating climate variability.

There is no relationship between the age, gender, farm size, family size, family income, extension contact and credit and subsidy orientation with the extent of adaptation measures in combating climate variability. These findings were in accordance with the findings of Debalke (2013), Luka and Yahaya (2012).

Multiple Linear Regression analysis of the selected independent variables with extent of adaptation measures in combating climate variability

An attempt has been made to find out the amount of contribution made by the independent variables in explaining the variation in the dependent variable through multiple linear regression. The results are presented in Table 3.

It was observed from the Table 3 that the thirteen independent variables with the extent of adaptation measures in combating climate variability taken on multiple linear regression analysis gave the R^2 (Co-efficient of multiple determination) value of 0.4453. Hence, it could be inferred that all the independent variables put together contributed 44.53 per cent of the total variation in the extent of adaptation measures in combating climate variability, leaving the rest to extraneous factors. The independent variables *viz.*, farm size, Farming experience and preparedness for adaptation significant towards the variation in the extent of adaptation measures in combating climate variability.

Table 3. Multiple Linear Regression analysis of the selected independent variables with extent of adaptation measures in combating climate variability

S. No.	Variable Number	Independent variables	Partial regression coefficients (b)	Computed 't' values
1.	X_1	Age	-0.188	-2.109*
2.	X_2	Gender	-2.027	-0.863NS
3.	X_3	Education	0.418	0.982NS
4.	X_4	Farm size	1.458	2.093*
5.	X_5	Farming experience	0.373	4.422**
6.	X_6	Family size	0.218	0.648NS
7.	X_7	Family income	0.003	0.557NS
8.	X_8	Achievement motivation	0.420	1.740NS
9.	X_9	Extension contact	0.222	0.675NS
10.	X_{10}	Social participation	0.102	0.245NS
11.	X_{11}	Mass media exposure	0.644	1.872NS
12.	X_{12}	Credit and subsidy orientation	0.141	0.809NS
13.	X_{13}	Preparedness for adaptation	0.544	2.809**

* : Significant at 0.05 level of probability
** : Significant at 0.01 level of probability
NS : Non- Significant

CONCLUSIONS

The present study revealed that most of the farmers had medium level of adaptation as most of the respondents are marginal and small farmers with low educational level. In order to improve the level of adaptation of the farmers towards climate variability, it is necessary to conduct various awareness programmes through mass media and there is a need to improve the social participation by the extension agencies by conducting group discussions and helping the farmers to operate in groups as the adaptation measures sometimes require group approach. Farmer to farmer extension strategy can be used to promote awareness and adoption of best practices in climate change.

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A STUDY ON FORECASTING OF AREA, PRODUCTION AND PRODUCTIVITY OF PEARL MILLET IN ANDHRA PRADESH

V. NIREESHA, V. SRINIVASA RAO, D.V.S. RAO AND G. RAGHUNADHA REDDY
Department of Agricultural Statistics, Agricultural College,
Acharya N.G. Ranga Agricultural University, Bapatla - 522101

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ABSTRACT

This paper attempted to identify the trends of area, production and productivity of pearl millet (Bajra) in Andhra Pradesh through fitting linear and non-linear equations, ARIMA and Exponential Smoothing techniques. Secondary data on area, production and productivity of Bajra for a period of 47 years *i.e.* from 1966 to 2012 was used. Cubic model was identified as the best model for area, production and productivity, forecasting for the Bajra crop upto 2020 AD. It was observed that there was an increasing trend in production and productivity, however, area is in decreasing trend. It was also identified that the traditional models capture the trend effectively as compared with the time series models.

INTRODUCTION

The millets are a group of small seeded species of cereal crops or grains widely grown around the world for food and fodder. Pearl millet covers an estimated 31 million hectares worldwide – an area about the size of Poland – and is grown in more than 30 countries located in the arid and semi-arid tropical and subtropical regions of Asia, Africa and Latin America. Pearl millet accounts for about 50% of the total global production of millets. India is the largest single producer of the crop, both in terms of area (9.3 Mha) and production (8.3 Mt). The West and Central Africa (WCA) region has large areas under millets (15.7 Mha.), of which more than 90% is pearl millet. The crop is cultivated on more than 2 million hectares in the Eastern and Southern Africa region.

Pearl millet is the most widely cultivated cereal crop in India after rice and wheat. It is grown on more than 9.3 Mha. with current grain production of 9.5 Mt and productivity of 1044 kg ha^{-1} during 2012-13. The major pearl millet growing states are Rajasthan, Maharashtra, Gujarat, Uttar Pradesh and Haryana which account for more than 90% of pearl millet acreage in country. The area under Pearl millet was 0.67 Mha. With a production of 0.111 Mt and productivity was 1657 kg ha^{-1} during 2012-13 in Andhra Pradesh. The objective of this study is to estimate trends in area, production, productivity and to forecast them for pearl millet crop in Andhra Pradesh.

MATERIAL AND METHODS

In this paper an attempt has been made for forecasting of area, production and productivity of pearl millet (Bajra) in Andhra Pradesh by using Linear, Non-linear, ARIMA and Exponential Smoothing models. The data was collected on area, production and productivity of Bajra for a period of 47 years *i.e.*, 1966 to 2012 from the websites of www.indiastat.com and www.agricoop.nic.in. Linear function, Quadratic function, Cubic function, Exponential function, Compound function, Logarithmic function, Inverse function, Power function, S-curve, Growth functions and Time Series (ARIMA) models were fitted by using SPSS software. Identified the best fitted model based

E-mail : vs_raoin@yahoo.co.in

on the model selection criteria. Forecasting the area, production and productivity of Bajra in Andhra Pradesh up to 2020 AD was done based on the best model identified. Among those models which were having highest Theil's U-Statistic (model accuracy), highest R^2, highest Adjusted R^2 and least MAPE values were selected as appropriate for the projections.

Model Selection

Best model was identified based on Theil's U-Statistic, coefficient of multiple determination (R^2), adjusted R^2 ($\bar{R}^2$) and least MAPE values.

Theil's U – Statistic

This statistics allows a relative comparison of normal forecasting methods with naive approaches and also squares the errors involved so that the large errors are given much more weight than small errors. The positive characteristic that is given up in moving to Theil's U-statistic as a measure of accuracy is that of intuitive interpretation. The difficulty will become apparent as the computation of this statistic and its application are examined. Mathematically, it is defined as,

$$U = \sqrt{\sum_{t=1}^{n-1} \frac{\left(\frac{F_{t+1} - Y_{t+1}}{Y_t}\right)^2}{\left(\frac{Y_{t+1} - Y_t}{Y_t}\right)^2}} * 100$$

Where F_{t+1} is the forecasted value at time t +1, and where Yt is the actual value of a point for a given time period t, n is the number of data points .

If U = 100 both models forecast with equal accuracy

U < 100 model forecast is best

Coefficient of Determination (R^2)

R^2 is a statistic that will give some information about the goodness of fit of a model. In regression, the R^2 *i.e,* coefficient of determination will explains the variability of the model . An R^2 of 1.0 indicates that the regression line perfectly fits the data. It provides a measure of how well future outcomes are likely to be predicted by the model.

$$R^2 = \frac{\sum_{i=1}^{n} (\hat{y}_i - \bar{y})^2}{\sum_{i=1}^{n} (y_i - \bar{y})^2} \qquad \frac{\text{Regression sum of squares}}{\text{Total sum of squares}}$$

Adjusted R^2 : $\bar{R}^2 = 1 - (1 - R^2)\frac{n-1}{n-p-1}$

Mean Absolute Percent Error (MAPE) :

It is a measure of accuracy of a method for constructing fitted time series values in statistics, specifically in trend estimation. It is usually expresses accuracy as a percentage, and is defined by the formula:

$$MAPE = \left(\sum_{t=1}^{n}\left(\left|\frac{A_t - F_t}{A_t}\right|\right) \times 100\right) / n$$

Where, A_t is the actual value and F_t is the forecast value

RESULTS AND DISCUSSION

Area

In Andhra Pradesh in early 1970's the area of Bajra was around 6,68,000 ha. Afterwards, it declined rapidly and at present it is only 40,000 ha only. The area of Bajra was analysed by using all the linear, Non linear and Time Series models and is presented in Table 1.

Table 1. Linear, Non-linear and Time series models of pearl millet area in Andhra Pradesh (1966-2012)

Model	Parameter					Criteria		MAPE
	a	b	c	d	Theil's U-	R^2	Adj R^2	
Linear	667.860**	-14.980**			91.76	0.917**	0.915**	33
Logarithmic	992.412	-210.971			85.75	0.757**	0.752**	45
Inverse	240.283**	720.761**			74.68	0.296**	0.280**	107
Quadratic	712.451**	-20.440**	0.114*		92.16	0.924**	0.923**	24
Cubic	**586.792****	**9.415**	**-1.425****	**0.021****	**94.94**	**0.973****	**0.969****	**13**
Compound	978.058**	0.940**			87.07	0.781**	0.776**	20
Power	2306.008**	-0.801**			65.40	0.660**	0.652**	47
S-curve	5.176**	2.491**			61.69	0.213**	0.196**	82
Growth	6.886**	-0.061**			87.07	0.781**	0.776**	20
Exponential	978.058**	-0.061**			87.07	0.781**	0.776**	20
			Time Series Models					
	ARIMA (0, 1, 0)				94.91	0.968**	0.967**	14
	ARIMA (0, 1, 1)				93.02	0.969**	0.968**	13
	ARIMA (1, 1, 0)				94.08	0.968**	0.967**	13
	ARIMA (1, 1, 1)				93.01	0.969**	0.968**	14
	Damped Trend Exponential Smoothing				94.17	0.971**	0.960**	15

***,* indicates significant at 1% and 5% level of probability, respectively*

Forecasted Cubic model is $Y_{area} = 586.792 + 9.415\ x - 1.425\ x^2 + 0.021\ x^3$

From Table 1 it was observed that all the traditional models, Time series models cubic model is showing highest adjusted R^2 and lowest MAPE. Similar results reported by Masuda *et al.* (2009) forecasted world production of soybean. Hence, cubic model was considered as the best model for forecasting purpose and the values were presented in Table 2.

Table 2. Forecasted values of pearl millet area by ARIMA

Year	Forecasted Area ('000 ha)
2013	54
2014	49
2015	45
2016	41
2017	37
2018	33
2019	30
2020	27

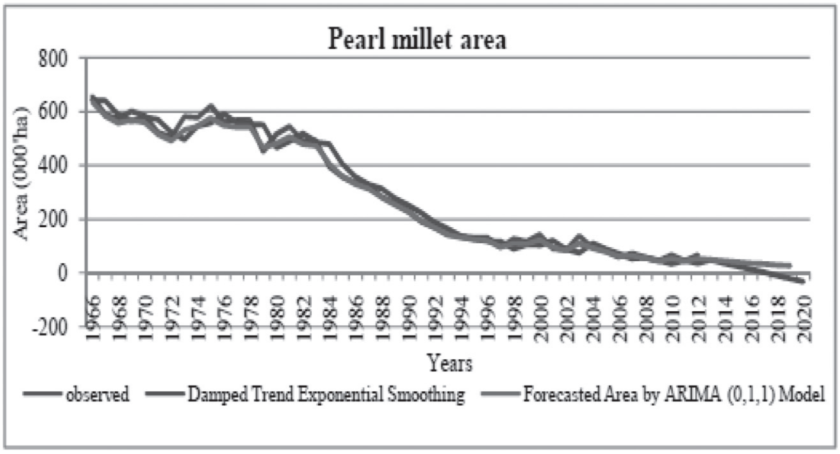

Fig.1. Observed and Forecasted area of pearl millet

From the Fig.1 it is observed that the area of Peal millet is in decreasing trend and for the year 2020 the area would be only 27,000 ha in Andhra Pradesh.

Production

It was observed that the average production Pearl millet for the study period (1966-2012) was 193 thousand tonnes in Andhra Pradesh. It was also observed that it is in decreasing trend from 1984 onwards. Maximum production was 444 thousand tonnes in the year 1981 and minimum was 47 thousand tones in the year 2006. The results obtained for production of pearl millet during the study period by fitting all the models were presented in Table 3.

Table 3. Linear, Non-linear and Time series models of pearl millet production in Andhra Pradesh (1966- 2012)

Model	Parameter				Theil's U-Statistics	Criteria		MAPE
	a	b	c	d		R^2	Adj R^2	
Linear	353.532**	-6.694**			86.28	0.699**	0.692**	28
Logarithmic	453.539**	-89.555**			82.50	0.521**	0.510**	38
Inverse	164.404**	301.489**			76.84	0.198**	0.180**	61
Quadratic	348.917**	-6.129*	-0.012**		86.28	0.699**	0.692**	28
Cubic	**256.770****	**15.764***	**-1.140****	**0.016****	**88.29**	**0.779****	**0.774****	**22**
Compound	420.400**	0.961**			84.56	0.624**	0.615**	25
Power	726.606**	-0.517**			76.24	0.530**	0.520**	37
S-curve	4.930**	1.636**			72.36	0.177**	0.159**	52
Growth	6.041**	-0.040**			84.56	0.624**	0.615**	25
Exponential	420.400**	-0.040**			84.56	0.624**	0.615**	25
			Time Series Models					
	ARIMA (0, 1, 0)				84.26	0.581**	0.572**	33.12
	ARIMA (0, 1, 1)				86.92	0.718**	0.712**	26.99
	ARIMA (1, 1, 0)				86.58	0.701**	0.694**	28.11
	ARIMA (1, 1, 1)				87.12	0.726**	0.720**	26.37

**,* indicate significant at 1% and 5% level of probability, respectively.

Forecasted Cubic model is $Y_{Production} =$ **256.770 + 15.764 x - 1.140 x^2 + 0.016 x^3**

It is evident from Table 3 that the value of Theil's U-Statistic (88.29%), R^2 (0.779) with significant adjusted R^2 (0.774) are higher for cubic model compared to the other models. The value of MAPE (22) was also lower for cubic model compared to other growth models. Thus, the cubic model is seemed to be the best fit not only for describing the growth pattern of coarse cereals but also for making forecast with minimum forecast error. Similar results were reported by Sandika *et al*. (2009) with cubic growth model for projecting Rice production and productivity. Based on the best identified model (cubic) the Pearl millet production was forecasted and tabulated in the Table 4 and Fig.2.

Table 4. Forecasted values of pearl millet production by cubic model

Year	Forecasted Production ('000 tonnes)
2013	119.74
2014	135.51
2015	153.60
2016	174.11
2017	197.14
2018	222.78
2019	251.12
2020	282.26

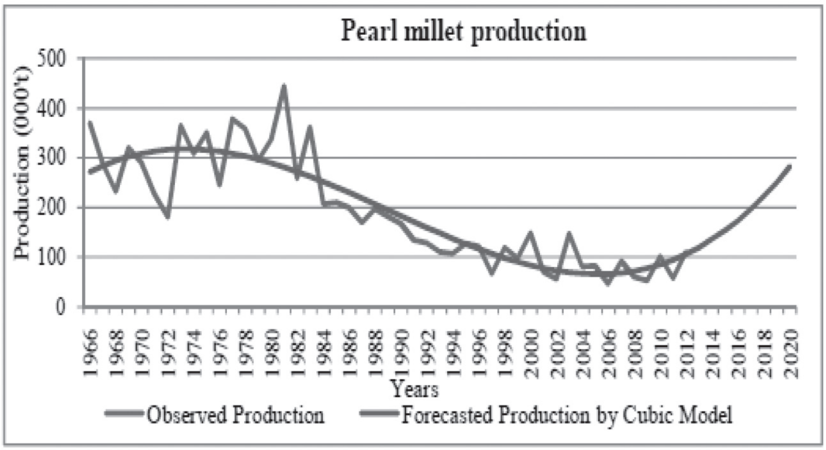

Fig. 2. Observed and Forecasted pearl millet production in Andhra Pradesh

It was observed from the table the forecasted values of pearl millet production showed an increasing trend by 2020 AD.

Productivity

It was recorded that the average productivity of sorghum crop for the entire period was 767 kg ha^{-1}

(Fig. 3). Maximum productivity was 1657 kg ha^{-1} in the year 2012 and minimum productivity was 355 kg ha^{-1} in the year 1972. Though the area showed declining trend but production and productivity is on increasing trend. Similar results were reported by Karim *et al.* (2010) and Hassan *et al.* (2011) with the same model for forecasting of coarse rice prices in Bangladesh. The results obtained for productivity of pearl millet during the study period by fitting all the models were presented in Table 5.

Table 5. Linear, Non-linear and Time series models of pearl millet productivity in Andhra Pradesh (1966- 2012)

Model	Parameter				Theil's U-Statistics	R^2	Adj R^2	MAPE
	a	b	c	d				
Linear	348.818**	17.406**			90.34	0.695**	0.688**	16
Logarithmic	132.266	217.916**			86.98	0.454**	0.442**	21
Inverse	826.609**	-636.015*			83.38	0.129**	0.110**	28
Quadratic	546.149**	-6.757	0.503**		91.83	0.780**	0.776**	14
Cubic	**384.995****	**31.531***	**-1.470***	**0.027****	**92.53**	**0.816****	**0.812****	**14**
Compound	427.848**	1.022**			91.01	0.742**	0.736**	14
Power	313.376**	0.287**			87.40	0.492**	0.480**	18
S-curve	6.663**	-0.860**			82.98	0.134**	0.115**	24
Growth	6.059**	0.022**			91.01	0.742**	0.736**	14
Exponential	427.848**	0.022**			91.01	0.742**	0.736**	14
			Time Series Models					
	ARIMA (0, 1, 0)				89.25	0.612**	0.603**	18.88
	ARIMA (0, 1, 1)				91.73	0.775**	0.770**	14.66
	ARIMA (1, 1, 0)				91.67	0.769**	0.764**	14.49
	ARIMA (1, 1, 1)				92.04	0.791**	0.786**	14.34
Damped Trend Exponential Smoothing					91.45	0.766**	0.761**	14.08

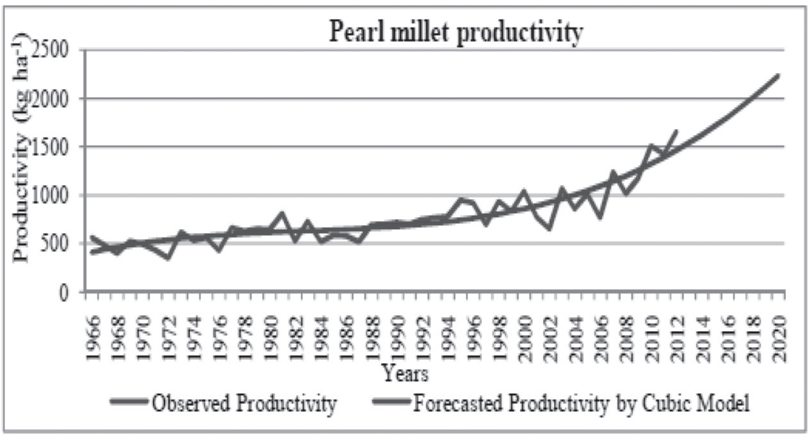

Fig.3. Observed and forecasted trends of pearl millet productivity in Andhra Pradesh

It is evident from the above Table 5 that the value of Theil's U-Statistic (92.53%), R^2 (0.816) with significant adjusted R^2 (0.812) are higher for cubic model compared to the other linear and non-linear growth models. The value of MAPE (14) also lower for cubic model compared to other growth models. Hence, cubic model was chosen for forecasting of productivity. The forecasts showed an increasing trend by 2020 AD and it was presented in Table 6. Same model was selected by Hossain and Hassan (2013) for describing the growth pattern of milk, meat and egg production in Bangladesh. Rahman *et al.* (2013) used cubic model for forecasting of pigeon pea, chickpea and field pea pulse production. The results were in confirmation with those obtained by Hassan *et al.* (2011) and Hossain and Hassan (2013).

Table 6. Forecasted values of pearl millet productivity by cubic model

Year	Forecasted Productivity (kg ha^{-1})
2013	1542.77
2014	1625.13
2015	1712.61
2016	1805.37
2017	1903.58
2018	2007.40
2019	2116.99
2020	2232.53

CONCLUSIONS

Among all the Linear, Non linear, Time Series ARIMA models cubic model was identified as the best model to capture trend in area, production and productivity of pearl millet. Accordingly, the forecasting was done upto 2020 which revealed that area is in declining trend and reached to 17,000 hectares in Andhra Pradesh state. However, in the same time the production is an increasing trend due to the higher productivity. In the year 2020, the bajra production would be 282 thousand tones with an average productivity of 2232 Kg ha^{-1}. It was also observed that traditional (Cubic) model identified the trend in area, production and productivity of bajra is better than the sophisticated time series (ARIMA) models.

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ESTIMATING THE EFFICIENCY IN VALUE CHAIN OF JAGGERY IN ANDHRA PRADESH

I.V.Y. RAMA RAO AND K. SRIRAM
Regional Agricultural Research Station, Acharya N.G.Ranga Agricultural University, Anakapalle - 531 001

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ABSTRACT

Present study was conducted with following objectives: to estimate the efficiency in value chain of cane jaggery and performance of regulated market in Andhra Pradesh; estimate the price and quantity effect on turn-over in Regulated market, map the value chain of Jaggery from farmer to the consumer and study the price spread, margins and costs in the value chain of jaggery. Two stages sampling procedure was adopted for collection of primary data related to identifying the value chains, estimating the marketing costs and marketing margins of each intermediary involved and to work out the price spread during crop year 2014-15. The secondary data about monthly arrivals and prices prevailed and annual turnover of regulated market for the cane jaggery, time series data relating to period 2000-01 to 2013-14 was obtained from the annual administrative reports of APMC's (Agricultural Produce Market Committee). Analytical tools such as decomposition analysis, price spread, producers' share in consumer rupee and marketing efficiency were employed to get meaningful conclusion from raw data. Results revealed that price had more affect on turn-over during recent times than olden days. Producer's share in consumer's rupee was 67.95 and 73.32 per cent in value chain – I and II, respectively. Marketing efficiency in value chain – II (2.75) is higher than value chain – I (2.12).

INTRODUCTION

During 2012, sugarcane is cultivated in the world with an area, production and yield of 26.10 Million hectares (Mha), 1842.3 Million tonnes (Mt) and 70.6 Tonnes per hectare (t ha^{-1}), respectively (Agricultural Statistics at a glance, 2014). India ranks second in both area and production, with an area of 5.09 Mha (19.76 % of world's area) and production of 361.04 Mt (19.71 % in world's production), whereas, yield was 68.8 t ha^{-1} (Sugar Statistics, 2014).

In India, during 2013-14, among the states, Utter Pradesh (U.P.) ranks first with an area of 2.22 Mha (44.45%) followed by Maharashtra (18.7 %), Karnataka (8.38 %) and Tamil Nadu (6.56 %). U.P. ranks first with average production of 135.16 Mt. In productivity, Tamil Nadu state ranks first with average productivity of 97 t ha^{-1} followed by Karnataka (85.5 t ha^{-1}) and Maharashtra (81.7 t ha^{-1}) (Statistics, 2014). Kumar *et al*. (2010) projected demand for sweeteners for 2020 as 36.40 Mt. Nerkar (2004) estimated that by 2020 per capita consumption of jaggery and khandasari is going to be 19 kgs /annum.

Sugarcane production scenario in Andhra Pradesh

Andhra Pradesh (A.P.) (as Telangana was separated and formed as new state on 02-06-2014) ranked fifth in area in India with area of 0.19 Mha (3.83 %). The average production is 15.36 Mt (4.40%). The average productivity was 80 t ha^{-1}.

In A.P, major sugar cane growing districts in Coastal Andhra, Rayalaseema and Telangana regions are Visakhapatnam (39,000 ha), Chittoore (28,000 ha) and Nizamabad (19,000ha), respectively. However, the average yield was highest in West Godavari (97.96 t ha^{-1}) followed by Nellore (94.14 t ha^{-1}), Chittoor (82.54 t ha^{-1}) and Mahaboob Nagar (80.50 t ha^{-1}).

E-mail: ramaraoeconomist@gmail.com

Jaggery production scenario in Andhra Pradesh

Jaggery manufacturing is an important cottage industry in sugarcane growing regions of Andhra Pradesh state, situated in southern part of India. It is worth nearly two billion rupees providing employment to nearly 300 thousand people. The jaggery manufacturers are mostly small and marginal relying on quick returns from jaggery. In A.P., Visakhapatnam, Chittoor and Nizamabad districts are the major jaggery producing districts. Anakapalli regulated market located in Visakhapatnam district is the second largest jaggery market in India. Chittoor and Kamareddy regulated markets located in Chittoor and Nizamabad districts are the other two important regulated jaggery markets.

In the recent times farmers of sweeteners cultivation are feeling the sour taste. Farmers are incurring losses by producing sugarcane for the purpose of sugarcane. This necessitates the farmers to think in producing various value added products. Sugarcane is raw material for various value added products of jaggery (Fig. 1.).The sugarcane supplied to sugar factories and crushed for jaggery manufacturing are seems to be interdependent. Naidu *et al.* (1986) opined that either the supply of sugarcane to the factory or the converted into jaggery mostly depends upon the prevailing prices of jaggery but not on the price of sugarcane. It is believed that a fairly better and stabilized price of jaggery is a threat to the sugar industry. Maheshwarappa *et al.* (1998) concluded that net income realized by the raw cane sellers was more because of high price paid by sugar factory (Rs. 810 per ton) than the price paid for jaggery (Rs.592 quintal^{-1}). In order to estimate the efficiency in value chain of cane jaggery and to assess the performance of regulated market study was conducted with objectives to estimate the price and quantity effect on turn-over in regulated market and to map the value chain of jaggery from farmer to the consumer. It also studied the price spread, margins and costs in the value chain of jiggery.

MATERIAL AND METHODS

Two stages sampling procedure was adopted. In the first stage, Visakhapatnam district is selected based on production. In the second stage, leading market *i.e.*, Anakapalle Jaggery Market, was selected based on criterion of maximum arrivals in the markets. The time series data relating to period 2000-01 to 2013-14 about monthly arrivals and prices prevailed for the cane jaggery and annual turnover of regulated market was obtained from the annual administrative reports of APMC's (Agricultural Produce Market Committee), Anakapalle. For analysis purpose time period was divided into two periods *viz.,* Period – I (2000-01 to 2006-07) and Period – II (2007-08 to 2013-14).

20 farmers were selected randomly among the three leading mandals *viz*., Anakapalle, Mungapaka and Thimmarajupeta in the district. Thus, total sample size was 60. The marketing of jaggery has been studied in order to identify the value chains to estimate the marketing costs and marketing margins of each intermediary involved and to work out the price spread *i.e.*, the producers share in consumers' rupee. The primary data was related to the crop year 2014-15. Various statistical and mathematical models were

employed to draw the meaningful conclusions from raw data.

Estimation of Quantity and Price factors affect on Turn-over

Minhas and Vaidyanatham (1964) utilized two way component analyses to disaggregate the change in production into area affect, yield affect and interaction affect. In the present study, quantity and price variables were taken as independent variables and turn-over as dependent variable which is represented in the following form:

DT = Qo.DP + Qo.DP + DQ.DP

Where,

DT = Change in Turn-over

Qo.DP = Quantity affect

Qo . DP = Price affect

DQ.DP = Interaction affect of Quantity and Price

Estimation of price spread

a) Total cost of marketing

The total costs incurred in the various marketing channels have been worked out by using the following formula (Wader and Murthy, 2003);

$$C = C_f + C_{m1} + C_{m2} + \ldots\ldots C_{mi}$$

Where,

C = Total cost of marketing of the commodity (₹)

C_f = Costs paid by the farmer from the time the produce leaves the farm till he sells it (₹)

C_{mi} = Costs incurred by i^{th} middle man in buying and selling the commodity (₹)

b) Marketing margin of i^{th} middle man

Concurrent margin method was used for computing the marketing margin of i^{th} middle man. The marketing margin received by i^{th} middle man in transacting the agricultural produce is given by

$$A_{mi} = P_{ri} - (P_{pi} + C_{mi})$$

Where,

A_{mi} = Absolute margin of i^{th} middle man (Rs.)

P_{ri} = Total value of receipts per unit (Rs./q)

P_{pi} = Purchase value of goods per unit (Rs./q)

C_{mi} = Costs incurred by i^{th} middle man (Rs.)

Farmers share in consumer's rupee

It is the price received by the farmer (P_f) expressed as percentage of the retail price (P_r) *i.e.* price paid by the consumer. It is expressed as follows:

$$P_s = \frac{P_f}{P_r} \times 100$$

Marketing efficiency (Acharya Approach)

According to Acharya, an ideal measure of marketing efficiency, particularly for comparing the efficiency of alternate markets/channels is

MME = FP ÷ (MC + MM)

Where,

MME = Modified measure of marketing efficiency

FP = Price received by the farmer

MC, MM = Marketing costs and Marketing margins

RESULTS AND DISCUSSION

Extent of Price and quantity factors affect on Turn Over

During period –I, quantity (44.45%) had higher affect on change in Turn-over than by price affect (38.72%) and interaction affect (16.83%) in Anakapalle regulated market (Table 1). Whereas, during the period – II, price (96.95%) had higher affect on change in Turn-over than by quantity affect (1.16%) and interaction affect (1.89%), Thus, till 2006-07 in the market's turn-over was led by arrivals (Quantity). However, since 2007-08 Turn-over change was led by price. That shows during period – II the prices of jaggery is increasing.

MARKETING ASPECTS OF JAGGERY

i) Value chains of jaggery

In Viskhapatnam district two Value chains of jaggery were identified

Value chain I: The identified channel – I was as give below

Farmer → Commission agent or Importer → Exporter → Wholesaler → Retailer → Consumer

Pattern of marketing in Value chain - I

Value chain - I represents the marketing of Jaggery through Anakapalli Agricultural Market Committee. The farmers usually bring their produce on bullock carts or tractors to the commission agent (also known as importer) existing in the market. The charges borne by the farmer were loading and unloading charges, transport charges to the Agricultural Market Committee, commission charges and weighment charges. The commission agent provides crop loans to the farmer in order to make the farmers sell the produce through him only. The produce is then graded by the Agricultural Market Committee staff based on colour, texture and hardness and then kept for bidding.

The exporters (Primary wholesalers) participate in the bidding and the lot is allotted to the highest bidder. The price offered by him depends on the quality of the produce and the demand from the wholesalers in other states or in distant market of A.P. The prices borne by the exporter (Primary wholesaler) are loading charges, market cess, Sales tax, charity, cost of Hessian cloth and stitching charges. The exporter forwards the produce to the wholesaler. The costs borne by the wholesaler are unloading and transportation charges. The wholesaler forwards the produce to the retailer and from him to the consumer.

a) Value chain - II : The second identified Value chain – II was as give below

Farmer → Commission Agent → Wholesaler → Retailer → Consumer

Pattern of marketing in Value chain II

The Value chain II also represents the marketing of jaggery through Agriculture Market Committee, but the wholesaler (exporter) sells the produce directly to the retailers existing in the district or adjacent district.The net price received by the farmers in Value chain - I and II was same *i.e.* Rs. 2094.3 per quintal (Table 2). However, the producer's share in consumer's rupee was 67.95 and 73.32 per cent, respectively.

Naidu and Reddy (1993) estimated that producers' share in consumers rupee was 80 and 93 per cent during 1991-92 and Ali Baba (2005) estimated it as 74.23 and 75.91 per cent during 2001-02, respectively in channel I and II. Thus, producers' share in consumers rupee was declined nearly by 12 per cent from 1991-92 to 2014-05. This was mainly due to increase in both marketing costs and margins.

ii) Share of Marketing Cost, Marketing Margin and Price Spread in Value chains

Marketing Cost, Marketing Margin and Price Spread in Value chain – I and II were calculated and

Table 1. Price and Quantity Affect on change in Turn-over in Regulated Market

Time Periods	Price Affect	Quantity Affect	Interaction Affect
Period - I (2000-01 to 2006-07)	38.72	44.45	16.83
Period - II (2007-08 to 2013-14)	96.95	1.16	1.89

Table 2. Marketing costs, marketing margins and price spread of jaggery in Value Chain – I and II

S. No.	Item	Value Chain – I (Rs.)	Value Chain – II (Rs.)
1	Net price received by the farmer	2094.3 (67.95)	2094.3 (73.32)
2	Costs incurred by the farmer		
	a. Loading, unloading and Weighment charges	5.85 (0.18)	5.85 (0.20)
	b. Transportation charges	28.4 (0.92)	28.4 (0.99)
	c. Commission charges (2 % advalorem) or Importer's charges	43.44 (1.41)	43.44 (1.52)
	Sub total	77.69 (2.52)	77.69 (2.72)
3	Farmer's selling price or exporters / wholesaler's purchase price	2172 (70.47)	2172 (76.04)
4	Costs incurred by the exporter		Nil
	a. Loading charges, Hessian cloth, stitching charges etc	13.33 (0.43)	
	b. Market cess (@1%)	21.72 (0.70)	
	c. Charity (@Rs.0.5 per Rs. 100)	10.86 (0.35)	
	Sub total	45.86 (1.49)	
5.	Exporter's margin	494.26 (16.04)	
6.	Exporter's selling price or whole sellers purchase price	2712.12 (70.48)	
7.	Costs incurred by whole seller		
	a. Loading and unloading charges	6.78 (0.22)	4.78 (0.17)
	b. Transportation charges	58.2 (1.89)	51.21(2.14)
	c. Market fee	-	21.72 (0.76)
	d. Charity	-	10.86 (0.38)
	e. Cost of Hessian cloth and stitching charges	-	8.52 (0.30)
	Sub total	64.98 (2.11)	107.09 (3.75)
8.	Whole seller's margin	161.6 (5.24)	326.51 (11.43)
9.	Whole sellers selling price/retailers purchasing price	2938.7 (95.34)	2605.6 (91.22)
10.	Costs incurred by retailer		
	a. Forwarding	9.25 (0.30)	8.82 (0.31)
11.	Retailers margin	134.25 (4.36)	245.5 (8.59)
12.	Retailer's selling price/consumer's purchase price	3082.2 (100.00)	2856.5 (100.00)

Figures in parentheses indicates percentage to consumer's purchase price

Table 3. Indices of marketing efficiency in value chains

Particulars	Value Chain – I	Value Chain – II
Farmer price (Rs./q)	2094.3	2094.3
Marketing Cost + Marketing Margin (**Rs.**)	987.9	762.2
Marketing efficiency	**2.12**	**2.75**

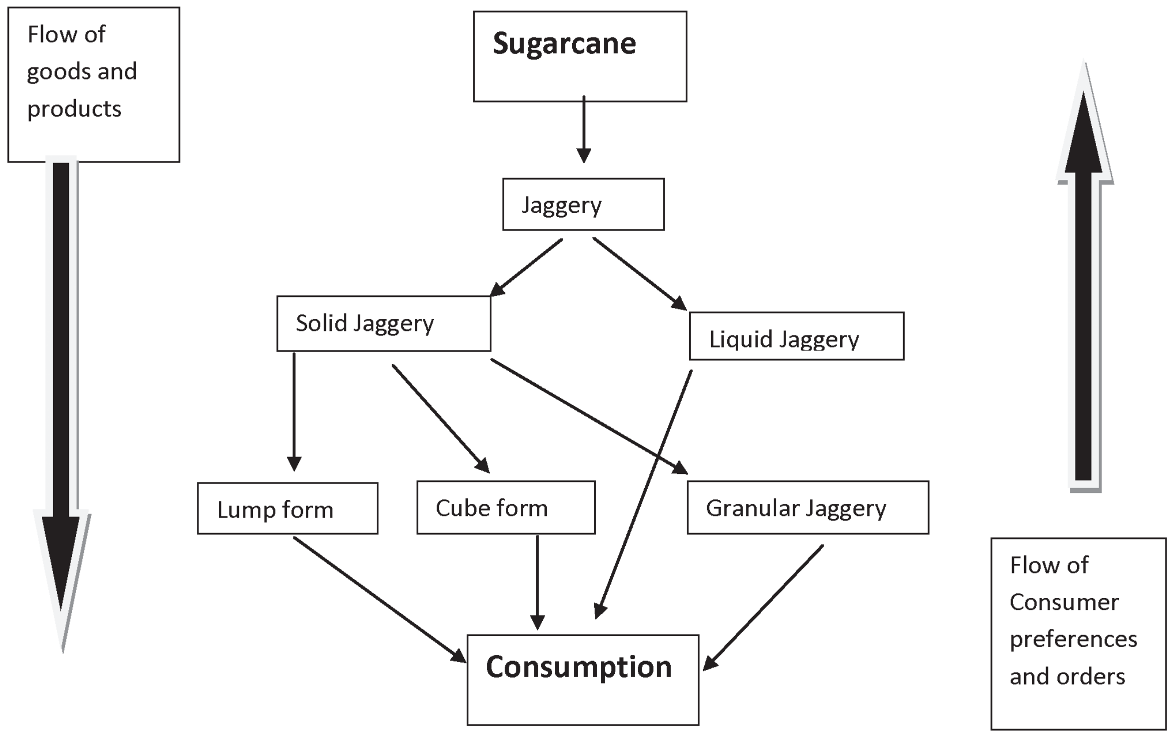

Fig. 1. Value chain in cane jaggery

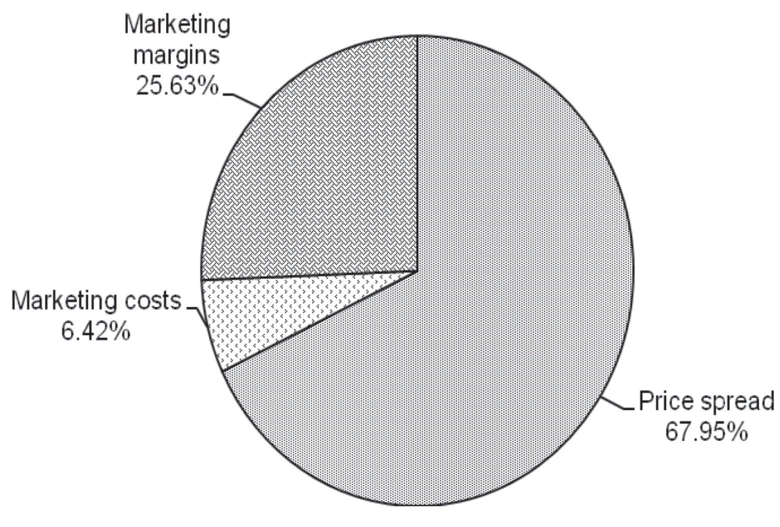

Fig. 2. Share of Marketing Cost, Marketing Margin and Price Spread in Value Chain – I

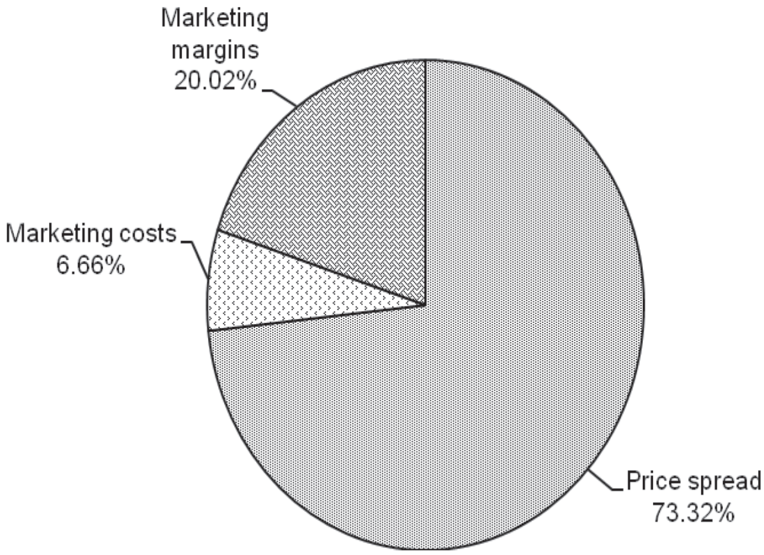

Fig. 3. Share of Marketing Cost, Marketing Margin and Price Spread in Value Chain – II

is presented in Figures 1 and 2, respectively. Figures 1 and 2 reveal that the total marketing costs in Value chain - I and II were Rs. 198 and Rs. 190 q^{-1} accounting for 6.42 and 6.66 per cent of consumer's rupee. The total marketing margins in above order of channels were Rs.790 and Rs.572 q^{-1} accounting for 25.63 and 20.02 per cent of consumer's rupee, respectively.

The high marketing costs and better margins in Value chain - I compared to Value chain - II was due to sale of jaggery to distant markets which resulted in high transportation costs and also fetched better price. Among market intermediaries, the marketing costs borne and margins earned by the exporter (Rs.45 and Rs. 494 q^{-1}) and whole seller (Rs.108 and Rs.327 q^{-1}) were highest in channel I and II, respectively.

iii) Marketing efficiency in value chain

The marketing efficiency was computed using Acharya's method and the results were presented in the Table 3. This marketing efficiency is influenced by certain factors such as market performance, market conduct and behaviour, market structure, wages, market cost and market prices. It is observed from the Table that the index of marketing efficiency was 2.12 in Value chain – I and 2.75 in Value chain – II. In other words, value chain – II is more efficient than value chain – I in jaggery.

CONCLUSIONS

Price had more affect on turn-over during recent times than olden days. The net price received by the farmers in Value chain – I and II was same *i.e.*, Rs.2094.3 q^{-1}. However, the producer's share in consumer's rupee was 67.95 and 73.32 per cent, respectively. Total marketing costs in Value chain – I and II were Rs.197.79 and Rs. 190.19 q^{-1} accounting for 6.42 and 6.66 per cent of consumer's rupee. The total marketing margins in above order of channels were Rs.790.11 and Rs. 572.01 q^{-1} accounting for 25.63 and 20.02 per cent of consumer's rupee, respectively. Efficiency in value chain – II is more than in Value chain – I.

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COMPARATIVE ADVANTAGE OF INDIAN OILSEEDS AND OILS EXPORT

A. ARUNA KUMARI AND K. KRISHNA REDDY
Agricultural Research Agency for Knowledge Advocacy (ARAKA), Guntur-522 034

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ABSTRACT

The present research was undertaken to study the comparative advantage of oilseeds and oils exports in India. Secondary data on oilseeds, oils exports of India and world, total merchandise export of India and world were collected for the period of 25 years *i.e.,* 1989-90 to 2013-14.The data collected from FAO trade year books and website www.fao.org. Balassa's export performance ratio was used as analytical tool. The results revealed that groundnut, castor, castor oil and sesame seed and oil only shows comparative advantage. Therefore, emphasis should be laid on export quality groundnut, castor seed and oil, sesame seed and oil by providing awareness to farmers on the new varieties and agronomic practices.

INTRODUCTION

India is the largest producer of oilseeds in the world and the oilseed sector occupies an important position in the country's economy. India accounts for 12-15 per cent of global oilseeds area, six to seven per cent of vegetable oils production, and nine to 10 per cent of the total edible oils consumption. In terms of acreage, production and economic value, oilseeds are second only to food grains. Besides the nine major oilseeds (Groundnut, Rapeseed/ Mustard, Linseed, Castor, Sesame, Soybean, Sunflower, Safflower and Niger) cultivated in India, a number of minor oilseeds of horticultural and forest origin, including coconut and oil-palm, are also grown. In addition, substantial quantities of vegetable oils are obtained from rice bran and cotton seed along with a small quantity from tobacco seed and corn. The area and production under the nine oilseeds was 26.48 million ha and 30.94Mt, respectively in 2012-13. As per the fourth advance estimates for 2013-14,the production of total nine oilseed crops is 32.88 Mt, which is a quantum jump over previous year's production. Oilseeds area and output are concentrated in the central and southern parts of India, mainly in the states of Madhya Pradesh, Gujarat, Rajasthan, Andhra Pradesh and Karnataka.

The proportion of imports in total availability (domestic production plus imports) of edible oils has increased from the meager three per cent in 1970-71 to about 56 per cent in 2009-10. Significant changes are evident in the quantum of imports of edible oils with reference to the periods that mark the implementation of the Technology Mission on Oilseeds (TMO) and the emergence of the new trade regime after the establishment of the World Trade Organization (WTO). From a high quantum of 1944 thousand tonnes in 1987-88, imports came down to 114 thousand tonnes in 1993-94. Imports started rising again after the establishment of the WTO and the initiation of trade related reform measures. From around 347 thousand tonnes in 1994-95, imports rose to 8034 thousand tonnes in 2009-10 (Girish Kumar Jha *et al.,* 2012). Imports of edible oils have serious implications for the domestic prices of edible oils as imports are subject to international price volatility. India's oil imports form a big share in world trade, especially in palm oil and soybean oil. India has the second position in import of palm oil (3.94 Mt) as

E-mail:aruna.settipalli@gmail.com

well as soybean oil (10.18Mt) contributing 13.25 per cent and 9.06 per cent, respectively, of the total world trade. A comparison of applied and bound tariff rates shows that except for soybean and rapeseed/ mustard, India has considerable flexibility to reduce imports by making them costly by raising tariffs. A comparision of the minimum support price (MSP) with the farm harvest prices shows that the farm harvest prices have been generally higher than the MSP for the three major oilseeds. Hence, MSP has little relevance for oilseeds. Moreover, very little procurement of oilseeds is done. The emphasis on the country's food management system viz., paddy and wheat has been adequate over the years through MSP. Hence, the main objective of the study is to the comparative advantage of oil seeds and oil exports from India. The following sections present the methodology of the study with analytical tools, results and discussion, concluding with policy implication.

MATERIAL AND METHODS

Comparative advantage implies country's specialization in the production and sale of commodities over time and across countries / regions. The Export Performance Ratio (EPR)/ Revealed comparative advantage suggested by Balassa (1965) was used to study the comparative advantage. Lalit (2013) calculated RCA of export performance of clothing sector of India and Bangladesh. Nawaz Ahmad and Rukhsana K (2013) worked out revealed comparative advantage of textile and clothing sector of Pakistan. Shahab and Mahmod (2013) estimated revealed comparative advantage of leather industry and various leather products of Pakistan, China, India and Iran, by using Balassa (1965) index and Kashika Arora (2015) also measured the revealed comparative advantage of Indian exports in the back drop of economic reforms. The EPR is based on the data from FAO trade year books and www.fao.org from 1989-90 through 2013-14. The commodities selected for study under exports include groundnut, rapeseed, linseed, castor, sesame, soybean, sunflower and safflower and their respective oils.

According to Balassa(1965), the EPR for a commodity is the share of that commodity in the country's total exports relative to the commodities share in the total world exports.

$$EPR = \frac{X_K/X_T}{W_K/W_T}$$

Where,

X_K = Export of selected commodity from a country in a year

X_T = Total merchandise export of that country in a year

W_K = Export of selected commodity of the world in a year

W_T = Total merchandise export of the world in a year

If EPR of commodity is > 1 then the export of that commodity is said to have comparative advantage. The data (1989-90 to 2013-14) used for the above equation on oil seeds and oils from India and World were presented in Table 3 and Table 4 in a five-year scale.

RESULTS AND DISCUSSION

Groundnut seed and oil

The EPRs for the oilseeds and oils from 1989-90 to 2013-14 i.e., 25 years period were presented in Table 1 and 2. From 1989-90 to 2013-14,as a whole there had been increasing trend in EPRs (almost half of the selected years), indicating that the share of groundnut seed in India's export basket is slightly increasing as compared to its share in the world market. The years 1989-90 to 1999-00 shows>1 EPR values, indicating export of this commodity is having comparative advantage except during 1991-92 and 1992-93.Similar results were observed during period 2000-01 to 2013-14 (Table1). Incase of groundnut oil, From 1989-90 to 2013-14 ,as a whole there had been decreasing trend in EPRs except during some years ,indicating that share of ground nut oil in India's export basket is decreasing as compared to its share in the world market. From 1989-90 to 1999-00, all the EPR values were < 1, indicating export of this commodity is not having the comparative advantage. From 2000-01 to 2013-14, the EPR values were < 1except during years 2003-05,2007-08 and 2011-13 , indicating that there was no comparative advantage (Table2).

Rapeseed and oil

As a whole there was an increasing trend in EPRs from 1989-90 to 2013-14. This increase in EPRs showed the increment of comparative advantage of rapeseed. The EPR values were zero from 1989-90 to 1992-93 indicating that the share of rapeseed in India's export basket was nil as compared to its share in the world market. All the EPR values were < 1, indicating that export of this commodity is not having the comparative advantage. Similar results were observed during period from 2000-01 to 2013-14 (Table1).In case of rapeseed oil, from 1989-90 to 2013-14, as a whole there had been decreasing trend in EPRs. This decrease in EPRs showed the decline of comparative advantage of rapeseed oil.EPR values were zero during years 1989-91 and all these values were < 1, indicating that export of this commodity is not having the comparative advantage. Similar results were observed during period from 2000-01 to 2013-14 (Table2).

Linseed and oil

In Linseed, there was an increasing trend in EPRs (from 2002-03 to 2013-14) indicating that the share of linseed in India's export basket was improved as compared to its share in the world market. The EPR values were zero during 1989-90 to 1999-00 except during 1993-94, 1996-97 and 1998-99, indicating that the share of linseed in India's export basket was insignificant as compared to its share in the world market. From 2000-01 to 2013-14, the EPR values were zero during years 2000 to 2002 and other remaining years shows <1 EPR values, indicating that there was no comparative advantage (Table1).In case of linseed oil, from 1989-90 to 2013-14, as a whole there had been increasing trend in EPRs indicating that the share of linseed oil in India's export basket was raised as compared to its share in the world market. Whereas from 1989-90 to 1999-00, the EPR values were zero during period from 1991 to 1994 and remaining years shows < 1 EPR values, indicating that there was no comparative advantage. From 2000-01 to 2013-14 also the EPR values were < 1, indicating that there was no comparative advantage (Table2).

Castor seed and oil

In castor seed, as a whole there was an increasing trend in EPRs from 1989-90 to 2001-02, indicating that the share of castor seed in India's export basket was improved as compared to its share

Table 1. Export performance ratios (EPR's) of oil seeds (1989-90 to 2013-14)

Year/ oilseeds	Groundnut	Rapeseed	Linseed	Castor	sesame	Soybean	Sunflower
1989-90	4.41	0	0	0	25.36	0.01	0
1990-91	4.66	0	0	0	11.45	0.002	0.03
1991-92	0.44	0	0	0	9.34	0.001	0
1992-93	0.58	0	0	0	11.11	0	0
1993-94	7.57	0.07	0.03	31.42	5.84	0	0.02
1994-95	4.37	0.03	0	37.44	13.30	0	0.06
1995-96	6.05	0.04	0	112.11	11.87	0.001	0.09
1996-97	7.90	0.02	0.01	139.99	9.40	0.01	0.13
1997-98	14.42	0.03	0	117.81	13.37	0.04	0.2
1998-99	3.49	0.01	0.01	120.64	14.08	0.004	0.22
1999-00	10.22	0.02	0	115.07	13.86	0.03	0.26
2000-01	6.41	0.09	0	146.82	17.46	0.29	0.19
2001-02	4.09	0.36	0	127.91	21.32	0.02	0.16
2002-03	3.03	0.24	0.030	NA	15.39	0.003	0.13
2003-04	10.02	0.41	0.006	NA	22.14	0.322	0.06
2004-05	7.75	0.19	0.016	NA	18.77	0.004	0.15
2005-06	7.25	0.13	0.045	NA	14.56	0.009	0.10
2006-07	10.65	0.11	0.044	NA	15.07	0.006	0.13
2007-08	10.66	0.18	0.001	NA	19.83	0.007	0.08
2008-09	12.80	0.20	0.054	NA	15.12	0.033	0.17
2009-10	14.30	0.08	0.333	NA	12.37	0.022	0.09
2010-11	15.51	0.06	0.067	NA	14.98	0.010	0.09
2011-12	17.65	0.10	0.099	NA	13.41	0.017	0.08
2012-13	12.71	0.04	0.072	NA	9.53	0.022	0.07
2013-14	9.34	0.06	0.951	NA	7.83	0.061	0.05
Average	**8.25**	**0.10**	**0.07**	**73.02**	**14.27**	**0.04**	**0.10**

NA-data not available

in the world market. The EPR values were zero during 1989-93.All the EPR values from 1993-94 to 2001-02 were >1, indicating that export of this commodity is having the comparative advantage (Table1).In case of castor oil, on the whole period, half of the period i.e., during nineties (1989-90 to 2001-02) shows increasing trend in EPRs indicating that the share of castor oil in India's export basket was raised as compared to its share in the world market. Whereas during 2000s (2002-03 to 2013-14) decreasing trend in EPRs was observed, indicating that the share of castor oil in India's export basket was reduced as compared to its share in the world market. From 1989-90 to 1999-00, all EPR values were >1, indicating that export of this commodity is having the comparative advantage. Similar results were observed during period from 2000-01 to 2013-14 (Table2).

Sesame seed and oil

From 1989-90 to 2013-14, as a whole there had been increasing trend in EPRs (almost half of the selected years).This raise in EPR showed the increase of revealed comparative advantage**.** From 19989-90 to 1999-00, all the EPR values were > 1 indicating that export of this commodity is having the comparative advantage. Similar results were observed during period from 2000-01 to 2013-14 (Table1). In case of sesame oil, from 1989-90 to 2013-14, as a whole there had been increasing trend in EPRs (almost half of the selected years) indicating that the share of sesame oil in India's export basket was amplified as compared to its share in the world market. From period 1989-90 to 1999-00, the EPR values were zero from 1989 to 1994 and remaining years show <1 EPR values except1994-95.It indicates that there was no comparative advantage.

Table 2. Export performance ratios (EPR's) of oils (1989-90 to 2013-14)

Year/oils	Groundnut oil	Rapeseed oil	Linseed oil	Castor oil	Sesame oil	Soybean oil	Sunflower oil	Safflower Oil
1989-90	0	0	0.001	78.83	0	0	0	0
1990-91	0.01	0	0.06	111.94	0	0	0	0
1991-92	0.01	0.002	0	115.48	0	0	0	0
1992-93	0.02	0.02	0	104.71	0	0.01	0	0
1993-94	0.03	0.11	0	119.61	0	0	0	0
1994-95	0.001	0.01	0.03	121.72	1.3	0.001	0	0
1995-96	0.001	0.01	0.06	138.46	0.31	0.03	0.12	0
1996-97	0.02	0.12	0.02	138.02	0.34	0.01	0.0001	0
1997-98	0.003	0.17	0.04	122.35	0.41	0.14	0.1	2.57
1998-99	0.01	0.04	0.03	133.56	0.6	0	0.004	0
1999-00	0.11	0.04	0.02	126	0.87	0.01	0.004	0
2000-01	0.01	0.06	0.04	138.27	1.38	0.23	0.02	0
2001-02	0.0009	0.43	0.04	119.45	1.35	0.09	0.18	0
2002-03	0.051	0.06	0.10	60.90	1.53	0.165	0.005	0.00
2003-04	6.696	0.11	0.07	59.90	2.66	0.046	0.011	0.00
2004-05	15.312	0.08	0.42	69.22	2.72	0.114	0.008	0.00
2005-06	0.674	0.05	0.15	54.53	6.78	0.135	0.058	0.00
2006-07	0.034	0.04	0.36	50.54	3.06	0.097	0.115	0.05
2007-08	8.590	0.04	0.28	40.10	3.93	0.106	0.105	0.08
2008-09	0.009	0.02	0.04	48.90	1.32	0.005	0.005	0.08
2009-10	0.024	0.04	0.11	48.95	2.71	0.012	0.015	0.08
2010-11	0.086	0.02	0.09	43.88	2.43	0.005	0.016	0.00
2011-12	1.505	0.02	0.09	35.04	3.19	0.048	0.013	0.20
2012-13	3.669	0.01	0.07	29.46	1.54	0.004	0.007	0.10
2013-14	0.521	0.02	0.12	28.15	2.16	0.003	0.008	0.04
Average	**1.50**	**0.06**	**0.09**	**85.52**	**1.62**	**0.05**	**0.03**	**0.13**

But from 2000-01 to 2013-14, all EPR values were >1, indicating that there was comparative advantage (Table2).

Soybean seed and oil

As a whole, there had been decreasing trend in EPRs. This decline in EPRs showed the decrement of revealed comparative advantage. From 1989-90 to 1999-00, the EPR values were zero during years 1992-95, indicating that the share of soybean in India's export basket was nil as compared to its share in the world market. Other remaining years show <1 EPR values, indicating that export of this commodity is not having the comparative advantage. From 2000-01 to 2013-14, all EPR values were <1, indicating that export of this commodity is not having the comparative advantage (Table 1).In case of soybean oil, from 1989-90 to 2013-14, as a whole there had been decreasing trend in EPRs except during some years, indicating that the share of soybean oil in India's export basket was diminished as compared to its share in the world market. From 1989-90 to 1999-00, half of the year's show zero EPR Values, indicated that the share of soybean oil in India's export basket was zero as compared to its share in the world market. Other remaining years show <1 EPR values, indicating that export of this commodity is not having the comparative advantage. From 2000-01 to 2013-14, all EPR values were <1, indicating that export of this commodity is not having the comparative advantage (Table2).

Sunflower seed and oil

From 1989-90 to 2013-14, as a whole there had been increasing trend in EPRs indicating that the share of sunflower seed in India's export basket was improved as compared to its share in the world market. From 1989-90 to 1999-00, some of the years i.e., 1989-90 and 1991-93 shows zero EPR values, indicated that the share of sunflower seed in India's export basket was negligible as compared to its share in the world market and all remaining EPR values were <1,indicating that export of this commodity is not having the comparative advantage. From 2000-01 to 2013-14, all EPR values were <1, indicating that export of this commodity is not having the comparative advantage (Table1).In case of sunflower oil, from 1989-90 to 2013-14, as a whole there had been decreasing trend in EPRs, indicating that the share of sunflower oil in India's export basket was reduced as compared to its share in the world market. From 1989-90 to 1999-00,more than half of the years shows zero EPR values, indicated that the share of sunflower oil in India's export basket was negligible as compared to its share in the world market and all remaining EPR values were < 1,indicating that export of this commodity is not having the comparative advantage. From 2000-01 to 2013-14, all EPR values were <1, indicating that export of this commodity is not having the comparative advantage (Table 2).

Safflower oil

No data available for safflower seed. From1989-90 to 1999-00, all the EPR values were zero except during the year 1997-98, indicating that the share of safflower oil in India's export basket was nil as compared to its share in the world market. From 2000-01 to 2013-14,half of the years shows zero EPR values and other remaining years shows decreasing trend of EPRs and < 1 EPR values, indicating that export of this commodity is not having the comparative advantage (Table2).

The results showed that there had been increasing trend in EPRs for groundnut seed, castor seed and its oil (1989-90 to 2001-02) and sesame seed and its oil (2000-01 to 2013-14) in India's export basket is increasing as compared to its share in the world market and all EPRs are > 1 indicated that these commodities are having the comparative advantage (Chaudary and Saleem 2003, Bardan 2007).The results also indicated that there has been increasing trend in EPR's for the following commodities namely rapeseed and mustard, linseed and its oil, sesame oil (1989-90 to 1999-00) and sunflower. It indicated that the share of these oilseeds and oils in India's export basket is increasing as compared to its share in the world market but all these values are less than one indicating these commodities are not having the comparative advantage (Bardan 2007 and Singh *et al.,* 2013). The real situation facing by Indian economy was net importer of oilseeds and oils. This is mainly due to less quality of product and at the same time other countries are offering the same product with low price at higher quality. It leads to the situation that the country attracts to import rather than producing here.

Castor oil during 2002-03 to 2013-14 shows decreasing trend in EPRs and >1 EPR values. The results also indicated that there has been decreasing trend in EPR's for groundnut oil, rapeseed oil, soybean seed and its oil and sunflower oil. Safflower oil also showed the similar results but most of the EPR's are zero values indicating this commodity share in the India's export basket was almost negligible (Brajesh Jha, 2002).

CONCLUSIONS

India has comparative advantage in export of groundnut seed, castor seed and oil and sesame seed and oil (2000-01 to 2013-14). More emphasis can be laid on export of items like groundnut, castor seed and oil, sesame seed and oil as these commodities were found to have comparative advantage. Concerted efforts have to be made by different stakeholders to increase the productivity of oilseeds. For increase export of oilseeds and oils, eco-friendly production *i.e.,* organic farming and development of technology to reduce the effect of residues is envisaged. Value added oilseed products, quality up gradation and aggressive brand and logo campaign would help in realization of better prices thus improving our competitiveness and profitability of oilseeds industry. Market diversification away from traditional markets offers great scope to boost Indian oilseeds exports.

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Table 3. Oil seed exports from India and World ('000 USD)

Sl. No	Oil seeds	Particulars	1989-90	1994-95	1999-00	2004-05	2009-10	2013-14
1	Groundnut	Export India (X_K)	23294	35595	89648	70965	287229	623337
		Total Merchandise export-India (X_T)	2657099	3239464	4642042	7058321	15660787	42489509
		World Export (W_K)	601002	975959	788552	787933	1219344	2195422
		Total Merchandise export - World (W_T)	302037820	388442789	417142628	607413800	950996874	1397068837
2	Rapeseed	Export India (X_K)	0	434	571	5933	8947	23873
		Total Merchandise export-India (X_T)	2657099	3239464	4642042	7058321	15660787	42489509
		World Export (W_K)	1545004	1716672	2459113	2665011	7035264	12523811
		Total Merchandise export - World (W_T)	302037820	388442789	417142628	607413800	950996874	1397068837
3	Linseed	Export India (X_K)	0	0	0	56	2790	26226
		Total Merchandise export-India (X_T)	2657099	3239464	4642042	7058321	15660787	42489509
		World Export (W_K)	210785	203915	205842	294502	509248	906712
		Total Merchandise export - World (W_T)	302037820	388442789	417142628	607413800	950996874	1397068837
4	Castor	Export India (X_K)	0	63849	1033175	NA	NA	NA
		Total Merchandise export-India (X_T)	2657099	3239464	4642042	7058321	15660787	42489509
		World Export (W_K)	179104	204515	806842	NA	NA	NA
		Total Merchandise export - World (W_T)	302037820	388442789	417142628	607413800	950996874	1397068837
5	Sesame	Export India (X_K)	75671	41299	76235	146220	308831	634966
		Total Merchandise export-India (X_T)	2657099	3239464	4642042	7058321	15660787	42489509
		World Export (W_K)	339225	372210	494265	670535	1516229	2667168
		Total Merchandise export - World (W_T)	302037820	388442789	417142628	607413800	950996874	1397068837
6	Soyabean	Export India (X_K)	525	0	2589	761	11916	106821
		Total Merchandise export-India (X_T)	2657099	3239464	4642042	7058321	15660787	42489509
		World Export (W_K)	6132402	7224078	7652749	15583857	33107347	57302866
		Total Merchandise export - World (W_T)	302037820	388442789	417142628	607413800	950996874	1397068837
7	Sunflower	Export India (X_K)	0	478	2942	2028	3486	6747
		Total Merchandise export-India (X_T)	2657099	3239464	4642042	7058321	15660787	42489509
		World Export (W_K)	1020359	881875	1029970	1153557	2347129	4151162
		Total Merchandise export - World (W_T)	302037820	388442789	417142628	607413800	950996874	1397068837

Table 4. Oils export from India and World ('000 USD)

Sl. No	Oils	Particulars	1989-90	1994-95	1999-00	2004-05	2009-10	2013-14
1	Groundnut	Export India (X_K)	0	3	274	41789	112	5564
		Total Merchandise export-India (X_T)	2657099	3239464	4642042	7058321	15660787	42489509
		World Export (W_K)	260912	307335	223197	234860	280146	351265
		Total Merchandise export - World	302037820	388442789	417142628	607413800	950996874	1397068837
2	Rapeseed	Export India (X_K)	0	158	775	1810	2808	5503
		Total Merchandise export-India (X_T)	2657099	3239464	4642042	7058321	15660787	42489509
		World Export (W_K)	911180	1666692	1568981	1835682	4625351	8571116
		Total Merchandise export - World	302037820	388442789	417142628	607413800	950996874	1397068837
3	Linseed	Export India (X_K)	1	31	38	940	428	865
		Total Merchandise export-India (X_T)	2657099	3239464	4642042	7058321	15660787	42489509
		World Export (W_K)	132338	110154	140345	194306	228799	239994
		Total Merchandise export - World	302037820	388442789	417142628	607413800	950996874	1397068837
4	Castor	Export India (X_K)	117339	163550	356998	206980	410779	779223
		Total Merchandise export-India (X_T)	2657099	3239464	4642042	7058321	15660787	42489509
		World Export (W_K)	169192	161113	254606	257325	509548	910057
		Total Merchandise export - World	302037820	388442789	417142628	607413800	950996874	1397068837
5	Sesame	Export India (X_K)	0	521	630	3077	6876	14516
		Total Merchandise export-India (X_T)	2657099	3239464	4642042	7058321	15660787	42489509
		World Export (W_K)	37952	47928	65340	97219	154248	220614
		Total Merchandise export - World	302037820	388442789	417142628	607413800	950996874	1397068837
6	Soyabean	Export India (X_K)	0	25	545	7390	1627	952
		Total Merchandise export-India (X_T)	2657099	3239464	4642042	7058321	15660787	42489509
		World Export (W_K)	1723658	3160635	3861998	5580256	7953618	10578066
		Total Merchandise export - World	302037820	388442789	417142628	607413800	950996874	1397068837
7	Sunflower	Export India (X_K)	0	0	96	221	1395	2499
		Total Merchandise export-India (X_T)	2657099	3239464	4642042	7058321	15660787	42489509
		World Export (W_K)	1218187	1664089	2077504	2413070	5490705	10023948
		Total Merchandise export - World	302037820	388442789	417142628	607413800	950996874	1397068837
8	Safflower	Export India (X_K)	0	0	0	0	74	75
		Total Merchandise export-India (X_T)	2657099	3239464	4642042	7058321	15660787	42489509
		World Export (W_K)	59764	80147	95994	45470	57450	61919
		Total Merchandise export - World	302037820	388442789	417142628	607413800	950996874	1397068837

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CORRELATION AND PATH ANALYSIS FOR YIELD ATTRIBUTES IN PIGEONPEA [*Cajanus cajan* (L.) Millsp.]

JAKE LEE GALIAN, NIDHI MOHAN, C.V. SAMEER KUMAR AND P.MALLESH
International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Telangana- 502 324

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Grain legumes are important food and feed crops in the dry land areas of the world, particularly in the developing countries. They serve as primary source of cheap protein. Among all the vegetables, grain legumes have more protein, contain fats and carbohydrates that may be a good alternative for animal meat. They are drought and heat resistant that can survive or thrive in low rain fall conditions. Because of this grain legumes are gaining more popularity not only in the developing countries but also in developed countries. One such crop is pigeonpea [*Cajanus cajan* (L.) Millsp.], is considered an orphan crop but now it's gaining popularity because of its untapped characteristics. It is a drought resistant crop, used in multiple ways as a human food, animal feed, fodder, forage, fuel wood, medicine, has the ability to fix nitrogen in the soil which improves soil fertility and other potential uses yet to be discovered. The correlation studies provide information about association between any two characters, but it's not enough to determine the relative importance of direct and indirect influence of each component characters on yield. Thus, path coefficient analysis provides the partitioning of correlation coefficients into direct and indirect effects giving the relative importance of each of the casual factors (Shoran,1982). Therefore, this study was undertaken to find out the relative importance of degree of association of different yield contributing traits and direct and indirect effects on yield using thirty-nine pigeonpea genotypes. Thirty-nine pigeonpea genotypes were arranged in alpha lattice design with two replications during the *kharif* season of 2015 at the International Crop Research Institute for Semi-arid Tropics (ICRISAT).

Each genotype was sown in two rows measuring 4 m length and spaced 75 cm row to row and 30 cm between plants. Recommended agronomic practices and need based plant protection measures were followed to obtain a good crop stand. Observations were taken on five randomly selected plants from each genotype in each replication for plant height at maturity (cm), number of primary branches plant^{-1}, numbers of secondary branches plant^{-1}, number of pods plant^{-1}, number of seeds pod^{-1}, 100-seed weight (g), and grain yield plant^{-1} (kg plant^{-1}). For 50% flowering and days to maturity observations were taken on plot basis. Estimates of correlation coefficient at genotypic and phenotypic level are presented in Table 1. In most cases, genotypic correlations were higher than the phenotypic correlation indicating an inherent association among the various characters, which is in conformity with the results of Linge *et al.* (2010). In the present study, grain yield was found to be highly significantly and positively correlated with plant height at maturity, number of pods plant^{-1}, number of primary branches plant^{-1}, days to maturity, number of

E-mail: jakeloilee@gmail.com

Table 1. Genotypic (G) and phenotypic correlation (P) coefficients among nine quantitative characters in 39 genotypes of pigeonpea

Character		Days to 50% Flowering	Days to maturity	Plant height at maturity	Number of primary branches plant^{-1}	Number of secondary branches plant^{-1}	Number of pods plant^{-1}	Number of seeds pod^{-1}	100 - seed weight	Grain Yield
Days to 50% flowering	G		0.9827**	0.7206**	0.6602**	0.4169**	0.3016**	0.3786**	0.3773**	0.5352**
	P		0.9815**	0.6808**	0.5915**	0.4089**	0.2925**	0.3267**	0.3603**	0.5069**
Days to maturity	G			0.7422**	0.6799**	0.4437**	0.3062**	0.3833**	0.4177**	0.5712**
	P			0.7030**	0.6115**	0.4351**	0.2979**	0.3202**	0.3952**	0.5447**
Plant height at maturity	G				0.7493**	0.3901**	0.4385**	0.1951^{ns}	0.1229^{ns}	0.7421**
	P				0.7062**	0.3755**	0.4217**	0.1920^{ns}	0.1155^{ns}	0.6921**
Number of primary branches plant^{-1}	G					0.5277**	0.4301**	-0.0295^{ns}	-0.1547^{ns}	0.5766**
	P					0.4951**	0.3850**	-0.0519^{ns}	-0.0916^{ns}	0.5172**
Number of secondary branches plant^{-1}	G						0.5154**	0.0341^{ns}	-0.0760^{ns}	0.5595**
	P						0.5084**	0.0281^{ns}	-0.0723^{ns}	0.5510**
Number of pods plant^{-1}	G							-0.1280^{ns}	-0.3317**	0.6510**
	P							-0.0686^{ns}	-0.3230**	0.6539**
Number of seeds pod^{-1}	G								0.6422**	0.1783^{ns}
	P								0.5192**	0.1654^{ns}
100-seed weight	G									-0.0086^{ns}
	P									-0.0182^{ns}

*Significant at 0.05, ** Significant at 0.01, ns = non-significant secondary branches plant^{-1} and days to 50% flowering both at the genotypic and phenotypic level. Similar results were reported by Sodavadiya *et al.* (2009) and Sharma *et al.* (2014). This means that improvement of these characters can contribute positively in the process of breeding program. Whereas, number of seeds per pod had non-significant positive correlation, while 100-seed weight showed non-significant negative correlation. Thus, characters with negative and non-significant correlation will be disregarded in selection for crop improvement (Akinyele and Osekita, 2006).

Among the yield components, days to 50% flowering registered positive and significant association with days to maturity, plant height at maturity, number of primary branches plant^{-1}, number of secondary branches plant^{-1}, number of pods plant^{-1}, number of seeds per pod and 100-seed weight both at genotypic and phenotypic levels. This is in conformity with the studies of Sreelakshmi number of secondary branches plant^{-1} was positively and significantly associated with number of pods plant^{-1} similar to number of seeds per pod with 100-seed weight at genotypic and phenotypic levels(Table 2). Pandey *et al.* (2015) also reported positive association for number of pods plant^{-1}. The above results entail that these characters (except number of seeds pod^{-1} and 100-seed weight) can be improved simultaneously without any compensatory negative effects on grain yield, as these characters are positively correlated.

The result of genotypic and phenotypic path analyses presented in Table 2 revealed that the direct effect of days to maturity on grain yield (kg plant^{-1}) was high and positive followed by plant height at maturity and number of pods plant^{-1} while number of secondary branches plant^{-1} and number of seeds pod^{-1} had negligible positive direct effect at both phenotypic and genotypic levels. Similar reports were obtained by Musaana and Nahdy (1998) for number of pods plant^{-1}. The implication is that the direct selection of these characters would be beneficial in pigeonpea yield improvement. Days to 50% flowering and number of primary branches plant^{-1} showed negative direct effect on grain yield but had a positive correlation, indicating that the indirect causal factors on this character such as days to maturity, plant height at maturity, number of pods plant^{-1}, number of secondary branches plant^{-1} and 100-seed weight are to be considered in simultaneous selection for enhancement of grain yield. Furthermore, the component of residual effect at phenotypic and genotypic levels on grain yield was 0.3093 and 0.2610, respectively indicating that the adequacy and appropriateness of the characters studied. However, there is scope for inclusion of some more characters.

Based on the results, positive and significant association was recorded between grain yield and yield contributing characters *viz.,* days to 50% flowering, days to maturity, plant height at maturity, number of primary branches plant^{-1}, number of secondary branches plant^{-1} and number of pods plant^{-1} both at phenotypic and genotypic levels. Hence, these characters should be given more importance in making selections to improve yield in pigeonpea breeding program. Path coefficient analysis revealed

Table 2. Genotypic (G) and phenotypic path (P) analysis direct (diagonal) and indirect effect (off-diagonal) path coefficients

Character		Days to 50% flowering	Days to maturity	Plant height at maturity	Number of primary branches plant^{-1}	Number of secondary branches plant^{-1}	Number of pods plant^{-1}	Number of seeds pod^{-1}	100-Seed weight
Days to 50% flowering	**G**	**-0.6804**	0.7136	0.4192	-0.1077	0.0825	0.0976	0.0599	-0.0495
	P	**-0.6399**	0.6845	0.3125	-0.0527	0.0758	0.1091	0.0331	-0.0155
Days to maturity	**G**	-0.6686	**0.7262**	0.4318	-0.1110	0.0878	0.0991	0.0606	-0.0548
	P	-0.6281	**0.6974**	0.3227	-0.0544	0.0807	0.1111	0.0324	-0.0170
Plant height at maturity	**G**	-0.4902	0.5390	**0.5818**	-0.1223	0.0772	0.1419	0.0308	-0.0161
	P	-0.4356	0.4903	**0.4591**	-0.0629	0.0696	0.1572	0.0194	-0.0050
Number of primary branches plant^{-1}	**G**	-0.4492	0.4938	0.4360	**-0.1632**	0.1045	0.1392	-0.0047	0.0203
	P	-0.3785	0.4264	0.3242	**-0.0890**	0.0918	0.1436	-0.0053	0.0040
Number of secondary branches plant^{-1}	**G**	-0.2837	0.3222	0.2270	-0.0861	**0.1980**	0.1668	0.0054	0.0100
	P	-0.2617	0.3034	0.1724	-0.0441	**0.1855**	0.1895	0.0028	0.0031
Number of pods plant^{-1}	**G**	-0.2052	0.2224	0.2551	-0.0702	0.1020	**0.3235**	-0.0202	0.0435
	P	-0.1872	0.2077	0.1936	-0.0343	0.0943	**0.3729**	-0.0069	0.0139
Number of seeds pod^{-1}	**G**	-0.2576	0.2784	0.1135	0.0048	0.0068	-0.0414	**0.1581**	-0.0842
	P	-0.2091	0.2233	0.0881	0.0046	0.0052	-0.0256	**0.1012**	-0.0224
100-Seed weight	**G**	-0.2567	0.3033	0.0715	0.0252	-0.0151	-0.1073	0.1015	**-0.1311**
	P	-0.2306	0.2756	0.0530	0.0082	-0.0134	-0.1204	0.0526	**-0.0431**

Genotypic Residual Effect^2 = 0.2610
Phenotypic Residual Effect^2 = 0.3093

that days to maturity, plant height at maturity and number of pods plant^{-1} had a high and positive direct effect on grain yield at both phenotypic and genotypic levels. However, it was also observed that characters with high indirect effects on grain yield such as days to maturity, plant height at maturity, number of pods plant^{-1}, number of secondary branches plant^{-1} and 100-seed weight are to be considered for selection.

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Research Note
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COSTS AND RETURNS ANALYSIS OF RED CHILLI CULTIVATION IN GUNTUR DISTRICT OF ANDHRA PRADESH: A COMPARATIVE ANALYSIS OF ADOPTERS VS. NON-ADOPTERS OF PRICE FORECASTS

A. INDHUSHREE AND G. RAGHUNADHA REDDY
Department of Agricultural Economics, Agricultural College, Bapatla – 522101

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Price volatility of cash crops is found to have severely inhibited investment in the sector and destabilized the earning of small holders (Rangachary, 2006). Thus, in order to bring about price stabilization in these crops and benefit the farmers with regard to farm income, price forecasting has been carried out as one of the mechanisms of price stabilization by the government. Chilli is cultivated in all the states and union territories of India with Andhra Pradesh leading in both area (17.74 per cent) and production (46.08 per cent). Guntur district of Andhra Pradesh produces 25.45 per cent of chilli produced in India. Guntur chilli market is one of the main physical market for chilies in India and rated as the largest of its kind in Asia. This study is being carried out to analyse and examine the difference in cost and returns structure of chilli cultivation by adopters and non-adopters of price forecasts.Multi-stage stratified purposive sampling technique was used for the study. as detailed below.Guntur district was purposively selected as it was having the highest area under chilli and also highest production and productivity of chilli in Andhra Pradesh. It contributes 25.45 per cent to overall chilli production in India. Out of 57 mandals, two mandals - Sattenapalle and Medikonduru – were selected purposively as they were having highest area under chilli and also nearer to the district headquarter, where the chilli market yard as well as maximum number of cold storages was located. From each mandal, two villages having maximum area under chilli were selected. Chilli farmers, who were progressive and adopted price forecasts were identified from data available with various institutes such as regional research station, AMIC of State Agricultural University. Thus, list of adopters and non-adopters for selected villages was prepared and for each village 15 adopters and 15 non-adopters were selected in random from the list. A total of 120 farmers were selected for the study and data pertains to agricultural year 2014-15.

Tabular analysis was used for estimating variable and fixed costs that can be arrived with simple percentages and averages using descriptive statistics. The cost concepts classification adopted by CACP (Commission on Agricultural Costs and Prices), New Delhi was used in the present study for estimating cost of cultivation (Palanisamy *et al.*, 2002).The cost incurred and returns realized from chilli cultivation by adopters and non-adopters of price forecasts are presented in Table 1. The total cost incurred per hectare of chilli by adopters of price forecasts was higher (Rs. 296338 ha^{-1}) as compared to non-adopters (Rs. 253794 ha^{-1}). The proportion of variable cost to the total cost was 66.51 per cent in

E-mail: indhuashree@gmail.com

Table 1. Cost of cultivation of chilli (Rs. ha^{-1})

S. No.	Particulars	By Adopters of price forecasts	Percent to total	By Non-adopters of price forecasts	Percent to total	Percent difference
A. Cultivation costs (Rs. ha^{-1})						
I	Hired human labour	124768	42.10	113599.70	44.76	9.37
II	Seeds (both owned and purchased)	7865	2.65	7530	2.97	4.35
III	FYM (both owned and purchased)	2845.95	0.96	786.18	0.31	113.42
IV	Fertilizers	32196.40	10.86	22983.02	9.06	33.39
V	Agro-chemicals	25653.60	8.66	18305.53	7.21	33.43
VI	Miscellaneous expenses (electricity charges ,fuel, etc)	3769.59	1.27	2365.54	0.93	45.77
Total variable cost (TVC)		197098.54	66.51	165569.97	65.24	17.39
B. Fixed cost						
I	Depreciation charges	3954	1.33	653.36	0.26	143.28
II	Land revenue	25	0.008	25	0.01	0
Total Fixed cost (TFC)		3979	1.34	678.36	0.27	141.74
TC: (TVC+ TFC)		201077.54	67.85	166248.33	65.51	18.96
Interest on working capital		9238.83	3.12	6487.12	2.56	34.99
1. **Cost A1** : (TC+ IWC)		210316.37	70.97	172735.45	68.06	19.62
2. **Cost A2** : (Cost A1+ Rental Charges)		250316.42	84.47	212735.35	83.82	16.23
3. **Cost B1** : (A1+ Interest on value of owned capital assets (excluding land)		210766.37	71.12	113135.45	44.58	60.28
4. **Cost B2** : (B1+Rental charges)		250766.42	84.62	213135.35	83.98	16.22
5. **Cost C1** : (B1+Imputed value of family labour)		229398.51	77.41	190721.69	75.15	18.41
6. **Cost C2** : (B2+Imputed value of family labour)		269398.6	90.91	230721.6	90.91	15.47
7. **Cost C3** : (C2 X 1.10 (10% of cost C2 is added to cost C2)		296338.42	100	253793.76	100	15.47

Source: Field survey data

case of adopters and 65.24 percent for non-adopters of price forecasts. This implies that almost both categories have same usage pattern regarding the input costs. The cost of hired human labour was highest under variable cost for both categories (Rs.124768 ha^{-1} and Rs.113600 ha^{-1} for adopters and non-adopters of price forecasts respectively) because of repeated harvesting of chillies followed by cost incurred on the fertilizers (Rs.32196 ha^{-1} and Rs.22983 ha^{-1}) and agro-chemicals (Rs. 25654 ha^{-1} and Rs. 18306 ha^{-1}).

The net returns realized from chilli cultivation by adopters of forecasts were Rs. 220297 ha^{-1}, which was higher than that for non-adopters of price forecasts Rs.177527 ha^{-1} (Table 2). The total output of chilli for adopters was 71.26 q ha^{-1} was higher than non-adopters 65.67 q ha^{-1}. This revealed that adopters were using inputs judiciously as compared to non-adopters. Table 2 shows that the price realised by the adopters was Rs.7250 q^{-1} which was Rs.682 higher than the non-adopters of price forecasts (Rs.6568 q^{-1}). This was due to the efficient and 'informed' farm decisions followed by the adopters of price forecasts like moisture level of red chillies to be maintained at the time of harvest and time span of storage to facilitate selling. The less price realised by the other group was because of selling the produce at farm gate and less knowledge regarding future price of produce. This is in accordance with the findings of Anjaly *et al.* (2010) and Burark*et al.* (2011).

Table 2. Returns from chill cultivation

S.No.	Particulars	Adopters	Non-adopters	Per cent difference between adopters and non-adopters (%)
1	Output (q ha^{-1})	71.26	65.67	8.51
2	Price (Rs. /q)	7250.00	6568.00	10.38
3	Gross Returns(Rs.)	516635.00	431320.56	19.78
4	Net income(Rs.)	220296.58	177526.80	24.09

Source: Field survey data

Farm business analysis of sample respondents

The various income measures of farm business analysis were calculated for chilli in study area and presented in Table 3. Gross margin, farm business income, owned farm business income, family labour income, farm investment income and net income were high for adopters than non-adopters of price forecasts for chilly crop because of more gross returns obtained by them.

Gross margin of adopters was more than that of non-adopters shows better management of risk, labour and capital investment by adopters. Higher owned farm business income and family labour income of adopters indicate the efficient utilization of own farm resources by adopters than non-adopters. Farm business income of adopters more than that of non-adopters indicate that various material and labour costs covered by gross returns was more efficient in case of adopters when compared to non-adopters and leaves better margin to cover other costs. In case of farm investment income, higher positive value implies sufficient farm business income the imputed value of family labour and it was robust for adopters than non-adopters which indicate the commercial returns efficiency of adopters over non-adopters.

Table 3. Farm business analysis of chilli crop in the study area

Particulars	Rs. ha^{-1}		Percent difference
	Adopters	Non-adopters	
A. Gross margin = Gross returns- Variable costs	319536.5	265750.59	18.38
B. Farm business income = Gross returns – cost A_1	306318.6	258585.11	16.89
C. Owned farm business income = Gross returns – cost A_2	266318.6	218585.21	19.68
D. Family labour income = Gross returns – cost B_2	265868.6	218185.21	19.70
E. Farm investment income = Farm business income – Imputed value of family labour	287686.5	240998.86	17.66
F. Net income = Gross returns – cost C_3	220296.6	177526.8	21.50

Source: Field survey data

Thus, overall farm business analysis implied that adopters have greater access to the purchased inputs like fertilizer, agro-chemicals, machinery and efficient farm management practices including efficient decision making power. This shows the importance and need of informed decision making in farming and thus awareness should be created among farmers regarding various market intelligence aspects especially the benefits of price forecasts and efficient price forecasts based recommendations should be provided to farmers.

From the above study it was concluded that the total costs incurred by adopters (Rs. 296338 ha^{-1}) was more than that of non-adopters of price forecasts (Rs. 253794 ha^{-1}). Adopters of price forecasts realized more income (24.09 per cent) than non-adopters as the productivity of chilli (8.51 per cent) and price realized per quintal were high (10.38 per cent) in case of adopters than non-adopters. Various farm income measures such as gross margin, farm business income, owned farm business income, family labour income, farm investment income and net income were high for adopters than non-adopters of price forecasts for chilli crop. Overall farm business analysis showed the efficiency of adopters of price forecasts over non-adopters.

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NUTRIENT REMOVAL AND SOIL FERTILITY STATUS ON APPLICATION OF ORGANIC NUTRIENT SOURCES TO TOMATO

P. PRABHU PRASADINI, S. SRIDEVI AND S. VANI ANUSHA
Department of Environmental Science and Technology,
Acharya N.G. Ranga Agricultural University, Rajendranagar, Hyderabad- 500030

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Soil organic matter plays a vital role in the functions of soil and also is a good indicator of soil quality as it mediates many of the chemical, physical and biological processes controlling the capacity of a soil to perform successfully. Organic manures are known for their role in maintenance of physical, chemical and biological conditions of soil and supply of macro and micronutrients to crops besides maintaining the organic matter status in soil. In India, FYM remains to be the most popular organic manure applied to fields and it can potentially supply about 6.8 million tonnes of N, P and K per year. As available organic manures cannot meet the demand, use of organic wastes as alternate option can be explored. In recent years, organic nutrient sources, commonly called as organic fertilizers, are being manufactured from raw materials of plant origin through ecofriendly fermentation process. In this context, an attempt was made to study the effect of organic wastes and a few of new generation organic fertilizers available in the market, on soil properties when applied to vegetable crops.

A pot culture study was taken up with tomato in the green house of the Department of Soil Science & Agricultural Chemistry, College of Agriculture, Rajendranagar during the year 2013 to evaluate the impact of using organic fertilizers and organic wastes on residual soils in comparision with recommended dose of inorganic NPK applied to the crop. The study was carried out with 14 treatments involving combinations of organic fertilizers, organic wastes and inorganic fertilizers *viz*., T_1 (control), T_2 (Recommended NPK @ 120-60-60 kg ha^{-1} supplied through inorganic fertilizers, hereafter referred as Inorganic NPK), T_3 (Inorganic NPK + $ZnSO_4$ @ 25 kg ha^{-1}), T_4 (Recommended N @ 120 kg ha^{-1} + BioPhos @75 kg ha^{-1} + BioPotash @75 kg ha^{-1}), T_5 (Inorganic NPK + BioZinc @ 13 kg ha^{-1}) and T_6 (Recommended N + BioPhos @75 kg ha^{-1} + BioPotash @75 kg ha^{-1}+ BioZinc @ 13 kg ha^{-1}), T_7 (New Suryamin @ 25 kg ha^{-1}), T_8 (New Suryamin @ 25 kg ha^{-1} + Inorganic NPK), T_9 (Aishwarya @ 125 kg ha^{-1}) , T_{10} (Aishwarya @ 125 kg ha^{-1} + Inorganic NPK), T_{11} (EM compost @ 5t ha^{-1}), T_{12} (EM compost @ 5t ha^{-1} + Inorganic NPK), T_{13} (Horse dung @ 5t ha^{-1}) and T_{14} (Horse dung @ 5t ha^{-1} + Inorganic NPK). The test materials evaluated in the study - Organic fertilizers *viz*., BioPhos, BioPotash, BioZinc, New Suryamin and Aishwarya were obtained from M/s Pratishta Industries, Hyderabad; Organic wastes *viz*., EM compost was prepared by JETL, Hyderabad from sludge waste obtained from industrial effluent and Horse dung obtained from local industry where in the horses were reared for extracting serum to develop anti venom. Urea, single super phosphate, muriate of potash and zinc sulphate fertilizers were the inorganic sources

E-mail: prabhuprasadini@rediffmail.com

utilized to supply recommended dose of N, P, K and Zn. Characterization of organic fertilizers and organic wastes was carried out by triacid wet digestion following standard procedures (Tandon, 1992). Nutrient uptake by tomato at 30 DAT (vegetative) and 90 DAT (harvest) was calculated from the dry weights of plants collected by destructive sampling and analysing their nutrient content (Tandon, 1992). Soil samples were also collected after removal of plants and were processed for estimation of soil physico-chemical and chemical properties using standard procedures (Jackson, 1973). Completely randomised design with three replications was followed and results were subjected to statistical analysis as per the procedures outlined by Snedecor and Cochran (1973).

Characterisation of organic fertilizers revealed that those were acidic to slightly acidic in nature with multinutrients and high (3.05 to 27.8%) total organic carbon (OC) content. Organic wastes, EM compost and horse dung, studied were neutral and were also multinutrient sources with 15 to 16 % organic carbon as shown in Table 1.

Table 1. Characteristics of organic fertilisers and organic wastes

	pH	EC (dS m^{-1})	OC (%)	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Zinc (mg kg^{-1})
Organic fertilizers							
BioPhos	5.03	4.88	3.23	0.016	1.91	1.00	1136
BioPotash	6.54	6.66	3.97	0.042	0.40	2.00	1520
BioZinc	6.31	6.45	4.42	0.032	0.49	1.25	2300
New Suryamin	5.77	1.19	3.05	0.950	0.91	0.59	1244
Aishwarya	6.02	5.05	27.8	1.200	0.68	2.30	1378
Organic wastes							
EM compost	7.10	0.67	15.01	0.570	0.32	0.08	302
Horse dung	6.78	0.89	16.32	0.610	0.43	0.14	347

Plant nutrient uptake was higher under conjunctive application of organic sources and inorganic fertilizers. Data set out in Table 2 revealed significant difference in N and P uptake, and nonsignificant variation in K uptake, due to the application of various nutrient sources at both the stages, 30 and 90 DAT. N uptake was highest at both the stages, when fertilized with Aishwarya + Inorganic NPK. Combined application of organic fertilizers (with high nitrogen content) and inorganic fertilizers had resulted in 41- 44% of higher uptake when compared to their sole application. Improvement in soil rhizospheric conditions could have minimized nutrient losses and slow release of N from the organic fertilizers resulted in more N availability and in turn higher absorption/uptake coupled with higher dry matter production (Akimasa Nakano *et al.*, 2003). Sole application of organic wastes (EM compost and Horse dung) hampered the plant phosphorus uptake at both stages while their conjunctive use with inorganic fertilizers helped in removal of more phosphorus. As found in this study, Rooge *et al.* (1998) also reported that BioPhos application increased the P content and nutrient uptake in soybean.

Table 2 . Effect of organic fertilizers and wastes on plant nutrient uptake

Treatments		N uptake (g $plant^{-1}$)		P uptake (g $plant^{-1}$)		K uptake (g $plant^{-1}$)	
		Vegetative stage	Harvest	Vegetative stage	Harvest	Vegetative stage	Harvest
T_1	Soil alone	0.57	0.29	0.015	0.027	0.155	0.237
T_2	Inorganic NPK (120-60-60)	1.23	0.56	0.044	0.059	0.345	0.548
T_3	Inorganic NPK + zinc sulphate	2.55	0.61	0.073	0.065	0.588	0.499
T_4	Inorganic N + BioPhos + BioPotash	1.94	0.65	0.055	0.083	0.458	0.806
T_5	Inorganic NPK + BioZinc	1.66	0.8	0.046	0.089	0.428	0.648
T_6	Inorganic N + BioPhos + BioPotash + BioZinc	2.94	0.76	0.067	0.107	0.577	1.027
T_7	New Suryamin	0.71	0.55	0.017	0.045	0.169	0.371
T_8	New Suryamin+ Inorganic NPK	3.57	0.79	0.084	0.085	0.831	0.811
T_9	Aishwarya	0.86	0.59	0.029	0.048	0.211	0.413
T_{10}	Aishwarya + Inorganic NPK	4.56	0.85	0.128	0.094	0.997	0.876
T_{11}	EM compost	0.73	0.54	0.026	0.048	0.219	0.611
T_{12}	EM compost + Inorganic NPK	1.36	0.77	0.067	0.083	0.632	0.921
T_{13}	Horse dung	0.81	0.47	0.041	0.047	0.224	0.511
T_{14}	Horse dung + Inorganic NPK	1.03	0.64	0.065	0.075	0.593	0.757
	SE (m)±	0.229	0.059	0.060	0.249	0.276	0.034
	CD (5%)	0.664	0.178	0.021	0.509	N.S.	0.248

Soil properties at both vegetative and harvest stages as influenced by the organic and inorganic sources are shown in Tables 3 and 4. All the organic sources with or without inorganics significantly lowered soil pH and increased electrical conductivity of the soil. Organic fertilizers recorded 50 to 67.8% higher soil organic carbon content at harvest compared to the treatment receiving recommended dose of inorganic NPK alone, while the treatments involving organic wastes recorded an additional organic carbon content of 32.1 to 42.8%. Increase in soil organic carbon was sustained till harvest with all organic sources except New Suryamin, 13.5 to 67.6% increase in case of treatments involving other organic fertilizers and 8.1% to 24.3% increase in case of organic waste combinations. Improvement in available N status during the vegetative stage ranged from 11.8% to 30.6% with application of organic fertilizers either solely or in conjunction with inorganic NPK fertilizers. Among the organic wastes, application of EM compost alone lowered the availability of nitrogen by 8.4% at vegetative stage and by 19.5% at harvest. However, its combined application with Inorganic NPK resulted in increased nitrogen availability by 19% during vegetative stage, but at harvest, combined application also resulted in lowered N availability by 2.4%. Nitrogen availability with application of horse dung was in general higher than application of inorganic fertilizers alone. However, available N was higher by 31.7% with combined application of 'Horse dung and Inorganic NPK' when compared its sole application and by 33.3% when compared to inorganic fertilizers. Aishwarya contained more organic carbon (besides higher N) than New Suryamin, more nitrogen was also recorded by the Aishwarya applied soil than New Suryamin. This might be due to the positive relationship between the dissolved organic carbon and dissolved organic N loads (You Jiao and Suing, 2004). At harvest stage, use of organic agricultural inputs improved soil N by the end of crop season and available N in soil ranged between 168 and 237 kg ha^{-1}. Though application of inorganic fertilizers recorded high N status in soil, the treatmental differences were non-significant.

Soil available phosphorous was higher by 16.5% in T_6 where P, K and Zn were supplied through organic fertilizers when compared to application of Inorganic NPK and by 29.3% over application of Inorganic NPK and Zn. Anuradha (2010) reported a difference of 20.73 kg ha^{-1} of more soil available P when it was supplied through BioPhos compared to single super phosphate. Among the organic wastes tested, application of Horse dung along with Inorganic NPK (T_{14}) resulted in 24.7% higher available phosphorus (43.9 kg ha^{-1}) while its sole application reduced the available phosphorus by 2.84%. With reference to EM compost combined application with Inorganic NPK resulted in additional 4.5% available phosphorus in soil. Bedi and Dubey (2009) reported that the treatment combinations of 25 and 50% of the recommended nitrogen levels with organic sources *i.e.,* FYM, green manure and wheat straw resulted in the buildup of organic matter and the total and available pools of nitrogen, phosphorus and sulphur.

Soil available K_2O increased with from 30DAT to 90DAT, highest being recorded by Horse dung + Inorganic NPK treatment (493.9 kg ha^{-1}) and by Aishwarya + Inorganics NPK (623.4 kg ha^{-1}), respectively. Initially, the availability of potassium in organic and inorganic treated soils was on par.

Table 3. Effect of organic fertilizers and wastes on soil physico-chemical properties and organic carbon

Treatments		pH		EC (dS m^{-1})	Organic Carbon (%)	
		Vegetative stage	Harvest	Harvest	Vegetative stage	Harvest
T_1	Soil alone	7.87	8.04	0.36	0.68	0.72
T_2	Inorganic NPK (120-60-60)	7.63	7.83	0.72	0.84	0.74
T_3	Inorganic NPK + zinc sulphate	7.48	7.65	0.83	0.94	0.77
T_4	Inorganic N + BioPhos + BioPotash	7.54	7.64	1.14	1.28	1.01
T_5	Inorganic NPK + BioZinc	6.41	7.06	0.98	1.26	0.91
T_6	Inorganic N + BioPhos + BioPotash + BioZinc	6.80	7.57	1.26	1.34	0.84
T_7	New Suryamin	7.47	7.55	1.05	1.30	0.71
T_8	New Suryamin+ Inorganic NPK	7.22	7.81	1.21	1.28	0.68
T_9	Aishwarya	7.01	7.42	1.19	1.41	1.24
T_{10}	Aishwarya + Inorganic NPK	6.98	7.41	1.30	1.39	1.20
T_{11}	EM compost	6.87	7.87	0.46	1.20	0.92
T_{12}	EM compost + Inorganic NPK	6.87	7.71	1.24	1.14	0.83
T_{13}	Horse dung	7.63	7.5	0.87	1.13	0.87
T_{14}	Horse dung + Inorganic NPK	7.54	7.69	1.16	1.11	0.80
	SE (m) $\pm$	0.166	0.111	0.063	0.067	0.077
	CD (5%)	0.480	0.321	0.181	0.194	0.223

Table 4. Effect of organic fertilizers and wastes on available nutrient content in soils

	Treatments	N (kg ha^{-1})		P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})	
		Vegetative stage	Harvest	Vegetative stage	Vegetative stage	Harvest
T_1	Soil alone	137.9	167.9	25.2	395.7	401.5
T_2	Inorganic NPK (120-60-60)	150.5	214.9	35.2	464.4	563.6
T_3	Inorganic NPK + zinc sulphate	186.1	217.5	33.2	424.5	557.7
T_4	Inorganic N + BioPhos + BioPotash	192.2	228.3	46.2	449.1	603.5
T_5	Inorganic NPK + BioZinc	186.7	226.1	36.2	440.2	598.8
T_6	Inorganic N + BioPhos + BioPotash + BioZinc	192.3	237.3	47	476.3	613.4
T_7	New Suryamin	168.2	170.6	40.5	411.3	602.1
T_8	New Suryamin+ Inorganic NPK	179.8	180.1	42.4	489.7	615.5
T_9	Aishwarya	188.2	218.1	38.5	342.3	599.9
T_{10}	Aishwarya + Inorganic NPK	196.5	228.5	50.8	400.2	623.4
T_{11}	EM compost	137.9	172.9	39.5	406.8	489.9
T_{12}	EM compost + Inorganic NPK	179.1	209.7	41.1	432.7	568.3
T_{13}	Horse dung	171.4	204.1	34.2	418.5	519.4
T_{14}	Horse dung + Inorganic NPK	225.8	234.9	43.9	493.9	609.8
	SE (m)$\pm$	16.076	22.79	5.770	22.374	11.196
	CD (5%)	46.519	N.S	16.69	64.745	32.4

This might be due the high percentage of available potassium in muriate of potash. However, at harvest stage, the availability was more in organic treated soils which implies the sustained supply of nutrients by the organic fertilizers. Application of P, K and Zn through different organic fertilizers resulted in increased soil available potassium content by 6.25% to 10.5% compared to application of inorganics which might be due to the potassium content in all organic fertilizers. Rutherford and Juma (1992) also reported maximum organic C, Bray-P and exchangeable K in soil with use of peanut cake. Application of wastes like EM compost and Horse dung did not help in improving the soil potassium either at vegetative or at harvest stage of the crop. Sole application of these wastes resulted in reduced availability of soil available potassium to an extent of 7.84% with horse dung and 13.08% with EM Compost but conjunctive application of these wastes with Inorganic NPK registered higher soil available potassium to an extent of 0.83% with EM Compost and 8.20% with Horse dung. Broadly, in case of organic wastes the available soil NPK recorded were significantly higher in T_{14} (Horse dung + NPK) when compared to T_2 (Inorganic NPK).

Organic sources studied contained more than one essential nutrient and improved the fertility status till the harvest of the crop. Similar to organic wastes, the organic fertilizers studied also increased the organic carbon content in soil which is the main component in betterment of soil properties. The beneficial effect was also reflected in higher nutrient uptake through good growth. Organic wastes performed better when applied along with inorganics.

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