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RESEARCH JOURNAL

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Correlation of Seed and Seedling Characters with Seed Yield of Sunflower Hybrids

S. S. Nichal[1], R. G. Chawhan[2], S. D. Tayade[3] and R. D. Ratnaparkhi[4]

ABSTRACT

The experiment was conducted at Oilseeds Research Unit, Dr. PDKV, Akola and at Seed Testing Research Unit, Dr. PDKV, Akola during *Kharif* 2012, to study the correlation of seed and seedling characters with yield of sunflower hybrids. The experiment consisted of eight sunflower hybrids and was laid out in randomized block design with three replications. The character association revealed that the seed characters viz., kernel to hull ratio (0.986), seed kernel percentage (0.984), volume weight (0.783) and hundred seed weight (0.741) showed highly significant positive correlation with yield per plant, indicating that yield of sunflower hybrids could be increase by increase in these seed characters. The seed characters like seed hull percentage (-0.949) and electrical conductivity of seed leachate (-0.407) recorded significant negative correlation with yield per plant, indicating, decrease in these characters will results in increase in yield. All the seedling characters studied viz., germination percentage (0.976), root length (0.986), shoot length (0.729), seedling vigour index (0.966) and seedling dry weight (0.841) shown highly significant positive correlation with seed yield per plant indicating the vital role of these characters towards corresponding gain in yield of sunflower hybrids. The sunflower hybrids shown high value of desirable seed and seedling characters also yielded higher, this may be due to high germination percentage and early vigour of these hybrids.

Sunflower (*Helianthus annuus* L.) probably originated in the south western United States, or somewhere in Mexico. In world trade with an annual production around 9 millions tones, sunflower oil is the fourth important vegetable oil. Russian Federation, Ukraine, India and Argentina contribute more than 50 per cent with respect to world acreage of sunflower crop. It was introduced in India in 1970 for commercial cultivation. Sunflower, despite its superiority in all aspects among oilseeds cultivated in India, has not attained its target productivity. Improvement in the productivity largely depends on the direction and magnitude of association between yield component and seed quality traits. Hence, the present investigation was carried out to determine the association of yield of sunflower hybrids with seed and seedling characters.

MATERIAL AND METHODS

The hybrid seed (F_1) of eight sunflower hybrids, PKVSH-27, DRSH-1, SH-3322, LSFH-171, PKVSH-952, PKVSH-953, PKVSH-954 and PKVSH-955 was obtained from Oilseeds Research Unit, Dr. PDKV, Akola and used for recording seed and seedling characters and to carryout field experiment. The experiment was carried out at Oilseeds Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *Kharif* 2012-13 in Randomized Block Design with three replications. The observations of seed (hundred seed weight, seed kernel percentage, seed hull percentage, kernel to hull ratio, volume weight, oil content of seed and electrical conductivity of seed leachate) and seedling characters (germination percentage, root length, shoot length, seedling vigour index and seedling dry weight) were recorded as per ISTA standards at Seed Testing Research Unit, Dr. PDKV, Akola, whereas yield per plant was recorded from field experiment.

RESULTS AND DISCUSSION

The analysis of variance (ANOVA) for the various characters under study has been revealed highly significant differences among the hybrids for all the seed and seedling characters studied and also for yield per plant. Significant amount of variability was exhibited by eight sunflower hybrids for all the seed and seedling charactes studied (Table 1).

The genotypic and phenotypic correlations were computed to understand the nature and magnitude of association among the characters studied. It was observed that genotypic correlations were higher in magnitude than the phenotypic correlations. So the results are presented here considering genotypic correlations.

The correlations of seed characters with yield per plant and correlations among seed characters are presented in Table 3. The seed characters, kernel to hull

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Table 1. Variability studies on seed and seedling characters in sunflower hybrids.

Sunflowr hybrid	Seed characters							Seedling characters					Yield plant^{-1} (g)
	Hundred seed weight (g)	Seed kernel (per cent)	Seed hull (per cent)	Kernel to hull ratio	Volume weight (gm/100ml)	Oil content of seed (per cent)	Electrical conductivity of seed leachate (µS/cm/g)	Germination (per cent)	Root length (cm)	Shoot length (cm)	Seedling vigour index	Seedling dry weight (mg)	
PKVSH-27	4.40	71.88	28.12	2.56	39.47	37.23	0.96	80.33	13.83	16.60	2444	206.7	45.64
DRSH-1	4.63	77.57	22.43	3.46	44.49	38.10	1.41	85.00	14.60	16.37	2634	246.7	56.88
SH-3322	4.28	72.67	27.33	2.66	37.27	39.61	0.88	80.00	14.17	15.33	2359	206.7	46.49
LSFH-171	5.01	70.02	29.98	2.34	45.43	34.79	1.16	86.00	13.70	17.15	2654	190.0	52.31
PKVSH-952	5.49	77.70	22.30	3.49	43.48	36.85	0.66	88.00	15.40	17.87	2928	253.3	72.67
PKVSH-953	3.89	74.47	25.53	2.92	41.83	37.17	0.62	89.3	15.60	18.70	3059	246.7	57.67
PKVSH-954	3.47	75.75	28.06	2.71	41.31	35.80	0.84	84.33	14.70	18.20	2778	163.3	53.42
PKVSH-955	2.83	68.12	31.88	2.15	38.33	33.74	1.04	72.00	13.27	16.53	2145	156.7	41.26
Mean	4.25	73.52	26.95	2.79	41.45	36.66	0.95	83.12	14.41	17.09	2625	208.8	53.29
SE (m) ±	0.09	1.54	0.67	0.10	0.60	0.37	0.07	1.85	0.48	0.69	108	14.4	4.56
CD at 5 %	0.28	4.67	2.05	0.32	1.82	1.13	0.22	5.60	1.47	2.07	326	43.8	13.84

Table 2. Genotypic and Phenotypic Correlation coefficient (r) between seed characters and yield per plant

Sources		Hundred seed weight (g)	Seed kernel percentage	Seed hull percentage	Kernel to hull ratio	Volume weight (gm 100^{-1}ml)	Oil content of seed (per cent)	Electrical conductivity of seed leachate (µS/cm/g)	Yield plant^{-1} (g)
		1	2	3	4	5	6	7	8
Hundred seedweight (g)	G		0.531**	-0.639**	0.603**	0.638**	0.387	0.037	0.741**
	P		0.349	-0.567**	0.527**	0.561**	0.362	0.029	0.591**
Seed kernel percentage	G			-0.973**	0.971**	0.487*	0.581**	-0.239	0.984**
	P			-0.863**	0.912**	0.347	0.468*	-0.084	0.783*
Seed hullpercentage	G				-0.995**	-0.472*	-0.636**	0.121	-0.949**
	P				-0.984**	-0.400	-0.592**	0.097	-0.732**
Kernel to hull ratio	G					0.499*	0.554**	-0.100	0.986**
	P					0.423*	0.524**	-0.057	0.727**
Volume Weight	G						-0.199	0.309	0.783**
(gm/100ml)	P						-0.160	0.244	0.670**
Oil content of Seed, %	G							-0.100	0.221
	P							-0.086	0.142
Electrical conductivity of	G								-0.407*
seed leachate (µS/cm/g)	P								-0.295

G- Genotypic correlation coefficient, P- Phenotypic correlation coefficient.
*, ** Significant at 5per cent and 1per cent level, respectively.

Table 3. Genotypic and Phenotypic Correlation coefficient (r) between seedling characters and yield per plant

Source		Germination percentage	Root length (cm)	Shoot length (cm)	Seedling vigour index	Seedling dry weight (mg)	Seed yield plant^{-1} (g)
		1	2	3	4	5	6
Germination percentage	**G**		0.986**	0.735**	0.975**	0.838**	0.976**
	P		0.732**	0.635**	0.904**	0.669**	0.784**
Root length (cm)	**G**			0.934**	0.989**	0.987**	0.986**
	P			0.851**	0.832**	0.796**	0.790**
Shoot length (cm)	**G**				0.872**	0.180	0.729**
	P				0.794**	0.168	0.616**
Seedling vigour index	**G**					0.739**	0.966**
	P					0.634**	0.839**
Seedling dry weight (mg)	**G**						0.841**
	P						0.767**

G- Genotypic correlation coefficient, P- Phenotypic correlation coefficient ** Significant at 1 per cent level, respectively.

ratio (0.986), seed kernel percentage (0.984), volume weight (0.783) and hundred seed weight (0.741) shown highly significant correlations in positive direction with yield per plant, indicating that yield could be increase by increase in these seed characters.Punia and Gill (1994), Doddamani *et al*. (1997), Madrap *et al*. (1998) and Nehru and Manjunath (2003) also revealed that hundred seed weight showed significant positive correlation with yield in sunflower. Sharankumar (2006) studied seed characters of F_1 hybrid seeds and reported highly significant positive correlation of hundred seed weight and kernel to hull ratio with commercial kernel yield in sunflower. The seed

characters, seed hull percentage (-0.949) and electrical conductivity of seed leachate (-0.407) shown significant correlation with yield plant^{-1} in negative direction, indicating that decrease in these characters will results in increase in seed yield. Uttam *et al.* (2006) also reported that the seed yield was significantly associated with electrical conductivity of seed leachate in negative direction.

Correlation among seed characters indicate significant positive correlation between hundred seed weight, seed kernel percentage, kernel to hull ratio and volume weight. The significant negative correlation of seed hull percentage with hundred seed weight (-0.639), seed kernel percentage (-0.973), kernel to hull ratio (-0.995) and volume weight (-0.472) was observed. Oil content was positively assocoated with seed kernel percentage (0.581) and kernel to hull ratio (0.554) were as shows negative correlation with seed hull percentage (-0.639).

The correlations of seedling characters with yield per plant and correlations among seedling characters are presented in Table 4. All the seedling characters studied *viz.*, germination percentage (0.976), root length (0.986), shoot length (0.729), seedling vigour index (0.966) and seedling dry weight (0.841) shown highly significant positive correlation with seed yield plant^{-1} indicating the vital role of these characters towards corresponding gain in yield of sunflower hybrids. The sunflower hybrids shown high value of seedling characters also yielded higher, this may be due to high germination percentage and early vigour of these hybrids. Thus, more emphasis should be given on seedling characters, as an early indicator of yield performance. Thus, seedling characters may be used as a selection criterion for identification of high yielding sunflower hybrid. Similar observations were reported by Herrera (1987), who have noticed decreased grain yield with decrease in germination percentage and seed density in rice. Chaudhary and Anand (1985) reported the positive and significant correlation between kernel yield and seedling fresh and dry weight in sunflower. Sharnkumar (2006) also reported highly significant correlation in positive direction of root length, shoot length and seedling vigour with commercial kernel yield of sunflower hybrid. Correlation among seedling characters shown that, all the seedling characters were highly correlated in positive direction with each other except shoot length with seedling dry weight, which shows non significant correlation.

In the present investigation, the hybrid PKVSH-952 recorded highest (72.67 g) yield plant^{-1} (Table 2). High yield plant^{-1} of PKVSH-952 was attributed mainly due to maximum values of desirable seed and seedling characters and significant positive correlation of these characters with yield in sunflower. Hence it is suggested that seed and seedling characters must necessarily be given proper weightage during sunflower improvement programme.

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Integrated Nutrient Practices for Management of Leaf Reddening in Rainfed *Bt* Cotton

A. N. Paslawar[1], P. W. Deshmukh[2], A. S. Deotalu[3], P. D. Bhalerao[4] and Godavari Gaikwad[5]

ABSTRACT

A field experiment was conducted at Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth , Akola during the year 2010-11, 2011-12, 2012-13 with a view to study integrated approach for management of reddening in rainfed Bt cotton on medium deep black soils. The experiment was laid out in RBD with three replications in 5.4 x 4.5 m plot size. Bunny Bt was a test crop sown at spacing of 90 x 60 cm. The trial comprised of 10 treatments viz. T_1-RDF (50:25:25 NPK kg ha^{-1}), T_2-RDF based on soil test values(62.5:32.5:32.5 NPK kg ha^{-1}), T_3 -T_2 + 5t FYM ha^{-1}, T_4 - T_3 + 2 sprays of 2 per cent Urea, T_5 – T_3 + 2 sprays of 2 per cent DAP, T_6 – T_4+ 2 sprays of 19:19:19, T_7 – T_4 + 2 sprays of 2per cent DAP, T_8 – T_3 + 2 sprays of 2 per cent KNO_3 + 2 per cent DAP, T_9 – T_3 + 1 spray of 2 per cent Urea and 1 spray of 1per cent Urea + 1 per cent $MgSO_4$, T_{10} – T_4 + 0.5per cent $ZnSO_4$. Moisture conservation practices and plant protection measures were common to all treatments. Application of FYM 5 tonne ha^{-1} + RDF at the time of sowing and split application of N at 30 and 60 DAS followed by foliar application of 2 per cent urea at flowering and 1 per cent urea + 1 per cent $MgSO_4$ was showed superior performance in respect of seed cotton yield, economic returns and B:C ratio (2.11), minimized the reddening in Bt cotton and also improved the chlorophyll content index over all other treatments.

In India, cotton is genetically modified crop, cultivated commercially more than 95 per cent area on various soils, climate and mostly rainfed. Cotton is one of the most important industrial crop grown in India and it contributes 29.8 per cent of the Indian agricultural gross domestic product. World's largest area of 11.5 m ha with productivity of 552 lint kg ha^{-1} (Anon, 2014). The area under Bt cotton is increasing but productivity is stagnated due to decreasing soil fertility especially micronutrients imbalance, indiscriminate use of fertilizer and occurrence of sucking pest and physiological disorders like square dropping, leaf reddening etc. Leaf reddening is serious problem in Vidharbha region of Maharashtra state, where moisture stress, high temperature, sucking pest complex and excess water stagnation for short period poor development of roots in rainfed situation observed every season at any stage of crop. Among these imbalance use of major and micro nutrients is the major problem of various soils. These nutrients are more important because in Bt cotton synchronized boll development attend the source sink relationship due to rapid translocation of saccharides and nutrients from leaves to the developing bolls (Hebbar *et al* 2007). Shanmugham (1992) reported that deficiency of N,P, Mg responsible for reddening. To overcome these constraints foliar feeding additional nutrients is needed over and above the recommended fertilizer and FYM along with judicious pest management. This is one of the most efficient method to supply essential nutrients to cotton crop. Hence, study was conducted for management of reddening in Bt cotton under medium deep soils of rainfed conditon.

MATERIAL AND METHODS

A field experiment was conducted at Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (MS) during *Kharif* season of 2010-11, 2011-12 and 2012-13 on medium deep black soil. The experiment was laid out in RBD with three replications in 5.4 x 4.5 m plot size Bunny Bt was sown at spacing of 90 x 60 cm. The trial comprised of 10 treatments viz. T_1-RDF (50:25:25 NPK kg/ ha), T_2-RDF based on soil test values(62.5:32.5:32.5 NPK kg ha^{-1}), T_3-T_2 + 5t FYM ha^{-1}, T_4 - T_3 + 2 sprays of 2per cent Urea, T_5 – T_3 + 2 sprays of 2 per cent DAP, T_6 – T_4+ 2 sprays of 19:19:19, T_7 – T_4 + 2 sprays of 2 per cent DAP, T_8 – T_3 + 2 sprays of 2 per cent KNO_3 + 2 per cent DAP, T_9 – T_3 + 1 spray of 2per cent Urea and 1 spray of 1per cent Urea + 1per cent $MgSO_4$, T_{10} – T_4 + 0.5per cent $ZnSO_4$.The experimental soil with available nitrogen (231 ka ha^{-1}), phoshhorus (20.1 kg ha^{-1}), potassium (382 kg ha^{-1}), magnesium (6.85 kg ha^{-1}) and organic carbon was (3.9 kg ha^{-1}) with pH 7.8. Sowing was done by hand dibbling and well decomposed FYM was applied before sowing in rows and RDF was applied through Urea, SSP and MOP. The entire dose of P_2O_5, K_2O and 50 per cent Nitrogen (N) was applied as basal dose and remaining 50 per cent Nitrogen was applied into two splits at 30 and 60 days after sowing

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Table 1: Leaf reddening (per cent) before spraying as influenced by different treatments in Bt cotton

Treatments	2010	2011	2012
T_1 - RDF (50:25:25 NPK kg ha^{-1})	15.12	7.35	23.15
T_2 - RDF based on soil test values (62.5:32.5:32.5 NPK kg ha^{-1})	15.15	7.37	24.12
T_3 - T_2 + 5t FYM/ha	15.19	7.12	25.15
T_4 - T_3 + 2 sprays of 2 % Urea	14.15	7.15	23.42
T_5 - T_3 + 2 sprays of 2 % DAP	16.16	7.13	24.15
T_6 - T_4 + 2 sprays of 19:19:19	14.12	7.32	24.11
T_7 - T_4 + 2 sprays of 2 % DAP	14.13	7.15	23.45
T_8 - T_3 + 2 sprays of 2 % KNO_3 + 2per cent DAP	15.17	7.35	23.56
T_9 - T_3 + 1 spray of 2 % Urea and 1 spray of 1% Urea + 1% $MgSO_4$	15.45	7.29	23.75
T_{10} - T_4 + 0.5 % $ZnSO_4$	15.12	7.12	23.62
Mean	14.82	7.18	23.31

Table 2: Chlorophyll content index (per cent) in Bt cotton leaves as influenced by spraying of nutrients at flowering

Treatments	2010	2011	2012
T_1 - RDF (50:25:25 NPK kg ha^{-1})	24	21	20
T_2 - RDF based on soil test values(62.5:32.5:32.5 NPK kg ha^{-1})	27	22	21
T_3 - T_2 + 5t FYM ha^{-1}	25	25	23
T_4 - T_3 + 2 sprays of 25 % Urea	27	25	24
T_5 - T_3 + 2 sprays of 2 % DAP	26	24	24
T_6 - T_4 + 2 sprays of 19:19:19	29	25	25
T_7 - T_4 + 2 sprays of 2 % DAP	32	24	24
T_8 - T_3 + 2 sprays of 2 % KNO_3 + 2 % DAP	29	26	24
T_9 - T_3 + 1 spray of 2 % Urea and 1 spray of 1 % Urea + 1 % $MgSO_4$	33	27	25
T_{10} - T_4 + 0.5per cent $ZnSO_4$	31	26	24

(DAS) and foliar spray was done as per treatments at flowering and boll development stages in Bt cotton. Reddening in plants per cent was recorded before spray of foliar nutrients and chlorophyll content index was recorded with chlorophyll meter after spraying of foliar nutrients at flowering stage. Growth and yield observations were taken and economics was worked out as per prevailing market prices. The plant protection measures were undertaken against sucking pests. Furrow opened in between two rows of cotton at 40 days after sowing for moisture conservation. The rainfall of the season was1006 mm, 456 mm and 684 mm during 2010-11, 2011-12 and 2012-13 against normal rainfall of 740 mm. Statistical analysis was done as described by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Leaf reddening per cent indicates the degree of reddening due to deficiency or pest complex. Cotton leaf reddening data before application of spray is presented in Table 1. Mean leaf reddening was 14.82 per cent in 2010, 7.18 per cent in 2011 and 23.31 per cent in 2012 was observed before foliar spray. Third year it was higher percent of reddening. Chlorophyll content determines the photosynthetic rate or photosynthetic efficiency of crop and data in respect of chlorophyll content index is presented in Table 2. The chlorophyll content index (CCI) was higher values, when RDF + 5 tone FYM and 2 per cent urea spray at flowering and 1 per cent urea and 1 per cent $MgSO_4$ at boll development stage and followed by T_7 i.e RDF 2 per cent DAP + 5 t FYM + Two spray of 2 per cent Urea and 2 per cent DAP and lowest with only RDF during three years of experimentation. Reddening of Bt cotton leaves was reduced by 30-40 per cent with foliar application of urea @ 2 per cent + DAP @ 2 per cent + $MgSO_4$ @ 1 per cent given at boll development stage. (CICR 2009). It might be due to better absorption of foliar nutrients under rainfed situation.

Table 3: Three years pooled data of Plant height, Sympodia, boll numbers, dry matter and seed cotton yield per plant as influenced by integrated nutrient management.

Treatments	PlantHeight (cm)	Sympodial branches	Boll numbers	SCY plant^{-1} (g)	Dry Matter (g)	Seed index(g)
T_1 - RDF (50:25:25 NPK kg ha^{-1})	75.83	16.3	16.13	61.76	116.1	8.69
T_2 - RDF based on soil test values(62.5:32.5:32.5 NPK kg ha^{-1})	78.06	16.2	17.06	69.96	120.5	8.80
T_3 - T_2 + 5t FYM ha^{-1}	80.13	16.7	17.96	70.03	122.8	8.70
T_4 - T_3 + 2 sprays of 2% Urea	80.63	17.4	20.50	71.83	131.0	8.70
T_5 – T_3 + 2 sprays of 2% DAP	77.80	16.9	17.93	67.96	123.3	8.76
T_6 – T_4+ 2 sprays of 19:19:19	80.60	17.1	19.6	73.90	128.6	8.85
T_7 – T_4 + 2 sprays of 2 % DAP	81.03	17.1	20.46	74.60	129.2	8.89
T_8 – T_3 + 2 sprays of 2 % KNO_3 + 2 % DAP	77.16	17.0	17.96	69.63	124.4	8.78
T_9 – T_3 + 1 spray of 2% Urea and 1 spray of 1% Urea + 1% $MgSO_4$	82.83	17.8	22.26	80.40	137.3	8.81
T_{10} – T_4 + 0.5 % $ZnSO_4$	79.83	17.0	19.7	74.86	128.5	8.88
S.E. (m) +	1.01	0.24	1.07	2.12	3.52	0.07
CD at 5%	3.03	0.73	3.20	6.30	10.5	NS

Table4: Seed cotton yield, Lint yield, Biological yield (kg ha^{-1}) and economics as influenced by integrated nutrient management in Bt cotton.

Treatments	Seed Cotton Yield (kg ha^{-1})				Lint Yield (kg ha^{-1})				Gross Monetary Returns (Rs/ha)	Net Monetary Returns (Rs/ha)	B:C
	2010	2011	2012	Pooled mean	2010	2011	2012	Pooled mean			
T_1 - RDF (50:25:25 NPK kg ha^{-1})	1082	917	1182	1060	387	326	419	377	46098	23843	2.07
T_2 - RDF based on soil test values (62.5:32.5:32.5 NPK kg ha^{-1})	1137	1009	1207	1117	408	350	423	393	47073	24042	2.04
T_3 - T_2 + 5t FYM/ha	1168	1017	1239	1141	401	345	425	390	48321	21830	1.82
T_4 - T_3 + 2 sprays of 2per cent Urea	1270	1233	1249	1250	455	441	438	444	48711	21429	1.78
T_5 - T_3 + 2 sprays of 2per cent DAP	1131	1007	1249	1132	400	352	444	398	49062	21551	1.78
T_6 - T_4 + 2 sprays of 19:19:19	1170	1133	1258	1195	422	400	457	426	50076	22554	1.82
T_7 - T_4 + 2 sprays of 2per cent DAP	1220	1201	1320	1247	435	417	466	439	51480	23898	1.86
T_8 - T_3 + 2 sprays of 2per cent KNO_3 + 2per cent DAP	1107	1003	1323	1144	397	362	455	404	51597	23366	1.82
T_9 - T_3 + 1 spray of 2per cent Urea and 1 spray of 1per cent Urea + 1per cent $MgSO_4$	1408	1254	1481	1381	501	423	529	484	**57759**	**30374**	**2.11**
T_{10} - T_4 + 0.5per cent $ZnSO_4$	1261	1195	1361	1272	444	404	475	441	53079	24597	1.86
S.E. m $\pm$	49.3	52.6	59.6	27.5	17.2	23.6	20.95	10.0	2324	2324	
CD at 5 %	146.6	147.8	177.0	82.1	51.7	66.3	62.2	29.7	6906	6906	

The three years pooled data revealed that the application of 5 tonne FYM + RDF and spraying of 2 per cent urea at flowering stage and 1 per cent urea + 1 per cent $MgSO_4$ at boll development stage was recorded significantly higher plant height (82.83 cm), sympodia per plant (17.8), boll numbers (19.7), seed cotton yield per plant (80.40 g), total dry matter production (128.5 g) and seed index (8.88 g) over RDF (control). It was on par with FYM + RDF + spraying of 2 per cent Urea and 2 per cent DAP at flowering and boll development stage. Higher the growth and growth attributes were reported in Bt cotton with three foliar application of micronutrients along with RDF by Ravikiran, *et. al.,* (2012), Rajendran, *et. al.,* (2011) and Hosmath (2011). The increase in growth components might be due to additional application of urea and magnesium spray along with RDF and incorporation of 5 t FYM ha^{-1}, which may balance nutrition with moisture conservation practices along with plant protection measures. This might be led to minimize the reddening of Bt cotton.

The individual year and pooled data recorded that application of 5 tone FYM + RDF + 2per cent urea spray at flowering and 1 per cent urea + 1 per cent $MgSO_4$ at boll development stage significantly recorded highest seed cotton yield (1408, 1254, 1481 and 1381 kg ha^{-1}) during 2010, 2011, 2012 and pooled. Similar trend was observed in lint yield as compared to control and other treatments. The SCY gain was maximum of 321 kg extra over only RDF (control). Similar results were reported by Shivamurthy and Biradar (2014).

The gross returns (Rs 57759 ha^{-1}) and net returns (Rs 30374 ha^{-1}) with benefit cost ratio (2.11) was obtained with 2 per cent urea at flowering and 1 per cent urea + 1per cent $MgSO_4$ along with RDF + 5 t FYM per hectare followed by 2per cent urea at flowering and boll development stage along with 0.5 per cent $ZnSO_4$ and RDF + 5 t FYM ha^{-1}.

Based on three years results it can be concluded that for minimizing the reddening in Bt cotton the application of FYM 5 tonne per ha + RDF at the time of sowing and split application of N at 30 and 60 DAS followed by foliar application of 2 per cent urea at flowering and 1 per cent urea + 1 per cent $MgSO_4$ at boll development stage along with moisture conservation practices and plant protection measures was found better in respect of seed cotton yield and economic returns.

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Effect of Planting Geometry on Growth, Nutrient Uptake and Yield of Medium Duration Pigeonpea Hybrid Under Rainfed Condition

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ABSTRACT

A field experiment was conducted during *Kharif* season to study the crop geomtery of different pigeonpea varieties under rainfed coditions of Akola, Maharashtra. Planting of pigeonpea at 90 x 20 cm was optimum. Amongst varieties BDN 708 realized higher crop growth, productivity net return and BCR. Higher content of nutrient and total uptake was reported with BDN 708 than remaining varieites. Increased uptake of macro nutrients (N, P and K) in pigeonpea was reported with the increase in plant density from 27777 to 55555 plants ha^{-1}. Interaction between variety and plant density was found non significant.

India has ascendancy in pigeonpea production by accounting 90 per cent of world's total production. Pigeonpea is one of the protein rich legume crops of semi arid and sub tropics and requires due attention in view of large scale shortage of pulses to meet the domestic requirement. The average pigeonpea productivity is very low 960 kg ha^{-1} which is limited by number of factors choice of suitable geometry, optimum population, imbalance fertilization, terminal drought etc. The popular pigeonpea cultivars under cultivation have admirable production potential but their cultivation is mostly carried out under rainfed condition. Maximum yield in a particular cultivar and the environment can be obtained at the density, which not only utilizes light, moisture and nutrients more efficiently but also avoids excessive competition among the plants. The hybrids help in increasing the productivity and some of the hybrids are being released for cultivation.

Information on agronomic performance of the pigeonpea hybrid is not available under *Vertisol* of Maharashtra. In such situations, the adoption of proper plant geometry will go a long way in making efficient use of limited use of limited resources and thus stabilize the pigeonpea yield. Hence there is a need to study their performance with check BDN 708 under rainfed condition.

MATERIAL AND METHODS

The experiment was conducted during *Kharif* season of 2009 at Pulses Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (MS) under AICRP on Pigeonpea. The soil was medium clayey in texture, medium in organic carbon (0.51per cent), available nitrogen (241 kg ha^{-1}), available phosphorous (18.60 kg ha^{-1}), available potassium (367 kg ha^{-1}) with pH (8.13). The treatments comprising of three varieties (AKPHM 6-12, ICPH 2671 BDN 708) and three spacing (90 x 20 cm, 90 x 30 cm and 90 x 40 cm) replicated three times in a Factorial Randomized Block Design. Pigeonpea seeds were treated with carrier based *Rhizobium* and PSB, each at the rate of 2.5 g kg^{-1} seed and dried in a shed before sowing. Among fertilizers N and P through urea and diammonium phosphate were applied at planting. The crop variety was sown on 3rd July, 2009 and was harvested on 25th December 2009.Thinning was done leaving single plant $hill^{-1}$ at 15 days after sowing. Observation on plant growth, yield and yield attributes were taken in five randomly selected plants in each treatment. N, P and K concentration in plant were analyzed as per standard procedure for studying nutrient uptake at harvest. Economics of the treatments was also calculated. The N and P_2O_5 through urea and diammonium phosphate were applied as basal. The total rainfall received during the crop growth was 642.5 mm in 34 rainy days during 2009.

RESULTS AND DISCUSSION

Yield

The differences in the seed yield differed significantly among the pigeonpea genotypes. The seed yield produced by genotypes BDN 708 (1707 kg ha^{-1}) was found to be significantly higher than the seed yield obtained by ICPH 2671 (1521 kg ha^{-1}) and AKPHM 6-12 (1117 kg ha^{-1}).The extent of reduction in seed yield by ICPH 2671 and AKPHM 6-12 was 12.23 and 52.82 per cent when compared to BDN 708, respectively. The differences in seed yield by the genotypes were reported by Tej Lal Kashyap *et al*. (2003). The factor mainly responsible for seed yield variation among genotypes is due to the

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Table 1: Grain yield, ancillary parameters and economics of pigeonpea as influenced by different treatments

Treatments	Yield (kg ha^{-1})		Plant	Branches	Pods	Seed weight	CC	Gross return	Net return	B:C	100-seed
	Grain	Straw	height (cm)	plant^{-1}	plant^{-1}	plant^{-1} (g)	(Rs ha^{-1})	(Rs ha^{-1})	(Rs ha^{-1})	ratio	weight (g)
Genotype											
ICPH 2671	1521	2456	150.0	5.8	77	45.8	18921	58575	39653	2.09	10.567
AKPHM 6-12	1117	2111	133.5	5.3	67	42.4	18517	44676	26159	1.41	10.078
BDN 708	1707	2865	149.4	5.7	84	49.8	17887	68268	50381	2.81	10.489
CD 5 %	121	358	5.66	0.32	6.80	2.61	—	4804	4684	—	0.27
Planting density											
90 x 20 cm i.e.55555 plant/ha	1590	2624	138.8	5.5	81	47.6	18583	62791	44208	2.39	10.711
90 x 30 cm i.e.37037 plant/ha	1435	2449	144.2	5.6	75	46.0	18428	56581	38153	2.08	10.300
90 x 40 cm i.e.27777 plant/ha	1320	2359	149.9	5.7	71	44.5	18314	52146	33832	1.86	10.122
CD 5 %	121	358	5.66	0.32	6.80	2.61	—	4804	4684	—	0.27
Interaction											
CD at 5 %	NS	NS	NS	NS	NS	NS	—	NS	NS	NS	NS
CV%	7.80	14.50	4.67	5.8	5.93	6.0	—	7.85	11.36	—	2.59

Selling price: Grain - ICPH 2671-38.50 kg^{-1}, AKPHM 6-12 & BDN 708- Rs.40 kg^{-1}

variation in yield components *viz.*, number of pods plant^{-1}, seed yield plant^{-1}, 100-seed weight. Among the yield components, seed weight plant^{-1} had closer influence on the seed yield per hectare. Significantly higher seed yield plant^{-1} was recorded by the genotype, BDN 708 (48.8 g) than ICPH-2671 (45.8 g) and AKPHM 6-12 (42.4 g). The significantly higher seed weight plant^{-1} was probably contributed by significantly higher number of pods per plant (84) in BDN 708 than ICPH 2671 and AKPHM 6-12 (77 and 67, respectively). These results are in conformity with the earlier findings of Pramesh *et al.* (2006). Along with this ICPH 2671 recorded higher 100-seed weight (10.28 g) followed by BDN 708 and AKPHM 6-12. Significantly higher number of pods per plant was observed in genotype, BDN 708, followed by ICPH 2671 and AKPHM 6-12 and is mainly attributed to its higher efficiency in translocating the photosynthates to the reproductive parts.

Plant spacing of 90 x 40 cm recorded superior plant height (149.9 cm) and number of branches plant^{-1} (5.7) while the plant spacing of 90 x 20 cm give the highest pods plant^{-1}, seed weight plant^{-1} and 100-seed weight plant^{-1}, however in case of seed weight plant^{-1} difference between 90 x 20 cm and 90 x 30 cm was found at par. These findings are contrary with Mula *et al.* (2010a) where wider spacing reported higher yield. However, wider plant geometry did not influence the increased in pods plant^{-1} and seed yield plant^{-1} because of fewer plant population as compared to closer spacing (Sinha *et al*. 1988 Mula *et al*., 2010b). In the present study, the spacing of 90 x 20 cm recorded significantly higher seed yield (1590 kg ha^{-1}) when compared to other spacings tested *viz.*, 90 x 30 cm (1435 kg ha^{-1}) and 90 x 40 cm (1320 kg/ha). This difference in the seed yield was mainly due to the significantly higher plant population accommodated per unit area with narrow spacings *i.e.*, 55555 plants ha^{-1} (90 cm x 20 cm) compared to wider spacing 37037 plants ha^{-1} (90 x 30 cm). These results are in accordance with the findings of Parameswari *et al.* (2003).

Nutrient content

On perusal of data (Table 2) showed that nitrogen, phosphorous and potassium content both in grain and straw influenced significantly due to different genotypes and different planting density. However, concentration of various nutrients in the plant system also affects their total uptake, but the differences among the cultivars are marginal owing to similar management conditions. Genotype BDN-708 recorded significantly higher nutrient content both in grain and straw over AKPHM 6-12 followed by ICPH-2671. However, with decrease in planting density increase in nutrient content was observed both in grain and straw due to less crop competition. Higher nutrient content both in grain and straw was significantly influenced with 90 x 20 cm spacing closely followed by 90 x 30 cm spacing over 90 x 40 cm spacing.

Nutrient uptake

Nutrient uptake both in grain, straw and total uptake influenced significantly due to different genotypes (Table 3), however, significantly higher nitrogen, phosphorus and potassium uptake by grain was recorded in case of genotypes BDN-708 over AKPHM 6-12 and closely followed by ICPH-2671. Amongst genotypes BDN-708 and ICPH-2671 nitrogen, phosphorus and potassium uptake by straw and their total uptake found at par excluding total uptake of phosphorous. Due to different planting density nitrogen and potassium uptake by straw and phosphorous uptake both by grain and straw did not influenced significantly. Closer row width tended to results in higher nutrient uptake in pigeonpea over wider spacing because of higher total dry matter production per unit area. Therefore, the total biological yield produced determines to a large extent the quantum of nutrient uptake. Ahlawat (1977) reported increase in nitrogen and phosphorus uptake with increasing plant densities in the range of 50000 to 150000 plants ha^{-1}.

Economics

With respect to economics, ICPH 2671 (Rs.18921 ha^{-1}) and AKPHM 6-12 (Rs.18517 ha^{-1}) recorded higher cost of cultivation due to its higher seed cost when compared to other genotypes BDN 708 (Rs.17887 ha^{-1}). Among varieties BDN 708 (Rs.50381ha^{-1}, 2.81) fetched significantly higher net profit and BC ratio followed by ICPH 2671 (Rs. 39653 ha^{-1}, 2.09) and lowest by AKPHM 6-12 (Rs.26159 ha^{-1}, 1.41). The ICPH 2671 fetched lower selling price compare to other cultivars owing to purple grain colour resulting in lower net profit besides lower grain yield. Among different spacing, the spacing of 90 x 20 cm recorded higher cost of cultivation (Rs.18583 ha^{-1}) as it required higher seed rate when compared to other row spacing and recorded higher gross returns (Rs.62791 ha^{-1}), significantly higher net returns (Rs.44208 ha^{-1}) than other spacing due to its higher seed yield than other wider spacing *viz.*, 90 x 30 cm (Rs.18428 ha^{-1}) and 90 x 40 cm

Table 2: Nutrient content in pigeonpea as influenced by different treatments

Treatment	Per cent nutrient content					
	N		P_2O_5		K_2O	
Genotype	Grain	Straw	Grain	Straw	Grain	Straw
ICPH 2671	3.20	1.13	0.33	0.22	0.95	0.73
AKPHM 6-12	3.17	1.12	0.33	0.20	0.93	0.71
BDN 708	3.21	1.14	0.35	0.23	0.99	0.73
S.E (m) ±	0.018	0.006	0.002	0.001	0.003	0.002
CD 5 %	0.055	0.019	0.005	0.004	0.010	0.007
Planting density						
90 x 20 cmi.e.55555 plant ha^{-1}	3.14	1.12	0.31	0.22	0.95	0.71
90 x 30 cmi.e.37037 plant ha^{-1}	3.18	1.13	0.34	0.22	0.96	0.73
90 x 40 cmi.e 27777 plant ha^{-1}	3.22	1.15	0.35	0.25	0.98	0.75
S. E (m) ±	0.018	0.006	0.002	0.001	0.003	0.002
CD at 5 %	0.055	0.019	0.005	0.004	0.010	0.007

Table 3: Nutrient uptake in pigeonpea as influenced by different treatments

Treatment	Uptake (kg ha^{-1})								
	N			P_2O_5			K_2O		
Genotype	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
ICPH 2671	42.40	27.66	70.06	4.41	5.31	9.71	12.70	17.72	30.42
AKPHM 6-12	37.51	23.72	61.22	3.91	4.30	8.21	10.96	15.07	26.03
BDN 708	47.94	29.18	77.12	5.17	5.96	11.12	14.84	18.72	33.56
S.Em±	1.29	1.56	2.38	0.13	0.33	0.41	0.39	1.02	1.22
CD 5per cent	3.87	4.69	7.12	0.41	0.99	1.22	1.17	3.05	3.67
Planting density									
90 x 20 cmi.e.55555 plant ha^{-1}	49.91	29.31	79.22	4.85	5.78	10.63	15.10	18.80	33.90
90 x 30 cmi.e.37037 plant ha^{-1}	46.25	28.16	74.41	5.00	6.08	11.08	14.18	18.28	32.46
90 x 40 cmi.e.27777 plant ha^{-1}	44.08	26.61	70.69	4.70	5.24	9.94	13.27	17.13	30.41
S.Em±	1.29	1.56	2.38	0.13	0.33	0.41	0.39	1.02	1.22
CD at 5 %	3.87	NS	7.12	NS	NS	1.22	1.17	NS	3.67

(Rs.18314 ha^{-1}). Benefit cost ratio was found significantly higher in a row spacing of 90 x 20 cm (2.39) when compared to other spacing of 90 x 30 cm (2.08) and 90 x 40 cm (1.86). This is mainly because of higher seed yield ha^{-1}. A similar finding was reported by Nedunzhiyan and Sambasiva Reddy (1993). .

CONCLUSION

The study suggested that pigeonpea cultivar BDN-708 was superior over hybrids at 90 x 20 cm spacing and was found optimum and economical for improving growth, uptake and yield under rainfed condition.

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Nutrient Addition Through Leaf Litter Biomass of Cotton as Influenced by Intercropping, Weed Control and Fertility Management in Rainfed Cotton Based Systems

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ABSTRACT

A field experiment was carried out at Research Farm of Agronomy Department, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (MS) during 2007-08 and 2008-09 with an object to quantify leaf litter biomass production of cotton and addition of nutrients to the soil. In cotton based intercropping system of six treatments like, cotton + blackgram, cotton + soybean, cotton + pigeonpea, cotton + cowpea, cotton + clusterbean and cotton + marigold were tested. Based on two years data, results revealed that the intercropping of cotton + pigeonpea recorded significantly higher leaf litter biomass of cotton during first year. Whereas, intercropping of cotton + pigeonpea being par with cotton + blackgram recorded significantly higher NPK addition through leaf litter biomass of cotton. Normal weeding significantly recorded greater values for leaf litter biomass production of cotton and addition of NPK to soil than no weeding treatment. In case of fertility management, increased dose of 125per cent RDF to base crop of cotton over 100per cent and 75per cent registered significantly more leaf litter biomass production of cotton and addition of NPK to the soil during both the years of study.

In rainfed condition, monocropping of cotton or any other crop is very risky because it mostly depends on monsoon rain. To avoid a risk, intercropping is an option in both space and time dimension to increase per unit area production insteed of growing only one crop like cotton or pigeonpea other short duration crops need to be tested to find out the most suitable crop/cropping system for the region. Traditionally cotton + pigeonpea cropping system is commonly practised by the farmers and recently many more cropping systems like, cotton + pigeonpea/ greengram/blackgram /soybean/sorghum/bajra/chilli/ marigold etc. in different proportions are becoming popular among the farmers. Because, products and byproducts produced from these crops are consumed by human and animals as well as have good demand and market price. Considering the important plant parts as a food, not much attention has been given towards other non-consumed and unused plant parts after harvest like fallen leaf litter, bur, petiole, roots etc. The unused plant parts are the non-expensive and cheapest source of nutrients which can be added to the soil. Such important issue has not been much studied for quantificaton of biomass production on and in soil after harvest and their contribution in addition of nutrients to the soil. Keeping in mind the present investigation was carried out to quantify and analyse the unused biomass production and addition of nutrients to soil through biomass of various crops tested in cotton based rainfed system.

MATERIAL AND METHODS

A field experiment was carried out at the Agronomy Research Farm,Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (MS) during *Kharif* 2007-08 and 2008-09. The experimental site was fairly levelled and uniform in topography. The soil was deep black cotton belonging to *Vertisols*. It was clay in texture and moderately alkaline in nature (p^H8.3), medium in organic carbon (0.51%) and available potassium (239.41 kg ha^{-1}), low in available nitrogen (169.76 kg ha^{-1}) and phosphorous (28.68 kg ha^{-1}) with slightly calcariousness. The total rainfall received during 2007-08 in 23rd- 52nd MW at Akola centre was 771.00 mm in 43 rainy days. Whereas, during 2008-09 the total rainfall recorded was 528.20 mm in 42 rainy days which was abnormal year. Rainfall was deficit by 30.70 per cent as against normal rainfall of 762.80 mm. Soon after sowing to flowering, boll development stage was adversely affected the cotton yields. American *hirsutum* variety (AKH-8828) was used for the experiment. It has a bushy, branchy growth habit attaining the height of about 70-80 cm, 2-4 monopodias, 12 - 20 sympodias. The intercrops popular among the farmers were used in replacement series of experiment and adopted spacing of 45 × 10 cm for drilling and 45 × 30 cm for dibbling by reducing the recommended spacing of 60 × 30cm.

In all 12 main plots (A) Intercropping (6): viz., I_1 - Cotton + blackgram (1:1), I_2 - Cotton + soybean (1:1), I_3 -

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Cotton + pigeonpea (6:2), I_4 - Cotton + clusterbean (1:1), I_5 - Cotton + cowpea (1:1) and I_6 - Cotton + marigold (1:1) and (B) Weed management (2): W_1- No weeding and W_2– Normal weeding at 25 and 50 days after sowing and Sub plots (3): F_1 – 75 per cent RDF (37.5,18.75, 18.75 kg ha^{-1}) to base crop of cotton, F_2 – 100 per cent RDF (50, 25, 25 kg ha^{-1}) to base crop of cotton and F_3 – 125 per cent RDF (62.5, 31.25, 31.25 kg ha^{-1}) to base crop of cotton. The experiment was laid out in a split plot design with three replications and cotton crop was sown at the spacing of 45 × 30 cm distance. The gross plot size was 6.30 m × 3.60 m, while net plot size was 5.40 m × 3.00 m and recommended dose of fertilizers of cotton was 50, 25, 25 kg NPK ha^{-1} with no fertilizers to intercrops. After harvest of crop, dried leaf litter biomass of cotton was collected from one square meter area per plot separated from foreign material, weighed, oven dried, ground, labelled and ground powder was used for estimation of NPK content with standard methods of KELPLUS, Olsons and Spectrophotometer (Jackson,1967), respectively.

RESULTS AND DISCUSSION

Leaf litter biomass of cotton

a) Effect of intercropping

Among the intercropping systems (Table1), cotton + pigeonpea recorded significantly highest leaf litter biomass production of cotton in 2007-08 but it was at par with cotton + blackgram. It might be due to more number of plants produced more biomass of cotton and intercrop of pegionpea also favoured complementary effects on cotton to increase growth and dry weight of plant (Turkhede, 2010). The second best position was registered by cotton + blackgram than rest of the treatments. The lowest leaf fall biomass of cotton was noticed in cotton + cowpea system during 2007- 08. Whereas, during 2008-09, intercropping of cotton + blackgram being par with cotton + pigeonpea and recorded significantly greater values for leaf litter biomass production. The second best position was registered by cotton + cowpea. While, cotton + soybean, cotton + clusterbean, cotton + marigold being par with one another recorded significantly maximum leaf litter biomass production in cotton than other intercropping.

b) Effect of weed management

Normal weeding produced significantly higher leaf litter biomass of cotton than no weeding during both the years of experiment. It could be attributed to minimization of losses caused by weed growth that leads to improve growth characters of cotton and thus increased leaf biomass in cotton. Similar type of results were coroborated by (Balyan and Singh,1986).

c) Effect of fertility management

Application of 125per cent to base crop of cotton recorded significantly higher leaf litter biomass of cotton over its lower dose of 100per cent and 75per cent RDF during 2007-08.The higher fertilizer dose might have increased growth of cotton that produced more leaf litter biomass of cotton. Similar results were reported by Gaud and Kale (2010), Kote *et al*. (2005) and Raskar (2006). Whereas, non significant results were observed during 2008-09.

d) Interaction Effect

Considering significant interaction, results were discussed separately (Table2). In 2007-08, at 100per cent RDF, cotton + soybean intercropping recorded highest leaf litter biomass production but it was at par with cotton + blackgram and cotton + pigeonpea intercropping. At 125 per cent RDF cotton + pigeonpea, cotton + blackgram and cotton + soybean intercroppings were at par. In 2008-09, at 100 per cent RDF cotton + marigold recorded highest leaf litter biomass production but it was at par with cotton + pigeonpea and cotton + blackgram. At 125 per cent RDF cotton + blackgram recorded maximum leaf litter biomass production and it was superior to all followed by cotton + marigold and cotton + clusterbean.

Overall it appears that during 2007-08 when rainfall was higher cotton + soybean intercropping was equally effective as that of cotton + blackgram and cotton + pigeonpea. But in 2008-09 when rainfall was deficit cotton + soybean recorded lower leaf litter biomass production than cotton+ blackgram and cotton + marigold.

Addition of nutrients through leaf litter biomass of cotton

a) Effect of intercropping

The nutrients addition through leaf litter biomass of cotton was influenced by different treatments during 2007-08 and 2008-09. Intercropping of cotton + pigeonpea being par with cotton + blackgram recorded significantly higher nitrogen, phosphorous and potassium than rests. The treatment of cotton + soybean being par with cotton + clusterbean registered significantly highest values for nitrogen over cotton + cowpea and cotton + marigold. While, cotton + marigold added more nitrogen than cotton

Table1. Leaf litter biomass production of cotton and addition of nutrients to soil.

Treatments	Wt. of leaf litter biomass of cotton (kg ha^{-1})		Addition of nutrients to soil through leaf litter biomass of cotton					
			2007-08 (kg ha^{-1})			2008-09 (kg ha^{-1})		
	2007-08	2008-09	Nitrogen	Phosphorous	Potassium	Nitrogen	Phosphorous	Potassium
Main plots								
A)Intercropping(6)								
I_{1-}Cotton+ blackgram	658.63	695.56	36.88	18.57	32.27	38.95	19.61	34.08
I_{2-}Cotton+ soybean	611.67	587.56	34.25	17.25	29.97	32.88	16.56	28.77
I_{3-}Cotton+pigeonpea	677.61	673.33	37.95	19.10	33.20	37.71	18.98	32.99
I_{4-}Cotton+ clusterbea	622.24	585.56	34.84	17.54	30.49	32.79	16.51	28.69
I_{5-}Cotton+ cowpea	504.37	611.11	28.24	14.22	24.71	34.22	17.23	29.94
I_{6-}Cotton+ marigold	542.81	563.33	30.39	15.30	26.60	31.55	15.88	27.60
SE (m) ±	8.53	1.75	0.47	0.24	0.42	0.98	0.49	0.86
CD at 5 %	25.00	5.14	1.40	0.70	1.22	2.88	1.45	2.51
B)Weed management (2)								
W_{1-} No weeding	536.67	567.69	30.05	15.13	26.30	31.76	16.00	27.81
W_{2-}Normal weeding	669.11	671.11	37.47	18.86	32.79	37.58	18.92	32.88
SE (m) ±	4.92	10.12	0.27	0.14	0.24	0.57	0.28	0.50
CD at 5 %	14.44	29.68	0.81	0.41	0.71	1.66	0.84	1.45
Sub plot								
C)Fertilitymanagement (3)								
F_{1-}75per centRDFto cotton	579.60	606.67	32.44	16.34	28.40	33.97	17.10	29.73
F_{2}100per centRDFtocotton	599.99	622.50	33.60	16.92	29.40	34.86	17.55	30.50
F_{3-}125per centRDFtocotton	629.07	628.89	35.29	17.74	30.82	35.22	17.73	30.82
SE (m) ±	5.82	8.30	0.33	0.16	0.28	0.47	0.23	0.41
CD at 5 %	16.55	NS	0.93	0.47	0.81	NS	NS	NS
Interactions(I×W×F)								
SE (m) ±	20.17	28.73	1.13	0.57	0.99	1.61	0.81	1.41
CD at 5 %	57.34	81.71	3.21	1.62	2.81	4.58	2.30	4.00
GM	602.89	619.35	33.76	18.00	29.54	34.58	17.46	30.35

Table 2. Interaction effects of Intercropping × Weed × Fertilizer management on leaf litter biomass production of cotton (kg ha^{-1})

Treats	2007-08				2008-09			
I×W×F	**F_1**	**F_2**	**F_3**	**Mean**	**F_1**	**F_2**	**F_3**	**Mean**
I_1W_1	527.57	591.07	672.90	597.18	523.33	533.33	733.33	596.66
I_1W_2	676.50	709.20	774.53	720.08	856.67	693.33	833.33	794.44
I_2W_1	511.77	531.57	533.40	525.38	566.67	506.67	450.00	507.78
I_2W_2	639.63	716.27	737.40	697.77	700.00	650.00	650.00	666.67
I_3W_1	504.40	540.97	549.43	531.60	590.00	616.67	523.33	576.67
I_3W_2	652.93	699.37	786.37	712.89	583.33	656.67	543.33	594.44
I_4W_1	387.53	432.63	454.47	424.88	566.67	533.33	466.67	604.44
I_4W_2	679.70	594.60	677.27	650.52	753.33	633.33	713.33	700.00
I_5W_1	427.33	474.47	538.43	480.08	540.00	533.33	533.33	535.55
I_5W_2	506.50	611.57	698.53	605.53	583.33	583.33	606.67	649.99
I_6W_1	603.57	681.67	696.87	660.70	633.33	633.33	733.33	666.66
I_6W_2	673.10	698.63	711.80	694.51	650.00	706.67	683.33	680.00
Mean	565.88	606.83	652.62	-	606.67	622.50	628.89	-
SEm±	20.17					28.73		
CD@ 5 %	57.14					81.71		

Table 3. Interaction effects of Intercropping × Weed × Fertilizer management on addition of nitrogen, phosphorous and potassium through fallen leaf litter of cotton during 2007-08 and 2008-09.

Treat Com	a) Addition of nitrogen (kgha^{-1})								b) Addition of phosphorous (kgha^{-1})							
	2007-08				2008-09				2007-08				2008-09			
IWF	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
I_1W_1	*29.54*	33.10	37.68	33.44	29.31	29.87	41.07	33.42	14.87	16.67	18.97	16.84	14.76	15.04	20.68	16.83
I_1W_2	39.71	37.88	43.37	40.32	38.83	46.67	47.97	44.49	19.07	20.00	21.84	20.30	19.55	23.49	24.15	22.40
I_2W_1	28.66	29.77	29.87	29.43	25.20	28.37	31.73	28.43	14.43	14.99	15.04	14.82	12.69	14.29	15.98	14.32
I_2W_2	35.82	40.11	41.29	39.07	36.40	36.40	39.20	37.33	18.03	20.19	20.79	19.67	18.33	18.33	19.74	18.8
I_3W_1	33.80	38.2	39.2	37.07	35.47	35.47	41.07	37.34	17.02	19.22	19.65	18.63	17.86	17.86	20.68	18.8
I_3W_2	37.69	39.12	39.86	38.89	36.40	38.27	39.57	38.08	18.98	19.70	20.07	19.58	18.33	19.27	19.92	19.17
I_4W_1	28.25	30.29	30.77	29.77	29.30	33.04	34.53	32.29	14.22	15.25	15.49	14.99	14.76	16.63	17.39	16.26
I_4W_2	36.56	39.17	44.04	39.92	30.43	32.67	36.77	33.29	18.41	19.72	22.17	20.1	15.32	16.45	18.51	16.76
I_5W_1	21.70	24.23	25.45	23.79	26.13	29.87	31.73	29.24	10.93	12.20	12.83	11.99	13.16	15.04	15.98	14.73
I_5W_2	26.86	33.30	37.93	32.70	35.47	39.95	42.19	39.20	13.52	16.76	19.10	16.46	17.86	20.11	21.24	19.74
I_6W_1	23.93	26.57	30.15	26.88	29.87	29.87	30.24	29.99	12.05	13.38	15.18	13.54	15.04	15.04	15.22	15.1
I_6W_2	28.36	34.25	39.12	33.91	32.67	32.67	33.97	33.10	14.28	17.24	19.70	17.07	16.45	16.45	17.11	16.67
Mean	30.91	33.83	36.57		32.12	34.43	37.53		15.48	17.11	18.40		16.18	17.33	18.88	
SEm±		1.13				1.61				0.57				0.81		
CD@5%		3.21				4.58				1.62				2.30		

Continued Table 3.....

TreatCom	c) Addition of potassium (kgha^{-1})							
	2007-08				2008-09			
IWF	F_1	F_2	F_3	Mean	F_1	F_2	F_3	Mean
I_1W_1	25.85	28.96	32.92	29.24	25.64	26.13	35.93	29.23
I_1W_2	33.15	34.75	37.95	35.28	33.97	40.83	41.98	38.93
I_2W_1	25.08	26.05	26.14	25.76	22.05	24.83	27.77	24.88
I_2W_2	31.34	35.10	36.13	34.19	31.85	31.85	34.30	32.67
I_3W_1	29.57	33.40	34.15	32.37	31.03	31.03	35.93	32.66
I_3W_2	32.98	34.23	34.88	34.03	31.85	33.48	34.63	33.32
I_4W_1	24.72	26.51	26.92	26.05	25.64	28.91	30.22	28.26
I_4W_2	31.99	34.27	38.53	34.93	26.62	28.58	32.18	29.13
I_5W_1	18.99	21.20	22.27	20.82	22.87	26.13	27.77	25.59
I_5W_2	23.50	29.13	33.19	28.61	31.03	34.95	36.91	34.30
I_6W_1	20.94	23.25	26.38	23.52	26.13	26.13	26.46	26.24
I_6W_2	24.82	29.97	34.23	29.67	28.58	28.58	29.73	28.96
Mean	26.91	29.73	31.97	-	28.10	30.12	32.82	
SEm±		0.99				1.41		
CD at 5 %		2.81				4.00		

+ cowpea. Increased addition of nitrogen to soil might be due to the inclusion of legumes as an intercrops which fixes atmospheric nitrogen, degenerate root nodules and absorption by plant at its late stage (Table1). The findings corroborates with the results reported by Giri *et al*., (2006).

During normal or higher rainfall year cotton + pigeonpea showed higher nutrient addition, while in rainfall deficit year (2008-09) cotton + blackgram recorded higher nutrient addition to the soil

b) Effect of weed management

Normal weeding recorded significantly higher addition of nitrogen, phosphorous and potassium through leaf litter biomass of cotton over no weeding during both the years of experimentation. Weeding might have improved the growth of cotton by reducing the competition between weed and crop for natural resources and absence of weeds permitted the availability of nutrients to the crop thereby increased nutrient content and their addition to the soil. The findings corroborates with the results reported by Prabhu Kumar *et al*., 2007 and Chalka and Nepalia, 2006). .

c)Effect of fertility management

Treatment of 125 per cent RDF application to base crop of cotton recorded significantly higher addition of nitrogen, phosphorous and potassium through leaf litter biomass of cotton over 100 per cent and 75 per cent RDF to cotton. Increased nitrogen might be due to efficient utilization of applied fertilizers by intercropping (Anuradha *et al*., 1988) and cumulative effect of better root development, higher root nodules and greater dry weight of biomass (Shivran and Ahlawat, 2000). Similarly, increased fertilizers dose might have increased P and K concentration in crop and ultimately increased addition of phosphorous to soil. While, 100 per cent RDF to base crop of cotton being par with 75 per cent RDF recorded equally effective quantity of phosphorous. Increased potassium might be due to advancement of crop age and increase in dry weight of leaf litter at harvest and thereby addition of potassium was higher (Belokar *et al*., 1992).

d) Interaction effect

The treatment combination of cotton + blackgram ($I_1W_2F_1$), cotton + soybean ($I_2W_2F_2$) and cotton + clusterbean ($I_4W_2F_3$) recorded significantly higher addition of nitrogen, phosphorous and potassium through leaf litter biomass of cotton during 2007-08 and 2008-09 (Table 3). But in mean, cotton + blackgram treatment combination recorded higher NPK addition to soil which was nearly followed by treatment of cotton + pigeonpea and cotton + clusterbean.

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Effect of Sowing Windows on New Mustard Genotype Under Vidarbha Region

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ABSTRACT

A field experiment was conducted at College of Agriculture, Nagpur during *Rabi* 2011-12 and 2013-14 under irrigated condition in split plot design replicated thrice with objective of adjusting the sowing date for higher productivity for new genotypes recommended for Vidarbha. The main treatments were four sowing dates, viz., D_1-10 th Oct., D_2-20 th Oct., D_3-30 th Oct. D_4-10 th Nov. and subplot treatments were mustard genotypes viz., V_1-Kranti, V_2-BIO-902 and V_3-GM-3. The recommended fertilizer dose i.e. 100per cent RDF was 50:40:0 NPK kg ha^{-1} under irrigated condition. The experiment was conducted on clayey soil with normal pH (7.6), medium in soil organic carbon(5.36 g kg^{-1}), low in available nitrogen (219.5 kg ha^{-1}), very low in available P_2O_5 (12.82 kg ha^{-1}) and very high in available K_2O (369.6 kg ha^{-1}). Number of siliqua plant^{-1} and seed yield plant^{-1} were significantly more due to 30 th October and 10 th Nov. sowing over 20 th Oct. sowing, while it was reduced by early, 10 th Oct. sowing during both the year. The seed yield per hectare was also significantly more due to 30 th oct. and 10 th Nov. over 20th oct. during both the year and in pooled results also. Similar trend of results was found in respect of stover yield. Among the genotypes the number of siliqua plant^{-1}, seed yield (g) plant^{-1} , seed and stover yield ha^{-1} were maximum and significantly more in GM-3 compared to check Kranti. Pooled results showed that GM-3 was significantly superior over check Kranti in terms of seed yield ha^{-1} and Bio-902 which was at par with Kranti.

Mustard (*Brassica juncea*) is an important *Rabi* oilseed crop under irrigated and rainfed condition and widely grown on large area in India. In India area under this crop is 6.5 million ha producing about 7.67 million tons of seeds with an average productivity of 1179 kg ha^{-1}. Rajasthan is the largest producer of mustard seed in the country with a contribution of 54 per cent to the country's total mustard seed production followed by Punjab and Haryana, which together contributes 14 per cent, Now a day's mustard is spreading to non-traditional areas like Maharashtra, Andhra Pradesh, Tamilnadu and Karnataka. Area under cultivation in Maharashtra was 7700 hectare with production of 3000 tons and productivity of 383 kg ha^{-1} (Anonymous, 2012) and in Vidarbha area under this crop is 2200 hectare with production of 800 tons and productivity of 312 kg ha^{-1} (Anonymous, 2011).

The productivity of mustard is low in Maharashtra. There are many reasons for low productivity of mustard. The major cause for low productivity is the proper management and suitability of cultivar for the region. The optimum management is necessary for yield maximization of mustard which is emerging as a newer crop in various cropping systems in Vidarbha region of Maharashtra. Some promising genotypes are identified for the zone IV comprising the Vidarbha area . The performance of such promising genotypes need to be tested in the agronomic trial for zone under irrigated condition. With objective of optimizing the sowing date for higher productivity for new entries recommended for Vidarbha, present investigation was planned to find out optimum sowing time for maximum yield and suitable entries in changing climate scenario.

MATERIAL AND METHODS

A field experiment was conducted at College of Agriculture, Nagpur during *Rabi* 2011-12 and 2013-14 under irrigated condition in split plot design replicated thrice. The main treatments were four sowing dates, viz., D_1-10 th Oct.(41 st MW), D_2-20 th Oct.(42 nd MW), D_3-30 th Oct.(44 th MW) D_4-10 th Nov. (45 th MW) and subplot treatments were mustard genotypes viz., V_1-Kranti, V_2-BIO-902 and V_3-GM-3. The recommended fertilizer dose of 50:40:0 NPK kg ha^{-1} was applied under irrigated condition. The experiment was conducted on clayey texture soil with normal pH (7.6), medium in soil organic carbon(5.36 g kg^{-1}), low in available nitrogen (219.5 kg ha^{-1}), very low in available P_2O_5 (12.82 kg ha^{-1}) and very high in available K_2O (369.6 kg ha^{-1}).

The observation on plant height at harvest, days to physiological maturity, days to 50 per cent flowering, number of siliqua plant^{-1}, yield plant^{-1}, test weight, yield ha^{-1} were recorded. Yield plant^{-1}, number of siliqua

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Table 1. Growth and yield attributes as influenced by sowing dates and varieties

Treatments	Days to 50 per cent flowering		Days to physiological maturity		Plant height (cm)		No. of branches		Test weight (g)		Number of siliqua /plant		
	11-12	13-14	11-12	13-14	11-12	13-14	11-12	13-14	11-12	13-14	11-12	13-14	Pooled
Main- Dates													
D_1 - 10th Oct.	41.8	51.2	92.2	91.7	123.8	93.9	3.1	3.0	4.4	3.9	83.6	52.3	68.0
D_2 - 20th Oct.	38.8	50.8	93.8	91.2	127.4	122.3	3.1	3.2	4.8	4.1	100.8	71.8	86.3
D_3 - 30th Oct.	39.6	49.5	88.8	88.2	135.8	122.3	3.5	3.4	4.9	4.3	135.2	88.3	111.8
D_4 - 10th Nov	40.0	48.8	86.9	87.8	128.1	121.2	4.5	4.1	4.9	4.5	129.8	117.8	123.8
SE (m) ±	0.3	0.1	0.5	0.3	3.15	2.73	0.35	0.13	-	-	6.83	3.2	5.5
D at 0.05	0.9	0.2	1.6	1.1	10.78	9.46	NS	0.45	-	-	23.63	11.2	19.05
Sub-Varieties													
V_1 - Kranti	39.8	50.8	90.0	89.4	132.0	119.4	3.6	3.3	3.9	3.8	103.7	79.1	91.4
V_2 - BIO-902	40.3	49.5	91.1	89.8	123.1	107.5	3.5	3.4	5.7	5.3	102.0	76.0	89.0
V_3 - GM-3	39.9	49.3	90.7	89.8	131.3	112.2	3.6	3.6	4.8	4.5	131.3	88.5	109.9
SE (m) ±	0.4	0.4	0.4	0.3	2.95	1.99	0.20	0.18	-	-	4.50	5.0	3.6
D at 0.05	NS	NS	NS	NS	NS	5.80	NS	NS	-	-	13.48	NS	10.79
Int.													
SE (m) ±	0.7	0.9	0.9	0.6	5.89	3.97	0.40	0.36	-	-	9.00	9.9	14.3
CD at 0.05	NS	NS	NS	NS	NS	NS	NS	NS	-	-	27.0	NS	NS

Table 2.Yield attributes and yield as influenced by sowing dates and varieties

Treatments	Seed yield plant^{-1} (g)			Seed yield kg ha^{-1}			Stover yield q ha^{-1}		Harvest index %	
	11-12	13-14	Pooled	11-12	13-14	Pooled	11-12	13-14	11-12	13-14
Main- Sowing Date										
D_1 - 10th Oct.	1.78	1.90	1.84	399.1	418.6	409.0	26.6	24.6	12.9	14.8
D_2 - 20th Oct.	2.07	2.13	2.10	490.5	490.2	490.0	29.6	24.6	14.3	17.0
D_3 - 30th Oct.	2.66	3.27	2.97	673.2	829.9	752.0	36.5	42.3	15.6	16.4
D_4 - 10th Nov.	2.67	3.41	3.04	644.4	874.2	759.0	33.9	42.1	16.0	17.3
SE (m) $\pm$	0.11	0.09	0.11	36.2	28.0	35.42	1.21	1.19	-	
D at 0.05	0.39	0.32	0.38	125.3	97.0	122.72	4.18	4.13	-	
Sub-Varieties										
V_1 - Kranti	2.01	2.60	2.31	497.3	630.1	564.0	28.1	31.2	14.6	16.4
V_2 - BIO-902	2.37	2.83	2.60	514.4	699.7	607.0	29.9	31.8	14.4	18.3
V_3 - GM-3	2.49	2.73	2.61	643.7	668.2	656.0	36.9	35.5	15.0	15.7
SE (m) $\pm$	0.08	0.09	0.07	23.9	27.9	18.17	1.5	1.7	-	
CD at 5per cent	0.24	NS	0.20	71.5	NS	54.57	4.6	NS	-	
Int.										
SE (m) $\pm$	0.16	0.19	0.27	47.7	55.8	37.75	3.1	3.4		
D at 0.05	0.48	-	0.81	143.05	-	80.03	-	-		

Table 3. Interaction effect as influenced by the interaction (2011-12 and Pooled)

Sowing Date X Variety		Seed yield kg ha^{-1} 2011-12	Siliqua plant $^{-1}$ 2011-12	Seed yield g plant $^{-1}$ 2011-12	Seed yield kg ha^{-1} (Pooled)
D_1-10 th Oct.	V_1-Kranti	317	69.8	1.46	365.5
	V_2-BIO-902	327	66.6	1.66	359.9
	V_3-GM-3	553	114.3	2.21	492.6
D_2-20 th Oct.	V_1-Kranti	357	77.3	1.58	397.9
	V_2-BIO-902	477	94.9	2.20	518.0
	V_3-GM-3	637	130.1	2.43	573.5
D_3-30 th Oct.	V_1-Kranti	795	159.8	2.91	840.8
	V_2-BIO-902	553	109.2	2.46	758.0
	V_3-GM-3	672	136.7	2.60	700.4
D_4-10 th Nov.	V_1-Kranti	520	108.0	2.10	650.4
	V_2-BIO-902	702	137.2	3.17	792.0
	V_3-GM-3	712	144.2	2.72	857.5
	SE(m)±	47.72	9.00	0.16	37.15
	CD at 5%	143.05	26.97	0.48	111.36

plant^{-1} and test weight were recorded on five observational plant while the yield ha^{-1} was based on net plot yield.

RESULTS AND DISCUSSION

Effect of sowing dates

The days to 50 per cent flowering and days to physiological maturity were significantly least due to late sowing date 10th November and with early sowing dates the maturity days increased during both the year of experimentation. Significantly higher plant height was recorded when the crop was sown on D_3-30th Oct over D_1-10th Oct. sowing, during both the year of experimentation. The number of branches were maximum with 10th Nov. sowing during both the year but effect was significant during 2013-14 only. Test weight maximum due to 10th Nov. sowing fallowed by the 30th oct sowing. The number of siliqua plant^{-1} were maximum and significantly more due to 30 th oct sowing fallowed by 10th Nov and were significantly higher over 10th and 20th oct sowing during 2011-12 but during the 2013-14 maximum and significantly higher number of siliqua plant^{-1} were recorded due to 10th Nov. sowing. The pooled results over two years showed that, 10th Nov. sowing recorded maximum(123.8) and significantly higher siliqa plant^{-1} fallowed by 30th Oct. sowing which was at par. The seed yield (g) plant^{-1} was maximum and significantly more under 10 th Nov. sowing and 30 th oct. sowing was found at par during both years as well as in pooled results. The seed yield kg ha^{-1} was significantly higher due to 30th Oct. and 10th Nov. sowing over 10th oct and 20th oct. during both the year and in pooled results also. The per cent increase in seed yield in pooled results were 53 per cent and 55 per cent by 30th Oct and 10th Nov. sowing over the 20th Oct. sowing. The stover yield was maximum and significantly higher due to 30th Oct. sowing fallowed by the 10th Nov. and both these sowing dates recorded significantly higher stover yield during both the years. The harvest index recorded increased trend from 10th Oct. to 10th Nov. sowing during both the year.

Effect of genotypes

Days to 50 per cent flowering, days to physiological maturity were not influenced significantly by the varieties. The plant height was maximum in Kranti which is check and lowest in BIO-902 and GM-3 during both the year and it was significantly less during 2013-14 which may be the varietal character. Number of branches

were not influenced significantly during both the year of experimentation. Test weight was maximum in BIO-902 fallowed by GM-3 higher than the check *Kranti* which might be attributed to varietal character. The number of siliqua plant^{-1} was maximum in GM-3, but the effect was significant only during 2011-12 and in pooled results. The seed yield plant^{-1} was maximum and significantly higher due to GM-3 over check *Kranti* and BIO-902 recorded at par seed yield plant^{-1} during 2011-12 and in pooled results, but during 2013-14 it was non significant.

Pooled results of seed yield kg ha^{-1} was found maximum and significantly higher due to GM-3 over Kranti and BIO-902 was at par with GM-3. This might be due more siliqua plant^{-1} and seed yield plant^{-1} as evidenced from the data. Anonymous (2011) and Anonymous (2013) also reported significantly higher yield due to BIO-902 among the different entries. Similarly the GM-3 recorded numerically higher stover yield but effect was significantly higher during 2011-12 only and non significant during 2013-14.

Interaction Effects

Interaction effects were found significant during the 2011-12 and pooled over seasons in respect of seed yield kg ha^{-1} and g plant^{-1} and siliqua plant^{-1}. The interaction effect in respect of pooled seed yield kg ha^{-1} was also significant where GM-3 sown on 10 th Nov. recorded maximum (857.5 kg ha^{-1}) and significantly higher seed yield ha^{-1} fallowed by Kranti sown on 30th Oct., BIO-902 sown on 10th Nov. and 30th Oct. which were at par.

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Evaluation of Pre and Post Emergence Herbicides on Weed Flora and Yield of Greengram

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ABSTARCT

An experiments was conducted during *Kharif* season to study the efficacy of pendimethalin as pre-emergence (PE), pendimethalin + imazethapyr (premix) as PE, imazethapyr, quizalofop-ethyl and fenoxoprop-ethyl as post-emergence (POE) on seed yield in greengram. The maximum increase in seed yield was occurred with pendimethalin @ 1.0 kg ha^{-1} as PE (1008 kg ha^{-1}), pendimethalin + imazethapyr @ 0.75 kg ha^{-1} as PE (987 kg ha^{-1}), imazethapyr @ 0.100 kg ha^{-1} as POE (981 kg ha^{-1}). Higher weed control efficiency was registered with the application of pendimethalin + imazethapyr @ 1.0 kg ha^{-1} as PE (96.77%), pendimethalin + imazethapyr @ 0.75 kg ha^{-1} as PE (96.13 %) and imazethapyr @ 0.075 kg ha^{-1} at 20 DAS (96.13 %). Higher monetary return was obtained with application of pendimethalin+imazethapyr @ 0.75 kg ha^{-1} as PE (Rs.29228 ha^{-1}) followed by pendimethalin @ 1.0 kg ha^{-1} as PE (Rs.29219 ha^{-1}), imazethapyr @ 0.100 kg ha^{-1} as POE (Rs.28028 ha^{-1}) over weedy check (Rs.14750 ha^{-1}). The higher BCR was obtained with pendimethalin + imazethapyr @ 0.75 kg ha^{-1} as PE at 20-25 DAS (1.81) and pendimethalin @ 1.0 kg ha^{-1} (1.81). Quizalofop-ethyl, fenoxoprop-ethyl and imazethapyr @ 0.050 kg ha^{-1} at 20-25 DAS did not provide satisfactory weed control in greengram fields.

Greengram is recommended for cultivation mainly in *Kharif* season on onset of monsoon in Maharashtra. At the same time, number of weeds, comes up simultaneously with the emergence of crop. Mechanical practices such as hand weeding and interculturing are effective but unavailability of labour, and incessant rains during the early crop season normally limit the weeding operations. Therefore chemical weed control practice under such circumstances become indispensible and can be the excellent alternative. Weed management in greengram is labour-intensive or involves intensive use of herbicides. The efficacy of post-emergence herbicide application is highly dose-sensitive and time/stage-dependent, and, therefore, sometimes may lead to phytotoxic effects on crops. Even selective herbicide poses risk when applied as post-emergence at higher dose. The leaves of crop can be burnt, shriveled or discolored when herbicides are sprayed. This damage can be extensive, and sometimes over 40per cent of the leaves of crop plants is damaged. In addition to giving crops a poor cosmetic appearance, plants can be weakened, their growth phases retarded and stunted. In contrast, pre-emergence application is less risky (Das, 2008). The higher moisture content of the soil, better the control efficacy of pendimethalin. Manual weeding is some time difficult in rainy season for efficient weed control. This warrants the use of pre and post-emergence herbicides for weed control, therefore, post-emergence herbicides were used to weed-control, including grasses and broadleaf weeds and their phytotoxicity, if any, to the crop. With this objective, efficacy of different pre and post-emergence herbicides in comparison to hand weeding (HW) was evaluated in greengram.

MATERIAL AND METHODS

A field study was conducted to study the effect of pre and post emergence herbicides on greengram during the *Kharif* season of 2011. The soil of experimental site was clayey with pH 8.14, having available nitrogen 229 kg ha^{-1}, available phosphorous 18.10 kg ha^{-1}, available potassium 344 kg ha^{-1} and organic carbon was 4.6 g kg^{-1}. The experiment was laid out in randomized block design having three replications. The treatment comprised of weedy check (without removal of weeds), weed free (weeding done weekly to keep the plot free of weeds), hand weeding twice at 20 and 40 DAS, pendimethalin 30 EC and pendimethalin 2 EC + imazethapyr 30 EC (premix) as pre-emergence and three post-emergence herbicides *viz.*, imazethapyr 10 EC, quizalofop-ethyl 10 EC and fenoxoprop-ethyl @ 10 EC. All the herbicides were applied 20 days after sowing (DAS) with knapsack sprayer fitted with flat-fan nozzle using 500 litres water ha^{-1}. Data on weed density and dry weight of weeds were recorded at 30 DAS and at harvest using quadrates 1.0 x 1.0 m. Greengram seed was treated with carrier based *Rhizobium* and PSB, each at the rate of 2.5 g kg^{-1} seed and mixed well

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to ensure the inoculums to stick on to the surface of the seeds. The treated seeds were dried in shade for an hour and used for sowing. The N and P through urea and diammonium phosphate were applied as basal at sowing. The economic analysis of each treatment was done on the basis of prevailing market rates of the inputs used and out-puts obtained under each treatment. The crop was sown on 6 July 2011 and was harvested on 17 September 2011. The total rainfall received during the crop growth period was 462.6 mm in 34 rainy days. The required plant population (45 cm row to row and 10 cm plant to plant) was maintained by thinning plants after three weeks of sowing. Benefit cost ratio was calculated over net benefit.The sale price of greengram seed was taken @ 45 kg^{-1}.

Table 1. Mean monthly temperature (°C), precipitation (mm) and rainy days during the seasons.

Month	Max. Temp.	Min. Temp.	Precipitation	Rainy days
June	36.5	25.8	81.2	6.0
July	31.7	24.2	166.2	12.0
August	30.2	23.5	126.6	10.0
September	30.8	23.0	88.6	6.0
Total	**-**	**-**	**462.6**	**34.0**

RESULTS AND DISCUSSION

Effect on weed

The weed flora emerges during the period of experimentation were: grasses like *Cynodon dactylon, Dactylectinum aegyptium* and *Bracharia* sp.; sedges like *Cyperus rotundus* and borad-leaved weeds like *Amaranthus viridis, Commelina benghalensis, Digeria arvensis, Parthenium hysterophorus, Physalis minima, Phyllanthus niruri, Tridax procumbens and Acalypha indica*. Grasses and sedges especially, *Cyperus rotundus* appeared during the initial growth stages, whereas broad-leaved weeds emerged later. These weeds emerged during 15 to 20 DAS thereafter continuously throughout the growth stages. Higher weed control efficacy and long lasting effects of imazethapyr in reducing weed dry matter might be primarily appeared due to broad-spectrum activity of herbicides particularly on established plants of both narrow and broad leaf weeds and its greater efficiency to retard cell division of meristems as a result of which weeds died rapidly. The result was confirmed by the findings of Kantar *et al*. (1999), where about 84.6 per cent weed biomass was controlled with application of imazethapyr. Richburg *et al*. (1996) reported that imazethapyr controlled C*yperus rotundus* more effectively when applied to weeds 5 to 20 cm tall compared with weeds 30 cm tall. Application of quizalofop-ethyl was effective for the plots where only grassy weeds were dominated as against imazethapyr which was effective against annual broadleaf weeds, grassy weeds and perennial sedges.

Effect on crop

The weed free treatment produced significantly maximum greengram yield (1191 kg ha^{-1}) over remaining treatments excepting hand weeding twice (1176 kg ha^{-1}). Among the herbicides pendimethalin as pre-emergence (PE) @ 1.0 kg ha^{-1} recorded statistically equivalent seed yield (1008 kg ha^{-1}) with pendimethalin+imazethapyr (premix) @ 0.75 kg ha^{-1} as pre-emergence (987 kg ha^{-1}), imazethapyr @ 0.100 kg ha^{-1} as post-emergence (981 kg ha^{-1}) and 0.075 kg ha^{-1} (925kg ha^{-1}) at 20-25 DAS, respectively. Younesabadin *et al*. (2013) reported significantly higher seed yield with tank-mix pre-emergence application of pendimethalin 0.5 kg ha^{-1} + imazethapyr 0.075 kg ha^{-1} in soybean. Raskar and Bhoi (2002) opined that pre plant incorporation of pemdimethalin + imazethapyr has been developed to control grassy and broad leaf weeds respectively. Pendimethalin 1.5 kg ha^{-1} pre emergence application did well in controlling all weeds compared to manual weeding at 25 DAS and 35 DAS. The significantly lower seed yield was recorded with the application of fenoxoprop-ethyl @ 0.075 kg ha^{-1} (718 kg ha^{-1}) and quizalofop-ethyl @ 0.075 kg ha^{-1} (728 kg ha^{-1}) as post-emergence (POE) at 20-25 DAS. Among pre-emergence herbicides application of pendimethalin + imazethapyr showed slight stunted growth and degree is more with higher level, but it proves beneficial for variety under investigation as it is tall growing.

Weed free (98.06 %) and hand weeding twice (96.13 %) recorded significantly higher weed control efficiency over all other treatments. Amongst herbicidal treatments higher weed control efficiency was observed with pre-emergence application of pendimethalin + imazethapyr @ 1.0 kg ha^{-1} as pre-emergence (96.77 %), pendimethalin + imazethapyr @ 0.75 kg ha^{-1} as pre-emergence (96.13 %), and post-emergence application of imazethapyr @ 0.075 kg ha^{-1} at 20 DAS (96.13 %). Weed index was computed as the yield reduction comparative to highest yielding treatment i.e. weed free. Among the

Table 2. Seed and straw yield, dry matter of weeds and economics of greengram as influenced by different weed management

Treatment	Weed dry weight(g/m^2) At		Weed index	WCE	Yield	CC	GMR	NMR	BCR
	30 DAS	Harvest	(%)	(%)	(kg ha^{-1})	(Rs ha^{-1})	(Rs ha^{-1})	(Rs ha^{-1})	
Pendimethalin 1.0 kg/ha as PE	5.9	0.9	15.37	94.19	1008	16141	45360	29219	1.81
Pendimethalin 30 EC + Imazethapyr	1.0	0.6	17.13	96.13	987	17919	44430	29228	1.81
2 EC (premix) @ 0.75 kg/ha as PE									
Pendimethalin 30 EC + Imazethapyr	0.2	0.5	23.93	96.77	906	18874	40770	25839	1.60
2 EC (premix) @ 1.0 kg/ha as PE									
Quizalofop-ethyl @ 0.075 kg/ha at 20-25 DAS	11.06	5.5	38.87	64.52	728	15162	32745	16682	1.03
Fenoxoprop-ethyl @ 0.075 kg/ha at 20-25 DAS	15.6	5.6	39.71	63.87	718	14931	32310	15901	0.99
Imazethapyr @ 0.050 kg/ha at 20-25 DAS	8.4	1.5	31.49	90.32	816	15022	36720	21698	1.34
Imazethapyr @ 0.075 kg/ha at 20-25 DAS	6.8	0.6	22.33	96.13	925	15615	41625	26010	1.61
Imazethapyr @ 0.100 kg/ha at 20-25 DAS	2.6	1.6	17.63	89.68	981	16122	44130	28028	1.74
HW at 20 and 40 DAS	0.2	0.6	1.26	96.13	1176	19292	52935	32443	2.01
Weed free plot	0.4	0.3	0.00	98.06	1191	24022	53595	30073	1.86
Weedy check	23.7	15.5	47.52	0.00	625	13390	28140	14750	0.91
CD 5% level	—	—	—	—	138	—	6221	6221	—

weed management practices HW twice registered minimum weed index (1.26) followed by pre-emergence application of, pendimethalin @ 1.0 kg ha^{-1} as PE (15.37) and pendimethalin + imazethapyr as PE @ 0.75 kg ha^{-1} (17.13) and post-emergence application of imazethapyr @ 0.100 kg ha^{-1} (17.63). Post emergence application of fenoxoprop-ethyl @ 0.075 kg ha^{-1} and quizalofop-ethyl @ 0.075 kg ha^{-1} recorded maximum weed index i.e. 39.71 and 38.87 per cent respectively, indicating the reduction in greengram seed yield due to presence of weeds throughout crop growth period. Lower weed index in chemical treatments alone and mechanical weed control practices might be due to better weed control which provided favourable conditions for crop growth which ultimately increased the seed yield of greengram crop as compared to absolute control treatment.

Economics

Among the weed-control treatments, pendimethalin + mazethapyr @ 0.75 kg ha^{-1} as PE (Rs.29228 ha^{-1}) followed by pendimethalin @ 1.0 kg ha^{-1} as pre-emergence (Rs.29219 ha^{-1}) followed by imazethapyr @ 0.100 kg ha^{-1}a as post-emergence (Rs.28028 ha^{-1}) and imazethapyr 0.075 kg ha^{-1}a as POE (Rs.26010 ha^{-1}) gave the maximum monetary returns over weedy check (Rs.14750 ha^{-1}), due to excellent control of grassy and broad-leaf weeds without any adverse effect on crop growth due to optimum soil moisture. Lower monetary returns which is at par with each other was recorded with fenoxoprop-ethyl @ 0.075 kg ha^{-1} (Rs.15901 ha^{-1}), quizalofop-ethyl @ 0.075 kg ha^{-1} (Rs.16682 ha^{-1}) due to inability of this herbicides to control weeds. Among the weed-control treatments, highest benefit ratio (1.81) was recorded with pendimethalin+imazethapyr @ 0.75 kg ha^{-1} followed by pendimethalin @ 1.0 kg ha^{-1} (1.81) and least with fenoxoprop-p-ethyl @ 0.100 kg ha^{-1} (0.99).

Pre-emergence application of pendimethalin + imazethapyr @ 0.75 kg ha^{-1} or application of pendimethalin @ 1.0 kg ha^{-1} or imazethapyr @ 0.100 kg ha^{-1} at 20-25 DAS was found effective in weed control.

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Studies on Productivity and Nutrient Gain as Influenced by Tillage Practices and Soybean Based Crop Sequences Under Irrigated Condition

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ABSTRACT

An experiment was carried out for five years at the Research Farm of Integrated Farming System Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (MS) during 2007-08 and 2011-12 with an object to find out the suitable method of tillage, soybean based crop sequence, equivalent yield, possibility of reducing cost and period of seedbed preparation. Results revealed that the broad bed furrow method recorded significantly higher values for grain and straw yields, monetary returns and gain of nutrients at the end of experiment. Among the crop sequences, soybean-safflower being par with soybean- chickpea and soybean- mustard recorded significantly more soybean grain yield over soybean-sorghum sequence. Soybean - safflower being par with soybean - chickpea registered significantly higher soybean grain equivalent yield over other sequences. In case of monetary returns, soybean - chickpea being par with soybean - safflower and soybean - sorghum recorded significantly more GMR (Rs. 89762 ha^{-1}), NMR (Rs. 63205/ha.) and B: C ratio (3.86). While, NPK and OC were observed maximum under soybean - chickpea crop sequence.

The main thrust of intensive farming system is to maximize productivity in both space and time dimension. This can be accomplished by efficient utilisation of scarce resources like land, labour and other inputs. Under irrigation, double cropping sequence is widely practised. Inclusion of legumes and oilseed in cropping systems is a substitute to augument productivity and profitability (Yadav *et al.*, 1998). Crops in sequence should be grown with the aim of maintaining soil fertility and productivity. Soybean- wheat crop sequence is commonly practiced in the semiarid to sub humid tropical regions of the country. In this system, yield is low owing to soil fertility and other production constraints. There is a greater emphasis on crop diversification due to growing concern about the un-sustainability of this system. In this context, a crop like soybean has emerged as a promising alternative for cotton and other crops. After harvest of soybean, various pulses, oilseeds and cereals are sown with limited irrigation. Generally, 4-5 intensive tillage operations are carried out by the farmers before sowing of *Kharif* crops, which resulted into higher cost of cultivation. Use of suitable pre-emergence weedicide to control the weeds under zero tillage cultivation is necessary because weeds often pose a serious constraint in realizing potential yield of soybean (Kumar *et al.*, 2012). All weeds growing previously are killed by pre sowing tillage and delayed emergence of new weeds. The closer crop spacing and wider furrow spacing lower down the weed population. Weeds got smothered due to advancement of crop growth and development of crop canopy cover (Balyan *et al.*, 1999). Moisture conservation practices like BBF, furrow opening and soil mulch etc. have effective role in making more soil moisture available to crops at later crop development stages. The reason is that conservation / tillage practices increased soil moisture and thereby increased grain yield (Barai *et al*., 1991). Considering all above, an attempt was made to see the effect of tillage and irrigated soybean based cropping sequence on productivity and nutrient status at the end of experiment.

MATERIAL AND METHODS

Five years experiment was carried out at the Research Farm of Integrated Farming System Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (MS) during 2007-08 to 2011-12. The experimental site was levelled and uniform in topography. The soil was medium to deep black (46 cm soil depth) belonging to *vertisols*. Soil consisted of clay-52 per cent, silt-12.8 per cent and sand -35.2 per cent. It was clayey in texture and moderately alkaline in nature (p^H 8.3). As regards initial nutrient status it was medium in organic carbon content (0.43per cent) and available NPK (205, 15.35 and 306 kg/ha). The experiment was laid out in split plot design and replicated thrice. The main plot treatments were tillage methods (4) viz., T_0- No tillage (sowing without cultivation and weed control by weedicide – pendimethalin @1.0 EC pre-emergence), T_1- Minimum tillage (1 harrowing), T_2 – Conventinal tillage (2 harrowings) and T_3 – Broad bed

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furrow (1 harrowing + 1 BBF opening). Tillage operations were carried out in *Kharif* season before sowing of soybean and same were used for *rabi* crops. Sub plot treatments were of soybean based crop sequences (4) viz., C_1 - Soybean - safflower, C_2 - Soybean – chickpea, C_3 - Soybean- mustard and C_4 - Soybean- sorghum. The University released varieties viz., TAMS-38, AKS-207, Jaki-9218, Pusa bold and PKV Kranti of crops soybean, safflower, chickpea, mustard and sorghum respectivelywere taken and crop wise recommended package of practices were adopted. *Rainfed* soybean was sown in *Kharif* season after receiving sufficient mansoon rain and after harvesting of soybean, *rabi* crops were sown under irrigated condition. Three channel irrigations before sowing and at flowering and fruiting were applied. Rainfall recorded during experimental years was 771.00 mm (2007-08), 528.20 mm (2008-09), 704.60 mm (2009-10), 1054.30 mm (2010-11) and 582.48 mm (2011-12).

RESULTS AND DISCUSSION

Pooled data presented in (Table1) showed the influence of various treatments on crop grain and straw yields, soybean grain equivalent yield, monetary returns and nutrient status of soil at the end of experiment.

Productivity and profitability

Effect of tillage practices

Among tillage methods (Table1), broad bed furrow method recorded significantly superior values for grain and straw yields, soybean grain equivalent yield and monetary returns. The decreasing trend of above mentioned characters was observed in sequence of broad bed furrow – conventional – minimum – no tillage methods. Increase in yield might be probably due to the moisture conservation practices found effective to check evaporation losses from soil surface and thus make more moisture available to crop at the later stages of crop development and hence yield increases. Similar results were reported by Barai *et al*., (1991).

Effect of crop sequence

Among the crop sequences, soybean – safflower being par with soybean – chickpea and soybean- mustard recorded significantly higher soybean grain yield and soybean grain equivalent yield. All crop sequences were found effective in recording maximum soybean straw yield. In case of *Rabi* crops grain yield, soybean – sorghum recorded significantly superior grain yield and fodder yield (22.36 and 68.58 q ha^{-1}) over rest of crop sequences. The higher straw yield in sorghum and safflower might be due to elongated stem of sorghum and long and spreading habit of safflower (Anonymous, 2012). Soybean – safflower being par with soybean – chickpea recorded significantly higher soybean grain equivalent yield over rest of sequences (Raskar *et al*., 2000). Treatment of soybean – sorghum resulted in recording significantly more soybean grain equivalent yield over soybean - mustard. The crop sequences of soybean – chickpea, soybean – safflower and soybean – sorghum being par recorded significantly higher monetary returns and B: C ratio over soybean – mustard.

Effect of interaction

Interaction effect was found significant. Treatment combination of broad bed furrow × crop sequence soybean-chickpea (T_3C_2) recorded significantly higher *Rabi* crops grain yield, soybean grain equivalent yield and monetary returns over rest of the treatment combinations except T_3C_1 i.e. BBF in combination with soybean-safflower.Soybean-sorghum and soybean-safflower were at par.

Nutrient balance sheet

Effect of tillage practices

The organic carbon content (6.60 g kg^{-1}) was registered by no tillage method. Higher carbon content in no tillage might be due to addition of organic matter through weeds at latter crop growth stage. Similar results were also reported by Sema Sepat and Rana, (2013) and further they have stated the zero tillage and residues linked to subsequent lesser oxidation of organic carbon content over the years. The restriction of tillage, improves soil structure especially micro-aggregates which actively hold liable carbon for longer period and hence organic carbon content increased in soil (Table2).

Effect of crop sequence

Whereas, nutrient status showed the higher gain of NPK (35.0, 4.34, 65.0) and organic carbon content (6.70 g kg^{-1}) through soybean – chickpea crop sequence at the end of experiment. This might be due to inclusion of legumes in cropping systems as they improves and maintain soil fertility. Similar results were reported by Dharma and Sinha (1985).

CONCLUSION

Based on five years experimental results it is concluded that adoption of broad bed furrow method of

Table 1. Pooled yield, equivalent yield, monetary returns and B: C ratio as influenced by tillage and soybean based crop sequences during 2007-08 to 2011-12 (five years pooled)

Treatments	Soybean yield(kg ha^{-1})		Rabi crops yield (kg ha^{-1})		Soybean equivalent yield (kg ha^{-1})	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	Cost of cultivation (Rs ha^{-1})	B: C ratio
	Grain	Straw	Grain	Straw					
Main plot- Tillage									
T0- No tillage	1561	3361	1236	3828	2613	63598	41665	21933	3.11
T1- Minimum tillage	2060	3597	1526	4348	3336	80120	56531	23589	3.76
T2- Conven. tillage	2318	3688	1824	4784	3851	91788	64311	27477	3.68
T3- BBF	2638	4018	2139	5261	4442	105539	76334	29205	3.95
SEm(±)	3.60	6.10	3.00	7.20	4.70	1028	1052	-	-
CD at 5 %	12.20	21.00	10.20	24.70	16.10	3561	3645	-	-
Sub plot- Crop sequence									
C1- Soy - safflower	2194	3712	1778	4799	3824	88219	63205	25014	3.86
C2- Soy - chickpea	2118	3548	1636	3257	3774	89762	63189	26573	3.67
C3-Soy - mustard	2190	3690	1074	3308	3247	75324	50386	24938	3.30
C4-Soy - sorghum	2069	3715	2236	6858	3396	87741	62061	25680	3.67
SEm(±)	2.80	5.60	3.20	7.80	3.80	879	871	-	-
CD at 5 %	8.00	-	9.00	22.60	10.90	2559	2538	-	-
Interaction									
SEm(±)	5.60	11.10	6.30	15.60	7.60	1757	1742	-	-
CD at 5 %	-	-	18.30	-	22.00	5119	5076	-	-

Table 2. Effect of interaction of tillage × crop sequence on yield, equivalent yield gross and net monetary returns asinfluenced by tillage and soybean based crop sequences during 2007-08 to 2011-12 (five years pooled)

	Grain/seed yield of rabi crops (kg ha^{-1})				Soybean grain/seed equivalent yield (kg ha^{-1})				Gross returns (Rs ha^{1})				Net returns (Rs ha^{1})			
Treatments	**C1**	**C2**	**C3**	**C4**	**C1**	**C2**	**C3**	**C4**	**C1**	**C2**	**C3**	**C4**	**C1**	**C2**	**C3**	**C4**
T0	1295	1241	865	1545	2871	2770	2493	2318	66765	61784	58324	62519	45341	43795	37029	40494
T1	1605	1387	972	2139	3476	3429	3056	3383	80433	81650	71067	87332	57363	56953	48057	63750
T2	2008	1773	1142	2371	4167	4066	3502	3668	95938	96407	80887	93921	69020	67969	54029	66227
T3	2209	2142	1348	2890	4784	4830	3936	4216	109740	114204	91017	107194	81094	84039	62431	77772
SE (m) ±	0.63	0.76	1757	1742												
CD at 5 %	1.83	2.20	5119	5076												

Table 3. Nutrients balance sheet of soil as influenced by tillage and soybean based crop sequences during 2007-08 to 2011-12

Treatments	**Nitrogen (kg ha^{-1})**	**Phosphorous (kg ha^{-1})**	**Potassium (kg ha^{-1})**	**Organic carbon (g kg^{-1})**	**Treatments**	**Nitrogen (kg ha^{-1})**	**Phosphorous (kg ha^{-1})**	**Potassium (kg ha^{-1})**	**Organic carbon (g kg^{-1})**
a)Main plot- Tillage	**b)**				**Subplot- Crop sequences**				
T0 - No tillage	19.00	2.91	45.00	6.60	**C1**-Soy-safflower	29.00	3.08	49.00	6.00
T1 - Minimum tillage	21.00	3.19	51.00	6.40	**C2**-Soy- chickpea	35.00	4.34	65.00	6.70
T2 - Conven. tillage	23.00	2.82	58.00	6.10	**C3**-Soy- mustard	30.00	3.54	51.00	6.20
T3 - BBF	26.00	3.63	61.00	6.20	**C4**-Soy - sorghum	28.00	4.32	55.00	5.80

tillage with soybean – chickpea crop sequence is beneficial for getting higher yield, monetary returns and maintaining soil fertility under irrigated condition.

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Soil Enzyme Activities as influenced by Decomposition of Crop Residues in Soil

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ABSTRACT

An incubation experiment entitled "Soil enzyme activity during decomposition of crop residues in soil" was carried out under controlled condition during 2009 to study the changes in soil enzyme activities during the decomposition of different crop residues in soil. The experiment was laid out in Completely Randomized Design with eight treatments and three replications. Soil samples incorporated with finely powder crop residues of wheat straw, sorghum stubble, cotton stalk, sunflower stalk, soybean straw, chickpea straw and pigeon pea stalk were incubated for 8 weeks at moisture content of 80 per cent of field capacity and incubation carried out at 26^0C. The samples were taken at 0, 2, 4, 6 and 8 weeks of incubation and stored at 4^0C for enzymes activities and microbial analysis. The incorporation of soybean straw @ 5 per cent (T_6) was significantly superior with highest soil enzyme activities of dehydrogenase, invertase, urease and aryl sulphatase as compared to other crop residues. Among all the soil enzyme activities, dehydrogenase activity was highest with incorporation of soybean straw. The activity of enzymes mostly increased up to 4 to 6 week of incubation and declined thereafter 8 week. Hence, it was concluded that, incorporation of crop residues enhanced the enzymes activity which subsequently helped to maintain soil biological activity.

Day by day food grain production is decreasing due to deterioration of soil health and imbalanced use of nutrients. Under such situation scientific management of land for soil fertility through organic recycling has to play a key role in achieving sustainability in agricultural production (Prasad and Power, 1991). A major agricultural research priority is to sustain soil productivity and to develop better methods to monitor changes in soil physical, chemical and biological properties as influenced by the management practices. The productivity and stability of soil as a medium for plant growth depends greatly on the balance between living and non-living (Howard, 1972). Maintenance of soil organic matter is a practical problem in tropical countries like India hence, the application of organic residues is a must for the maintenance of fertility level of these soils. The type of organic residues no doubt, influences the quality as well as quantity of humus formed to a great extent, but the suitability of organic residues to be used in the field will be determined by its decomposability as well as the pattern of mineralization of nutrient elements contained therein.

In recent years the growing interest in the determination of enzymatic activity in the soil has promoted significant advances in this field (Trasar-cepeda and Gil-Sotres, 1987). Enzyme activity is a sensitive indicator of soil health. The enzyme is a substance composed of protein that is capable of lowering the activation energy of selected other compounds enough to allow the breaking of a particular bond under a particular environment (Mehra, 2006).

Soil enzymes are participatory in assuring the correct sequence of all the biochemical routes in soil biochemical cycle. Hence, it is pertinent to study the activity of soil enzymes during the decomposition of crop residues differing in chemical composition. Soil enzymes activity may provide a useful index of changes in soil quality. Crop residues of common cultivated crops (wheat straw, chickpea straw, soybean straw, cotton stalk, sunflower stalk, pigeon pea stalk, sorghum stubble) are an important resource not only as a source of significant quantities of nutrients for crop production but also affecting soil physical, chemical and biological functions (Kumar and Goh, 2000).

Soil is the habitat for plants, animals and microorganisms. As the plants builds up soil organic matter, soil animals feed on them and their debris, microbes decompose the complex organic compounds to their minerals components and CO_2. Hence, there is tremendous scope to study the enzyme activities which are greatly influenced by the soil micro biota under different crop residues decomposition and environmental conditions.

Keeping in view the above facts and great role of enzyme activities in decomposition of crop residues

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and finally improvement in soil health the present investigation was carried out.

MATERIAL AND METHODS

The laboratory experiment entitled "Soil enzyme activity during decomposition of crop residues in soil" was studied under controlled condition in the Department of Soil Science and Agricultural Chemistry during 2009.

The pot experiment was carried out in Completely Randomized Design with eight treatments replicated three times. The eight treatments involving different crop residues were, Control (No crop residues) (T_1), Wheat straw @ 0.5 per cent (T_2), Sorghum stubble @ 0.5per cent (T_3), Cotton stalk @ 0.5 per cent (T_4), Sunflower stalk @ 0.5 per cent (T_5), Soybean straw @ 0.5 per cent (T_6), Chickpea straw @ 0.5 per cent (T_7) and Pigeon pea stalk @ 0.5 per cent (T_8). Each pot was incorporated with finely powdered crop residues at the rate of 0.5per cent of 5 kg soil.

In order to know the physico-chemical properties of the experimental soil, the soil samples (0-15cm) were collected from field of Soil Science and Agricultural Chemistry, before start of experiment during 2009. The samples were air dried and sieved (2 mm) and analyzed for physical and chemical characteristics. The soil was clayey in nature, soil type Vertisols, water retention at 33 kPa (31.57%), water retention at 1500 kPa (21.04%), pH (7.68), EC (0.30 dSm^{-1}), calcium carbonate (11.10per cent), organic carbon (3.4 g kg^{-1}), total nitrogen (0.058per cent), available nitrogen (202.69 kg ha^{-1}), available phosphorus (16.10 kg ha^{-1}) and available potassium (376.50 kg ha^{-1}).

The crop residues (wheat straw, sorghum stubble, cotton stalk, sunflower stalk, soybean straw, chickpea straw and pigeon pea stalk) were collected from respective field. The samples were dried at 65^0C in over and then finely powdered. These finely powdered crop residues were used for incorporation in potted soil at the rate of 0.5 per cent of 5 kg soil. The sub samples of crop residues were analyzed for organic carbon (C), total nitrogen (N) and C: N ratio. The chemical composition of crop residue under study is presented in Table 1. air-dried and sieved soils were placed in 24 plastic pots. Each pot was amended with crop residues at the rate of 0.5per cent of 5 kg soil and replicated three times. After through mixing of finely powdered samples with soil, sufficient water was added to bring it to 80 per cent field capacity and maintained at this level throughout the incubation. Incubation was carried out at 26^0C for 8 weeks and managed in a way that all the samples were taken at 0, 2, 4, 6 and 8 weeks of incubation. The soil samples were stored at 4^0C for microbial analysis. For accessing the decomposition rate of plant residues another set carried out in conical flasks.

The methods for soil analysis were mechanical fractions of soils by using Bouyoucos hydrometer (Bouyoucos, 1928), Moisture retention by pressure plate membrane method at 33 kPa and 1500 kPa (Klute and Dirksen, 1986). pH and EC (Jackson, 1967), Calcium carbonate was determined using acid neutralization method described by Jackson (1967), organic carbon by modified Walkley and Black's rapid titration method (Jackson, 1967), Total nitrogen was determined by using macro Kjeldahl's method described by Jackson (1967), Available nitrogen was determined by alkaline potassium permanganate method (Subbiah and Asija, 1956), Available phosphorus was determined by Olsen's method by using 0.5 M sodium bi-carbonate as an extractant (Watanabe and Olsen, 1965) and Available potassium was determined by flame photometer using 1 N neutral ammonium acetate (pH 7.00) solution as an extractant (Jackson, 1967).

In case of plant analysis, Organic carbon from plant sample was estimated by dry combustion method as described in AOAC, 1984 and total nitrogen was estimated by Kjeldahl's digestion method as suggested by Jackson (1967).

However, in case of Soil enzymes activities during the decomposition of crop residues in soil was determined by dehydrogenase activity by TTC method described by Singh (2005), urease and cellulase activity determined by assay method as described by Pancholy and Rice (1973), invertase activity determined by assay method by Ross (1966) and alkaline phosphatase and aryl sulphatase activity determined by Assay method by Tabatabai and Bremner (1969).

Statistical analysis of the experimental data was carried out as described by Gomez and Gomez (1984) by using completely randomized design.

RESULTS AND DISCUSSION

Effect of incorporation of crop residues in soil on Dehydrogenase activity

Activity of dehydrogenase enzyme was assayed at 0, 2, 4, 6 and 8 weeks of incubation of soil with wheat straw, sorghum stubble, cotton stalk, sunflower stalk,

soybean straw, chickpea straw, and pigeon pea stalk and the data are presented in Table 2.

Results pertaining to the soil dehydrogenase activity presented in Table 2 revealed that the content of TPF ranged between 49.13 to 251.66 µg TPF formed g^{-1} soil 24 hr^{-1} at various period of incubation indicating the enhancement in dehydrogenase activity due to addition of crop residues.

Significant differences were observed in various crop residues incorporated soil under the study. Among the crop residues incorporation of soybean straw @ 5 per cent (T_6) significantly recorded the maximum dehydrogenase activity (251.66 µg TPF formed g^{-1} soil 24 $hr^{-1)}$ followed by the treatment (T_7) chickpea straw @ 5 per cent and sunflower stalk @ 5 per cent (T_5). Dehydrogenase activity was found to increased up to 4th week of incubation and declined thereafter in 6th to 8th weeks of incubation.

Similar results are also reported by Moreno *et al.* (1999) and Masciandaro *et al.* (2000) who have studied dehydrogenase activity under the influence of organic matter and reported an increase due to the organic matter amendment. However, the enzyme activity remained unchanged during extended period of incubation. Whereas, Azam and Malik, 1985, and Lodhi *et al.*, 2000 noticed decreased dehydrogenase activity with the time. The dehydrogenase activity was found increased due to incorporation of soybean straw which might be due to the low C: N ratio resulting in faster decomposition of organic matter in the soil.

Effect of crop residues incorporation in soil on cellulase activity

Data presented in Table 3 revealed that the reducing sugars released was in the range of 18.86 to 52.23 µg reducing sugars released g^{-1} soil 24 hr^{-1} at various period of incubation.

The incorporation of wheat straw @ 5 per cent was found significantly superior over other crop residues and recorded maximum cellulase activity (52.23 µg reducing sugars released g^{-1} soil 24 hr^{-1}) followed by incorporation of cotton stalk @ 5 per cent and incorporation of sorghum stubble @ 5 per cent (T_3). The cellulase activity was found to be increased gradually up to 6th week incubation period and it was declined during 8th week of incubation period.

The higher cellulase activity during early incubation period was represented by Sajjad *et al.* (2002). Further they noticed the rapid oxidation of C from soil amended with wheat straw. The increased cellulase activity with the time of incubation was also reported by Deng and Tabatabai (1994). Comparatively the cellulase activity was found more in the incorporation with cereals and cotton crop residues, might be due to high C: N ratio.

Effect of crop residues incorporation in soil on invertase activity

Data presented in Table 4 showed that the invertase activity in term of mg reducing sugars released g^{-1} soil 24 hr^{-1} was in the range of 2.00 to 9.93 mg reducing sugars released g^{-1} 24^{-1}.

Among crop residues, the incorporation of soybean straw @ 5 per cent (T_6) was found significantly superior and recorded maximum invertase activity (9.93 mg reducing sugars released g^{-1} soil 24 hr^{-1}) followed by treatment of incorporation of chickpea straw @ 5 per cent (T_7) and treatment of incorporation of pigeon pea stalk @ 5 per cent (T_8). Significantly lowest value of invertase activity was recorded under control (no crop residues). Further it is noticed that the invertase activity was increased up to 2nd week of incubation period and the activity sucessively declined with the incubation period.

The increased activity of dehydrogenase and invertase due to addition of organic amendments was also reported by Sajjad *et al.* (2002). Pancholy and Rice (1973) observed that there were striking and remarkably consistent changes in activity of five soil enzymes (amylase, cellulase, invertase, urease and dehydrogenase) under three diverse vegetative types. The enzyme invertase is involved in the breakdown of sucrose into glucose and fructose. The invertase activity was found increased due to incorporation of soybean straw might be due to low C: N ratio which resulted in faster decomposition of organic matter in soil.

Effect of crop residues incorporation in soil on urease activity

The data presented in Table 5 revealed that the incorporation of crop residues had favourably increased the urease activity. However, the differences among the various crop residues were non-significant. Among the treatments, incorporation of soybean straw @ 5 per cent (T_6) recorded highest urease activity i.e. 0.321 mg NH_4-N released g^{-1} soil hr^{-1} and followed by treatment (T_7) chickpea straw and treatment (T_8) pigeon pea stalk @ 5 per cent. The urease activity was found to increase with

the incubation period up to 6th week and thereafter decreased.

Urease is a more specific enzyme involved in the hydrolysis of urea to ammonium carbonate. This enzyme is produced by both microorganism and plant roots and help in the transformation of urea N into NH_4 form.

An increase in urease activity due to the organic amendament has been reported by (Moreno *et al.*, 1999). On the contrary negligible effect was reported by (Azam and Malik, 1985). The complexation with humus compounds is responsible to stabilize urease activity resulting in a stable enzyme activity during prolong incubation (Nannipieri *et al.*, 1983). In the present study also the urease activity was not markedly influenced by the various treatments of crop residues and was some-whatstable during the incubation periods.

Effect of crop residues incorporation in soil on alkaline phosphatase activity

The data regarding the alkaline phosphatase activity as influenced by crop residues incorporation in soil are presented in the Table 6. The alkaline phosphatase activity was significantly influenced by the various crop residues incorporation. Comparetively higher activity was recorded in the treatment of chickpea crop residues (T_7) followed by the treatment of soybean straw and pigeon pea stalk (T_5 and T_8).

Further, it is observed that the alkaline phosphatase activity was found to increase up to 4th week of incubation and declined thereafter steadly at 6 th and 8 th week of incubation. The alkaline phosphatase activity for the soil phosphorus cycle was reflected by its significant correlation with the most labile soil phosphate fractions, specially resion extractable P. The alkaline phosphatase increased due to incorporation of chickpea straw might be due to low C: N ratio which resulted in faster decomposition of organic matter in soil.

In a study conducted by Tarafdar and Claassen (1988) it was reported that the higher activity of phosphatase enzyme in the rhizosphere was due to decomposition or organic residues resulted in higher mobilization and exploitation of native soluble source of phosphorus. The phosphotase activity either activated or inhibited in a soil treated with different crop residues (Perucci and Sacrponi, 2004) and the higher alkaline phosphatase activity was recorded under legumes than under cereals in arid soil of India (Tarafdar *et al.*, 1981).

Effect of crop residues incorporation in soil on aryl sulphatase activity

The data on Aryl sulphatase activity as influenced by crop residues incorporation in soil are presented in Table 7. It is revealed from the data presented in Table 7 that the aryl sulphatase activity was significantly influenced by the crop residues incorporation and significantly highest activity was noticed with the soybean straw incorporation @ 5 per cent (T_6) (4.90 µg of p-nitrophenol released g^{-1} soil hr^{-1}) and followed by chickpea straw @ 5 per cent (T_7) and pigeon pea stalk @ 5 per cent (T_8).

The incubation period also influenced the aryl sulphatase activity and was found to increased up to 4th week of incubation and declined thereafter in 6th and 8th weeks. The aryl sulphatase activity found increased due to incorporation of soybean straw might be due to low C: N ratio which resulted in faster decomposition of organic matter in soil.

The enzyme aryl sulphatase hydrolyze sulfate esters with an aromatic radical and important role in the process where-by organic soil sulfur is mineralized and made available for plant growth (Tabatabai and Bremner, 1969). Ross *et al.* (1966) measured the amylase, dehydrogenase, aryl sulphatase and phosphatase activity in a clay loam soil amended with seven different crop residues. All enzymes activities except phosphomonoesterase were higher in the derived soil sample than the original soil. The addition of tobacco and sunflower residues caused an increased in most of the enzyme activities.

Table 1. Chemical composition of crop residues (oven dry basis)

S. N.	Crop residues	Organic C (%)	Total N (%)	C: N ratio
1)	Wheat straw	33.45	0.65	51.46
2)	Sorghum stubble	40.85	0.97	42.11
3)	Cotton stalk	33.20	0.55	60.36
4)	Sunflower stalk	47.29	0.95	49.77
5)	Soybean straw	44.10	1.45	30.41
6)	Chickpea straw	35.40	1.07	33.08
7)	Pigeon pea stalk	34.40	1.10	31.27

CONCLUSION

The incorporation of soybean straw @ 5 per cent significantly increased the all enzyme activities and among

Table 2. Dehydrogenase activity (µg TPF g^{-1} soil 24 hr^{-1}) as influenced by incorporation of crop residues

Treatments	Weeks of incubation				
	0	2	4	6	8
T_1 - Control (no crop residues)	49.13	49.15	50.54	51.44	51.96
T_2 - Wheat straw @ 5per cent	52.83	124.48	175.67	97.67	67.83
T_3 - Sorghum stubble @ 5per cent	52.90	126.09	198.38	118.31	78.73
T_4 - Cotton stalk @ 5per cent	51.48	118.14	154.69	80.89	57.38
T_5 - Sunflower stalk @ 5per cent	54.71	133.38	235.57	192.50	94.12
T_6 - Soybean straw @ 5per cent	57.40	154.72	251.66	223.68	135.44
T_7 - Chickpea straw @ 5per cent	55.40	149.60	244.16	212.35	126.31
T_8 - Pigeon pea stalk @ 5per cent	54.60	130.33	221.08	178.37	90.60
SE(m)±	0.03	0.02	0.01	0.02	0.02
CD at 5 %	0.09	0.07	0.04	0.06	0.06

Table 3. Cellulase activity (µg reducing sugars released g^{-1} soil 24 hr^{-1}) as influenced by incorporation of crop residues

Treatments	Weeks of incubation				
	0	2	4	6	8
T_1 - Control (no crop residues)	18.86	23.26	19.06	21.4	12.26
T_2 - Wheat straw @ 5per cent	23.00	30.60	41.63	52.23	38.53
T_3 - Sorghum stubble @ 5per cent	21.63	27.26	36.66	47.30	34.53
T_4 - Cotton stalk @ 5per cent	22.26	28.40	39.36	50.60	36.70
T_5 - Sunflower stalk @ 5per cent	19.60	23.63	32.16	43.40	26.66
T_6 - Soybean straw @ 5per cent	20.60	25.73	36.13	45.36	31.20
T_7 - Chickpea straw @ 5per cent	20.53	25.23	34.36	43.46	28.93
T_8 - Pigeon pea stalk @ 5per cent	19.16	22.00	32.46	40.20	24.03
SE(m) ±	0.17	0.07	0.15	0.06	0.17
CD at 5 %	0.51	0.21	0.47	0.19	0.52

Table 4. Invertase activity (mg reducing sugars released g^{-1} soil 24 hr^{-1}) as influenced by incorporation of crop residues

Treatments	Weeks of incubation				
	0	2	4	6	8
T_1 - Control (no crop residues)	2.60	2.33	3.03	2.23	2.00
T_2 - Wheat straw @ 5per cent	6.53	6.80	6.43	5.53	5.36
T_3 - Sorghum stubble @ 5per cent	5.53	5.73	5.20	4.46	4.20
T_4 - Cotton stalk @ 5per cent	5.40	5.56	5.36	4.73	4.23
T_5 - Sunflower stalk @ 5per cent	6.23	6.66	6.43	4.76	4.16
T_6 - Soybean straw @ 5per cent	9.40	9.93	9.56	7.40	6.20
T_7 - Chickpea straw @ 5per cent	8.53	9.43	9.26	6.63	5.73
T_8 - Pigeon pea stalk @ 5per cent	8.20	8.66	8.03	6.50	5.20
SE (m) ±	0.12	0.11	0.15	0.14	0.07
CD at 5 %	0.37	0.34	0.47	0.42	0.23

Table 5. Urease activity (mg NH_4-N released g^{-1} soil 24 hr^{-1}) as influenced by incorporation of crop residues

Treatments	Weeks of incubation				
	0	2	4	6	8
T_1 - Control (no crop residues)	0.269	0.273	0.286	0.299	0.278
T_2 - Wheat straw @ 5per cent	0.270	0.275	0.290	0.298	0.295
T_3 - Sorghum stubble @ 5per cent	0.268	0.272	0.287	0.293	0.294
T_4 - Cotton stalk @ 5per cent	0.269	0.270	0.285	0.290	0.287
T_5 - Sunflower stalk @ 5per cent	0.271	0.279	0.293	0.302	0.297
T_6 - Soybean straw @ 5per cent	0.275	0.288	0.297	0.321	0.313
T_7 - Chickpea straw @ 5per cent	0.272	0.284	0.295	0.317	0.308
T_8 - Pigeon pea stalk @ 5per cent	0.272	0.283	0.295	0.312	0.306
SE(m)±	0.001	0.001	0.001	0.001	0.001
CD at 5 %	0.005	0.005	0.003	0.002	0.003

Table 6. Alkaline phosphatase activity (mMol p-nitrophenol kg^{-1}) as influenced by incorporation of crop residues

Treatments	Weeks of incubation				
	0	2	4	6	8
T_1 - Control (no crop residue)	1.20	2.12	3.12	2.10	1.10
T_2 - Wheat straw @ 5per cent	1.50	2.22	3.14	2.00	0.90
T_3 - Sorghum stubble @ 5per cent	1.80	2.13	3.11	1.90	0.80
T_4 - Cotton stalk @ 5per cent	1.70	2.31	3.15	0.90	1.30
T_5 - Sunflower stalk @ 5per cent	1.60	2.46	3.20	1.20	0.70
T_6 - Soybean straw @ 5per cent	1.90	2.34	3.41	1.70	1.40
T_7 - Chickpea straw @ 5per cent	1.80	2.74	3.66	1.30	1.50
T_8 - Pigeon pea stalk @ 5per cent	1.90	2.70	3.09	1.40	1.60
SE(m)±	0.06	0.01	0.01	0.05	0.05
CD at 5 %	0.17	0.03	0.04	0.14	0.16

Table 7. Aryl sulphatase activity (µg of p-nitrophenol released g^{-1} of soil hr^{-1}) as influenced by incorporation of crop residues

Treatments	Weeks of incubation				
	0	2	4	6	8
T_1 - Control (no crop residues)	1.80	1.90	2.80	2.20	1.20
T_2 - Wheat straw @ 5per cent	2.70	3.20	4.10	2.30	2.40
T_3 - Sorghum stubble @ 5per cent	3.10	3.80	4.40	2.70	2.60
T_4 - Cotton stalk @ 5per cent	2.60	3.70	4.70	2.60	2.00
T_5 - Sunflower stalk @ 5per cent	2.50	3.90	3.90	2.80	3.10
T_6 - Soybean straw @ 5per cent	3.20	4.50	4.90	3.00	2.90
T_7 - Chickpea straw @ 5per cent	3.14	4.10	4.60	1.90	2.80
T_8 - Pigeon pea stalk @ 5per cent	3.00	4.20	4.20	3.10	3.20
SE(m)±	0.021	0.06	0.06	0.06	0.06
CD at 5 %	0.063	0.17	0.19	0.18	0.19

the enzymes dehydrogenase enzyme was significantly influenced and found superior with highest activity than other enzymes due to crop residues incorporation. Hence, it is concluded that, incorporation of crop residues enhanced the enzymes activity which subsequently helped to maintain soil biological activity.

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Mapping of Nutrients Status Using Information Technology in Soils of Yavatmal District

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ABSTRACT

The georeferenced surface soil samples were collected representing different soils types in all the tehsils of Yavatmal. From all the tehsils 858 soil samples were collected from 143 villages. The collected soil samples were analyzed for major and micronutrients. The results revealed that soil pH was neutral to alkaline (6.47 to 8.79), non saline (0.03 to 0.44 dSm^{-1}) and non-calcareous to calcareous ($CaCO_3$ 0.75 to 15.0 %) whereas organic carbon content found to vary from very low to very high (1.19 to 9.87 g kg^{-1}).

The available nitrogen content was low and ranged from 52.7 to 295.0 kg ha^{-1} and the available phosphorus varied from 2.16 to 61.93 kg ha^{-1} indicating 35.4 per cent deficiency. The available potassium was in the range of 112.0 to 941.0 kg ha^{-1} (2.4 % deficiency) and 20 per cent samples were in medium category. The available sulphur varied from 7.50 to 42.29 kg ha^{-1} indicating 10.7 per cent deficiency.

The available zinc ranged from 0.10 - 4.99 mg kg^{-1} showing 68 per cent deficiency while available iron (1.20 to 54.37 mg kg^{-1}) indicated 4.8 per cent deficiency while available Mn and Cu were found sufficient in most of soils.

The nutrient indices were found low for nitrogen and zinc while that of phosphorus, sulphur, iron and boron were medium. The nutrient indices of potassium, manganese and copper were recorded high. It could be inferred that, fertility of soils in Yavatmal district of Maharashtra was low in nitrogen, zinc, medium in iron while high in phosphorus, sulphur, potassium, copper and manganese.

In post green revolution era, the soils are showing fatigue indicating decline in productivity. The decrease in efficiency of major nutrients has been reported by many workers. The wide spread deficiencies of major and micronutrients in soils of agriculturally progressive states are being observed. In the present era of precision farming, the inputs such as fertilizer, crop varieties and management practices are matched precisely with the variability of soil and climatic conditions so that inputs are applied as per the location specific requirements of the crop. The introduction of information technology has provided tools *viz.,* Global Positioning System (GPS) which helps in collecting a systematic set of georeferenced samples and generating the spatial data about the distribution of nutrients with Geographical Information System (GIS). Singh *et al.* (2009) used remote sensing and GIS to study potential suitability for different water harvesting structures in Soankhad watershed of Kandi region situated in Talwara block in Hoshiarpur district of Punjab, whereas Maji *et al.* (2000) used GIS application in bringing out the different aspects of the rice-wheat based cropping system in the Indo-Gangetic Plains of India. The soil factors *viz.,* texture, pH, organic matter content, calcium carbonate content, type of clay minerals and interactions among the nutrients markedly regulate the availability of nutrients in soils (Malewar, 2005). Imbalanced and inadequate use of fertilizers coupled with low efficiency of other inputs, the response efficiency of chemical fertilizer nutrients has declined tremendously under intensive agriculture in recent years.

The intensive cultivation of soils and use of improved high yielding crop varieties which takes up nutrients from the soil are the major causes of deficiency, continuous application of one or two macronutrients may in due course of time deplete the soil reserve of sulphur and micronutrients and limit the crop performance. For sustainability purpose there is need to know the nutrients status of the soil. Keeping this in view, the present investigation was undertaken with the objectives to assess the status of major and micronutrients in soils and to identify and delineate areas of nutrient deficiencies in Yavatmal district of Maharashtra.

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MATERIAL AND METHODS

Yavatmal district in Vidarbha region of Maharashtra lies between 19°26' N and 20°42' N latitude and 77°18' E and 79°98' E longitude and average elevation of 445 m above mean sea level. Cotton, soybean and wheat are predominant field crops grown in the district. Besides this, different pulses, oilseeds and vegetables are grown in each tehsil.

Geologically, the district is covered with deccan trap of weathered basaltic material. Physiographically, this district comes under north deccan Maharashtra lower plateau. The different landforms in a region constitute its physical set-up.

The average annual rainfall of the Yavatmal district is 911.3 mm with wide variability from 791 to 1305 mm in different tehsils.

The major area falls under AESR 6.3, with the length of growing period (LGP) ranging from 120-150 days which is characterized by semi-arid eco-system with shallow and medium to deep black soils belonging to Ustorthents, Haplusterts, Haplustepts, (Challa *et al*., 1995, Challa *et al*., 1999).

The georeferenced surface soil samples (0-20 cm) were collected in 143 villages from sixteen tehsils of Yavatmal district during the year 2010-11. Six farmers from each village were selected based on land holdings. Two soil samples were collected from fields of small (less than 1 ha), medium (1-3 ha) and large (above 3 ha) land holding group. The eight hundred fifty eight geo-referenced soil samples were collected from all the tehsils and Latitude, Longitude was recorded using Geographical Position System (GPS). Soil pH and EC were determined in soil: water suspensions (1:2.5 w/v) as described by Jackson (1973). Organic carbon was determined by dichromate wet oxidation method described by Walkley and Black (Nelson and Sommers, 1982) and free $CaCO_3$ was determined by Rapid Titration method (Piper, 1966).

The available N was estimated by alkaline permanganate method (Subbiah and Asija, 1956) and available P by Olsen's method (Olsen *et al.* 1954). The available K by ammonium acetate extraction method (Jackson, 1967) and the available S was estimated by turbidimetric method (Chesnin and Yien, 1951).

The soil samples were extracted with 0.005M diethylene triamine penta acetic acid (DTPA) for estimation of available Zn, Fe, Cu and Mn using Atomic Absorption Spectrophotometer (Lindsay and Norvell, 1978). The available boron was determined by $CaCl_2$ extract with Azo-methine method given by Berger and Truog (1939) and the nutrient indices were calculated by using the formula given by Parker *et al.* (1951).

RESULTS AND DISCUSSION

Soil properties

The pH of soils in Yavatmal district was neutral to alkaline (6.47 – 8.79) (Table 1). The higher pH was observed in Digras tahsil (7.97) and lowest value in Zari Jamni tehsil (7.33). The alkaline reaction of soil probably due to presence of sufficient free lime content in soil (Kaushal *et al.* 1980). The EC varied from 0.03 - 0.44 dS m^{-1} indicating that all the soils are non-saline in nature and suitable for healthy plant growth. The organic carbon content in soils ranged from 1.19 – 9.87 g kg^{-1} which showed the organic carbon deficiency in 34 per cent samples. The high temperature during summer and non-addition of organic matter regularly might have shown its deficiency in Yavatmal district. The tehsils Zari Jamani (50.0 per cent), Maregaon (47.9 per cent), Wani (45.5 per cent), Ner (42.8 %) and Umarkhed (40.7 %) were deficient in organic carbon. The calcium carbonate content in soils of district varied from 0.75 – 15.00 per cent, which indicated, the soils are non-calcareous to calcareous in nature. The highest calcium carbonate content was noticed in Babulgaon and Pusad tehsils and high calcium carbonate might have adversely affected the concentration of micronutrient cations in soils, resulted in deficiency of micronutrients (Deb *et al.* 2009).

Status of major nutrients

The available nitrogen was noticed 52.7 to 295.0 kg ha^{-1}, which showed 99.1 per cent deficiency and it might be due to very less addition of organic manures and heavy uptake of nutrients under intensive cultivation of improved high yielding varieties of different crops. The available P varied from very low (2.16 to 61.93 kg ha^{-1}) to very high indicating 35.4 per cent deficiency. Ner, Kalamb and Babhulgaon tehsils showed more than 50 per cent deficiency. The deficiency of available P may be because of its fixation in the form of calcium phosphate due to high $CaCO_3$ content. The available K ranged from 112 to 941 kg ha^{-1} and 2.4 per cent samples were found deficient while 20 per cent samples were found medium. During post green revolution era, the available potassium was

Table 1. Chemical properties of soils in Yavatmal district

Nameof tehsil	pH (1:2.5)		EC (dS m^{-1})		$CaCO_3$ (p%)		Organic carbon (g kg^{-1})	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Ner	6.96-8.24	7.43	0.106-0.276	0.213	1.62-12.12	7.70	2.24-8.55	5.36
Babulgaon	7.10-8.04	7.65	0.109-0.281	0.207	6.75-15.00	7.80	1.50-8.80	5.47
Kalamb	6.97-8.15	7.49	0.106-0.295	0.198	1.50-11.87	6.46	2.13-8.80	5.61
Yavatmal	6.87-8.31	7.46	0.119-0.295	0.193	2.87-12.12	7.34	1.82-8.83	5.60
Darva	6.96-8.71	7.90	0.102-0.285	0.204	5.87-12.37	9.85	2.05-9.53	5.37
Digrus	7.57-8.46	7.97	0.198-0.274	0.234	6.37-12.37	10.36	2.05-8.97	5.18
Pusad	7.02-8.49	7.62	0.197-0.287	0.242	0.75-13.02	6.52	2.10-8.97	4.71
Umarkhed	7.01-7.95	7.65	0.117-0.281	0.227	1.70-12.00	7.32	1.35-8.10	4.46
Mahagaon	7.02-8.39	7.66	0.102-0.270	0.178	3.25-12.5	9.40	1.19 -8.85	5.09
Arni	7.04-8.39	7.77	0.104-0.294	0.203	1.50-12.12	6.17	2.23-7.85	4.68
Ghatanji	6.90-8.25	7.44	0.132-0.295	0.218	2.37-12.37	7.26	3.60-8.53	6.14
Pandharkawada	6.82-8.53	7.37	0.118-0.291	0.206	1.25-12.0	7.27	2.43-8.71	5.30
Ralegaon	7.06-8.38	7.65	0.132-0.440	0.217	1.62-12.12	7.70	2.24-8.55	5.36
Maregaon	7.15-8.22	7.75	0.102-0.298	0.227	2.0-10.9	7.20	2.53-8.13	4.85
Zari Jamni	6.89-7.86	7.33	0.128-0.261	0.194	1.0-12.25	6.51	2.13-9.87	5.37
Wani	6.98-8.56	7.40	0.03-0.285	0.206	1.12-12.25	6.95	2.13-8.93	5.16
Yavatmal district	**6.82-8.79**	**7.54**	**0.03-0.440**	**0.210**	**0.75-15.0**	**7.58**	**1.19-9.87**	**5.15**

Table 2. Nutrients status of Yavatmal district

Name of tehsil	N		P		K		S	
			(kg ha^{-1})					
	Range	PSD	Range	PSD	Range	PSD	Range	PSD
Ner	84.3 - 200.2	100	2.33 - 28.44	64.3	112 - 504	14.3	9.20 – 28.90	11.9
Babulgaon	63.2 - 252.9	100	4.57 - 26.77	58.3	112 - 806	6.2	9.52 – 42.29	6.2
Kalamb	52.7 - 221.3	100	5.53 - 36.57	53.7	168 - 582	0	8.51 – 24.21	11.1
Yavatmal	84.3 - 273.9	100	5.56 - 61.93	50.0	123 - 448	9.5	8.82 – 25.06	7.1
Darva	94.8 - 284.5	96.6	4.96 - 43.94	35.0	157 - 683	0	9.81 – 31.20	6.7
Digrus	94.8 - 263.4	100	9.09 - 27.85	41.7	134 - 582	2.8	9.89 - 27.83	2.8
Pusad	115.9 - 231.8	100	2.16 - 40.76	38.1	157 - 661	0	9.09 – 29.50	9.5
Umarkhed	73.8 - 231.8	100	6.42 – 46.51	35.2	213 -918	0	9.81 – 33.23	3.8
Mahagaon	115.9 - 295.0	98.4	5.67 - 34.4	13.3	134 - 526	1.7	9.70 – 27.20	5.0
Arni	105.4 - 189.6	100	5.66 - 43.27	56.2	123 - 683	10.4	8.56 – 27.07	16.7
Ghatanji	94.8 - 221.5	100	9.40 - 44.83	6.2	157 - 560	0	8.60 – 19.46	18.7
Pandharkawada	94.8 - 284.5	93.3	2.34 - 46.5	35.0	202 - 728	0	8.45 – 21.59	15.0
Ralegaon	126.4 - 221.3	100	7.32 - 60.1	14.8	168 - 717	0	7.79 – 17.97	13.0
Maregaon	115.9 - 252.9	100	8.39-41.03	45.8	202 - 605	0	7.50 – 22.0	12.5
Zari Jamni	94.8 - 273.9	100	6.72 - 61.18	14.8	168 - 941	0	7.60 – 21.42	22.2
Wani	115.9 - 284.5	98.5	9.85 - 61.75	24.2	157 - 918	0	7.67 – 29.20	9.1
Yavatmal district	**52.7 - 295.0**	**99.1**	**2.16 - 61.93**	**35.4**	**112 – 941**	**2.4**	**7.50 – 42.29**	**10.7**

PSD – Percent sample deficient

Table 3. DTPA- extractable micronutrients status in soil

Name of tehsil	Zn		Fe		Cu		Mn		B	
	(mg kg^{-1})									
	Range	PSD	Range	PSD	Range	PSD	Range	PSD	Range	PSD
Ner	0.12-1.42	66.7	2.08-36.80	7.1	0.27-7.69	0	3.46-65.82	0	0.22-1.64	16.67
Babulgaon	0.14-1.58	58.3	3.74-52.02	2.1	1.53-5.84	0	8.57-75.52	0	0.42-1.52	16.67
Kalamb	0.18-1.59	53.7	6.41-50.86	0	1.50-7.93	0	12.94-76.4	0	0.31-1.64	12.50
Yavatmal	0.13-4.99	42.8	1.34-35.28	7.1	0.82-7.85	0	2.44-67.35	0	0.30-1.65	25.00
Darva	0.10-1.58	71.7	1.25-36.71	10.0	0.52-7.79	0	2.22-60.84	0	0.36-1.62	20.83
Digrus	0.22-1.08	80.5	2.38-34.90	8.3	0.86-5.26	0	5.47-64.35	0	0.25-1.78	16.67
Pusad	0.11-1.61	75.0	1.53-54.37	5.9	1.24-7.87	0	8.84-77.16	0	0.22-1.75	8.34
Umarkhed	0.27-1.59	46.3	2.94-47.44	3.7	0.54-5.22	0	7.32-55.40	0	0.46-1.42	4.12
Mahagaon	0.24-1.52	75.0	3.60-25.9	3.3	0.85-5.91	0	8.50-20.70	0	0.36-1.62	16.67
Arni	0.21-1.78	39.6	4.91-41.95	0	1.56-5.18	0	6.05-33.99	0	0.24-1.75	25.00
Ghatanji	0.10-1.53	85.4	3.85-45.72	2.1	0.82-6.68	0	4.80-42.32	0	0.44-1.52	8.34
Pandharkwada	0.14-1.48	85.0	2.02-31.92	5.0	0.81-6.15	0	12.78-60.7	0	0.22-1.42	8.34
Ralegaon	0.10-1.33	79.6	1.27-47.78	9.2	1.03-7.97	0	5.74-71.64	0	0.43-1.65	8.34
Maregaon	0.12-3.04	91.7	3.30-23.50	4.1	0.85-7.57	0	5.90-78.60	0	0.22-1.63	16.67
Zari Jamni	0.15-1.57	74.1	2.87-26.82	1.8	0.60-5.63	0	7.77-69.80	0	0.37-1.49	12.50
Wani	0.14-1.68	66.7	1.20-34.61	6.1	0.64-7.59	0	7.94-52.72	0	0.24-1.63	20.83
Yavatmal	**0.10-4.99**	**68.8**	**1.20-54.37**	**4.8**	**0.27-7.97**	**0**	**2.22-78.60**	**0**	**0.22-1.78**	**14.84**

PSD – Percent sample deficient

considered very high in black cotton soils. The recent trends indicated that slight potassium deficiency occurred showing response to its addition. Moreover, the results of long-term fertilizers experiments indicating mining of K from soils under major cropping system. The available sulphur varied from low to very high (7.50 to 42.29 g kg^{-1}) with 10.7 per cent deficiency, whereas 68.9 per cent samples were found medium (Table 2). The intensive cultivation of crops and application of fertilizers devoid of sulphur might be depleting the sulphur from soil. The application of balanced nutrition to the crops under intensive cultivation is essential for maintaining the soil fertility and sustainable productivity *Micronutrients status.*

The DTPA-Zn in soils of Yavatmal district ranged from 0.10 to 4.99 mg kg^{-1} (Table 3) indicating 68.8 per cent deficiency, whereas 30.9 per cent samples of available Zn were in medium category showing widespread deficiency of zinc. The highest deficiency of zinc was observed in Maregaon tehsil followed by Ghatanji and Pandharkawada. The availability of micronutrient cations is generally low in alkaline soils and crops grown on these soils suffer from hidden hunger (Malewar, 2005).

The major crops grown in these tehsils are cotton, pigeon pea, green gram, wheat etc. and their intensive cultivation might have mined the zinc along with N, P and K from the soil. The deficiency of zinc was observed higher in the Maregaon (91.7%), Ghatanji (85.4%), Pandharkawda (85.0%), Digrus (80.5%), Ralegaon (79.6%), Mahagaon (75.0%), Pusad (75.0%), Zarjamni (74.1%), Darva (71.7%), Ner (66.7%), Wani (66.7%), Babulgaon (58.3%), and Kalamb (53.7%) tehsil. This indicated wide spread zinc deficiency in Yavatmal district. This might be due to high nutrient requirement of recently introduced high yielding varieties. The imbalanced use of N, P and K fertilizers, reduction in organic carbon contents of soil and decline in the level of micronutrient in soil below critical level also leading to zinc deficiency (Singh, 2003). The less availability of organic manures leading to non- application of manures by many farmers to soil posses the problems of micronutrient deficiency. Moreover, the farmers are not testing the soils for micronutrients which are not being added along with macronutrients. Hence, this might led to deficiency of micronutrients in the soils of Yavatmal districts. The widespread deficiency of zinc in intensively cultivated districts of Western Maharashtra having predominant alkaline, calcareous, black clayey soils was reported by Patil and Kharche (2001). It has also been reported that the soils of Maharashtra did not show response to application of zinc during seventies (Kharche *et al.*, 2003). However, afterwards due to intensification of agriculture the soils became deficient in zinc. The deficiency of nutrients creates imbalance in soils which results into nutritional stress in plants (Malewar, 2005). Sakal (2001) reported zinc deficiency as most serious constraint to sustainable productivity in several states. Micronutrient deficiency of plants occur more frequently in calcareous soils with high pH such as those found in arid and semiarid regions (Alloway, 2006).

The wide variation was noticed in iron content (1.20 – 54.37 mg kg^{-1}) in Yavatmal district. The per cent deficiency of iron was 4.8, while 71.9 per cent samples under medium category (Table 3) indicating that the soils are becoming deficient in iron followed by zinc. Patil *et al.* (2004) reported 40.0 and 34.7 per cent soils deficient in zinc and iron respectively, in Vidarbha.

The DTPA extractable Cu in the soils Yavatmal district ranged from 0.27 – 7.97 mg kg^{-1} (Table 3). Patil and Sonar (1994) also reported that in swell-shrink soils of Maharashtra, available Cu in range of 0.58 to 1.7 mg kg^{-1}.

Further the DTPA-Mn status of soils ranged from 2.22 – 78.60 mg kg^{-1} (Table 3). Gajbhe *et al*. (1976) also noticed available Mn content in surface soils of Marathwada ranged from 13.3 to 65.20 mg kg^{-1}. The available boron varied from 0.22 to 1.78 mg kg^{-1} with mean of 0.93 mg kg^{-1} which categorized as low to high *viz.*, 14.84 per cent in low category and 44.27 per cent in medium category and 40.88 percent in high category. Data in relation to nutrient indices are reported in Table 8. The highest boron deficiency was recorded in Arni and Yavatmal followed by Darva and Wani.

Table 4. Status of micronutrients and nutrient indices in Yavatmal district.

Nutrients	Percent samples			Nutrient
	Low	Medium	High	index
N	99.1	0.9	0	1.01
P	35.4	52.9	11.7	1.76
K	2.4	20.0	77.6	2.75
S	10.7	68.9	20.4	2.09
Zn	68.8	30.9	0.3	1.31
Fe	4.8	71.9	23.3	2.18
Cu	0	1.02	98.8	2.99
Mn	0	6.1	93.9	2.94
B	14.84	44.27	40.88	2.26

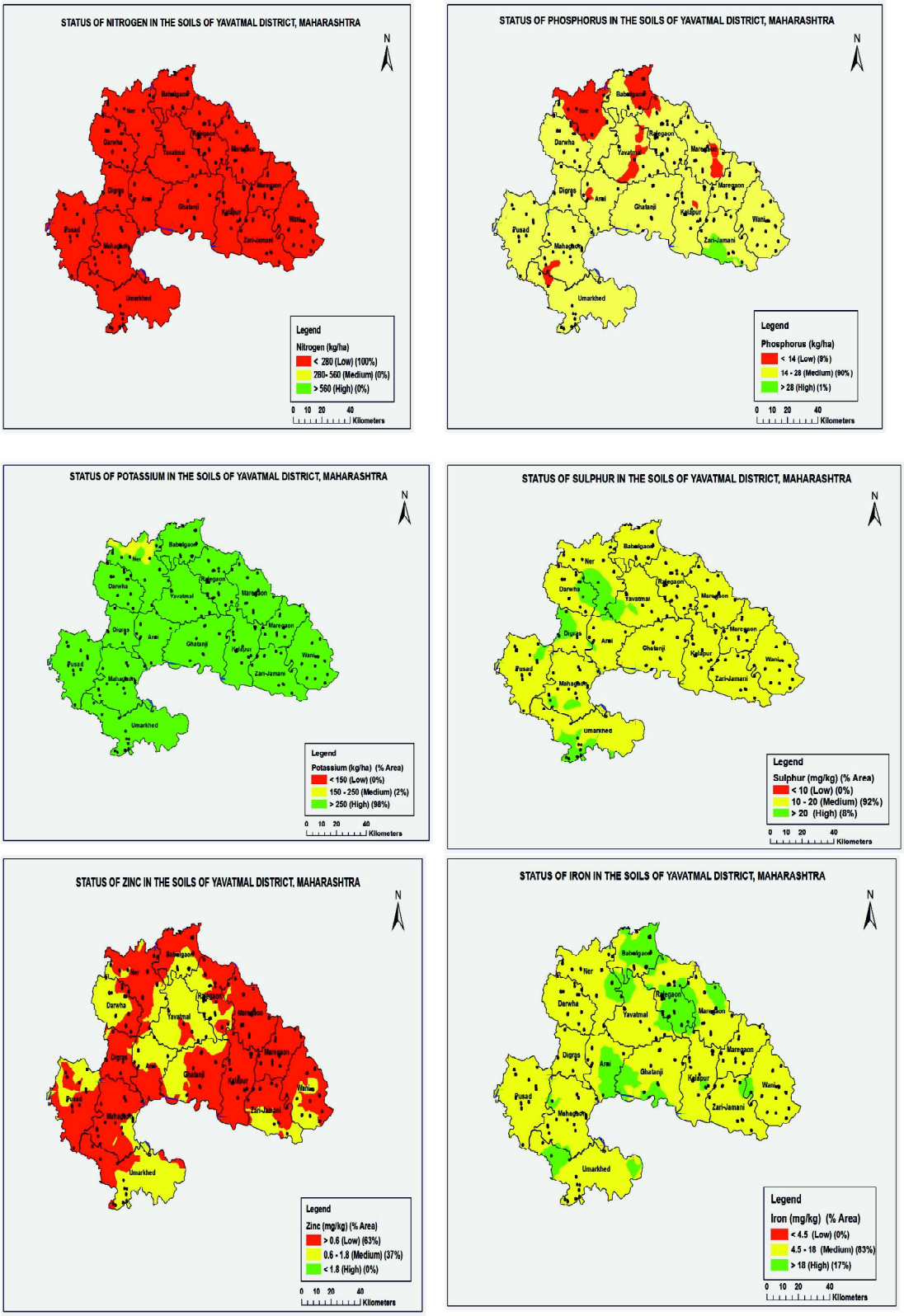

Fig. 1. Fertility maps of N, P, K, S, DTPA-Zn and Fe in Yavatmal district

Nutrient Indices

In Yavatmal district, the nutrient indices (Table 4) were found low in available N (1.01) and Zn (1.31) whereas medium in available P (1.76), S (2.09), B (2.26) and Fe (2.18) and high in K (2.75), Mn (2.94) and Cu (2.99).

Table 5. Relationship of available micronutrients with soil properties

S. N.	Parameters	Zn	Fe	Cu	Mn
1	pH	-0.072	-0.10*	-0.025	-0.056
2	$CaCO_3$	-0.134*	-0.112**	+0.041	-0.10
3	Org. Carbon	+0.049	+0.078	+0.0213	+0.019

* Significant at 5per cent level, ** Significant at 1per cent level

Relationship of nutrients with soil properties

The DTPA extractable zinc showed negative relationship with soil pH (r = -0.072) and calcium carbonate (r = 0.134*). An increase in pH normally affects the availability of zinc in soils adversely. Whereas, positive correlation with organic carbon (r = +0.049) was observed. Available zinc was positively and significantly correlated with organic carbon in some soil series of Punjab, (Chakraborty, 1981). Similar results were reported by Malewar and Randhwa (1978) in most of the soils of Maharashtra. The positive and significant correlation of iron with organic carbon (r = +0.078) was noticed, indicating availability of iron increases with an increase of organic carbon in soil and negatively and significantly correlated with pH (r = - 0.10*) and $CaCO_3$ (r = - 0.112*). Significant negative relationship of available iron with pH and $CaCO_3$ content of soil were also reported by Maji *et al.* (1993).

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Insect - Pollinators and their Abundance Associated with Sunflower Ecosystem

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ABSTRACT

The diversity of pollinating insects and their abundance in sunflower, study was studied at Oilseed Research Unit Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *Kharif* 2013 and 2014. The study indicated that ten diversified species of insect pollinators belongs to order hymenoptera and diptera were recorded visiting sunflower capitulum during the flowering period, *Apis dorsata* Fabricus was the dominant one, with 60.26 per cent abundance followed by *Apis florea* Fabricius had 16.67 per cent abundance. Hymenopteran pollinatorsshared 92.31 per cent abundance that too Apidae 85.63 pr cent.

Sunflower (*Helianthus annuus* L.) belongs to typical alogamic (cross pollinated) entomophilic plant, which requires pollinators for high quality fertilization. The contribution of wind in transferring sunflower pollen is negligible (Low and Pistillo, 1986).

It needs animal pollinators to be transferred from male to female flowers (Free,1993). A frequently visited sunflower can produce significantly highet hybrid seed yield than a les visited cultivar (Skinner, 1987). Moreti *et al*. (1993) reported an increase in sunflower productivity about 98.4per cent, due to the pollination made by honeybees. Honeybee pollination can increase seed yield in sunflower by 30per cent and oil content of seed by 6per cent in hybrid varieties with self – fertility (Jyoti and Brewer, 1999). Insect pollinators play a crucial role in improving the productivity of cross pollinated crops. The availability of sufficient number of suitable pollinators during flowering time is essential for achieving optimum pollination. Little attention is paid to the need of conserving and enhancing the pollinator diversity in crop ecosystem (Jadhav *et al*. 2011). To maintain sustainable insect pollination services it is essential to conserve flower-rich natural habitats (Steffan -Dewenter and Tscharntke.1999).Considering the importance of pollinating insects for high quality fertilisation and to produce higher hybrid seed yield, present study was carried out to know the diversity and abundance of pollinating insects in sunflower ecosystem.

MATERIAL AND METHODS

Experiment was conducted at Oilseed Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *Kharif* 2013 and *Kharif* 2014 to document the pollinators diversity and their abundance in sunflower agroecosystem. Sunflower KBSH 44 was raised with all recommended agronomic practices except insecticidal sprays. Randomly selected ten plants were observed daily during 10.00 to 12.00 hours and recorded the insects visited to sunflower capitulum and was expressed as mean number of pollinators plant^{-1} 5 min^{-1}. Species diversity was also documented by collecting insects visiting sunflower capitulum and get it identified from NPIB coordinating cell, IARI New Delhi through NPIB project, Department of Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

RESULTS AND DISCUSSION

Ten diversified species of pollinating insects were observed visiting sunflower capitutlum belongs to order Hymenoptera and Diptera on hybrid sunflower KBSH 44. Four species viz., *Apis dorsata* Fabricius, *Xylocopa* sp., *Teragonula laeviceps* Smith, *Apis florea* Fabricius from Apidae, two species *viz., Scolia quadripustulata* Fabricius and *Megascolia* sp. from Scoliidae and one species i.e *Nomia* sp. from Halictidae were recorded under Hymenoptera. Dipteran foragers belonging to familiy Syrphidae, constituted *Eristalinus quinquelineatus* Fabricius, *Phytomia crassa* Fabricius and *Phytomia argyrocephala* Macquart (Table 1). Relative abundance of pollinating insect was in the order of *Apis dorsata* Fabricius (60.26 %), *Apis florea* Fabricius (16.67 %), *Xylocopa* sp. (3.85 %), *Teragonula laeviceps* Smith (3.85 %) and 2.56 per cent other species (Table 2). Amongst the pollinating insect visited sunflower during the flowering period, *Apis dorsata* Fabricius was the most dominant and shared 60.26 per cent abundance followed

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by *Apis florea* Fabricius (16.67 %). In all, Hymenopterans pollinators shared 92.31 per cent abundance as compared to Dipteran pollinators (7.6%).

Present findings are in the tune to the findings of Jadhav *et al*. (2011) who reported that *Apis dorsata* was the more frequently visiting insect pollinator in hybrid sunflower. Relative abundance of insect visitors to sunflower capitula revealed that *Apis* sp. constituted 88.85 per cent indicating the dominance of hymenopterans in sunflower ecosystem. In the present investigation Apidae had 85.63 per cent share among the total pollinators (Table 2). Swaminathan and Bharadwaj (1982) recorded *Apis dorsata*, the most frequenting bee species visiting sunflower. Renganayaki *et al*. (2008) also reported that sunflower crop was foraged by sufficient number of four species of honey bees viz., *Apis dorsata, Apis cerana indica, Apis florea* and *Mellifera irridipennis*. An essential pollination service is performed by domesticated honeybees (*Apis mellifera*) and by wild bees (feral honeybees, 58 species of bumble bees, and hundreds of species of solitary bees) (Corbat *et al*. 1992). Kasina *et al*. (2007) found the diversity of pollinators associated with sunflower at Makueni district, a semi-arid area in Eastern Kenya and they were *Merylis flavipes* LeConte, Coleoptera (Melyridae: Melyrinae), *Phytomia incisa* Wiedemann, Diptera (Syrphidae: Syrphinae), *Rhynchomydaea* sp. Malloch Diptera (Muscidae: Muscinae), *Apis mellifera* Linnaeus Hymenoptera (Apidae: Apinae), *Plebeina denoiti* Vachal Hymenoptera (Apidae: Apinae), *Ceratina* sp. Latreille Hymenoptera (Apidae: Xylocopinae), *Heriades* sp. Cresson Hymenoptera (Megachilidae: Megachilinae), *Pseudoanthidium* sp. Fs Sandanski Hymenoptera (Megachilidae: Megachilinae), *Belenois aurota* Fabricius Lepidoptera (Nymphalidae: Pierinae), *Byblia ilithyia* Drury

Table 1. Species of pollinating insects associated with Sunflower.

S. N.	Species	Family	Order
1.	*Apis dorsata* Fabricius	Apidae	Hymenoptera
2.	*Xylocopa* sp. Indent	Apidae	Hymenoptera
3.	*Teragonula laeviceps* Smith	Apidae	Hymenoptera
4.	*Eristalinus quinquelineatus* Fabricius	Syrphidae	Diptera
5.	*Scolia quadripustulata* Fabricius	Scoliidae	Hymenoptera
6.	*Nomia* sp. Indent	Halictidae	Hymenoptera
7.	*Phytomia crassa* Fabricius	Syrphidae	Diptera
8.	*Megascolia* sp. Indent	Scoliidae	Hymenoptera
9.	*Phytomia argyrocephala* Macquart	Syrphidae	Diptera
10.	*Apis florea* Fabricius	Apidae	Hymenoptera

Table 2. Relative abundance of pollinating bees on sunflower hybrid KBSH - 44.

Order	Family	Species	Abundance (%)
Hymenoptera	Apidae	*Apis dorsata Fabricius*	60.26
Hymenoptera	Apidae	*Xylocopa* sp.	3.85
Hymenoptera	Apidae	*Teragonula laeviceps Smith*	3.85
Diptera	Syrphidae	*Eristalinus quinquelineatus Fabricius*	2.56
Hymenoptera	Scoliidae	*Scolia quadripustulata Fabricius*	2.56
Hymenoptera	Halictidae	*Nomia* sp.	2.56
Diptera	Syrphidae	*Phytomia crassa Fabricius*	2.56
Hymenoptera	Scoliidae	*Megascolia* sp.	2.56
Diptera	Syrphidae	*Phytomia argyrocephala Macquart*	2.56
Hymenoptera	Apidae	*Apis florea Fabricius*	16.67
Total			**100.00**

Lepidoptera (Nymphalidae: Nymphalinae), *Cephonodes hylas* Walker Lepidoptera (Sphingidae: Macroglossinae), *Danaus chrysippus* Linnaeus Lepidoptera (Nymphalidae: Danainae), *Junonia hierta* Trimen Lepidoptera (Nymphalidae:Nymphalinae), *Junonia oenone* Linnaeus Lepidoptera (Nymphalidae: Nymphalinae). *Andrena sp.* (2.40per cent) (Andrenidae: Hymenoptera). *Halictus* sp. (3.69 per cent) (Halictidae: Hymenoptera) and a Syrphid fly (0.46per cent) (Syrphidae: Diptera). Glaiim *et al.* (2008) found the spices associated with sunflower were *Apis mellifera* , *Megachile* sp. , *Nomia* sp. , *Xylocopa fenestrate* and *X. aestuans*. It is clear from the findings that the sunflower capitulum in bloom is highly attractive to multitude of insect species among them *Apis dorsata* Fabricus is dominant and, contributed more in entomophilic pollination at Akola conditions.

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Performance of Various Nozzles of Knapsack Sprayer Against Sucking Pests on *Bt* Cotton

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ABSTRACT

Field efficacy of popular nozzles of Knapsack sprayer and their characteristic were studied against cotton sucking pests at experimental farm of Department of Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The results revealed that aphid, leafhopper, thrips and whiteflies were effectively control by using hallow cone wide angle nozzle of four holes(local) with effective range of droplet size of 150-250 µm, density of15-30 drops/cm^2 and angle of spray coverage of 65-120^0. The operative pressure of this nozzle by manual labour ranged between 2.00 – 2.5 kg/cm^2, which is in consistent with under laboratory condition. At this pressure the water discharge varied as per stages of crop and ranged between 330 to 466 litre ha^{-1}, which is optimum on cotton crop. Highest yield of seed cotton (15.10 q ha^{-1}) and ICBR (7.55) was also received in the plot of spray application using hallow cone wide angle nozzle four holes (local).

Cotton is an important cash crop of India. Maharashtra contributes nearly 1/3rdarea at national level. Cotton plays akey role in synergizing the economy of Maharashtra as well as Vidarbha. There are many causes of low productivity of cotton; one of the importantreasons for the low productivity is the attack of pests like aphids, leaf hopper, thrips and whitefly (Pawar*et.al.* 2003). The recommended spraying technology particularly application of sprays by using appropriate nozzles of knapsack sprayer as per stage of the crop is not followed mostly by the farmer, which pose uneven discharge of spray solution leading to ineffectiveness of chemicals against these pests.

Success of spraying techniques depends upon the ability of the nozzle to produces uniform spray pattern of the desired size with the appropriate discharge. Nozzleis an important part of sprayer, which perform main three functions i.e. regular flow, atomize the mixture into droplets and disperse the spray in a desirable pattern. A range of nozzles are available in the market to meet the needs of various applications. Appropriate selection of nozzle is crucial for effective spray and their safety to environment. Water volume usedshould not be too high which lead wastage of pesticide and exposure to environment through drift. When targeting the plant, spray droplets should be distributed uniformly over the entire plant, including the underside of the leaves as well as on top of the plant.

This study will give information on type of nozzles to be used and water discharge at various stages of crop which will ultimately provide better spray coverage for control of pests. This will result in saving of pesticide, reducing the exposuretoenvironment and health risk.

MATERIAL AND METHODS

Popular nozzles of knapsack sprayer viz. Hollow cone nozzle (PTB Local), Hollow cone nozzle (Plastic ASPEE XLB/N), Solid cone nozzle (Brass), Hollow cone wide angle nozzle four holes (Local), Hollow cone wide angle nozzle five hole (Local) were evaluatedalone and in combination against sucking pests (aphids, leafhoppers, thrips and whitefly using the variety RCH-2 BG II, during Kharif season of 2013-2014 at experimental farm of Department of Entomology, Post Graduate Institute, Dr. PDKV., Akola.

Field trial was conducted in Randomized Block Design with three replications by sowing of Bt transgenic cotton (RCH 2 BG II) at 90 cm x 60 cm spacing. All the agronomical practices were carried out as per university recommendations. First foliar spray of insecticide by using various nozzle treatments were undertaken at ETL against sucking pests and subsequent 3 sprays were undertaken at 10-12 days interval. The insecticides, fipronil 5 SC @ 30 ml, acephate 75 SP @ 30g,imidachloprid 17.8 Sl @ 7 ml and acetameprid 20 SP @ 5 g 10^{-1} lit of water were applied in sequence in the form of total four sprays. The effect of these nozzles on population of aphid, leafhopper, whitefly, thrip and predator was studied. Total water discharge, droplet densityof nozzles, plant height and cost economics of these treatments were also studied.

Nozzle discharge rate measured as per Indian

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Standard (IS) 8548 test code (2004) by knapsack sprayer endurance test rig. The nozzles discharge was recorded at three different pressure level 2.0, 2.5 and 3.0 kg/cm^2 to find out the discharge of the nozzle on knapsack sprayer.Procedure was evaluated in laboratoryof Farm Machinery Testing and Training centre, Dr. PDKV, Akola.

Measurement of droplet deposition and characters

Three glossy papers were stapledat selected top, middle and bottom position of plant to observe the deposition of the droplet, droplet density and their size.In order to achieve uniform exposure on crop, the spraying was started 3m before the canopy and sample was collected on the cards of glossy paper, sample cards of size 4.00 cm x 4.00 cm were used to collect the sample.The Bromophenol Blue colour dye spray was allowed to fall on to the sample glossy photographic paper.After the experiment, the sample cards were carefully removed and then taken for further analysis in the laboratory, digital image analyzer was used to determine stain diameter and droplet size, which were later analyzed after 24 hours of application to ensure that droplets had stopped spreading.

Image Pro-Plus image analysis software makes it easy to acquire images, count, measure and classify objects, and automate the work.Image pro plus most powerful electronic imaging program was used for analysis of glossy paper to obtained droplet size (VMD-Volume mean diameter), droplet density and UC (Uniformity co-efficient)(http://www. mediacy.com). Procedure was evaluated in the laboratory of ASPEE, Agriculture Research Foundation, Tansa Farm, Mumbai during October, 2013.

RESULTS AND DISCUSSION

Effect of various nozzles on population of sucking pests

Cumulative average data (Table 1) recorded on sucking pests (No./leaf) of cotton revealed that treatment plots noted significantly lower population than control plot. The lowest population (2.63) of leaf hopper was recorded in T4- Hollow cone wide angle nozzle four holes (Local) and was superior to rest of the treatments. T6 (3.33) ranked second and was on par with rest of the treatments, except, T7 & T3. While the whitefly population was effectively checked by using T1- Hollow cone nozzle (PTB Local) and T5- Hollow cone wide angle nozzle five holes (Local) (1.26) & it was at par with T4 and T8. T2 being next effective, it was at par with remaining treatments. Minimum thrips population was recorded (1.21) in T4- Hollow cone wide angle nozzle four holes (Local) and found at par with T7, T5 and T8. Hollow cone nozzle (PTB local) stood 2nd and being on par with combination of nozzle i.e. T9. T3 was least effective in reducing the thrips population followed by T6 and T2 and both were on par with each other. However, lowest population (1.05) of aphid was recorded in T4- Hollow conewide angle nozzle four holes (Local) and it was at par with rest of the treatments.The results of this investigation is in the agreement of work conducted by Greene and Capps (2001), who concluded that effective control of thrips can be achieved by using Hollow cone nozzle of knapsack sprayers. Mohammad *et al*. (2008) reported significant mortality against sucking pests by using hollow cone nozzle of knapsack sprayer. Hence, these findings are in line with present study.

Since, RCH–2 BG II is highly susceptible to leafhoppers, the population of thrips remains below during the crop season. Similarly, the grandular leaf hairs on this hybrid are partial or low, hence, being negative character for livelihood of white flies, the whitefly population was also noted low during the season.Similarly, the population of aphid, whitefly and thripswas reported to be low on RCH-2 BG II i.e. 6.14, 6.40 and 6.05 per leaf, respectively during *Kharif* season of 2013 (Anonymous, 2014).

Effect of various nozzle treatments on yield of seed cotton and ICBR

Seed cotton yield (Table 1) recorded in hollow cone wide angle nozzle four holes four holes (Local) was highest among all other treatments i.e. 15.10 q/ha and being on par withT_7 – (T2 fb T3 fb T4 fb T5), hollow cone wide angle nozzle five holes and hollow cone nozzle (Plastic ASPEE XLB/N). Control plot produced lowest yield of 7.63 q ha^{-1}. However, hollow cone wide-angle nozzle four holes (Local) was proved to be the cost effective treatments in which highest ICBR was recorded i.e. 7.55 followed by T7 – (T2 fb T3 fb T4 fb T5) (7.44), hollow cone wide angle nozzle five holes (Local)(6.51), hollow cone nozzle (PTB Local) (5.93), hollow cone nozzle (Plastic ASPEE XLB/N) (5.85), T6- (T1 fbT2 fb T3 fb T4) (5.57). Lowest ICBR was noted in solid cone nozzle (Brass) because of low yield and low performance against sucking pests.

Table 1: Effect of various treatments on population of sucking pests.

S. N.	Treatments	Mean population of sucking pests leaf^{-1}				Seed Cotton Yield (q ha^{-1})	ICBR
		Thrips	Aphid	Leaf hopper	Whitefly		
1.	Hollow cone nozzle (PTB Local)	1.47 (1.21)*	1.21 (1.10)*	3.68 (1.91)*	1.26 (1.12)*	12.32	5.93
2.	Hollow cone nozzle (Plastic ASPEE XLB/N)	1.71 (1.30)	1.25 (1.12)	3.55 (1.88)	1.44 (1.20)	13.36	5.85
3.	Solid cone nozzle (Brass)	1.80 (1.34)	1.25 (1.11)	3.94 (1.98)	1.60 (1.26)	11.51	4.21
4.	Hollow cone wide angle nozzle four holes (Local)	1.21 (1.10)	1.05 (1.02)	2.63 (1.62)	1.30 (1.14)	15.10	7.55
5.	Hollow cone wide angle nozzle five holes (Local)	1.37 (1.16)	1.18 (1.09)	3.65 (1.88)	.28 1(1.12)	14.35	6.51
6.	T1 fb T2 fb T3 fb T 4	1.70 (1.3)	1.17 (1.08)	3.33 (1.82)	1.50 (1.22)	12.73	5.67
7.	T2 fb T3 fb T 4 fb T5	1.28 (1.13)	1.22 (1.10)	3.93 (1.98)	1.47 (1.21)	14.75	7.44
8.	T2 fb T 4 fb T 5 fb T 5	1.37 (1.17)	1.15 (1.06)	3.52 (1.87)	1.41 (1.18)	12.61	5.20
9.	T 1 fb T2 fb T 4 fb T 4	1.51 (1.23)	1.16 (1.07)	3.36 (1.83)	1.52 (1.23)	11.97	4.65
10.	Control	2.50 (1.58)	2.63 (1.62)	5.53 (2.35)	2.32 (1.52)	7.63	–
	SE (m) ±	0.02	0.03	0.03	0.02		
	C.D. at 5%	0.08	0.10	0.09	0.07		
	C.V.%	4.08	5.53	2.91	3.49		

* Square root of X + 0.5 values, fb- Followed by

Table 2 : Droplet size (VMD), density and uniformity co-efficient of nozzles under field condition.

S.N.	Types of Nozzles	Parameter of Nozzles		
		Droplet Density (Drops/cm^2)	VMD (micron)	UC
1.	Hollow cone nozzle – Single hole (PTB Local)	15.06	247.37	1.97
2.	Hollow cone nozzle – Single Hole (Aspee XLB/N)	19.15	240.81	2.27
3.	Solid cone nozzle – (Brass)	13.80	205.43	2.39
4.	Hollow cone Wide angle Four holes nozzle (Local)	18.71	229.03	2.3
5.	Hollow done wide angle five holes nozzle (Local)	14.13	234.26	1.82

Satyanarayana and Patil (2000) reported highest seed cotton yield and cost effectiveness by using hollow cone nozzle.

Droplet size (VMD), density and uniformity co-efficient of various nozzles under field condition

The volume median diameter (VMD) of hallow cone nozzle- single hole (PTB local), hallow cone nozzle-single hole (Aspee XLB/N), Solid cone nozzle- Brass, Hallow cone wide angle four holes nozzle (Local) and hallow cone wide angle five holes nozzle (local) varied from 247.37, 240.81, 205.43, 229.03, 234.26 micron, respectively (Table 2). The droplet density of tested five nozzles was an average 15.06, 19.15, 13.8, 18.71 and

Table 3: Discharge rate of nozzles, quantity of water and time required for application of spray at different stages of crop

S.N.	Types of nozzle	Nozzle discharge rate (lpm) at laboratory condition at pressure of			Nozzle discharge rate (Ipm/ 32.4 m^2 plot) at field condition i.e. at operational pressure					Time require (hrs/ha)
		2.00 kg/cm^2	2.5 kg/cm^2	3.00 kg/cm^2	At square initiation (42 DAG)	At flower initiation (53 DAG)	At 25per cent flowering (63 DAG)	At 50per cent flowering (73 DAG)	Mean	
1.	Hollow cone nozzle – Single hole (PTB Local)	0.613	0.673	0.720	0.656 (202.76)*	0.777 (239.83)*	0.803 (248.04)*	0.903 (278.91)*	0.785 (242.39)*	11.21
2.	Hollow cone nozzle – Single Hole (Aspee XLB/N)	0.960	1.000	1.080	0.912 (281.78)	1.096 (338.31)	1.136 (350.83)	1.289 (397.90)	1.108 (342.21)	12.70
3.	Solid cone nozzle – (Brass)	0.860	0.952	1.076	0.844 (260.50)	1.013 (312.77)	1.050 (324.34)	1.19 1(367.86)	1.025 (316.37)	12.24
4.	Hollow cone Wide angle Four holes nozzle (Local)	1.088	1.210	1.260	1.070 (330.37)	1.285 (396.65)	1.332 (411.33)	1.511 (466.52)	1.300 (401.22)	10.85
5.	Hollow done wide angle five holes nozzle (Local)	1.300	1.520	1.860	1.209 (373.26)	1.424 (439.54)	1.243 (383.77)	1.650 (509.41)	1.382 (426.50)	9.15
6.	T1 fb T2 fb T3 fb T 4	-	-	-	0.656 (202.76)	1.096 (338.31)	1.050 (324.34)	1.511 (466.52)	1.078 (332.98)	11.31
7.	T2 fb T3 fb T 4 fb T5	-	-	-	0.912 (281.78)	1.031 (312.77)	1.332 (411.33)	1.650 (509.41)	1.231 (378.82)	10.28
8.	T2 fb T 4 fb T 5 fb T 5	-	-	-	0.912 (281.78)	1.285 (396.65)	1.243 (383.77)	1.650 (509.41)	1.273 (392.90)	9.00
9.	T 1 fb T2 fb T 4 fb T 4	-	-	-	0.656 (202.76)	1.096 (338.31)	1.332 (411.33)	1.511 (466.52)	1.149 (354.73)	11.36

*****Figure in the parenthesis indicated quantity of spray solution (lit/ha). DAG- Days after germination.

Table 4: Angle and coverage of spray at different growth stages of cotton crop

DAG	Average height of plant (cm)	Types of nozzle									
		Hollow cone nozzle (PTB Local)		Hollow cone nozzle (Plastic ASPEE XLB/N)		Solid cone nozzle (Brass)		Hollow cone wide angle nozzle four holes(Local)		Hollow cone wide angle nozzle five holes(Local)	
		Angle^{o}	Spray canopy (cm)	Angle^{o}	Spray canopy (cm)	Angle^{o}	Spray canopy (cm)	Angle^{o}	Spray canopy (cm)	Angle^{o}	Spray canopy (cm)
Square initiation-(42 DAG)	61.87*	91	90.00	98	89.00	92	94.00	103	100.00	105	109.00
Flowering initiation-(53 DAG)	73.12*	93	95.00	101	90.00	95	98.00	105	104.00	107	113.00
25per cent Flowering(63 DAG)	83.12*	93	95.00	103	92.00	97	100.00	106	108.00	108	115.00
50per cent Flowering (73 DAG)	96.34*	95	100.00	104	102.00	100	104.00	108	111.00	110	118.00

*Average height of plant including nozzle height (40 cm) from top of the plant

14.13drop/cm^{2}respectively and uniformity Co-efficient (UC) of such nozzles wasin range of 1.82 to 2.39. Mathewsand Hilsop(1984)was suggested that the range 150 to 250 micron of droplet size was most effective against cotton pests. Hence, the various nozzles tested in this study having droplet size was within (205.43 to 247.37micron) the effective range as suggested.

Discharge rate of nozzles under laboratory condition

The different nozzles were tested in laboratory condition for 2.0, 2.5 and 3.0 kg/cm^2 nozzle pressure (Table 3). It was observed that hallow cone nozzle- single hole (Local) had a discharged rate of 0.613, 0.673 and 0.720 lmp, respectively, for the above operating pressure. Similarly for hallow cone nozzle-single hole (Aspee XLN/ B) it was 0.960, 1.00 and 1.08 lpmfor solid cone nozzle-Brass (single hole) 0.860, 0.952 and 1.076lpm, for hallow cone wide angle four hole nozzle (Local) 1.088, 1.21 and 1.26 lpm and for hallow cone wide angle five holes nozzle (Local) 1.30, 1.52 and 1.86 lpm, respectively. At fieldcondition, from these nozzles, we could get more or less similar discharge rate at operational pressure tested in the laboratory and it varies with the crop stage. This discharge rate increases or decreases with variation in operating pressure. Paul (2008) reported that insecticides application for optimum insect control can be achieved by using solid cone and hollow cone nozzle. These nozzles operate40 – 60 psi i.e. 2- 4 kg/cm^2. Hence, present studies confirms the findings that these nozzles can operate effectively at 2 to 2.5 kg/cm^2 pressure. However, the discharge rate of these nozzles was also in line with the study conducted by Rudolf (2006) who reported the discharge rate of hollow cone nozzle 3.20 lpm at 4 kg/cm^2 pressure.

Discharge rate of nozzles at field condition

Water and time required per plot was recorded under field condition(Table 3).Water required (lit/ha) and time consumed (hrs/ha) for sprayingis increased with crop stage. At square initiation stage (42 DAG) lowest water discharge (Iit ha^{-1}) rate was observed and least time (hrs ha^{-1}). Lowest water requirement of 242.38 lit ha^{-1} was noted by usinghollow cone nozzle (PTB Local) and it was followed by solid cone nozzle (Brass) i.e. 316.36 lit. ha^{-1}.Highest water requirement was noted in hollow cone wide angle nozzle five holes (Local) i.e. 426.49 lit. ha^{-1} followed by hollow cone wide angle nozzle four holes (Local) i.e. 401.21 lit ha^{-1} at flowering stage (73 DAG).

Angle and coverage of sprays at different growth stages of cotton crop

It was observed from the Table 4 that increases in angle with plant height the spraycoverage was also increased.At square initiation stage angle of nozzle was minimum (91 - 105) compared to other stage of crop and it increased with the crop stages. The maximum angle (95-110) noted at 50 per cent flowering stage due to highest plant height and foliage. Spray angle increase with increase in pressure and height of plant. At this stage number of stroke of sprayers were increased with increase of pressure. Hofmman and Solseng (2004) suggested most agricultural nozzles have an angle from 65 to 120 degrees.

CONCLUSION

Spraying with hollow cone wide angle four holes nozzles (Local) proved best in respect of managing pests and optimum water discharge.

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Bio Intensive Management of Powdery Mildew of Sunflower

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ABSTRACT

Non significance difference was observed amongst the treatments against powdery mildew at 30 and 45 days after sowing. While at 70 days after sowing two spray of Difenoconazole 25 EC @ 2 ml l^{-1} of water at 45 and 60 DAS recorded minimum 9.33, 13.20 and 12.47 per cen t powdery mildew with highest yield of 1574, 1460 and 1528 kg yield ha^{-1} during all experimental years. Three years pooled data revealed that, two foliar sprays of Difenoconazole 25 EC @ 2 ml l^{-1} of water at 45 and 60 DAS recorded minimum 11.67 per cent intensity of powdery mildew with highest yield (1521 kg ha^{-1}) and highest ICBR 1 : 7. 39. The next best treatment was NSKE @ 5 ml l^{-1}at 45 + Difenoconazole 25 EC @ 2 ml l^{-1} at 60 DAS followed by *Psedumonus fluorescens* (Coimbatore strain) 10 g l^{-1} followed by *Psedumonus fluorescens* (Raichur strain) 10 g l^{-1} at 45 and 60 DAS , recorded 25.51, 29.11 and 35.30 per cent powdery mildew, respectively.

Sunflower (*Helianthus annus* L.*)* is an important oilseed crop. At present, the productivity is 623 kg ha^{-1} (Anonymous, 2015), while the yield potential is 1500 to 1800 kg ha^{-1} The gap in yield level of is mainly due to several biotic and biotic factors. Among these susceptibility to disease is considered to be one of the major constraints. The crop is reported to suffer heavy losses because of fungal, bacterial and viral diseases, one of the prominent disease among them is powdery mildew caused by *Erysiphe cichoracearum*. The disease is an epidemic form during *rabi* season in most of the sunflower areas. Losses due to powdery mildew are proportionate to the disease severity and vary considerably depending on the stage of the plant growth at which disease occurrs. High inocula in the field coinciding with favorable environmental conditions lead to early infection causing severe losses up to 37.61 per cent (Karuna *et al;* 2015). Singh (2012) and Surwase *et al*, (2009) reported botanicals are effective against powdery mildew while working with other crops. Karuna *et al*, (2015) and Akhileshwari *et al*, (2012) in worked on fungicidal management of sunflower powdery mildew disease. Keeping in view the severity of the disease in sunflower, present investigation was carried out with an objective to find out and recommend effective control measures against powdery mildew of sunflower.

MATERIAL AND METHODS

Field experiments was conducted at Oilseeds Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *Rabi* season of 2012-13, 2013-14 and 2014-15 with protective irrigation at the peak growing stages of the crop. The experiment was laid down in Randomized Block Design (RBD) with seven treatments and three replications. Treatments *viz*; *Psedumonus fluorescens* (DOR strain) 10 g l^{-1}, *Psedumonus fluorescens* (Coimbatore strain) 10 g l^{-1}, *Psedumonus fluorescens* (Raichur strain) 10 g l, NSKE @ 5 ml l^{-1}, NSKE @ 5 ml l^{-1} + Difenoconazole 25 EC @ 2 ml l^{-1}, Difenoconazole 25 EC @ 2 ml l^{-1} were tested with one untreated control. Two sprays of each treatment were given, first at 45 and second at 60 days after sowing of the crop. Observations were recorded at 35, 45 and 70 Days after sowing of the crop on 6 leaves of each plant i.e two leaves each from bottom, middle and top of randomly selected 5 plants in each plot and per cent severity was calculated. At the time of harvest, sunflower head from all the treatments were separated. After threshing and winnowing, seed weight of each replication was recorded and yield ha^{-1} was computed by using net plot yield data and the data was subjected to statistical analysis.

RESULTS AND DISCUSSION

During 2012-13, treatments showed non significant difference at 30 and 45 days after sowing against the powdery mildew. While at 70 days after sowing significance difference was observed, where in two spray of Difenoconazole @ 25 EC @ 2 ml l^{-1} at 45 and 60 DAS recorded minimum 9.33 per cent intensity of powdery mildew with highest seed yield 1574 kg ha^{-1} followed by NSKE @ 5 ml l^{-1} at 45 + Difenoconazole @ 25 EC @ 2 ml l^{-1} recorded 17.67 per cent intensity, 1283 kg ha^{-1} yield and found superior over all other treatments. The next best treatment was *Psedumonus fluorescens* (Coimbatore) @ 10 g l^{-1} followed by *P. fluorescens* (Raichur) @ 10 g l^{-1} and

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Table 1. Per cent intensity of Powdery mildew at 30 and 45 days after sowing

S. N.	Treatments	30 DAS				45 DAS			
		12-13	13-14	14-15	Pooled mean	12-13	13-14	14-15	Pooled mean
T_1	*Psedumonus fluorescens* (DOR) 10 g/l,	11.33	10.93	10.47	10.91	15.93	15.33	14.33	15.20
	two spray at 45 and 60 DAS	(19.67)*	(19.31)	(18.87)	(19.14)	(23.53)	(22.95)	(22.24)	(22.94)
T_2	*Psedumonus fluorescens* (Coimbatore)	11.80	11.53	10.67	11.33	16.47	16.53	15.07	16.02
	10 g/l, two spray at 45 and 60 DAS	(20.09)	(19.85)	(19.06)	(19.41)	(24.04)	(24.09)	(22.83)	(23.59)
T_3	*Psedumonus fluorescens* (Raichur)	12.40	11.60	12.20	12.07	15.93	15.80	14.20	15.31
	10 g/l, two spray at 45 and 60 DAS	(20.62)	(19.91)	(20.44)	(20.50)	(23.47)	(23.42)	(22.13)	(23.03)
T_4	NSKE @ 5 ml/l, two spray at 45 and	12.93	12.27	12.67	12.62	16.27	16.00	14.87	15.71
	60 DAS	(21.05)	(20.49)	(20.85)	(20.92)	(23.89)	(23.67)	(22.67)	(23.35)
T_5	NSKE @ 5 ml/l at 45 DAS +	13.40	13.00	13.20	13.20	16.07	15.27	13.73	15.02
	Difenoconazole 25 EC @ 2 ml/l at 60 DAS	(21.47)	(21.13)	(21.30)	(21.36)	(23.00)	(21.74)	(21.75)	(22.79)
T_6	Difenoconazole 25 EC @ 2 ml/l at	12.80	12.27	12.53	12.53	16.00	16.27	15.87	16.04
	45 and 60 DAS	(20.96)	(20.50)	(20.73)	(20.81)	(23.21)	(23.52)	(23.47)	(23.61)
T_7	Control	13.33	12.67	12.33	12.78	17.13	17.00	16.13	16.76
		(21.42)	(20.85)	(20.56)	(20.85)	(24.65)	(24.65)	(23.67)	(24.16)
	SE (m) $\pm$	-	-	-		-	-	-	-
	CD at 5 %	-	-	-		-	-	-	-
	CV %	-	-	-		-	-	-	-

*Arc sin transformed values

Table 2. Effect of different treatments against Powdery mildew, yield and ICBR.

S.N.	Treatment	Powdery mildew at 70 DAS (per cent intensity)				Yield kg/ha				ICBR
		12-13	13-14	14-15	Pooled mean	12-13	13-14	14-15	Pooled mean	
T_1	*Psedumonus fluorescens*(DOR)	33.3	48.67	28.33	36.77	914	920	1213	1016	1 : 5.56
	10 g/l, two spray at 45 and 60 DAS	(35.17)*	(44.23)	(32.15)	(33.19)					
T_2	*Psedumonus fluorescens* (Coimbatore)	25.0	30.33	32.00	29.11	1010	1040	1083	1044	1 : 5.70
	10 g/l, two spray at 45 and 60 DAS	(29.93)	(33.36)	(34.44)	(32.97)					
T_3	*Psedumonus fluorescens* (Raichur) 10 g/l,	28.3	43.33	34.27	35.30	973	978	1153	1035	1 : 5.61
	two spray at 45 and 60 DAS	(32.14)	(42.46)	(36.76)	(34.60)					
T_4	NSKE @ 5 ml/l, two spray at 45 and 60 DAS	45.0	55.13	44.20	48.11	791	850	859	833	1 : 2.37
		(42.11)	(47.99)	(41.67)	(41.82)					
T_5	NSKE @ 5 ml/l at 45 DAS + Difenoconazole	17.67	27.67	31.20	25.51	1309	1283	1139	1243	1 : 5.47
	25 EC @ 2 ml/l at 60DAS	(24.82)	(31.59)	(33.92)	(30.92)					
T_6	Difenoconazole @ 25 EC @ 2 ml/l at	9.33	13.20	12.47	11.67	1574	1460	1528	1521	1 : 7.39
	45 and 60 DAS	(17.77)	(21.17)	(20.61)	(19.71)					
T_7	Control	62.67	83.33	65.67	70.56	519	501	588	536	0.00
		(52.34)	(67.03)	(54.50)	(53.53)					
	SE (m) $\pm$	1.93	3.21	2.77	1.29	52.54	75.62	52.54	49.52	-
	CD at 5 %	5.95	9.90	8.53	3.96	161.91	233	161.91	152.61	-
	CV%	10.00	13.54	13.20	6.32	9.00	13.04	8.4	8.31	-

*Arc sin transformed values

P. fluorescens (DOR) @ 10 g l^{-1} recorded 25.00, 28.30 and 33.30 per cent powdery mildew with 1010, 973 and 914 kg ha^{-1} yield respectively (Table 1) .

During 2013 - 2014 powdery mildew was very low at 30 and 45 days after sowing and showed non significance difference in all treatments. At 70 days after sowing significance difference was observed amongst the treatments, where in Difenoconazole @ 25 EC @ 2 ml l^{-1} two spray at 45 and 60 DAS recorded minimum 13.20 per cent intensity of powdery mildew with highest seed yield 1460 kg ha^{-1} followed by treatment NSKE @ 5 ml l^{-1} at 45 + Difenoconazole @ 25 EC @ 2 ml l^{-1} at 60 DAS recorded 27.67 per cent intensity of powdery mildew, 1283 kg ha^{-1} yield and found superior over all other treatments (Table 1). In bio agents *Psedumonus fluorescens* (Coimbatore) and *P. fluorescens* (Raichur) @ 10 g l^{-1} found at par with each other, recorded 30.33 and 43.33 per cent powdery mildew with 1040 and 978 kg ha^{-1} yield, respectively.

During 2014 - 2015 non significance difference was observed amongst the treatments against powdery mildew at 30 and 45 days after sowing. Data given in table 1 revealed that, minimum 12.47 per cent intensity of powdery mildew was recorded at 70 DAS from the two spray of Difenoconazole 25 EC @ 2 ml l^{-1} 45 and 60 DAS . Next best treatment was *Psedumonus fluorescens* (DOR) 10 g l^{-1} followed by NSKE @ 5 ml l^{-1} spray at 45 DAS + Difenoconazole 25 EC @ 2 ml l^{-1} at 60 DAS, *P. fluorescens* (Coimbatore) 10 g l^{-1} at 45 and 60 DAS, *P. fluorescens* (Raichur) 10 g l^{-1} recorded 28.33, 31.20, 32.00 and 34.27 per cent powdery mildew, respectively, which were at par with each other. Highest yield 1528 kg ha^{-1} was obtained from the treatment of Difenoconazole 25 EC @ 2 ml l^{-1} .

Pooled results

Data given in Table 1 showed non significant differences in intensity of Powdery mildew at 30 and 45 days after sowing in experimental plots. Inocula was there but might not favored by environmental features required for development of disease. Karuna *et al*, (2015) reported that, high inocula in the field coinciding with favouable environmental conditions lead to early infections causing severe losses. At 70 days after sowing three years pooled mean (Table 2) revealed that, two foliar sprays of difenoconazole 25 EC @ 2 ml l^{-1} at 45 and 60 DAS recorded minimum 11.67 per cent intensity of powdery mildew. The next best treatment was NSKE @ 5 ml l^{-1} at 45 + Difenoconazole 25 EC @ 2 ml l^{-1} at 60 DAS followed by bioagent *Psedumonus fluorescens* (Coimbatore) 10 g l^{-1} at 45 and 60 DAS followed by *P. fluorescens* (Raichur) 10 g l^{-1} at 45 and 60 DAS , recorded 25.51, 29.11 and 35.30 per cent powdery mildew respectively. *Psedumonus fluorescens* (Raichur) 10 g l^{-1} in the form of two sprays at 45 and 60 DAS was found at par with *P. fluorescens* (Coimbatore) 10 g l^{-1}. The next best treatment was spraying of *P. fluorescens* (DOR) 10 g l^{-1} at 45 and 60 DAS recorded 36.72 per cent intensity of powder mildew and found at par with *P. fluorescens* (Coimbatore) 10 g l^{-1} and *P. fluorescens* (Raichur) 10 g l^{-1}.

Three years pooled differences in respect to yield also revealed significance among all treatments. Difenoconazole25 EC @ 2 ml l^{-1} recorded highest yield 1521 kg ha^{-1} followed by NSKE @ 5 ml l^{-1} at 45 + Difenoconazole 25 EC @ 2 ml l^{-1} at 60 DAS (1243 kg ha^{-1}). Two spray of *Psedumonus fluorescens* (Coimbatore) 10 g l^{-1} at 45 and 60 DAS recorded 1044 kg ha^{-1} yield followed by *P. fluorescens* (Raichur) 10 g l^{-1} (1035 kg ha^{-1}) and *P. fluorescens* (DOR) 10 g/l (1016 kg ha^{-1}). Higher monetary return 1 : 7.39 was obtained from two spray of Difenoconazole 25 EC @ 2 ml l^{-1} at 45 and 60 DAS. Difenoconazole 25 EC is a , broad spectrum, systemic fungicide for long-lasting prophilactic and strong curative measure. After being application of difenoconazole is taken up by the plant and acts on the fungal pathogen during penetration and haustoria formation. It prevents the development of fungi by interfering with the biosynthesis of sterols in cell membranes and inhibits ergosterol biosynthesis. Ergosterol is essential to the structure of cell wall and its absence causes irreparable damage to the cell wall and fungus dies.

The result of present investigation are in agreement with the findings of Karuna *et al*, (2015) and Akhileshwari *et al*, (2012). Surwase *et al*, (2009) studied the management of Pea powdery mildew by fungicides, botanicals and bioagents, result indicated that, hexaconazole (0.05%), penoconazole (0.05 %), NSKE (5 %) and trichoderma harzianum (0.5 %) found highly effective and economical.

Difenoconazole 25 EC @ 2 ml l^{-1} at 45 and 60 DAS found more effective against the powdery mildew disease of sunflower as compare to other treatment, with minimum 11.67 per cent intensity of powdery mildew, resulted in highest yield 1521 kg ha^{-1} with higher monetary return.

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Adoption of Herbicide Application Practices by the Soybean Farmers

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ABSTRACT

Soybean is the most important pulse crop in vidarbha region. Therefore, the study was undertaken to assess extent of adoption of selected herbicides application practice by the soybean farmers.The study was conducted in Akola district of Maharashtra State. With the help of exploratory research design, data was collected from 120 soybean farmers and analyzed with the help of suitable statistical methods. In this study extent of adoption of selected herbicide application practices were measured by using adoption index. The study revealed that, more than half (52.50%) of the soybean farmers have medium level of adoption followed by 38.33 per cent have high level of adoption of herbicide application practices. In constraint analysis non-availability of money at proper time (45.83%) and non-availability of labour for spraying of herbicides (41.66 %) are the major constraints faced by selected respondents.

Pearl of oil called as "soya". Soybean (*Glycine max* L. merill) became the miracle crop of the 21st century.On the global scale, it is tops on the list of oil seed crops. It is introduced as an oil seed crops in India to increase edible oil resources in the country due to its high yield potential. It contain about 20 per cent oil and 40 per cent high quality proteins, its sprouting grains contains a considerable amount of vitamin C and vitamin A in the form of precursor carotene which is converted into vitamin A in the intestine. Madhya Pradesh is the first and Maharashtra is second largest soybean producing States in India. Madhya Pradesh produced 70 per cent and Maharashtra produced 18 per cent of countries soybean production. In India 120.32 lakh hectare of land was under soybean cultivation during 2013 with an average yield of 10.79 quintals ha^{-1}. In Maharashtra total 38.704 lakh hectare of land under soybean cultivation during 2013 with an average yield of 12.55 quintals ha^{-1} (Anonymous 2013). Vidarbha becomes the main region of soybean production in Maharashtra. Cotton was main crop of this region in kharif season but from last five years farmers prefer soybean crop because of less input and high output and also requires less agronomical practices as compared to cotton crop.

To improve the agricultural production some form of improved appropriate technology is necessary. The plant protection is an important and vital aspect of agricultural crop production. Weed is the serious problem in crop production. Day by day productivity of soybean crop is reduced because the crop suffered from weed infestation. Manual weed control is difficult and costly because of unavailability of labours and high cost of labour. Presence of weeds in an around agricultural land causes enormous losses which may be borne by us. About one third of potential food production in India is lost due to insect, weed, disease etc.(Mathur,1998). Among all pest in India weeds alone are responsible for about one third loss in crop production (Kulshreshta and Parmar, 1992). An analysis revealed that losses caused by weeds in India were to the tune of 9.28 million tones in cereals, 0.57 million tones in oilseeds, 0.78 million tones in pulses and 7.2 million tones in fibre and other commercial crops (Sahoo and Saraswat,1998). Chemical weed control is the easy and economical way of controlling weeds.The importance of herbicides for improving crop productivity is not only in situation where labour is scarce and expensive but also where labour is plentiful and cheap as well as relatively less effective. Keeping these facts in mind the study was formulated with an objective to study the adoption of herbicides by the soybean farmers.

MATERIAL AND METHODS

The present study was conducted in Akola *Panchayat Samiti* of Akola district. Exploratory research design of social research was used for the study. Ten villages were selected randomly. Twelve farmers from each village were selected with the help of random sampling method thus the total 120 farmers were selected for the study. Data was collected personally by contacting with selected respondents with the help of pretested interview schedule. The statistical procedures following for the analysis of data were frequency, percentage, arithmetic

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mean, standard deviation and coefficient of correlation.To measure the adoption level of farmers' adoption index was prepared by taking 14 herbicide application practices. These practices were decided by referring university literature and after the discussions held with subject matter specialist. In constraint analysis, constraints faced by soybean farmers in use of herbicides in soybean crop were recorded. The adoption level categories were formulated as low, medium and high by equal interval method.

RESULTS AND DISCUSSION

Practice wise adoption of herbicide application practices:

It is clear from Table 1 that, majority (86.67%) of the respondents completely adopted recommended herbicide application practices in soybean crop followed by 9.17 per cent did not adopted herbicides in soybean crop these respondents mainly from non-adopters group. More than half of the respondents 55.00 per cent partially adopted recommended dose of herbicides in soybean crop followed by 35.83 per cent have completely adopted recommended dose of herbicides and remaining 9.17 per cent farmers were found non adopters of herbicides in soybean crop.

About 58.33 per cent of farmers adopted proper spray pump i.e. knapsack sprayer followed by 32.50 per cent respondents have adopted power sprayer. More than half (57.50per cent) of the respondents have used the herbicides at recommended time and remaining 3.33 per cent of respondents partially adopted that means after 20 days of sowing. In case of calibration of spray pump not a single respondent adopted this practice of calibration of pump. Majority (79.17%) of the respondents partially adopted the practice of 500 lit of water ha^{-1} for application of herbicides, that means they are not using recommended 500 liter of water per hector, the main reason is most of the farmers in Akola district using power sprayer for herbicide application, even though it is not recommended for herbicide application. It was followed by 11.66 per cent of respondents completely adopted recommended quantity of water for spraying.

Table.1. Distribution of the soybean farmers according to their adoption of herbicide application practices

S. N.	Herbicide application practices	Respondents (n=120)		
		Complete Adoption	Partial Adoption	No Adoption
1	Use of recommended herbicides for soybean crop.	109 (90.83)	0 (0.00)	11 (09.17)
2	Application of recommended dose of herbicide in soybean crop	43 (35.83)	66 (55.00)	11 (09.17)
3	Knapsack spray pump used for spraying of herbicide	70 (58.33)	39 (32.50)	11 (09.17)
4	Application of herbicide at recommended time i.e. before 20 days after sowing.	69 (57.50)	40 (33.33)	11 (09.17)
5	Calibration of spray pump was done	0 (0.00)	0 (0.00)	120(100.00)
6	Quantity of water used for spraying of herbicide (200 lit $acre^{-1}$)	14 (11.66)	95 (79.17)	11 (09.17)
7	Application of herbicide in clear weather.	108 (90.00)	01 (0.83)	11(09.17)
8	Flat fan or flood jet type of nozzle used for spraying herbicide	68 (56.66)	41(34.17)	11 (09.17)
9	Clean water used for spraying of herbicide	105 (87.50)	04 (03.33)	11 (09.17)
10	Application of herbicide was done when sufficient moisture present in soil	105 (87.50)	04 (03.33)	11 (09.17)
11	Use of separate pump for spraying herbicide	02 (01.67)	0 (0.00)	118 (98.33)
12	Not to take any inter-cultural operation for 8-10 days after herbicide application	104 (86.67)	05 (04.16)	11 (09.17)
13	Spraying of herbicides with pesticide (by mixing)	01 (0.83)	0 (0.00)	119 (99.17)
14	Followed the crop rotation	116 (96.67)	0 (0.00)	04 (03.33)

(Figures in parenthesis indicate percentage)

Majority (90.00 %) of the respondents have applied herbicides in clear weather followed by 0.83 per cent of the respondents partially adopt this practice More than half (56.66 %) of the herbicide adopters have used the recommended type of nozzle for spraying of herbicides that is flood jet or flat fan nozzle followed by 34.17 per cent of the respondents not adopted recommended type of nozzle.

Majority (87.50 %) of the respondents completely adopt the clean water for application of herbicides and 3.33 per cent respondents partially adopted these practice. Three fourth (87.50 %) of soybean farmers done spraying when sufficient moisture present in soil and only 3.33 per cent respondents partially adopted this practice. Majority (98.33%) of the respondents not have separate spray pump only 1.67 per cent respondents have separate pump for spraying.

Majority (86.67%) of the farmers had not taken any intercultural operations for 8-10 days after herbicide application. Whereas, 9.17 per cent respondents where the non-adopter of herbicides. Majority (99.17%) of the respondents have applied herbicide separately. Regarding the crop rotation majority of 96.67 per cent respondents completely adopted crop rotation. Only 3.33 per cent respondents not adopted crop rotation. As far as overall adoption concerned, it is evident from Table 2 that more than half (52.50 %) of the respondents were having medium level of adoption of herbicide application practices and 38.33 per cent as well as 09.17 per cent were found in high and low category, respectively.

Table 2. Distribution of the respondents according to their overall adoption of herbicide application practices

S. N.	Category	Respondents (n=120)	
		Frequency	Percentage
1	Low **(Up to 33.33)**	11	09.17
2	Medium **(33.34 to 66.66)**	63	52.50
3	High **(Above 66.66)**	46	38.33
	Total	120	100.00

From above discussion, it can be concluded that concluded that, majority of soybean farmers (52.50 %) found in medium category of adoption level. Similar finding was observed by Borhade (2011) and Mohite (2013) who stated that majority of respondents had medium level of adoption.

Constraints in adoption of herbicide application practices in soybean crop

From Table 3 it is observed that in case of technical constraints one fourth (25.00 %) of the farmers expressed that they are not getting the proper information about herbicide applications from extension functionaries, this was followed by lack of proper knowledge with 22.50 per cent respondents. More than one third (41.66%) of the respondents expressed the lack of labourers for herbicide application as main constraints.

Table 3. Distribution of the respondents according constraints faced by them in adoption of herbicides application practices

S. N.	Constraints	Respondents (n=120)	
		Frequency	Percentage
1	**Technical constraints**		
a)	Lack of proper information about herbicide application practices from extension functionaries.	30	25.00
b)	Lack of proper knowledge about herbicide.	27	22.50
c)	Lack of labourers for herbicide application.	50	41.66
2	**Financial constraints**		
a)	Non availability of money at proper time.	55	45.83
3	**Other constraints**		
a)	If rains occur after herbicide application not gets the effective results in weed control.	25	20.83
b)	Long gap in monsoon leads to delayed application.	15	12.50

In case of financial constraints 45.83 per cent respondents faced the constraints of non-availability of money at proper time. In case of other constraints if rains occur after herbicide application not gets the effective results in weed control were mentioned by 20.83 per cent farmers and long gap in monsoon leads to delayed application of herbicide were expressed by 12.50 per cent farmers. On the parallel line Asane (2003) and Ambhore (2006) found the similar technical constraints in adoption of improved technology of soybean cultivation.

CONCLUSIONS

From the present study it is concluded that, majority of soybean farmers (52.50 %) found in medium category of adoption followed by high level of adoption regarding herbicides application practices (38.33 %). It was observed that some of the important herbicide application practices like recommended dose of herbicide, recommended quantity of water etc. were partially adopted by considerable group of farmers. Partial adoption could not give the relative advantage as expected, which can be demoralizing the farmer for adoption of herbicides in future. Hence, it is necessary that extension functionaries should provide the detailed information to the farming community about use of herbicides, it will definitely useful for increasing the complete adoption level and farmers will gets the good results of the herbicide application. In constraint analysis non-availability of money at proper time (45.83 %) and non-availability of labour for spraying (41.66 %) are the major constraints experienced by the farmers.

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Economic Analysis of Goat Farming System in Osmanabad District of Marathwada Region

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ABSTRACT

The farmers from Osmanabad district are adopting crop + goatery farming system for increasing the income. These subsidiary occupations have also potential to provide regular and continuous self-employment throughout the year. This farming system was found to be profitable in the region as BC-ratio was 1.57. However the output-input ratio for goat rearing was 2.16. Therefore the farmers from Osmanabad district can expand goat rearing business so that socio-economic status of the farmers would bring prosperity in the farming.

Since, there is no further scope for horizontal expansion of land for cultivation of farm enterprise; the emphasis should be on vertical expansion by increasing the productivity using the available recourses properly and choosing the best enterprise mix. The income from cropping alone is hardly sufficient to sustain the farmers family in case of small and marginal farmers, who constitute 80.30 per cent of agricultural population with only 36 per cent of area operated with decline in farm size due to explosion of population. It would be difficult to produce enough food for the family by the end of 21st century. The progress in production or steady growth in output is necessary. In this context, farming system approach is one of the important solution to face this peculiar situation because in farming system approach the different enterprises can be carefully under taken and the location specific system should be developed based on available resources which will result in to sustainable development. Different farming system which has been practiced in India is an outcome of several hundred years of trial and error. The different farming system as understood in modern farming system with all their proven merits needs scientific organization and optimum combination which will increase productive efficiency of various resources and also increase income of the farm family. Therefore, in the Eleventh Five Year Plan, greater emphasis has been laid on integration of crop production with rearing of high yielding milch animals as one of the measures to solve problems of seasonal income and employment, high risk and uncertainty associated with crop farming. In Maharashtra, where famines are of common occurrence and majority of area is dry, adoption of different farming systems offers special advantages. The present investigation would like to verify these propositions through field study. Farming system is an integrated set of activities that farmers perform in their farms under their resources and circumstances to maximize the productivity and net farm income on a sustainable basis. Farming systems relates to the whole farm rather than individual elements; it is driven as much by the overall welfare of farming households as by goals of yield and profitability. Farming systems are closely linked to livelihoods of most rural people's living. The need for farming systems approach in the present scenario is mainly due to high cost of farm inputs, fluctuation in the market price of farm produce, risk in crop harvest due to climatic vagaries and biotic factors.

Goat is called as "cow" of poor people because of getting more profit from low investment on goat. There are 102 breeds of goat in the world, out of them 20 are found in India. India has the highest i.e. 117 million heads (20.30 % of the world goat population). Goat can be reared for meat, milk and manure purpose. It is important to note that goat rearing occupation has been increasing fastly as competitive enterprise rather than complementary one. Near about 15 lakh of families rearing the goats in India. Osmanabadi goat is one of the most popular goat breed found in Marathwada region of Maharashtra state. Therefore systematic investigation was carried out in crop + goatery farming system in Osmanabad district of Marathwada region to study the socio-economic profile of the farmers practicing crop + goatery farming systems and to study the cost, return and its profitability in the studied districts.

MATERIAL AND METHODS

In order to study the economics of farming systems in Osmanabad district a scarcity zone of Marathwada region of Maharashtra state, the primary data pertaining to various aspects viz., family information,

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cropping pattern, inputs, outputs, etc. of farming systems were collected from 30 cultivators from three villages from two talukas of Osmanabad district. The multistage sampling technique was adopted for selection of tahasils, villages and the respondents. For identification of dominant farming systems in selected tahasils of the district the extensive survey was undertaken and crop + goatery for Osmanabad district was identified. The simple tabular analysis was carried out to study socio-economic aspects, cropping pattern, economics of farming systems, etc. The collected data were tabulated and simple statistical measures such as ratio, percentage, mean, etc were applied. Various cost concepts such as Cost-A, Cost-B, Cost-C were also employed and only Cost-C is considered for estimating the costs in studying the economics of farming systems.

RESULTS AND DISCUSSION

Socio-economic characteristics of selected farmers

Socio-economic characteristics of farmer's crop + goatery farming systems were estimated and are presented in Table 1. The result revealed that middle age farmers (36-49) years were observed in crop + goatery farming system and it was observed 43.33 per cent. Old age farmers were 36.67 per cent. Related to education level, middle school level was dominating i.e. 60.00 per cent. High school and above level was observed 26.67 per cent. Related to marital status, married farmers were observed 93.33 per cent of total farmers. About average family size, number of male observed 30.65 per cent, number of female and children were observed 27.52 per cent and 41.83 per cent respectively. In occupational status, agriculture with allied enterprise was fully dominating in crop + goatery farming system i.e. 100.00 per cent. In case of land holding, large type land holding (4 ha and above) was observed highest i.e. 64.07 per cent.

Table 1 Socio-economic characteristics of selected farmers from crop + goatery farming system

	Particular	Crop + Goatery	
		Frequency (n=30)	Per cent
1	**Age (Years)**		
i)	Young (>18 to d"35)	6	20.00
ii)	Middle (>36 to d"49)	13	43.33
iii)	Old (>50)	11	36.67
2	**Education level**		
i)	Illiterate	4	13.33
ii)	Up to middle school	18	60.00
iii)	High school and above	8	26.67
3	**Marital status**		
i)	Married	28	93.33
ii)	Unmarried	0	0.00
	Widower	2	6.67
4	**Family size**		
i)	Male	1.37	30.65
ii)	Female	1.23	27.52
iii)	Children	1.87	41.83
	Total	4.47	100.00
5	**Occupational level**		
i)	Agriculture + Dairy/Fruit/ Goat/Sericulture	30	100.00
ii)	Agriculture + Service	0	0.00
6	**Land holding (ha)**		
i)	Small (d" 1ha)	0.55	7.66
ii)	Medium(>1ha to d" 4 ha)	2.03	28.27
iii)	Large (>4 ha)	4.60	64.07
	Total	**7.18**	**100.00**

Cropping pattern and livestock pattern

Yearly sequence and spatial arrangement of crops and fallow on a given area is called cropping pattern (Chavan, 2011).

Cropping pattern and livestock pattern on crop + goatery farming systems were estimated and are presented in Table 2. The results revealed that grossed crop area was 2.39 hectares in which soybean was dominant crop with 25.94 per cent area followed by cotton (18.83 %), sugarcane (15.06 %), wheat (14.64 %) and *Rabi* sorghum (10.88 %) are major crops. In regard to livestock pattern, cow was observed 2.65 per cent. Goat was major animal in crop + goatery farming system i.e. 95.64 per cent. Total livestock was i.e. 21.54 unit in crop + goatery farming system.

Table 2. Cropping pattern of selected farmers from crop + goatery farming system

Particular	Crop + Goatery	
	Area (ha)	Per cent
Kharif		
1. Soybean	0.62	25.94
2. Cotton	0.45	18.83
3. *Kharif* Sorghum	0.04	1.67
4. Pigeonpea	0.17	7.11
5. Green gram	0.01	0.42
6. Black gram	0.02	0.84
Rabi		
7. Wheat	0.35	14.64
8. Chickpea	0.03	1.26
9. *Rabi* Sorghum	0.26	10.88
Summer		
10. Groundnut	0.00	0.00
11. Maize	0.07	3.35
Annual		
12. Banana	0.00	0.00
13. Turmeric	0.00	0.00
14. Sugarcane	0.36	15.06
15. Mulberry	0.00	0.00
16. Net cropped area	1.81	75.73
17. Double cropped area	0.58	24.27
18. Gross cropped area	2.39	100.00
19. Cropping intensity	132.04	
Livestock		
20. Cow	0.57	2.65
21. Buffalo	0.37	1.72
22.Goat	20.60	95.64
Total	**21.54**	**100.00**

Per goat input utilization and output

Per goat annual input utilization and output in various farming systems were estimated and presented in Table 3. Result revealed that use of dry fodder; green fodder and concentrate were found 27.01 kg, 19.57 Kg and 10.36 kg, respectively. Use of human labour was 5.20 mandays. In respect to milk production, young calve and FYM produce was found in crop + goatery farming system i. e. 3.14 liters, 0.66 numbers and 1.10 quintals ,respectively.

Table 3. Per goat annual input utilization and output in crop + goatery farming system

	Particular	Unit	Crop + Goatery
1	Dry fodder	kg	27.01
2	Green fodder	kg	19.57
3	Concentrate	kg	10.36
4	Human labour	manday	5.20
5	Production of milk	L	3.41
6	Young calves	No.	0.66
7	FYM	q	1.10

Per goat annual costs and returns

Per goat annual costs and returns in crop + goatery farming systems were calculated and are presented in Table 4. The result showed that variable cost on crop + goatery was found Rs 1138.38 and its contribute 70.60 per cent of the total cost. Fixed cost was observed 29.40 per cent of total cost. Total cost was found Rs 1612.37, respectively.

It implied that near about 55 per cent expenditure was done on use of dry fodder, human labour and interest on working capital together in goat enterprise. Gross return was found Rs 3488.97. In case of returns goat^{-1} production of milk, young calve and FYM produce were Rs. 102.30, Rs 3112.50 and Rs. 274.17, respectively. Thus net profit and output- input ratio was found i.e. Rs 1873.60 and 2.16, respectively.

Table 4 Per goat annual costs and returns from crop + goatery farming system (Rs goat^{-1})

	Particular	Crop + Goatery
1	Dry fodder	137.00
		(8.50)
2	Green fodder	68.89
		(4.27)
3	Concentrate	105.51
		(6.54)
4	Human labour	624.47
		(38.73)
5	Veterinary aids	52.62
		(3.26)
6	Electricity charges	22.93
		(1.42)

7	Miscellaneous expenditure	14.15
		(0.88)
8	Interest on working capital	112.81
		(7.00)
9	**Variable cost**	**1138.38**
		(70.60)
10	Depreciation on goat	314.16
		(19.48)
11	Depreciation on shed	79.60
		(4.94)
12	Deprecation on equipment	10.28
		(0.64)
13	Deprecation on Fixed capita	69.95
		(4.34)
14	**Fixed cost**	**473.99**
		(29.40)
15	**Total cost**	**1612.37**
		(**100.00**)
16	Production of milk	102.30
		(2.93)
17	Young calves	3112.50
		(89.21)
18	FYM	274.17
		(7.86)
19	**Gross return**	**3488.97**
		(**100.00**)
20	Net profit	1873.60
21	output-input ratio	2.16

Economics of crop + goatery farming system

Economics of crop + goatery farming system were calculated and are presented in Table 5. In relation to crop + goatery farming system, sugarcane showed net profit ha^{-1} Rs 139297.34 while cotton and soybean net profit was Rs 32674.25 and Rs 25654.52 ha^{-1}, respectively. Similarly net profit of chickpea and wheat were Rs 17849.97 and Rs 16946.02 ha^{-1}, respectively. In respect to, per buffalo and per cow showed net profit Rs 31726.19 and Rs 19910.40 while goat^{-1} gave net profit Rs 1873.60. BC-ratio was found for crop + goatery farming system was 1.57.

Table 5 Economics of crop + goatery farming system

Enterprise		Crop + Goatery		
		Cost-C/ TC (Rs)	**Gross return (Rs)**	**Net profit (Rs)**
1.	Soybean (Rs ha^{-1})	38993.17	64647.69	25654.52
2.	Cotton (Rs ha^{-1})	69058.28	101732.53	32674.25
3.	*Kharif* Sorghum (Rs ha^{-1})	30092.97	35686.87	5593.90
4.	Pigeonpea (Rs ha^{-1})	32552.42	43667.85	11115.43
5.	Green gram (Rs ha^{-1})	28087.86	33425.18	5337.32
6.	Black gram (Rs ha^{-1})	26730.62	33856.30	7125.68
7.	Wheat (Rs ha^{-1})	36308.36	53254.38	16946.02
8.	Chickpea (Rs ha^{-1})	32338.78	50188.75	17849.97
9.	*Rabi* Sorghum (Rs ha(Rs/ha))	29988.07	35219.87	5231.80
10.	Groundnut (Rs ha^{-1})	-	-	-
11.	Maize (Rs ha^{-1})	19636.22	23724.00	4087.78
12.	Banana (Rs ha^{-1})	-	-	-
13.	Turmeric (Rs ha^{-1})	-	-	-
14.	Sugarcane (Rs ha^{-1})	133314.42	272611.76	139297.34
15.	Mulberry (Rs ha^{-1})	-	-	-
16	Cow (Rs cow^{-1})	32963.04	52873.44	19910.40
17	Buffalo (Rs buffalo^{-1})	54780.14	86506.32	31726.19
18	Goat (Rs goat^{-1})	1615.37	3488.97	1873.60
19	Cocoon production x Rs. batch^{-1}	-	-	-
20.	BC-ratio		1.57	

Constraints faced by farmers in crop + goatery farming systems

Constraints faced by goat rearers in goat rearing business were studied in frequency and percentage form and are presented in Table 6. The results revealed that, major constraint faced by goat rearers were non availability of drainage facilities in shed during rainy season which was expressed by 76.67 per cent goat rearers. Lack of grazing land was expressed by 63.33 per cent goat rearers, non availability of medicinal facilities was expressed by 53.33 per cent goat rearers and non-availability of breeding facility was expressed by 50.00 per cent goat rearers. In

Table 6 Constraints faced by farmers in crop + goatery farming systems

	Particular	Frequency (n=30)	Per cent	Rank
1	Non availability of drainage facilities in shed during rainy season	23	76.67	I
2	Lack of grazing land	19	63.33	II
3	Non availability of medicinal facilities	16	53.33	III
4	Non availability of breeding	15	50.00	IV
5	High mortality of kids during rainy season	14	46.67	V
6	Unavailability of vehicle for transportation of goats	13	43.33	VI
7	Lack of knowledge and training facilities about goat rearing	10	33.33	VII

the next order, high mortality of kids during rainy season, unavailability of vehicle for transportation of goats for marketing and lack of knowledge and training facilities about goat rearing was found problem faced by goat rearers in goat rearing business which were expressed by 46.67 per cent, 43.33 per cent and 33.33 per cent goat rearers, respectively.

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Gender Perspectives in Livestock Management Activities in Maharashtra

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ABSTRACT

Present investigation was carried out in six agro-climatic zones of Maharashtra viz., South Konkan Coastal, North Konkan Coastal, Western Ghat, Sub montane, Western Maharashtra Plain and Eastern Vidarbha. From each zone one district, two blocks and from these blocks five villages were randomly selected. From each village 30 households (30 male and 30 female) were selected randomly as the respondents. Hence from each zone 150 households (150 male and 150 female = 300) were randomly selected. The total households selected from six zones were 900 and the total respondents selected were 1800. The data included the role, responsibility, access to and control over resources of male and female pertaining to livestock management activities. It was noticed that majority of the rural women and men were middle aged, married and engaged in farming. As regards education, rural women were illiterate and men were educated up to high school level. In livestock management, rural women from the South Konkan, Sub Mountain and Western Maharashtra Plain agro climatic zones were participating jointly with male whereas her independent participation was noticed in North Konkan, Western Ghat and Eastern Vidarbha agro climatic zones. Rural men from South Konkan and Sub Mountain agro climatic zones were jointly participating with male and his independent participation was seen in North Konkan, Western Ghat and Eastern Vidarbha agro climatic zones. Rural women from all the agro climatic zones were having partial responsibility, while rural men were having complete responsibility. Rural women from all the agro climatic zones except Western Ghat zone and Eastern Vidarbha zone were having partial access and control over the livestock resources while rural men from all the agro climatic zones were having complete access and control over the livestock resources.

Livestock is an important segment of agricultural sector in India as it makes multifaceted contributions to socio-economic uplift of the rural poor. Livestock in India is kept mainly by the small holders and the landless that constitute bulk of rural population. Thus by being an important means of income and employment, livestock helps to alleviate poverty and smoothers income distribution in the process assuring a balanced development of rural economy. Women are responsible for milking animals and caring for the young stock and sick animals, while men are primarily the managers and supervisors. They are responsible for gathering information on range conditions, selling of milk, water availability and markets and then making the subsequent herding decisions. Men often oversee watering and supervise herding. Likewise, men household members make the majority of the decisions. (Hassan *et al. - 2007*).

The participation of women in farm decisions as well as participation in animal management practices increased now a day. Women contribute significantly in taking decisions about use of dairy animal management practices, use of new machinery in the dairy, etc. Thus women play very important role not only in maintaining their cattle but also managing their farms, depending upon the situational, personal and socio-economic characteristics of the family to which they belong. For making drastic change in the field of dairying and agriculture, the women make it a strong force, so as to work as a "vehicle of change". Therefore considering above points in mind present investigation 'Gender perspectives in livestock development activities' was undertaken with following objectives

Objectives

1. To study the socio-personal profile of the respondents.
2. To assess the gender role, responsibilities, access and control over different activities in live stock management.

MATERIAL AND METHODS

Present investigation was carried out in six agro-climatic zones of Maharashtra viz., South Konkan Coastal, North Konkan Coastal, Western Ghat, Sub Montane, Western Maharashtra Plain and Eastern Vidarbha. From each zone one district, two blocks and from these blocks

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five villages were randomly selected. From each village 30 households (30 male and 30 female) were selected randomly as the respondents. Hence from each zone 150 households (150 male and 150 female = 300) were randomly selected. The total households selected from six zones were 900 and the total respondents selected were 1800. The data on gender perspectives were collected personally by using the structured interview schedule supplied by the Technical Coordinator (AICRP - Extension). The data were collected agro-climatic zone wise regarding role, responsibilities, access and control of the respondents in case of livestock management related activities. The data were analyzed by using percentages.

RESULTS AND DISCUSSION

1. Socio -Personal profile of the respondents

It was observed from Table 1, that as far as socio-personal profile of respondents was concerned, about forty seven per cent (47.10 %) of the rural women were belonging to middle aged category, followed by 29.18 per cent and 23.72 per cent of rural women were belonging to young age and upper age category, respectively.

Table 1: Personal and economic profile of the respondents

n=900

Profile Characteristics \ Categories	Women(%)	Men (%)
Age		
Young (18 - 30) years	29.18	12.48
Middle (31 – 45) years	47.10	56.12
Upper (46 years and above)	23.72	31.40
Marital Status		
Unmarried	0.00	0.67
Married	97.33	98.67
Widow	2.67	0.67
Divorcee	0.00	0.00
Family Education		
Illiterate/ unlettered	33.52	12.03
Can read and write/ lettered	2.90	8.13
Primary School	16.37	14.92
Middle School	14.92	14.03
High School	24.50	29.84
Post matric diploma	4.68	13.36
Graduate and above	3.12	7.68
Occupation of Respondent		
Non-wage earner	15.81	0.33
Wage earner		
Farming	58.46	67.15
Service	1.22	10.91
Enterprise	9.02	8.35
Labour	15.48	13.25

The above finding is comparable with the finding of Bhamare *et al.* (2006).

In case of rural men, more than half of them (56.12 %) were also belonging to middle age category, followed by 31.40 per cent of them were belonging to upper age category. Only 12.48 per cent of them were from young age category. A great majority of the rural women and men were married (97.33 and 98.67 %) whereas only 2.67 per cent of rural women and 0.67 per cent rural men were widow and widower, respectively.

As regards the education, it was noticed that more than one third of rural women (33.52 %) were illiterate or unlettered, whereas near about one fourth of them (24.50 %) were educated up to high school level followed by 16.37 per cent and 14.92 per cent rural women were educated up to primary school and middle school level respectively. Further it was noticed that 4.68 per cent and 3.12 per cent rural women were having post matric diploma and graduation. Only 2.90 per cent of them were from lettered category. In case of rural men, it was observed that more than one fourth (29.84 %) were educated up to high school level followed by 14.92 per cent, 14.03 per cent, 13.36 per cent and 12.03 per cent of them were educated up to primary school level education, middle school level, post matric diploma and un lettered category respectively where as 8.13 and 7.68 per cent rural men were lettered and educated graduate level respectively.

The observation regarding females' education coinciding with the study of Bhamare *et al.* (2006).

As regards their occupation, it was seen from the table that more than half (58.46 %) of the rural women and 67.15 per cent of rural men engaged in farming. Further it was noticed that 15.81 per cent and 15.48 per cent rural women were non-wage earners and agriculture labour respectively. About 9.00 per cent rural women were in different enterprises while only 1.22 per cent of them were having service. About thirteen per cent (13.25 %) rural men were found to be agriculture, where as about eleven

per cent (10.91%) rural men was having service followed by 8.35 per cent were engaged in enterprises.

2. Gender role in different activities of Live-stock management Role in Live-stock management activities

Independent participation of rural women was noticed in fresh excreta management (34.01 %), processed excreta management (33.89 per cent), retention of produce (33.67 %), processing of produce (31.21 %) and shed management (24.32 %) (Table 2).

The result is in line with the finding of the report Qualitative Data Base on Rural Women - Ecologically Friendly Empowerment - 2003.

Procure source (49.55 %), repay mode (49.28 %), procure amount (49.19 %), repay amount (49.10 %), procuring fodder (40.59 %), growing fodder (39.01 %) and breeding of animal (30.43 %) were the activities in which independent male participation was observed.

Joint participation of rural women with female was noticed in the live-stock management activities like fresh excreta management (25.30 %), processed excreta management (24.12%), shed management (22.66%), retention of produce (21.63%) and processing of produce (21.15%).

This finding is in agreement with the result of the report Qualitative Data Base on Rural Women - Ecologically Friendly Empowerment - 2003.

It was observed that less than half of the rural women were jointly participating with male in the activities like fodder storage (49.19 %), shed management (47.35%), retention of produce (47.24%), care of livestock (46.17 %), feed of animal (43.86 %), care of sick animal (42.46 %), fresh excreta management (40.69 %).

The result in case of feed of animals is supporting with the result of Bhamare *et al*. (2006).

Majority of the rural women were participating jointly with male in the activities as care of sick animal (66.88 %), care of livestock (63.99 %), feed of animal (62.35 %). Joint participation of women with male was also noticed in fodder storage (55.17 %), grazing of animal (46.12per cent), management of cash (44.56 %) and shed management (44.07 %) whereas joint participation of male with rural men was observed in the activities like grazing of animal (54.94%), breeding of animal (51.45%), feed of animal (36.82 %), care of sick animal (36.21%), procuring fodder (34.92 %) and care of livestock (32.48 %).

3. Responsibility in Live-stock management activities

It was noticed from the Table 2 that more than half of the rural women were shouldering complete responsibility in the activities processed excreta management (54.04 %), retention of produce (51.88 %) and fresh excreta management (51.35%). They were also completely responsible for processing of produce (41.72%) and shed management (30.00 %). Further it was noticed that near about three fourth of the rural men were completely responsible for repay amount (75.41 %), procure source (75.18 %), repay mode (74.77%), procure amount (74.36 %), procuring fodder (73.75 %), fodder storage (71.95 %) and feed of animal (70.07 %).

It was seen that more than half of the rural women were partially responsible for feed of animal (60.42 %), care of sick animal (57.73 %), fodder storage (57.72%), care of livestock (56.3 %), shed management (55.32 per cent) followed by grazing of animal (49.68 %), management of cash (42.74 %), engagement of labour (41.77 %) and marketing of produce (40.80 %). More than one fifth of the rural men were partially responsible for all the live-stock management activities.

4. Access in Live-stock management activities

More than three fourth of the rural women were completely having access to fresh excreta management (75.98 %), processed excreta management (75.88 %) followed by management of produce at house hold level-processed (69.64 %), management of produce at house hold level-fresh (69.44 %). (Table 3) Rural men were having complete access to no. of animals for sale/purchase (88.95per cent), purchase of cattle feed (81.80 %), procuring of fodder (79.96 %), procure amount (76.54 %), repay mode (76.20 %), repay amount (76.11per cent), grazing of animal (75.64 %), procure source (75.14 %), feeding of animal (73.44 %), breeding of animals (70.47 %), storage of fodder (69.37 %), care of sick animals (69.30 %), growing of fodder (68.63%), management of cash (63.26 %).

Care of sick animals (54.99 %), feeding of animal (51.68 %), storage of fodder (45.42 %), hiring of labour (41.06%) were the activities to which rural women had partial access followed by management of cash (40.00per cent), grazing of animal (38.51 %), no. of animals for sale/ purchase (36.70 %), assigning of duty (35.86 %), supervising (34.86 %), procuring of fodder (31.31 %). More than one fifth of the rural men were having partial access

Table 2: Distribution of women and men according to role and responsibility in live-stock related activities

n=900

Sr. No	Live-stock management activities	ROLE (%)										RESPONSIBILITY (%)							
		Independent		Joint with female		Joint with male		No Participation		Not Applicable		Complete		Partial		No Responsibility		Not Applicable	
		RW	RM	RW	RM	RW	RM	RW	RM	RW	RM	RW	RM	RW	RM	RW	RM	RW	RM
1	Breeding of animal	2.86	30.43	2.66	9.6	20.65	51.45	73.01	8.15	0.82	0.36	6.68	67.34	25.26	25.50	66.81	6.42	1.25	0.73
2	Care of livestock	4.94	15.69	12.96	46.17	63.99	32.48	17.9	5.47	0.21	0.18	19.96	68.82	56.3	27.68	23.11	2.95	0.63	0.55
3	Care of sick animal	4.82	16.91	5.87	42.46	66.88	36.21	22.22	4.23	0.21	0.18	15.45	68.59	57.73	27.51	26.39	3.35	0.43	0.56
4	Eng. of labour	2.48	23.22	1.66	18.28	37.27	30.9	54.04	22.12	4.55	5.48	6.12	58.78	41.77	21.44	47.4	13.49	4.64	6.28
5	Feed of animal	7.0	15.16	11.73	43.86	62.35	36.82	18.52	3.79	0.41	0.36	15.16	70.07	60.42	26.28	24.0	2.92	0.42	0.73
6	Fodder storage	11.57	15.14	15.29	49.19	55.17	31.17	17.77	4.14	0.21	0.36	20.08	71.95	57.72	24.59	21.99	2.73	0.21	0.73
7	Fresh Excreta Mgt.	34.01	2.71	25.3	41.05	28.74	5.97	11.94	49.01		1.27	51.35	45.44	35.4	27.74	13.25	24.82		2.01
8	Grazing of Animal	2.91	13.79	1.94	13.1	46.12	54.94	48.79	17.7	0.24	0.46	8.15	64.27	49.88	27.15	41.23	7.89	0.74	0.7
9	Growing fodder	2.04	39.01	0.41	3.3	14.29	28.39	75.31	25.64	7.96	3.66	4.38	56.75	22.34	19.78	65.34	19.41	7.93	4.07
10	Marketing of produce	10.54	12.0	6.2	16.36	40.08	29.45	39.05	36.36	4.13	5.82	16.49	42.02	40.8	22.75	38.05	30.09	4.65	5.14
11	Mgt of cash	8.16	14.18	2.51	20.52	44.56	27.61	40.17	32.28	4.6	5.41	11.54	46.7	42.74	21.09	41.03	27.31	4.7	4.9
12	Processed Excreta Mgt.	33.89	2.37	24.12	40.69	29.73	7.12	12.27	48.54		1.28	54.04	44.3	32.34	29.04	13.62	25.0		1.65
13	Processing of produce	31.21	3.3	21.15	29.72	33.47	9.17	12.73	53.58	1.44	4.22	41.72	37.78	42.77	20.37	14.47	37.78	1.05	4.07
14	Procur Amount	2.86	49.19	0.2	12.43	32.11	27.57	62.78	9.19	2.04	1.62	4.18	74.36	19.83	16.73	73.28	7.45	2.71	1.45
15	Procur Source	2.89	49.55	0.21	12.3	31.82	27.67	62.6	8.86	2.48	1.63	4.43	75.18	20.04	15.88	72.57	7.48	2.95	1.46
16	Procuring fodder	5.59	40.59	6.42	21.39	25.26	34.92	62.32	2.93	0.41	0.18	8.07	73.75	27.81	23.66	63.48	2.03	0.64	0.55
17	Repay Amount	2.87	49.1	0.41	12.64	31.3	27.62	62.7	8.84	2.66	1.81	4.18	75.41	20.08	15.48	72.59	7.65	3.14	1.46
18	Repay Mode	2.87	49.28		12.23	31.56	27.7	62.7	8.99	2.87	1.8	4.18	74.77	19.46	16.15	72.8	7.62	3.56	1.45
19	Retention of produce	33.67	2.57	21.63	47.24	31.84	5.15	11.84	41.54	1.02	3.49	51.88	41.93	34.52	26.35	12.76	28.39	0.84	3.34
20	Shed management	24.32	7.31	22.66	47.35	44.07	15.9	8.52	28.7	0.42	0.73	30.0	66.91	55.32	25.88	14.04	6.28	0.64	0.92

to care of sick animals (26.47 %), storage of fodder (25.46%), feeding of animal (24.61 %), hiring of labour (22.92 %).

Remarkable percentage of the rural women was having no access to breeding (75.30 %), purchase of cattle feed (68.00per cent), repay mode (67.72 %), procure source (67.52 %), growing of fodder (64.71 %), procure amount (62.40 %), management of produce at commercial level-processed (58.25 %), management of produce at commercial level -fresh (57.74 %), no. of animals for sale/ purchase (57.28 %) and grazing of animals (51.91 %) whereas management of produce at commercial level-fresh (63.94 %), management of produce at commercial level-processed (63.09 %), management of produce at house hold level-processed (50.11 %), management of produce at house hold level -fresh (49.81 %) and processed excreta management (45.86 %) were the activities to which the rural men were not having access.

5. Control over Live-stock management activities

It can be also noted from table 3 that more than half of the rural women were having complete control over processed excreta management (58.67 %), fresh excreta management (57.95 %), management of produce at house hold level -fresh (54.69 %) and management of produce at house hold level -processed (54.18per cent). More than three fourth of the rural men were having complete control over the activities no. of animals for sale/purchase (83.61 %), procuring of fodder (82.54 %), feeding of animal (82.23 %), storage of fodder (81.92per cent), purchase of cattle feed (78.86per cent), grazing of animals (77.03 %) followed by care of sick animals (73.53 %), procure amount (71.14 %), repay mode (70.85), procure source (70.69 %) and repay amount (70.37 %).

Rural women were found to have partial control over feeding of animals (51.95per cent), care of sick animals (48.89per cent), storage of fodder (48.69 %), grazing of animals (47.92 %), management of cash (42.20 %), hiring of labour (41.90 %) followed by assigning of duty (37.30 %), growing of fodder (36.79per cent), supervising (36.68 %) and no. of animals for sale/purchase (35.61 %). One fifth of the rural men were also found to have partial control over the resources processed excreta management (22.56 %), hiring of labour (21.81 %), care of sick animals (21.69 %), fresh excreta management (21.63 %), management of produce at house hold level -fresh (21.24 %), breeding of animals (20.58 %) and repay amount (20.19 %).

More than three fourth of the rural women were having no control over procure amount (76.95 %), repay mode (76.11 %), repay amount (75.86 %), procure source (75.56 %) followed by breeding of animals (68.78 %), procuring of fodder (66.53 %), purchase of cattle feed (64.30 %), management of produce at commercial level - processed (58.12per cent), management of produce at commercial level-fresh (57.14per cent) no. of animals for sale/purchase (56.54per cent) and growing of fodder (55.89 %) while rural men were having no control over management of produce at commercial level -fresh (52.97 %), management of produce at commercial level-processed (52.92 %), management of produce at house hold level - processed (32.89), management of produce at house hold level-fresh (31.39 %).

Zone wise gender role in different activities of Live-stock management

Role in Live-stock management activities

Independent Participation-

More than one fourth of the rural women from Western Ghat (25.10 %) agro climatic zone were participating independently in live-stock management related activities followed by the rural women from Eastern Vidarbha (17.77 %), Western Maharashtra Plain (13.57 %) and North Konkan Coastal agro climatic zone (12.97 %) in live-stock management related activities (Table 4).

The same result was reported by Bhamare *et al.* (2006).

Very negligible percentage of the rural women from South Konkan Coastal agro climatic zone (2.10 %) and Sub montane (0.76 %) were participating independently in live-stock management related activities. More than one fourth of the rural men from Eastern Vidarbha (29.44 %) and Western Ghat (25.83 %) agro climatic zones were participating independently in live-stock management related activities followed by the rural men from North Konkan Coastal (22.96 %), Western Maharashtra Plain (22.13 %), Sub montane (17.50 %) and South Konkan Coastal (17.46 %) agro climatic zones were found participating independently in live-stock management related activities.

Participation Joint with Female

It was studied that 15.28 and 14.48 per cent rural women from Western Maharashtra Plain and Western Ghat agro climatic zones respectively were participating jointly with female in live-stock management related activities whereas 9.18 and 8.88 per cent of the rural women were noticed participating jointly with female in live-stock

Table 3 : Distribution of women and men according to access and control over resources in live-stock

n=900

Sr. No.	Live-stock management activities	ACCESS (%)								CONTROL (%)							
		Complete		Partial		No access		Irrelevant		Complete		Partial		No access		Irrelevant	
		RW	RM	RW	RM	RW	RM	RW	RM	RW	RM	RW	RM	RW	RM	RW	RM
1	Assigning of duty	20.32	56.26	35.86	19.25	41.43	21.12	2.39	3.36	18.85	62.06	37.3	16.26	41.39	18.32	2.46	3.36
2	Breeding	5.93	70.47	18.77	16.82	75.3	12.34	--	0.37	7.35	67.66	23.47	20.56	68.78	11.4	0.41	0.37
3	Care of sick animals	14.87	69.3	54.99	26.47	30.14	4.23	--	--	13.94	73.53	48.89	21.69	37.17	4.78	--	--
4	Feeding of animal	24.79	73.44	51.68	24.61	23.53	1.95	--	--	19.05	82.23	51.95	16.8	29.0	0.98	--	--
5	Fresh excreta mgt	75.98	34.38	13.67	19.04	10.35	46.4	--	0.18	57.95	48.98	28.77	21.63	13.28	29.39	--	--
6	Grazing of animal	9.57	75.64	38.51	15.05	51.91	8.91	--	0.4	9.41	77.03	47.92	16.04	42.67	6.53	--	0.4
7	Growing of fodder	3.73	68.63	27.65	9.04	64.71	18.08	3.92	4.24	3.66	69.56	36.79	10.89	55.89	15.31	3.66	4.24
8	Hiring of Labour	10.02	51.02	41.06	22.92	46.56	22.92	2.36	3.14	9.72	54.71	41.9	21.81	45.95	20.33	2.43	3.14
9	Mgt of prod comm.-fresh	27.78	14.68	10.32	17.66	57.74	63.94	4.17	3.72	20.61	25.46	17.96	17.84	57.14	52.97	4.29	3.72
10	Mgt of prod comm.-processed	27.24	15.44	10.34	17.51	58.25	63.09	4.17	3.95	20.08	25.05	17.42	17.89	58.2	52.92	4.3	4.14
11	Mgt of prod h.hold-fresh	69.44	32.52	13.49	16.17	16.87	49.81	0.2	1.5	54.69	46.05	27.96	21.24	17.14	31.39	0.2	1.32
12	Mgt of prod h.hold-processed	69.64	33.08	13.1	15.21	17.06	50.19	0.2	1.52	54.18	46.58	27.7	18.82	17.92	32.89	0.2	1.71
13	Mgt. of cash	12.53	63.26	40.0	12.12	44.85	21.02	2.63	3.6	11.02	65.15	42.2	11.74	44.07	19.51	2.7	3.6
14	No. of animals for sale/purchase	6.02	88.95	36.70	10.5	57.28	0.55	--	--	5.63	83.61	35.61	15.65	56.54	0.74	2.21	--
15	Processed excreta mgt	75.88	34.4	13.73	19.55	10.39	45.86	--	0.19	58.67	49.06	28.43	22.56	12.9	28.2	--	0.19
16	Procure Amount	4.0	76.54	26.6	15.27	67.4	7.26	2.0	0.93	3.09	71.14	18.31	18.99	76.95	8.94	1.65	0.93
17	Procure Source	4.75	75.14	25.94	16.14	67.52	7.79	1.78	0.93	3.67	70.69	18.74	19.11	75.56	9.28	2.04	0.93
18	Procuring of fodder	4.89	79.96	31.31	18.2	63.8	1.84	--	--	4.67	82.54	28.8	16.36	66.53	1.1	--	--
19	Purchase of cattle feed	4.31	81.8	27.65	15.63	68.04	2.57	--	--	6.09	78.86	29.61	19.12	64.3	2.02	--	--
20	Repay Amount	4.73	76.11	26.63	16.3	67.06	6.67	1.58	0.93	3.45	70.37	18.66	20.19	75.86	8.52	2.03	0.93
21	Repay Mode	4.53	76.2	26.18	15.87	67.72	7.01	1.57	0.92	3.44	70.85	18.62	19.56	76.11	8.67	1.82	0.92
22	Storage of fodder	34.31	69.37	45.42	25.46	20.27	5.17	--	--	24.44	81.92	48.69	14.76	26.87	3.32	--	--
23	Supervising	21.91	56.13	34.86	18.96	41.04	21.56	2.19	3.35	20.08	62.08	36.68	15.61	41.19	18.77	2.05	3.53

Table 4 : Agro-climatic zone wise distribution of respondent's role and responsibility in live-stock management

n=900

Sr. No.	Live – stock mgt related Activities / Agro-climatic zone ↓	ROLE (%)										RESPONSIBILITY (%)							
		Independent		Joint with female		Joint with male		No Participation		Not Applicable		Complete		Partial		No Responsibility		Not Applicable	
		RW	RM	RW	RM	RW	RM	RW	RM	RW	RM	RW	RM	RW	RM	RW	RM	RW	RM
1	South Konkan Coastal	2.10	17.46	6.09	34.66	63.37	44.51	28.44	3.24	--	0.13	9.63	54.27	56.03	44.21	34.27	1.52	0.07	--
2	North Konkan Coastal	12.97	22.96	9.18	16.60	11.28	21.02	66.57	39.41	--	--	16.50	61.98	14.82	8.39	68.68	28.95	--	0.68
3	Western Ghat	25.10	25.82	14.48	22.60	20.55	20.57	34.90	26.54	4.97	4.47	29.17	62.73	34.21	18.03	30.38	14.80	6.25	4.45
4	Sub montane	0.76	17.50	2.72	44.91	73.08	31.96	23.43	5.63	--	--	23.38	62.84	42.02	30.82	34.55	6.34	0.05	--
5	Western Maha. Plain	13.57	22.13	15.28	27.64	36.81	24.14	27.65	18.88	6.69	7.21	10.36	63.69	62.36	23.96	20.18	5.06	7.11	7.29
6	Eastern Vidarbha	17.77	29.44	8.88	17.92	20.79	23.75	52.55	28.89	--	--	24.32	60.95	19.85	15.65	55.83	23.40	--	--

Table 5 : Agro-climatic zone wise distribution of respondent's access and control in live-stock management

n=900

Sr. No.	Live – stock mgt related Activities / Agro-climatic zone ↓	ACCESS (%)								CONTROL (%)							
		Complete		Partial		No access		Irrelevant		Complete		Partial		No control		Irrelevant	
		RW	RM	RW	RM	RW	RM	RW	RM	RW	RM	RW	RM	RW	RM	RW	RM
1	South Konkan Coastal	23.14	84.61	46.96	11.54	29.90	3.85	--	--	20.69	81.66	43.84	14.43	34.96	3.90	0.52	--
2	North Konkan Coastal	16.31	56.56	16.41	11.81	65.78	31.63	1.50	--	12.87	62.31	15.23	11.21	70.39	26.48	1.51	--
3	Western Ghat	33.75	49.81	20.88	18.90	45.31	31.24	0.06	0.06	30.94	53.97	27.34	22.73	41.29	23.18	0.43	0.11
4	Sub montane	23.50	69.58	33.33	12.67	43.11	17.74	0.05	--	23.21	64.47	27.49	15.88	49.15	19.66	0.15	--
5	Western Maha. Plain	25.00	44.53	36.56	31.93	32.82	15.95	5.61	7.59	8.46	59.19	59.33	28.20	26.26	5.06	5.95	7.54
6	Eastern Vidarbha	19.98	57.60	19.83	15.97	60.14	26.43	0.05	--	18.83	62.68	20.33	14.85	60.79	22.43	0.05	0.04

management related activities. The rural women from South Konkan Coastal (6.09 %) and Sub montane (2.72 %) agro-climatic zones were jointly participating with female in live-stock management related activities. More than two third of the rural men from Sub montane (44.91 %) agro climatic zone were found to be participating jointly with female in live-stock management related activities followed by the rural men from South Konkan Coastal (34.66 %), Western Maharashtra Plain (27.64 %) and Western Ghat (22.60 %) agro-climatic zones. Only 17.92 and 16.60 per cent of the rural men from Eastern Vidarbha and North Konkan Coastal agro-climatic zones were found to have joint participation with female in live-stock management related activities

Participation Joint with Male

Remarkable percentages of rural women from Sub montane (73.08 %) and South Konkan Coastal agro-climatic zones (63.37%) were found jointly participating with male in live-stock management related activities followed by the rural women from Western Maharashtra Plain zone (36.81%). More than one fifth of the rural women from Eastern Vidarbha (20.79 %) and Western Ghat (20.52 %) agro-climatic zones were jointly participating with male in live-stock management related activities whereas only 11.28 per cent rural women from North Konkan Coastal agro-climatic zone were also jointly participating with male in live-stock management related activities. More than two third of the rural men from North Konkan Coastal (44.51 %) agro-climatic zone were found to participate jointly with male followed by the rural men from Sub montane zone (31.96 %). More than one fifth of rural men from Western Maharashtra Plain (24.14%), Eastern Vidarbha (23.75 %), North Konkan Coastal (21.02 %) and Western Ghat (20.57 %) agro-climatic zones were participating jointly with male in live-stock management related activities.

No Participation

Significant percentages of the rural women from North Konkan Coastal (66.57%) and Eastern Vidarbha (52.55 %) agro-climatic zones were not participating in live-stock management related activities followed by Western Ghat (34.99 %), South Konkan Coastal (28.44%), Western Maharashtra Plain (27.65%) and Sub montane (23.43per cent) agro-climatic zones. More than one third of the rural men from North Konkan Coastal agro-climatic zone (39.41%) were not participating in live-stock management related activities whereas the percentages of rural men not participating in live-stock management related activities from Eastern Vidarbha, Western Ghat and Western Maharashtra Plain agro-climatic zones were 28.89, 26.54 and 18.88 per cent, respectively. Very meager percentage of the rural men from Sub montane (5.63%) and South Konkan Coastal (3.24%) agro climatic zones were not participating in live-stock management related activities.

Responsibility in Live-stock management activities

Complete Responsibility

It is also observed from table 4 that more than one fourth of the rural women from Western Ghat (29.17%) were having complete responsibility in live-stock management related activities followed by the rural women from Eastern Vidarbha (24.32%), Sub montane (23.38 %) and North Konkan Coastal zones (16.50 %). Only 10.36 and 9.63 per cent of the rural women from Western Maharashtra Plain and South Konkan Coastal agro-climatic zones were found to have complete responsibility in live-stock management related activities respectively. Significant percentages of the rural men from all the agro-climatic zones - Western Maharashtra Plain (63.69 %), Sub montane (62.84 %), Western Ghat (62.73 %), North Konkan Coastal (61.98 %), Eastern Vidarbha (60.95 %) and South Konkan Coastal (54.27%) were having complete responsibility in live-stock management related activities.

Partial Responsibility

More than half of the rural women from the zones Western Maharashtra Plain (62.36 %) and South Konkan Coastal (56.03%) followed by the rural women from Sub montane (42.02 %) and Western Ghat agro-climatic zones (34.21 %) were found to have partial responsibility in live-stock management related activities. Only 19.85 and 14.82 per cent of the rural women from Eastern Vidarbha and North Konkan Coastal agro-climatic zones were found to have partial responsibility in live-stock management related activities. It was found that 44.21 and 30.82 per cent of the rural men from South Konkan Coastal and Sub montane agro climatic zones respectively were partially responsible for live-stock management related activities followed by the rural men from Western Maharashtra Plain (23.96 %) and Western Ghat (18.03 %) agro climatic zones. Only 15.65 and 8.39 per cent of the rural men from Eastern Vidarbha and North Konkan Coastal agro-climatic zones were found to have partial responsibility in live-stock management related activities.

No Responsibility

More than half of the rural women from North Konkan Coastal (68.68 %) and Eastern Vidarbha agro-climatic zones (55.83 %) were found to have no responsibility in live-stock management related activities while more than one third of the rural women from Sub montane (34.55 %) and South Konkan Coastal agro-climatic zones (34.27%) were also having no responsibility in live-stock management related activities. The rural women from Western Ghat (30.38 %) and Western Maharashtra Plain (20.18 %) agro climatic zones were also having no responsibility in live-stock management related activities. More than one fourth of the rural men from North Konkan Coastal agro climatic zone (28.95 %) were found to have no responsibility in live-stock management related activities followed by the rural men from Eastern Vidarbha (23.40 %) and Western Ghat (14.80 %) agro climatic zones. It was further seen that only 6.34, 5.06 and 1.52 per cent of the rural men from Sub montane, Western Maharashtra Plain and South Konkan Coastal agro-climatic zones, respectively were having no responsibility in live-stock management related activities.

Access in Live-stock management activities

Complete access

Findings of the table 5 reveals that one third (33.75 %) of the rural women from Western Ghat agro-climatic zone were found to have complete access to live-stock management activities while one fourth of them (25.00 %) from Western Maharashtra Plain agro-climatic zone were having complete access to live-stock management activities followed by the rural women from Sub montane (23.50 %) and South Konkan Coastal (23.14 %) agro-climatic zones. Less than one fifth of the rural women from Eastern Vidarbha (19.98 %) and North Konkan Coastal (16.31%) agro-climatic zones were also having complete access to live-stock management activities. Significant percentages of the rural men from the agro-climatic zones, South Konkan Coastal (84.61%) and Sub montane (69.58 %) were found to have complete access to live-stock management activities while more than half of them from Eastern Vidarbha (57.60 %) and North Konkan Coastal (56.56 %) and less than half of them from Western Ghat (49.81%) and Western Maharashtra Plain (44.53 %) agro-climatic zones were found to have complete access to live-stock management activities.

Partial access

In the South Konkan Coastal agro-climatic zone, less than half (46.96 %) of the rural women were found to have partial access to live-stock management activities followed by the rural women from Western Maharashtra Plain (36.56 %), Sub montane, (33.33 %) and Western Ghat (20.88 %) agro-climatic zones. It was also observed that less than one fifth of the rural women were from Eastern Vidarbha (19.83 %) and North Konkan Coastal (16.41%) agro-climatic zones were found to have partial access to live-stock management activities. Further it was seen that 31.93 per cent of the rural men from Western Maharashtra Plain agro-climatic zone were found to have partial access to live-stock management activities whereas in Western Ghat (18.90per cent), Eastern Vidarbha (15.97%), Sub montane (12.67%), North Konkan Coastal (11.81 %) and South Konkan Coastal (11.54 %) agro-climatic zones, less than one fifth of them were having partial access to live-stock management activities.

No access

Remarkable percentages of the rural women from North Konkan Coastal (65.78 %) and Eastern Vidarbha (60.14 %) agro-climatic zones were having no access to live-stock management activities while less than half of them from Western Ghat (45.31%) and Sub montane (43.11%) agro-climatic zones were also having no access to live-stock management activities. The percentages of the rural women having no access to live-stock management activities from Western Maharashtra Plain and South Konkan Coastal agro-climatic zones were 32.82 and 29.90 respectively. More than one fourth of the rural men from North Konkan Coastal (31.63 %), Western Ghat (31.24%) and Eastern Vidarbha (26.43 %) were having no access to live-stock management activities whereas less than one fifth of them from Sub montane (17.74%) and Western Maharashtra Plain (15.95%) agro-climatic zones were having no access to live-stock management activities. Very negligible percentage of the rural men from South Konkan Coastal (3.85%) agro-climatic zone was having no access to live-stock management activities.

Control over Live-stock management activities

Complete control

It is clear from the same table (Table 5) that more than one fourth of the rural women from Western Ghat (30.94%) were having complete control over live-stock management activities followed by the rural women from Sub montane (23.21%) and South Konkan Coastal (20.69%) agro-climatic zones. Less than one fifth of the rural women from Eastern Vidarbha (18.83%), North Konkan Coastal

(12.87%) were having complete control over live-stock management activities followed by the rural women from Western Maharashtra Plain (8.46%) agro-climatic zone. Significant percentage of the rural men from South Konkan Coastal (81.66%), Sub montane (64.47%, Eastern Vidarbha (62.68%) and North Konkan Coastal (62.31%) agro-climatic zones were having complete control over live-stock management activities while more than half of the rural men from Western Maharashtra Plain (59.19%) and Western Ghat (53.97%) agro-climatic zones were found to have complete control over live-stock management activities.

Partial control

It was observed that more than half of the rural women (59.33%) from Western Maharashtra Plain agro-climatic zone were found to have partial access to live-stock management activities followed by the rural women from South Konkan Coastal (43.84 %) agro-climatic zone. Equal percentage of the rural women from Sub montane (27.49%) and Western Ghat (27.34%) agro-climatic zones were found to have partial control over live-stock management activities whereas 20.33 and 15.23 per cent of the rural women from Eastern Vidarbha and North Konkan Coastal agro-climatic zones, respectively were having partial control over the live-stock management activities. More than one fourth of the rural men from Western Maharashtra Plain (28.20%) were having partial control over live-stock management activities followed by the rural men from Western Ghat (22.73%) agro-climatic zone. Less than one fifth the rural men from Sub montane (15.88 %), Eastern Vidarbha (14.85%), South Konkan Coastal (14.43%) and North Konkan Coastal (11.21%) agro-climatic zones were also having partial control over live-stock management activities.

No control

Significant percentages of the rural women from North Konkan Coastal (70.39%) and Eastern Vidarbha (60.79 %) agro-climatic zones were having no control over live-stock management activities followed by the rural women from Sub montane (49.15%), Western Ghat (41.29 %), South Konkan Coastal (34.96%) and Western Maharashtra Plain (26.26%) agro-climatic zones. More than one fourth of the rural men from North Konkan Coastal (26.48%) were found to have no control over live-stock management activities followed by the rural women from Western Ghat (23.18 %), Eastern Vidarbha (22.43%) and Sub montane (19.66%) agro-climatic zones were having no control over live-stock management activities. Negligible percentages of the rural men from Western Maharashtra Plain (5.06 %) and South Konkan Coastal (3.90 %) were also found to have no control over live-stock management activities.

CONCLUSION

Majority of the rural women and men were middle aged, married and engaged in farming. As regards education, rural women were illiterate and men were educated up to high school level.

In livestock management, rural women from the South Konkan, Sub Mountain and Western Maharashtra Plain agro climatic zones were participating jointly with male whereas her independent participation was noticed in North Konkan, Western Ghat and Eastern Vidarbha agro climatic zones. Rural men from South Konkan and Sub Mountain agro climatic zones were jointly participating with male and his independent participation was seen in North Konkan, Western Ghat and Eastern Vidarbha agro climatic zones. Rural women from all the agro climatic zones were having partial responsibility, while rural men were having complete responsibility.

Rural women from all the agro climatic zones except Western Ghat zone were having partial access and control over the livestock resources while rural men from all the agro climatic zones were having complete access and control over the livestock resources.

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Socio-Economic Transformation due to Adoption of Recommended Cultivation Practices of Pomegranate

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ABSTRACT

The present study conducted in the year 2013at Chikhali, Buldana and Motala Panchayat Samitis of Buldana district of Vidarbha region with the objective to ascertain the socio-economic transformation of growers due to cultivation of Pomegranate crop. An experimental research design was used for this study. From twelve villages, 120 Pomegranate growers were selected as respondents for the study.

The findings revealed that majority of Pomegranate grower's high level of knowledge and medium level in adoption of Pomegranate cultivation practices.In case of socio-economic transformation, 32.85 per cent change was in the pomegranate growers. In case of relational analysis education, land holding, annul income, experience in Pomegranate cultivation, sources of information, innovativeness, knowledge and adoption were found positively and significantly correlated with socio-economic transformation of Pomegranate growers at 0.01 level of probability. Whereas, age was found negatively and risk preference was found positively correlated with SET at 0.05 level of probability.

Pomegranate (*Punica granatum* L.) belongs to family punnicaceae is one of the most favorites fruits of tropical and sub-tropical regions of the world. The origin of pomegranate is Iran and is extensively cultivated in Mediterranean countries like Spain, Egypt, Iran, Burma, Guinea and India. Pomegranate is grown in tropical and sub-tropical regions of the World.

It contains protein (1.6 %), fats (0.1%), carbohydrates (14.5%), fiber (5.1%), calcium (10 mg100 g^{-1}), thiamine (0.06 mg 100 g^{-1}) and phosphorus (70 mg100 g^{-1}) and Vitamin- C (14 mg 100 g^{-1}). It is having 68 per cent edible portion. It can be processed into drinks and jelly. The rind of the fruit and flower yield a dye which is used in indigenous system of medicine for prevention of intestinal disorders.

In World, it is estimated that approximately 1439.1 thousand tons of Pomegranate is produced. Out of this 849.1 thousand tones are produced in India. Rest of production is concentrated in Iran, Spain, Afghanistan, Pakistan, Egypt, Tunisia, Jordan, Lebanon, Israel, Chili, Peru and USA.

The total area under cultivation of Pomegranate in India is 116.4 thousand ha and production 849.1 thousand tones. In India, the total production of Pomegranate is concentrated mainly in Maharashtra, Karnataka, Andhra Pradesh, Gujarat and to a smaller extent in Rajasthan, Tamil Nadu and Himachal Pradesh.

Maharashtra is the leading producer of Pomegranate followed by Karnataka, Andhra Pradesh, Gujarat and Tamilnadu. In Maharashtra, Pomegranate is commercially cultivated in Solapur, Sangli, Nasik, Ahmadnagar, Pune, Dhule, Aurangabad, Satara, Osmanabad, Buldana and Latur district. Ganesh, Bhgava, Rubi, Arakta and Mrudula are the different varieties of Pomegranate cultivated in Maharashtra.

The study was taken up with objective, to study socio-economic transformation of growers due to adoption of recommended cultivation practices by pomegranate and to find out relationship between selected characteristics of the growers with the growers with their SET.

MATERIAL AND METHODS

The present study aims to ascertain socio-economic transformation of Pomegranate growers after cultivation and adoption of recommended cultivation practices this of this crop. Hence, experimental research design of social research was used for the study.

The purposively selection of three Panchayat Samities were made on the basis of large area under Pomegranate crop in the Buldana district. The study was

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conducted in three Panchayat Samities of Buldhana district namely Chikhali, Buldana and Motala in Vidarbha region of Maharashtra State. The four villages from each Panchayat Samiti were selected on the basis of large number of farmers. From selected villages, 10 respondents from each village were selected randomly. Thus total 120 respondents were constituted sample for the present study.

The method used for data collection was, "Personal Interview Method." The interviews with all 120 respondents were conducted at their field and residence in informal atmosphere after establishing report with them for getting reliable information.

RESULTS AND DISCUSSION

I. Distribution of growers according to their frequency of knowledge of recommended cultivation practices of pomegranate.

From Table 1, it has been revealed that majority of the respondents were having complete knowledge about climate, soil, ploughing and harrowing were 96.66, 93.33, 86.67 and 81.67 percentage, respectively.

It was found that knowledge about time of planting, preplanting treatment, planting distance, size of pits and filling of pits was 72.50, 75.00, 66.67, 63.33 and 61.67 per cent, respectively. Regarding knowledge of

Table 1: Distribution of the growers according to their frequency of knowledge and adoptionof recommended cultivation practices of Pomegranate.

S.N.	Pomegranate cultivation practices	Knowledge (n=120)		Adoption(n=120)		
		Frequency	Per cent	Complete	Partial	No
A.	**Climate**					
	Cold and dry	116	96.66	106 (88.33)	11 (9.17)	03 (2.50)
B.	**Soil**					
	Loamy, alluvial, well drained and murum	112	93.33	86 (71.67)	18 (15.00)	16 (13.33)
C.	**Land preparation**					
i)	Deep ploughing	104	86.67	21 (89.17)	95 (17.50)	04 (03.33)
ii)	Harrowing (2 to 3 no.)	98	81.67	61 (50.83)	38 (31.67)	21 (17.50)
D.	**Planting**					
i)	Time of planting (July-August)	87	72.50	64 (53.33)	37 (30.83)	19 (15.84)
ii)	Preplanting treatment to seedling	90	75.00	56 (46.67)	46 (38.33)	18 (15.00)
iii)	Planting distance (5x5m.)	80	66.67	62 (51.67)	36 (30.00)	22 (18.33)
iv)	Size of pit (60x60x60 cm.)	76	63.33	74 (61.67)	36 (30.00)	10 (08.33)
v)	Filling of pits (20-25kg compost + 10g Carbaryl wp+1kg SSP)	74	61.67	53 (44.17)	39 (32.50)	28 (23.33)
E.	**Propagation**					
i)	Hardwood cutting	70	58.33	42 (35.00)	51 (42.50)	27 (22.50)
ii)	Air layering	63	52.50	78 (65.00)	34 (28.33)	08 (06.670
iii)	Tissue culture	27.0	22.50	16 (13.33)	(14.67) 17	(72.50) 87

F.	**Varieties**					
a)	**Name of varieties**Ganesh / Mrudula / Bhagwa / Arakta/ Others (please specify)	68	56.67	74 (61.67)	40 (33.33)	06 (05.00)
b)	**Source**(Govt. Nursery/Private Nursery/ University Nursery)	74	61.67	76 (63.33)	30 (29.17)	09 (07.50)
G	**Training and pruning**					
i)	Removal of water shoots	48	40.00	50 (41.67)	31 (25.83)	39 (32.50)
ii)	Pruning kept 4 -5 shoots	64	53.33	53 (44.17)	52 (43.3)	15 (12.50)
H.	**Fertilizer doses (per plant)**					
	Year FYM (kg) N (g) P (g) K (g) First 10 125 125 125 Second 20 250 250 250 Third 30 500 250 250 Forth 40 500 250 250 **5 years and onwards** FYM – 50kg. N -600 g. P – 250 g. K – 250 g	79	65.83	63 (52.50)	37 (30.83)	20 (16.67)
I.	**Use of growth regulators**					
i)I	Bahar treatment	74	61.67	47 (39.17)	41 (34.17)	32 (26.67)
ii)	Fruit development	66	55.00	42 (35.00)	36 (30.00)	42 (35.00)
J.	**Bahar treatment**					
i)	Ambiabahar – Jan –Feb.	69	57.50	13 (10.83)	37 (30.83)	70 (58.34)
ii)	Mrigbahar- June –July.	76	63.33	10 (08.33)	26 (21.67)	84 (70.00)
iii)	Hast bahar- Sept –Octo.	102	45.00	85 (70.83)	17 (14.67)	18 (15.00)
K.	**Special Bahar Treatments**					
i)	Use of chemicals	56	46.67	43 (35.83)	43 (35.83)	34 (28.34)
ii)	Light pruning	62	51.67	66 (55.00)	38 (31.67)	16 (13.33)
L.	**Fruit Thinning**					
i)	Hand thinning	53	44.17	51 (42.50)	39 (32.50)	30 (25.00)
ii)	Chemical thinning	33	27.50	34 (28.33)	42 (35.00)	44 (36.67)
M.	**Intercultural Operation**					
i)	Weeding	99	82.50	36 (30.00)	43 (35.83)	41 (34.67)
ii)	Hoeing	81	67.50	30 (25.00)	40 (33.33)	50 (41.67)

N.	**Irrigation**					
i)	Drip Irrigation	107	89.17	86 (71.67)	20 (16.67)	14 (11.66)
ii)	Furrow irrigation	26	21.67	19 (15.83)	28 (23.33)	73 (60.84)
O.	**Intercropping** (groundnut, chilli, soybean, cluster bean, mung, udid, palak) other crops etc.	39	32.50	14 (11.67)	28 (23.33)	78 (65.00)
P.	**Pest and their control measures**					
i)	**Anar caterpillar** (Carbaryl 50per cent W P 40g 100 lit^{-1},Phospomidon 85% EC. 35 ml 100 lit^{-1})	90	75.00	39 (32.50)	45 (37.50)	36 (30.00)
ii)	**Bark eating caterpillar** (Borer solution, E.D.C.T. Mixture)	72	60.00	48 (40.00)	39 (32.50)	33 (27.50)
iii)	**Mites**(Sulphur 80 % W.S 25g 10 lit^{-1}, Phospomidon 85% EC. 35 ml 100 lit^{-1},Neem extract)	86	71.67	38 (31.67)	38 (31.67)	44 (36.67)
Q.	**Diseases and their control measures**					
i)	**Oily spot**(1 % Bordeaux mixture, Streptocycline 250ppm + Copperoxychloride .0.25 %)	94	78.33	22 (18.33)	27 (22.50)	71 (59.67)
ii)	**Fruit Rot**(Eradication of diseased fruits and branches, COC 25.0 g 10 lit^{-1}, Tricoderma 25 g $plant^{-1}$)	87	72.50	30 (25.00)	42 (35.00)	48 (40.00)
iii)	**Leaf spot**(Eradication of diseased fruits and branches, COC 25.0 g 10 lit^{-1})	84	70.00	30 (25.00)	40 (33.33)	50 (41.67)
R.	**Harvesting**					
i)	Fruit rind attain yellowish pink to red colour	77	64.17	35 (29.17)	30 (25.00)	55 (45.83)
ii)	Cracking sound on pressing of rind	72	60.00	39 (32.50)	42 (35.00)	39 (32.50)
iii)	TSS becomes 16-18 ^{0} B.	37	30.83	16 (13.33)	22 (18.33)	82 (68.34)
S.	**Grading (According to fruit weight)** A grade- 350 g and above B grade - 250-350 g C grade - <250 g	88	73.33	28 (23.33)	36 (30.00)	56 (46.67)
T.	**Packing and Transportation of the fruit**					
i)	Bamboo baskets	85	70.83	30 (25.00)	47 (39.17)	43 (35.83)
ii)	Corrugated boxes	86	51.67	32 (26.67)	37 (30.83)	51 (42.50)
U.	**Average Yield**					
i)	150-200 fruits $plants^{-1}$	83	69.17	60 (50.00)	37 (30.83)	23 (19.17)
ii)	Economic bearing of 20-30 years	76	63.33	49 (40.83)	34 (28.33)	37 (30.83)
V.	**Storage of Fruits**					
i)	In Cold storage	92	76.67	24 (20.00)	44 (36.67)	52 (43.33)
ii)	Modified atmospheric storage	70	58.33	12 (10.00)	19 (15.83)	89 (74.17)

propagation methods such as hardwood cutting was 58.33per cent and air layering was 52.50 per cent. The respondent's knowledge about verities was 56.67 per cent and source of getting seedlings was 61.67 per cent followed by knowledge about pruning was 53.33 per cent and knowledge about fertilizers 65.83 per cent, In case of use of growth regulators for bahar treatment and fruit development was 61.67 and 55.00 percentage, respectively.

It was found that knowledge about bahar treatment such as Ambiabahar, Mrigbahar and Hast bahar was 57.50, 63.33 and 45.00 per cent, respectively. The 46.67 per cent of respondents used chemicals followed by 51.67 per cent of respondent used the light pruning for the special bahar treatment.

It has been revealed that majority of the respondents were having knowledge about intercultural operation such as Weeding (82.50%) and Hoeing (65.50%). The respondents knowledge about drip irrigation 89.17 per cent.

In case of pest and their control measures of Anar caterpillar, bark eating caterpillar and mites was 75.00, 60.00 and 71.67 percent, respectively. In case of diseases and their control measures of oily spot, fruit root and leaf spot was 78.33, 72.50 and 70.00 percent, respectively

It was found that knowledge about harvesting sign such as Fruit rind attains yellowish pink to red colour was 64.17 per cent and Cracking sound on pressing of rind was 60.00 per cent. The respondents knowledge about grading was 73.33 per cent and packing and transportation of the fruit from bamboo basket and corrugated boxes was 70.83 per cent and 51.67per cent, respectively. In case of knowledge about average yield such as 150- 200 fruits per plant was 69.17 per cent and economic bearing 20-30 years was 63.33 per cent the respondents knowledge about fruit storage such as cold storage was 76.67 per cent and modified atmospheric storage was 58.33 per cent.

II. Distribution of growers according to their frequency of adoption of recommended cultivation practices of pomegranate.

From Table 1 it has been revealed that majority of the respondents had completely adopted the climate, soil recommendation, ploughing and harrowing was 88.33, 71.67, 89.17 and 50.83 percentage, respectively. The adoption in case of time of planting, per planting treatment, planting distance, size of pits and filling of pits was 53.33, 46.67, 51.67, 61.67 and 44.17 percentages, respectively. Regarding adoption in case of propagation method air layering was 65.00 per cent .The adoption of verities was 61.67 per cent and source of getting seedlings was 63.33 per cent. In case of training and pruning adoption were found to be removal of water shoot was 41.67 per cent and pruning kept 4-5 shoots was 44.17 per cent it was found that 52.50 per cent respondents adopt fertilizers doses per plant. The adoption in case of bahar treatment such as Hast bahar was 70.83 per cent and special bahar treatment such as light pruning was 55.00 per cent, fruit thinning done through hand adopted 42.50 per cent.

In case pest and their control measures completely adopted by 40.00 per cent for Bark eating caterpillar. It was found that 50.00 per cent adoption for average yield such as 150- 200 fruits per plant and 40.83 per cent for economic bearing 20-30 years.

From Table 1, it has been revealed that majority of the respondents had no adoption of propagation by tissue culture (72.50 %), furrow irrigation (60.84%). Regarding no adoption in case of oily spot and fruit diseases and their control measures was 59.67 and 40.00 per cent, respectively. No adoption in case of harvesting sign T.S.S was 68.34 per cent, grading was 46.67 per cent and no adoption in case of modified atmospheric storage was 74.17 per cent.

III. Knowledge about Pomegranate cultivation practices

Data with regards to the level of knowledge possessed by Pomegranate growers have been furnished in Table 2.

Table 2. Distribution of respondents according to their level of knowledge about recommended cultivation practices of Pomegranate.

S. N.	Knowledge level	Respondents (n=120)	
		Number	Percentage
1.	Low	15	12.50
2.	Medium	33	26.66
3.	High	72	60.84
	Total	**120**	**100.00**

It is seen from Table 2 that majority of the respondents (60.84 %) were having high level of knowledge about Pomegranate cultivation practices. The

percentage of respondents having medium level of knowledge was 26.66 per cent. Whereas only 12.50 per cent respondents belonged to low level of knowledge about Pomegranate cultivation practices.

IV. Adoption about Pomegranate cultivation practices.

Table 3: Distribution of the respondents according to their level of adoption of recommended cultivation practices of Pomegranate.

S. N.	Adoption level	Respondents (n=120)	
		Number	Percentage
1.	Low	23	19.17
2.	Medium	69	57.50
3.	High	28	23.33
	Total	**120**	**100.00**

Table 3 revealed that, majority of the respondents (57.50 %) had medium level of adoption of Pomegranate cultivation, followed by 23.33 per cent of respondents having high level of adoption and 19.17 per cent of respondents were found in low level of adoption of Pomegranate cultivation practices.

V. Socio- economic transformation

Socio- economic transformation studied in terms of changes in seven dimensions of SES i.e. occupation, land holding, annual income, socio-political participation, household, material possession and other attributes and SES as a whole of Pomegranate growers before and after the cultivation of Pomegranate. The data thus obtained have been furnished in Table 4.

Table 4. Socio-economic transformation due to cultivation of Pomegranate.

S. N.	Dimensions of Socio-economic transformation	Before	After	per cent Change
1	Occupation	42.36	49.63	17.16
2	Land holding	61.77	84.46	36.73
3	Annual income	17.82	23.07	29.46
4	Social political participation	02.37	02.79	17.72
5	Household	28.35	40.87	44.16
6	Material possession	43.75	70.02	60.04
7	Other attributes	03.22	03.39	05.27
	Mean total SET	07.02	09.27	32.85

A cursory look at Table 4 reveals that, the means of occupation (49.63 %), land holding (84.46 %t), annual income (23.07 %), socio-political participation (02.79 %), household (40.87 %), material possession (70.02 %), other attributes (03.39 %) and socio-economic status (07 %) of the growers after cultivation of Pomegranate crop were higher than the means of occupation (42.36 %), land holding (61.77 %), annual income (17.82 %), socio-political participation (02.37 %), household (28.35 %), material possession (43.75 %), other attributes (03.22 %) and socio-economic status (07.02 %) of the growers before cultivation of Pomegranate crop.

It was also found that there was change in occupation, land holding, annual income, socio-political participation; household, material possession and other attributes were 17.16, 36.73, 29.46, 17.72, 44.16, 60.04 and 05.27 per cent, respectively after the cultivation of Pomegranate over before cultivation of it as a result of adoption of recommended cultivation practicesof Pomegranate crop in the field.

When socio-economic transformation as a whole in terms of change in socio-economic status of grower before and after cultivation of Pomegranate was considered, it is evident from Table 4 that there was change in socio-economic status to the i.e. 32.85 per cent after the cultivation of Pomegranate as a result of adoption of recommended cultivation practices of crop over the before cultivation of it. Thus, it could be stated that cultivation of Pomegranate crop created a definite socio-economic transformation in the Pomegranate growers.

Table 5: Distribution of respondents according to their socio-economic status before and after cultivation of Pomegranate crop.

S. N.	Socio-economic status	Respondents (n=120)			
		Before		After	
		Number	Percen-tage	Number	Percen tage
1	Very low	1	0.83	0	0.00
2	Low	80	66.67	33	27.50
3	Medium	30	25.00	71	59.17
4	Medium high	5	4.17	9	7.50
5	High	4	3.33	7	5.83
	Total	**120**	**100.00**	**120**	**100.00**

It was observed from Table 5 that 59.17 per cent of the found in medium category of socio-economic statusafter cultivation of Pomegranate crop. This was followed (27.50 %) and (07.50 %) of the growers observed in low and medium high category of socio-economic statusafter cultivation of Pomegranate crop, respectively. Whereas only (5.83 %) of the growers had belonged in high socio-economic status and no one (0.0 %) growers observed in the very low category of socio-economic statusafter cultivation of Pomegranate crop.

VI. Relational analysis

The result of relational analysis of selected characters of the Pomegranate growers with their Socio-economics transformation have been furnished in Table6.

Table 6: Coefficient of correlation of selected characteristics of growers with their socio-economic transformation.

S.N.	Variables	'r' value
1.	Age	-0.177*
2.	Education	0.428**
3.	Land holding	0.210**
4.	Annual income	0.296**
5.	Area under Pomegranate cultivation	0.150
6.	Experience in Pomegranate cultivation	0.296**
7.	Benefits availed	-0.030
8.	Source of information	0.201**
9.	Innovativeness	0.264**
10.	Risk preference	0.186*
11.	Knowledge	0.416**
12.	Adoption	0.249**

*, ** Significant at 0.05 level and 0.01 level of probability, respectively.

It is evident from Table-6 that, among the selected characteristics namely education, land holding, annul income, experience in Pomegranate cultivation, source of information, innovativeness, knowledge and adoption found to have positive and highly significant correlation with the socio-economic transformation of Pomegranate growers at 0.01 level of probability. Whereas, age was negatively correlated with socio-economic transformation of Pomegranate growers and risk preference was found to be significant at 0.05 level of probability. The null hypothesis was therefore rejected for these variables.

The variables namely as area under Pomegranate cultivation and benefits availed did not show any significant association with the socio-economic transformation of Pomegranate growers. The null hypothesis for these variables was accepted.

It is therefore, from this result, it may be concluded that growers with higher education, higher land holding, more annual income, more experience under Pomegranate cultivation, higher source of information, high innovativeness, higher knowledge and more adoption had higher the socio-economic transformation.

VII. Conclusion: As regard to the Socio-economic transformation of the Pomegranate growers, it was found that there was change of 32.85 per cent found after cultivation of Pomegranate crop. The calculated 'Z' value was also found statistically significant. It means cultivation of Pomegranate crop created a positive significant change in the socio-economic status of the growers**.**

The finding of relational analysis revealed that, out of twelve characteristics, nine characteristics namely education, land holding, annual income, experience in Pomegranate cultivation, sources of information, innovativeness, knowledge and adoption found to have positive and highly significant correlation with the socio-economic transformation of Pomegranate growers at 0.01 level of significant at probability. Whereas, age was negatively correlated and risk preference was found to significant at 0.05 level of probability.

The variables namely as area under Pomegranate cultivation and benefits availed did not show any significant correlation with the socio-economic transformation of Pomegranate growers.

The findings of the regression analysis revealed that twelve independent variables contributed 42.57 per cent variation in socio-economic transformation of growers, whereas variables namely annual income, innovativeness and knowledge of Pomegranate growers contributed significantly at 0.05 level of probability and education of Pomegranate growers contributed significantly at 0.01 level of probability. The contribution of remaining variables were found to be non significant.

The findings regarding major constraints faced by the grower revealed that 78.33 per cent of the respondents expressed lack of knowledge about furrow irrigation to Pomegranate crop, followed by lack of

knowledge about tissue culture(77.50 %), lack of knowledge about chemical thinning (72.50 %), lack of knowledge about T.S.S. (69.17 %), lack of knowledge about intercropping (67.50 %), fluctuation in markets (60.00 %), shortage of irrigation water (56.70 %), high cost of fertilizers (53.30 %), shortage of fertilizers (50.00 %), short of capital (50.00 %) and non-availability of labours at the time of pruning as well as thinning (50.00 %).

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Determinants of Income Liability Gap Amongst Farmers in Distress Prone District of Western Vidarbha

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ABSTRACT

The present research study was purposively conducted in one of the distress districts of Vidarbha region of Maharashtra state with exploratory design of social research. Mix population of small and marginal farmers were selected randomly. The study revealed that majority 91.00 per cent of the small and marginal farmers have an income liability gap that means their income that gets from all sources is not found enough to fulfil the essential livelihood expenditure. Whereas the low annual income and low socio-economic status level are the important indicators/determinants observed for increasing the income liability gap amongst the selected farmers in distress district.

The most shrinking indicator of agrarian distress in the country is the rainfed farming. The agricultural income that gets to the farmers from rainfed farming is some times not enough to fulfil the essential livelihood expenditure and the results of which are the farmers could not repay the borrowed debts and pushed into the debt trap.

Agriculture is still considered the major sector providing employment in India (Singh 1994). However, the small and marginal farmer families and agricultural labourers have to face employment and under employment due to seasonal work in crop production (Swaminathan 1981) and also due to the natural calamities occurring at one or the other seasons of the year. As per the Radhakrishna Committee Report (2007) the Government of India declared 31 districts in four States (Andhra Pradesh-16, Karnataka-6, Maharashtra-6 and Kerala-3) as distress district. These districts are mostly rainfed, agriculturally less developed and low productivity districts, where the Prime Minister's Relief and Rehabilitation package is being implemented. This package designed with regional specificity to address issues of moisture conservation, infrastructural development, augmentation of non-farm sources of income and employment to farmers. Among distress districts six districts are from Vidarbha region of Maharashtra State. These districts are Yavatmal, Buldana, Amravati, Akola, Washim and Wardha (Anonymous, 2007).

The current research study has been formulated in order to assess the income liability gap amongst small and marginal farmers in distress district with following specific objectives.

1. To study the income liability gap amongst the small and marginal farmers of the distress district.
2. To find out the important determinants of the income liability gap amongst the farmers of the distress district.

MATERIAL AND METHODS

The present study was purposively conducted in Akola District of Vidarbha region of Maharashtra state as this is one of the distress prone districts of Vidarbha, declared by the Government of India. Exploratory design of social research was used. Out of 199 villages of Akola district 10 villages were selected randomly and from each selected villages 10 small and marginal farmers (Mix population of small and marginal farmers) were selected randomly to constitute sample size of 100 respondents. In this study income liability gap is the excess expenditure made by the respondent on livelihood items as against his annual income.

RESULTS AND DISCUSSION

Income liability gap

The gap between income and expenditure of the selected farmers was analyzed for demonstrating the income and expenditure status of the farmers. The income liability gap is computed as the excess expenditure incurred by the farmers as against his annual income. The gap is considered 'nil' if the gap between expenditure and income is zero or if the income is greater than the expenditure. The details are presented in Table 1 wherein the distribution of the respondents in accordance with the income liability gap existing is classified as per the range of gap.

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It is evident from the Table 1 that there was wide variation in the income gap prevailing for the sample. As much as 91.00 per cent of the respondents had an income gap ranging from upto Rs. 3000 to above Rs. 9000. A closer perusal of the table indicates that 37.00 per cent of the respondents had an income liability gap of Rs. 9000 and above, followed by 21.00 per cent in the income gap of Rs.6001 to 9000, 18.00 per cent in the income gap of Rs. 3001 to 6000 and 15.00 per cent in the income gap of upto Rs. 3000. On the contrary, around 9.00 per cent of the respondents had no income liability gap indicating that they were forced to curtail their expenditure in accordance with their income. The average annual income of all the selected households during 2008-09 was observed Rs. 44,450 and the average annual expenditure of the selected small and marginal farmers was estimated Rs. 50,810. Out of total expenditure of overall farmers, the expenditure on food occupies largest share (59.41%), followed by expenditure on health, religious functions and clothing has shown 10.20, 7.09 and 6.20 per cent share respectively. Here shockingly to note that the average annual expenditure of the selected farmers was found higher, than the annual income by Rs. 7061.

Table 1: Distribution of respondents according to their Income liability gap

S. N.	Income liability gap range in Rs.	Respondents (n = 100)	
		Number	Percentage
1.	No gap	09	09
2.	Up to 3,000 /-	15	15
3.	3001 /- to 6,000 /-	18	18
4.	6,001 /- to 9,000 /-	21	21
5.	Above 9,000 /-	37	37
	Total	**100**	**100.00**

Mean = 7061

It can be summed up that the in majority of the respondents there exists an income liability gap. That means the annual income that gets to the respondents from all sources is not enough to fulfil the livelihood expenditure. This warrants for appropriate micro level policy implications to create alternative employment opportunities, introducing integrated farming system approaches for enhancing the livelihood security system to curtail the distress prone situation in study area.

The results of the present investigation found in line with the results reported by Kale (2008) that majority (88.00 %) of the respondents had an income gap ranging from up to Rs. 3000 to above 9,000.

Relational analysis

The data were subjected to the statistical tools like correlation and regression. The correlation analysis will help in determining the relationship of selected personal, socio-economic, situational and socio-psychological characteristics of distress prone farmers and their identified income liability gap. While regression, analysis helps for identifying important variables/ determinants influencing the identified income liability gap amongst the respondents. The results are presented in the subsequent sub-parts as follows.

Table 2: Coefficient of correlation and multiple linear regression coefficient of independent variable with income liability gap amongst the respondents

S. N.	Independent variables	'r' value	Regression coefficient 'b' value	S.E. (b)
1.	Age	0.257*	114.132	64.242
2.	Education	-0.142	318.33	218.485
3.	Family size	0.108	800.57	1963.28
4.	Family type	0.126	-504.46	481.93
5.	Subsidiary occupation	-0.146	57.803	478.298
6	Land holding	0.001	-1220.12	1777.21
7	Cropping pattern	-0.018	72.57	722.94
8	Socio-economic status	-0.261**	-1600.65*	764.982
9	Irrigation facility	-0.106	380.202	903.58
10	Indebtedness	0.037	0.02808	0.035
11	Annual income	-0.067	-0.0735*	0.038
12	Expenditure pattern	0.0127	0.145**	0.041
13	Family health	0.134	1423.88	1964.76

$R^2 = 0.410$ F = 2.4581**

*Significant at 0.05 level of probability

**Significant at 0.01 level of probability

Correlational Analysis

A closer look at the values of correlation coefficient Table 2 brings into light that the personal characteristics namely, the education, family size, family type subsidiary occupation, land holding, cropping pattern, Irrigation facility, indebtedness, annual income, expenditure pattern, family health, of the respondents did not show any significant relationship with the identified income liability gap. The non-significant relationship of these variables indicates that these variables have no significant influence over the identified income gap. Where as age of the respondents has observed positively

significant relationship with income liability gap that means with increasing age of the respondents and indirectly the expenditure on important family responsibilities of an individual farmers which lead to the income liability gap. While the socio-economic status of the respondents has observed negative significant relationship with the income liability gap. That means that with the decrease in the socio-economic status level of the farmer's income liability gap is more prominent. Hence presence of low socio-economic status with increasing age related family responsibilities like education, health problems; marriage of daughters/sisters, etc. in family has been proved as one of the specified cause of income liability gap.

Regression Analysis

With a view to find, the significant contributions of independent variables in identified income liability gap the independent variables were fitted into the multiple linear regression models. The result pertaining to the regression analysis is presented in Table 2. The data reveals that there is negative and significant contribution of socio-economic status, annual income with identified income liability gap whereas annual income and socio-economic status were observed to have negative significant relationship with the income liability gap of the selected respondents. This shows that with the decrease in income and socio-economic status, the income liability gap of the respondents are more prominent and hence presence of low income and low socio-economic status has been proved as one of the specified causes of income liability gap amongst the small and marginal farmers in distress district of Western Vidarbha. The reason may be that income of the family is most important basic factor in everybody's life for fulfilling family needs. Everything can be adjusted but not the money. The annual income of the respondents directly influences the economic viability, stability and rational behavior of an individual and hence the decrease in the income levels increases the income liability gap that is quite natural.

Whereas expenditure pattern of the respondents has shown positive and significant contribution with their income liability gap. It shows that when expenditure of respondents were increased the income liability of the respondent was increased according to it .When all the 13 variables were fitted in multiple regression equation the Coefficient of Multiple Determination (R^2) comes to 0.410 and the obtained R^2 value was tested for its significance by computing "F" value and comparing it with "t" table value at n-k-1 degrees of freedom and was found significant. This shows that all the selected 13 variables contributed 41.00 per cent significant variation in identified income liability gap with the selected respondents.

CONCLUSIONS

It can be concluded that majority 91.00 per cent of the selected small and marginal farmers were living in non sustainable condition and around 9.00 per cent of the respondents had no income liability gap indicating that they were forced to curtail their expenditure in accordance with their income. Whereas the low annual income and low socio-economic status level are the important indicators observed for increasing the income liability gap amongst the selected farmers in distress district. Hence this study suggests for improving the socio-economic condition of the small and marginal farmers in distress district by improving annual income through integrating crop cultivation with allied remunerative ventures and creating irrigation facilities in study area. Because while conducting field survey it was observed that majority area is under rainfed condition and they have not integrated their farming with allied ventures except wage earning. To make agriculture remunerative facilities like irrigation potencial need to be developed. Age and socio-economic status were found to be related with income liability gap. In regression analysis only 41 per cent variation is explained by 13 variables inclcluded in the study. It means 59 per cent variation is caused by other factors. It is there fore imperative that these factors need to be find out in order to know the exact cause of income liability gap.

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Farmers' Vulnerability to Climate Change and Variability in Distress Prone Districts of Vidarbha

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ABSTRACT

The Vidarbha region in Maharashtra experiences extreme climatic conditions and the impacts of climate change further exacerbated its current vulnerability. Six districts in Vidarbha is declared distress prone being hotspot of farmers' suicides since 2001. This study was undertaken in highly suicide prone Akola and Yavatmal district to assess the extent of farmers' vulnerability to climate change with view to provide policy makers with apt information about where the most vulnerable group of farmers are located and their vulnerability stage. The data were collected through field survey from 300 farmers' spread over 10 villages across 5 tahsils. Vulnerability index calculated for Akola district demonstrated 48 percent vulnerability in 2001 and 52 per cent in 2011 whereas Yavatmal showed 51 and 48 per cent in 2001 and 2011, respectively. Survey at household level confirmed farmers' increased vulnerability to climate change in 2012 by 63 and 67 per cent in Akola and Yavatmal districts respectively. On average 65 percent farmers' in distress prone districts are vulnerable to impacts of climate change. Furthermore vulnerability assessment at household level pointed out farmers' vulnerability to the availability of irrigated land (0.87) followed by scarce sources of irrigation (0.81). Vulnerability indices as regards education (0.62), socio-political participation (0.80) farm income(0.85) buying crop insurance (0.61), access to credit (0.37) and live stock possession (0.76) showed high vulnerability signifies the need of empowerment of adaptive capacity of farmers on these aspects. Farmers of village Bhanus and Wai paras being highest vulnerable to climate change need urgent attention by the development departments.

Food production of many countries including India would be badly affected due to climate change, particularly wheat, paddy and other crops (Pachauri, 2009). Maharashtra the third largest and the second most populous state of India is not an exception to these changes. Climate change and its impact do have serious implications on rural livelihood of the people (Dwivedi, 2011). Total 11,737 farmers in Maharashtra committed suicides between the period from 2001-10 and the number of incidences of suicides from Vidarbha were at the top (Talule, 2013). The six districts out of total 11districts of Vidarbha region in Maharashtra is the hotspot for farmers' suicides since 2001 and declared as distress prone districts by Government of India. The region experiences extreme climatic conditions and the impacts of climate change further exacerbated its current vulnerability. More than 50 per cent (53.44 %) of the crop failure has to be accrued to an inadequate or untimely rainfall (TERI 2009). Nearly 58 per cent of reported farmers' suicides in Vidarbha were during monsoon months and are highly sensitive to the changes in climatic conditions (Pande and Akermann, 2010). Unpredictability of the monsoon, shifting rainfall patterns drought-like conditions in some areas and excessive rainfall in others has become frequent (Satpute and Vanjari, 2011). This is likely to endanger livelihoods of communities dependent on it and food security of the state. In view of this, the study was conducted to assess the present level of farmers' vulnerability to climate change at household level in 2012 as well as at district level in two purposively selected and highly suicidal concentrated districts' in Vidarbha namely, Akola and Yavatmal to provide policy makers with apt information about where the most vulnerable individuals are located and their vulnerability stage. Moreover vulnerability indicators are considered necessary for realistic decision-making process, thus, policy makers use these indicators not only for understanding vulnerability, but also for direct decision making. The present study is a first attempt in this region.

MATERIAL AND METHODS

Area Descriptions

The present study was undertaken in purposively selected Akola and Yavatmal districts of Vidarbha region of Maharashtra state in India. Six districts namely Yavatmal, Washim, Buldhana, Akola, Amravati and Wardha are declared distress prone districts in Vidarbha. The study was focused in Yavatmal and Akola districts due to its varying agro climatic characteristics and the

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number of incidences of farmers' suicide was found high than other districts. The Yavatmal district is situated between 20.24° N and 78.06° E whereas Akola district lies between 19° 51' and 21° 16' latitude and 76° 38' and 77° 44' longitude. The average annual rainfall of both the districts is 888 mm and 710mm respectively. Nearly 85 percent of the agriculture is rain dependent. The major crops grown are cotton, soybean, groundnut, pigeon pea, wheat and chick pea.

1.2 Research design and research approach

The diagnostic research design of social research was used for investigation, since the emphasis of the study was mainly fact-finding operation, where variables were assumed to be known and the hypotheses were formulated and concerned with testing of hypothesis and specifying relationship among variables used for development and testing of causal mode. Exploratory research approach was used to investigate farmers' vulnerability to secure greater insight into the practical aspects of the problem.

1.3 Sample and sampling plan

It has been established that the sample survey if planned properly, can give very precise information since in a survey, a part of the population is only surveyed and inference is drawn about the whole population. Hence sample survey method was followed in gathering the information for its wider application. On the basis of climate variability and extremities, decadal annual rainfall, incidences of farmers' suicides total five talukas were selected from both districts. Yavatmal district is relatively a larger district (13582 sq.km) than Akola having geographical area 10567 sq.km. Therefore, three talukas were selected from Yavatmal district and two from Akola district purposively. A list of villages was obtained from five talukas. Proportionate numbers of villages were randomly selected on the basis of number of villages in each selected taluka; (five from Akola, five from Yavatmal).Thereafter official list of farmers' were obtained from respective villages and within each selected village, 30 farmers' were identified for data collection. Following the procedure in ten selected villages, total of 300 farmers were selected for this investigation. The data were collected with the help of structured and pre-tested interview schedule developed for this purpose. All the data were collected from the respondents at their residence or at farm through personal interview. Two FGDs were carried out for realistic decision-making process. Secondary data sources were used to assess the extent of district vulnerability to climate change during 2001 and 2011.

1.4 Methodology followed in vulnerability assessment

1.4.1 Definition of Vulnerability

It is extensively used in climate change literature to denote the extent of damage a region is expected to be affected by various factors affected by climate change. Watson *et al*. (1996) defined vulnerability as the extent to which climate change may damage or harm a system, depending not only on a system's sensitivity but also on its ability to adapt to new climatic conditions. For the purpose of this study, researcher followed definition of vulnerability given in the Intergovernmental Panel on Climate Change third assessment report (2001) according to which vulnerability is defined as "The degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity" (McCarthy et al. 2001). Thus, as per this definition, vulnerability has three components: exposure, sensitivity and adaptive capacity. Exposure can be interpreted as the direct danger (i.e., the stressor), and the nature and extent of changes to a region's climate variables (e.g., temperature, precipitation, extreme weather events). Sensitivity describes the human–environmental conditions that can worsen the hazard, ameliorate the hazard, or trigger an impact. Adaptive capacity represents the potential to implement adaptation measures that help avert potential impacts. The first two components together represent the potential impact and adaptive capacity is the extent to which these impacts can be averted. Thus vulnerability is potential impact || I || minus adaptive capacity ||AC||. This leads to the following mathematical equation for vulnerability:

$$V = f(I-AC)$$

1.4.2 Index approach to study vulnerability

Quantitative assessment of vulnerability was done by constructing a 'Vulnerability index' following (Narayanan et al. 2006) and International Crop Research Institute for the Semi- Arid Tropics (ICRISAT 2012) Hyderabad. A set of indicators were selected for each of the three component of vulnerability: exposure, sensitivity and adaptive capacity for each district. In present study 'Vulnerability index' is numerical scale calculated from a

Table 1: Vulnerability indicators to assess the vulnerability of farmers' to climate change and variability at districts level in 2001 & 2011

Sr.no.	Vulnerability indicators	Functional relationship	Unit of measurement
A	**Exposure**		
1	Annual rainfall	-	mm
2	Rainfall variation 1901-2006	+	In percent
3	Maximum temperature	+	mm
4	Minimum. temperature	-	Degree C
B	**Sensitivity**		
1	Irrigation IntensityDefined as the ratio of total irrigated area in year to total command area.	-	percent
2	Percentage of gross irrigated area to net irrigated area	-.	percent
3	Infant mortality rates	+	infant per 1000 live births
4	Population density	-	No. of persons per sq. km
5	Percent small-scale farmers'.	+	percent
6	Percentage of gross irrigated area to gross cropped area	-	percent
7	Percentage of actual irrigated area.	-	percent
8	Percentage of rural families below poverty line(2002)	+	percent
9	Suicide rural	+	No. of suicides per 100000
C	**Adaptive Capacity**		
1	Literacy rate	-	percent
2	Percentage of total area under food grains to total cropped area	-	percent
3	**Average yield per hectare of principal crops (2001)**	-	
	Wheat	-	Kg./ha
	Jowar	-	Kg./ha
	Pearl	-	Kg./ha
	All cereals	-	Kg./ha
	Pigeon-pea	-	Kg./ha
	Gram	-	Kg./ha
	All pulses	-	Kg./ha
	Cotton	-	Cotton lint per hectare
4	Cropping intensity.	-	percent
5	HD Index	-	percent
6	Livestock	-	number
D	**Sum of the Scores**		
E	**Vulnerability Index**		

***Indicators were selected as suggested in (ICRISAT Manual 2012)**

***Data sources**

District State Agriculture Department, Akola and Yavatmal
http://mahades.Maharashtra.gov.in/files/districtglance/Yavatmal_at_a_glance.pdf
Economic Survey of Maharashtra, Directorate of Economics and Statistics, Planning Department2010-11
Commissioner of Agriculture, Government of Maharashtra, Pune. Population Census, 2001and 2011
www.mahaagri.gov.in/Irrigation Department, Government of Maharashtra, Mumbai
Director of Census Operations, Maharashtra, Mumbai. Registrar General and Census
Commissioner, Govt. of India, New Delhi. Office of the Registrar-General, India
Directorate of Economics and Statistics, Government of Maharashtra, Mumbai
Regional Meteorological Centers, Nagpur and Mumbai
Global HDR, 2003, NFHS, 1991-93, SRS, 1993, Registrar General of India, Ministry of Home Affairs, and Economic Survey of India, Info change (2005) and Agricultural Statistics at a Glance, (2004)

set of variables selected by the researcher for all the farmers' of Akola and Yavatmal districts and used to compare them with one another or with some reference point. That is, this numerical value was used in the ordinal sense i.e. on the basis of this index both the selected districts as well as farmers' of both districts were ranked and grouped in relatively less or more vulnerable. It was constructed in such a way that it always lies between 0 and 1 so that it was easy to compare the vulnerability of districts and farmers. The index was then expressed in percentage after multiplying by 100. The list of selected indicators based on the availability of data and personal judgment for assessment of vulnerability of Akola and Yavatmal districts is given in Table 1 whereas; the list of indicators selected for assessment of vulnerability at household level based on the personal judgment is provided in the Table 2.

1.4.3 Normalization of indicators using functional relationship

The indicators selected to assess the vulnerability of farmers' and districts obviously were in

Table 2: Vulnerability indicators to assess the vulnerability of farmers' at household level in 2012

S .N.	Vulnerability indicator	Unit of measurement	Prior functional relationship between the indicator and vulnerability
A	**Exposure**	+	Number of times
1	Number of events of flood and droughts in last 10 years**.**One of the key constraints to agriculture is a high climate variability that has historically included numerous droughts and floods (e.g., the 2000 floods and the 2002/2003 drought). In regions, With a higher frequency of droughts or floods, crop production is more risky.		
2	Annual rainfall	_	mm
B	**Sensitivity**		
1	Irrigated land	_	hectares
2	Crop diversification index (Area under major crops		percent
3	Source of irrigation	_	No source /rainfed 0River 1Well / Tube well / farm pond 2 Canal 3Canal+ river/ well/farm pond 4
4	Irrigation intensity (Gross area comes under irrigation with reference to net area under irrigation)	_	percent
C	**Adaptive capacity**		
1	Education	_	Number of classes passed by the farmer was considered as his/her educational score
2	Farm size	--	Hectares
3	Social participation	_	Membership in informal organization -1 Office bearer in informal organization -3 Membership in formal organization -2 Office bearer in formal organization- 4
4	Farm income (Net farm income)	_	Income in INR
5	Livestock possession	_	Farm animals: Non Discrete-2 Discrete- 1 Milch animals: Non Discrete-2Discrete- 1 Goat/sheep:Non Discrete-2 Discrete- 1 Poultry : Non Discrete-2 Discrete- 1
6	Buy crop insurance	_	Yes : 1 No : 0
7	Access to credit	_	Credit received in rupees

***Data source: field survey & own calculations**

different units and scales. The methodology used in UNDP's Human Development Index (HDI) (UNDP, 2006) was followed to normalize them. That is, in order to obtain figures which are free from the units and also to standardize their values, first they were normalized so that they all lie between 0 and 1. Before doing this, it was important to identify the functional relationship between the indicators and Vulnerability. Two types of functional relationship are possible: Vulnerability increases with increase (decrease) in the value of the indicator. Assume that higher the value of the indicator more is the vulnerability. For example, suppose the researcher had collected information on change in maximum temperature or change in annual rainfall. It is clear that higher the values of these indicators more will be the vulnerability of the region to climate change as variation in climate variables increase the vulnerability. In this case we say that the variables have upward functional relationship with vulnerability .For such case the normalization score was computed using the formula (1).

$$Xij = \frac{\text{Actual value-minimum value}}{\text{Maximum – minimum value}} \quad \cdots\cdots (1)$$

By adopting the above formula No.1, all the scores were laid in between 0 and 1. The value 1 corresponds to that district with maximum value and 0 corresponds to the district with minimum value. In this way the normalized scores for each district and farmers' were computed. On the other hand, consider education. A high value of this variable implied more literates in the region and so they had more awareness to cope with climate change. So the vulnerability was lower and therefore education has downward functional relationship with vulnerability. For this case the normalized score was computed using the formula.

$$Yij = \frac{\text{Maximum value – actual}}{\text{Maximum – minimum value}} \quad \cdots\cdots (2)$$

It is important in the construction of the indices. If the functional relation is ignored and if the variables are normalized simply by applying formula (1), the resulting index will be misleading.

1.4.4 Construction of Vulnerability Index

After computing the normalized scores the researcher used simple average of all the normalized scores to construct the vulnerability index giving equal weights to all the selected indicators of vulnerability by using the formula:

$$VI = \frac{\Sigma Xij + \Sigma Yij}{K} \times 100 \quad \cdots\cdots (3)$$

VI is vulnerability index. ΣXij and ΣYij is the sum of all the indicators of vulnerability and K is the total number of indicators. Finally, the vulnerability indices were used to rank the two districts in terms of vulnerability. A district /villages with highest index is said to be most vulnerable and it was given the rank1, the district/villages with next highest index was assigned rank 2. Similar procedure was followed for assessment of farmers' vulnerability to climate change and variability at household level. Following Iyengar and Sudharshan (1982) the fractile intervals were used to characterize the various stages of vulnerability of districts and farmers'.

The developed index was used to map vulnerability of farmers' in 10 villages of two distress prone districts of Vidarbha of Maharashtra in 2012 as well as vulnerability of farmers' at respective district level during the year 2001 and 2011 and categorization was done in terms of stages of vulnerability.

RESULTS AND DISCUSSION

Results pertaining to set of indicators selected for each of the three components of vulnerability exposure, sensitivity and adaptive capacity is given in Table 3. It revealed that amongst the selected villages under present investigation, farmers' of village Wai paras of Yavatmal district was highly vulnerable to number of floods in their villages. Farmers' of village Gonapur of Akola taluka and village Bhanus of Patur taluka were highly vulnerable to the variability of mean annual rainfall. Almost all the farmers' under study villages were very highly vulnerable to the availability of irrigated land for crop cultivation. Similarly, in almost every village, farmers' were highly vulnerable to the sources of irrigation and irrigation intensity. It is noticed that farmers' of all the villages were less vulnerable to crop diversification. This might be due to shift from traditionally grown cotton crop to soybean cultivation in recent years. Pertaining to vulnerability of farmers' to adaptive capacity indicators viz. education, farm size, social participation, farm income, live stock possession and crop insurance discovered that majority of farmers' of both the districts were highly vulnerable to climate change and its variability on these facets. Vulnerability indices as regards education (0.62), socio-political participation (0.80) farm income(0.85)

Table 3: Vulnerability Index of the farmers according to their sensitivity, exposure and adaptive capacity

	Exposure		Sensitivity				Adaptive Capacity								
Village	**NFDs**	**MAR**	**IL**	**CDI**	**SI**	**II**	**EDN**	**FS**	**SPP**	**FI**	**LP**	**CI**	**ACr**	**VI**	**RANK**
	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10	*11	*12	*13	*14	
Gonapur ,Dist. Akola	0.5	0	0.76	0.29	0.76	0.68	0.63	0.77	0.77	0.79	0.72	0.47	0.10	0.56	9
Washimba,Dist.Akola	0.5	0	0.85	0.31	0.81	0.76	0.70	0.81	0.89	0.82	0.82	0.4	0.17	0.65	5
Palodi, Dist. Akola	0	0	0.89	0.34	0.88	0.90	0.63	0.79	0.82	0.76	0.73	0.50	0.43	0.59	8
Nandkhed Dist.Akola	0	1.00	0.89	0.36	0.74	0.75	0.55	0.87	0.80	0.85	0.76	0.57	0.47	0.66	4
Bhanus, Dist. Akola	0.50	1.00	0.94	0.43	0.87	0.88	0.62	0.86	0.80	0.84	0.83	0.57	0.50	0.74	1
Wai Paras Dist. Yavatmal	1.00	0.01	0.96	0.41	0.92	0.92	0.64	0.88	0.86	0.92	0.84	0.73	0.37	0.72	2
Taroda Dist. Yavatmal	0	0.83	0.83	0.37	0.70	0.72	0.65	0.82	0.75	0.90	0.69	0.6	0.33	0.63	7
Shelu(Brahmanwada)Dist. Yavatmal 4		0.50	0.83	0.82	0.38	0.72	0.73	0.60	0.80	0.79	0.86	0.66	0.63	0.27	0.66
Inchuri Dist.Yavatmal	0.50	0.08	0.90	0.33	0.81	0.87	0.58	0.78	0.72	0.85	0.70	0.8	0.37	0.64	6
Waki road. Dist. Yavatmal	0.50	0.08	0.93	0.42	0.87	0.88	0.62	0.87	0.84	0.89	0.86	0.8	0.50	0.70	3
Average	**0.40**	**0.38**	**0.87**	**0.36**	**0.81**	**0.81**	**0.62**	**0.83**	**0.80**	**0.85**	**0.76**	**0.61**	**0.37**	**0.73**	

*1 - Number of floods and droughts (NFDs) *2 - Mean annual rainfall (MAR) *3 - Irrigated land(IL)

*4 - Crop diversification index(CDI) *5 - Source of irrigation(SI) *6 - Irrigation intensity(II)

*7 - Education(EDN) *8 - Farm size(FS) *9 - Socio-political participation(SPP)

*10 - Farm income(FI) *11 - Livestock possession(LP) *12 - Crop insurance(CI)

*13 - Access to credit (ACr) *14 - Vulnerability index(VI)

***Data Source: Field survey, own calculations**

buying crop insurance (0.61), access to credit (0.37) and live stock possession (0.76) showed high vulnerability in 2012 indicated the need of empowerment of adaptive capacity of farmers 'on these parameters in distress prone districts of Vidarbha. Village Bhanus and Wai Paras of Akola and Yavatmal district respectively being highest vulnerable to climate change need urgent attention by the development departments

Vulnerability ranking based on overall vulnerability index indicated that farmers' of village Bhanus of Akola district were most vulnerable to climate change and rank 1. Moreover the farmers' of village Gonapur of Akola district were relatively less vulnerable to climate change and its variability and received last rank amongst all other selected villages. The results obtained were further subjected to statistical analysis for classifying villages into different categories such as very less vulnerable, less vulnerable, moderately vulnerable, highly vulnerable and very highly vulnerable. In respect of overall vulnerability index (Table 4) findings further revealed that out of 10 surveyed villages; respondent farmers' of 80 percent villages that is 8 belonged to highly vulnerable categories (60 to 80%) while farmers' of only 20 per cent villages are slightly less vulnerable to climate change. Vulnerability index ranged between 61 to 80 per cent. This clearly indicates that majority of the farmers' of surveyed villages were highly vulnerable to climate change and its variability during the year of investigation that is 2012.The vulnerability stages of farmers' in study villages is depicted in Fig.1 revealed that nearly three fourth farmers falls in moderately vulnerable to highly vulnerable category (27.33 & 45.00 %, respectively) to the impacts of climate change. Nearly one fifth of the respondents belonged to very highly vulnerable category (19.33%). Very small proportions of farmers' were found in very less vulnerable to less vulnerable category (0.67 and 7.67%, respectively). On average 65 per cent farmers' in distress prone districts of Vidarbha are vulnerable to impacts of climate change in year 2012. It is concluded that majority of the farmers' are vulnerable to climate change and its variability in the distress prone districts of Vidarbha and most of the farmers' falls in the category of vulnerability ranging from moderately vulnerable to highly vulnerable. The data in Fig.2 indicates the vulnerability indices calculated for the district level and at farmers' level. Data showed that Akola district had vulnerability index of 0.48 in 2001 and 0.52 in 2011. It demonstrates that Akola district is in the moderate category of vulnerability to the impacts of climate change; however, the level of vulnerability is slightly increased over the decade. However at household level the vulnerability much increased to 63 per cent in 2012. The picture is differing in respect of Yavatmal district, here the vulnerability of district as whole was slightly decreased in 2011 (0.48) as compared to 2001(0.51). Yavatmal district also falls in the moderate category of vulnerability. However at household level the vulnerability significantly increased to 67 per cent in 2012. The assessment of vulnerability of farmers' to climate change and variability at household levels clearly indicated that farmers' of both the districts are highly vulnerable to climate change during the year of investigation. Moreover the farmers' of Yavatmal district were slightly more vulnerable compared to farmers' of Akola. Studies on causes of farmers' suicides in distress districts pointed out the number of farmers' suicides was highest in Yavatmal district in Vidarbha region (Kale, 2008b). Palanisami *et al.* (2010) also discovered that among all the districts under Godavari river basin, 4 districts from Maharashtra falls under very highly vulnerable category. Following periods of droughts in contiguous semi-arid regions there has been consistent reporting of increased suicide among poor male farmers' (Behere & Behere 2008; Nagaraj 2008). In the study conducted by Kumar and Rao (2002) in Warangal district of Andhra Pradesh to elicit the reasons for suicide of cotton farmers' concluded that 70.00 percent area under rainfed condition and fluctuating production levels in cotton crop was one of the factor for the suicide of cotton farmers'. The present study findings made crystal clear that vulnerability to climate change and its variability is one of the causes of farmers' distress

Table 4 : Stages of vulnerability of farmers under study villages

S. N.	Category	Index range	Number of villages
1	Very Less vulnerable	Up to 20 %	-
2	Less vulnerable	21 to 40 %	-
3	Moderately vulnerable	41 to 60 %	2
4	Highly vulnerable	61 to 80 %	8
5	Very highly vulnerable	81 to 100 %	-

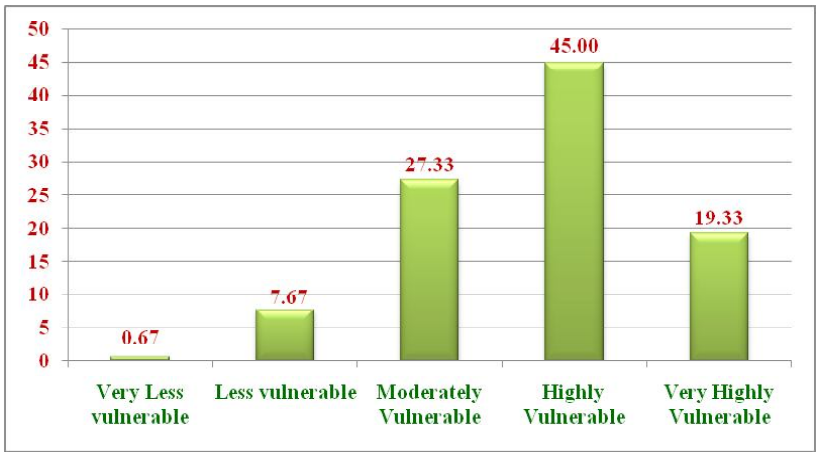

Fig. 1 : Distribution of the farmers(in percent) on the basis of their vulnerability stage to climate change(n=300)

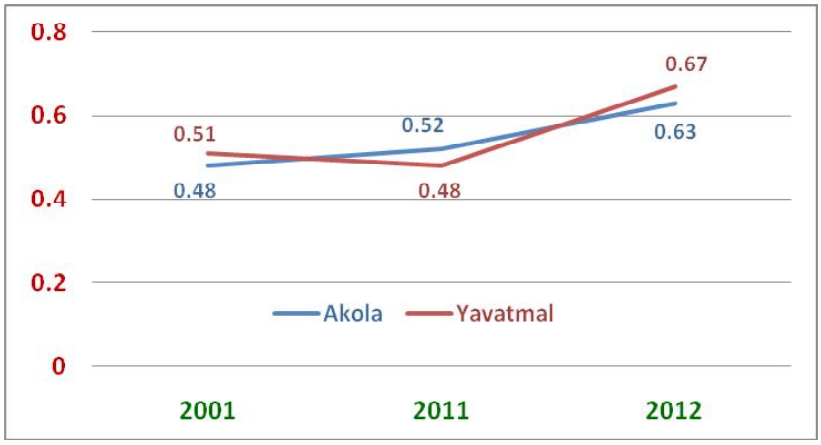

Fig. 2 : Vulnerability index of farmers at district level in 2001 and 2011and at household level in 2012

and suicides in the study area. The overall vulnerability level of farmers' of both the districts to climate change was high (0.6496).

CONCLUSIONS

The findings clearly indicated the farmers' high level of exposure and sensitivity indicators of vulnerability to climate change & variability in terms of floods and irrigation facilities. Under current climate scenario, where farmers' of few locations (here farmers' of village Wai paras) are vulnerable to excess rains, on the other hand majority of farmers' are vulnerable to availability of irrigation facilities during moisture deficit. This clearly pointed out the urgent need of soil and water conservation programme to store the excess rain water during heavy rains and popularizing improved methods of sowing like broad bed and furrow amongst farming community. There is a need to do more research in this regard. Secondly, there is urgent need to increase the irrigation potential of the region, because drought is a recurrent phenomenon in Vidarbha region in the last decade and irrigation is the only solution left in combating climate change and removing distress of agrarian community in the region. The findings also indicated the need of empowerment of vulnerability indicators of adaptive capacity of farmers' in terms of education, social participation, farm income, buying crop insurance, access to credit and live stock possession .Although government is taking serious efforts on all these issues but the fruits are yet to be seen. There is need to re-evaluate, re-validate all the schemes related to welfare of farmers' of the region.

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Correlates of Adoption of Herbicide Application Practices by the Soybean Farmers

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ABSTRACT

Soybean is the most important pulse crop in vidarbha region. Vidarbha becomes the main region of soybean production in Maharashtra. Therefore, the study was undertaken to study the characteristics of soybean farmers and their relationship with overall adoption of herbicide application practices by the soybean farmers. The study was conducted in Akola district of Maharashtra State during 2013-2014 with the help of exploratory research design; data was collected from 120 soybean farmers and analyzed with the help of suitable statistical methods. Findings revealed that 53.33 per cent respondents were belonged to middle age group. Majority (38.33%) of the respondents educated up to high school. Majority (41.66%) of the respondents belonged to semi-medium category of land holding and 44.17 per cent respondents had annual income between 75,000 to 1,50,000/-. The 35.83 per cent respondents put 1.01 to 2.00 ha area under soybean crop and 60.00 per cent respondents had medium experience in soybean cultivation. Majority (56.67%) of the respondents had 7.51 to 12.50 ha^{-1} productivity and about 42.50 per cent respondents had no participation in any social organization. Majority of respondents belonged to medium category of extension contact and economic motivation. Findings revealed that, majority (53.33%) of soybean farmers was having medium level of knowledge about herbicide application practices, followed by high level of knowledge (40.84%) remaining 5.83 per cent soybean farmers were belonged to low level category of knowledge. The significant relationship was observed between age, education, land holding, annual income, area under soybean, experience in soybean cultivation, extension contact and economic motivation with adoption level of soybean farmers about herbicide application practices.

Pearl of oil called as "soya". Soybean (*Glycinemax* L. merill) became the miracle crop of the 21st century. On the global scale, it tops on the list of oil seed crops. It is introduced as an oil seed crops in India to increase edible oil resources in the country due to its high yield potential. Madhya Pradesh is the first and Maharashtra is second largest soybean producing States in India. Madhya Pradesh produced 70 per cent and Maharashtra produced 18 per cent of countries soybean production. Vidarbha becomes the main region of soybean production in Maharashtra. Cotton was main crop of this region in *Kharif* season but from last five years farmers prefer soybean crop because of less input and high output, requires less agronomical practices as compared to cotton crop.

To improve the agricultural production some form of improved technology is necessary. The plant protection is an important and vital aspec t of agricultura l crop production. The farmer as a cultivator has to play an important role for augmenting agricultural production which may be enhanced by increasing the productivity of crops and reducing the losses caused by weeds. Farmers' adoption is one of the most crucial inputs for increasing the yield per unit area. Keeping this fact in mind the present investigation was undertaken to study the characteristics of soybean farmers and their relationship with overall adoption of herbicide application practices.

MATERIAL AND METHODS

The present study was conducted in Akola Panchayat samiti of Akola district. Ten Villages were selected randomly. Exploratory research design of social research was used for the study. Twelve farmers from each village were selected with the help of random sampling method and total 120 farmers were selected for the study. Data was collected personally by contacting all the respondents with the help of pretested interview schedule. The data were analyzed by means of frequencies, percentages, arithmetic mean, standard deviation and coefficient of correlation.

RESULTS AND DISCUSSION

Table 1: Profile of respondents

S. N.	Characteristics	No. of Respondents (n=120)	
		Frequency	Percentage
1	**Age**		
	i. Young	20	16.67
	ii. Middle	64	53.33
	iii. Old	36	30.00

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2	**Education**		
	i. Illiterate	03	02.50
	ii. Primary school	10	15.84
	iii. Middle school	19	08.33
	iv. High school	46	38.33
	v. Higher secondary school	39	32.50
	vi. College level	03	02.50
3	**Land holding**		
	i. Marginal (Up to 1.00 ha)	14	11.67
	ii. Small (1.01 to 2.00 ha)	38	31.67
	iii. Semi-medium (2.01 to 4.00 ha)	50	41.66
	iv. Medium (4.01 to 10.00 ha)	15	12.50
	v. Large (Above 10.00 ha)	03	02.50
4	**Annual income**		
	i. Up to 75,000/-	40	33.33
	ii. 75,001 to 1,50,000/-	53	44.17
	iii. 1,50,001 to 2,25,000/-	14	11.67
	iv. 2,25,001 to 3,00,000/-	10	08.33
	v. Above 3,00,000/-	03	02.50
5	**Area under soybean (ha)**		
	i. Up to 1.00 ha	36	30.00
	ii. 1.01 to 2.00 ha	43	35.83
	iii. 2.01 to 4.00 ha	29	24.17
	iv. 4.01 to 10.00 ha	12	10.00
6	**Experience in soybean cultivation**		
	i. Low (Up to 6 years)	36	30.00
	ii. Medium (7 to 12 years)	72	60.00
	iii. High (Above 12 years)	12	10.00
7	**Productivity of soybean (q/ha)**		
	i. 2.50 to 7.50	29	24.16
	ii. 7.51 to 12.50	68	56.67
	iii. 12.51 to 17.50	19	15.84
	iv. 17.51 to 22.50	04	03.33
8	**Social participation**		
	i. No participation	51	42.50
	ii. Office bearer of formal organization	04	03.33
	iii. Member of formal organization	12	10.00
	iv. Office bearer of informal organization	08	06.67
	v. Member of informal organization	45	37.50
9	**Extension contact**		
	i. Low (Up to 7)	20	16.67
	ii. Medium (8 to 12)	86	11.67
	ii. High (Above)	14	71.66
10	**Economic motivation**		
	i. Low (Up to 20.86)	73	23.34
	ii. Medium (20.87 to 27.16)	28	60.83
	iii. High (Above 27.16)	19	15.83
	Total	**120**	**100.00**

The data from Table 1 revealed that over half (53.33 per cent) of the respondents were belonged to middle age group category having age between 36 to 50 years. It was followed by 30.00 per cent respondents were belonged to old age category i.e. above 50 years and remaining 16.67 per cent respondents were observed in young age category i.e. up to 35 years**.** Data also revealed that more than one third (38.33 %) of the respondents were educated up to high school level education, 32.50 per cent respondents were educated up to higher secondary school level followed by middle school (15.84 %), primary school (8.33 %), college level (2.50 %), and only 2.50 per cent respondents were illiterates have not attended formal schooling.

The data in Table 1 also revealed that more than one third (41.66 %) of the respondents were observed in semi-medium category of land holding, followed by 31.67 per cent respondents were having land holding between 1.01-2.00 ha i.e. small category. Whereas, 12.50 per cent of respondents had land holding between 4.01 to 10.00 hectares i.e. medium category and 11.67 per cent of respondents had land holding up to 1.00 ha i.e. marginal category. Only 3.33 per cent respondents comes under large i.e. above 10.00 ha land holding category. The data further revealed that majority of 44.17 per cent of the respondents were having annual income between Rs. 75,001 to 1, 50,000/- this was followed by 33.33 per cent of the respondents were having annual income up to Rs. 75,000/- and 11.67 per cent of respondents have annual income between Rs. 1,50,001 to 2,25,000/-. Whereas, 8.33 per cent farmers had annual income between 2,25,001 to 3,00,000/- and only 2.50 per cent of respondents had annual income above 3,00,001/-.

The data from Table 1 noted that more than one third (35.83per cent) of the respondents had 1.01 to 2.00 ha area under soybean followed by 30.00 per cent of respondents had sown up to 1.00 ha area under soybean crop. Whereas 24.17 per cent of the respondents put area between 2.01 to 4.00 ha under soybean crop and only 10.00 per cent

respondents put 4.01 to 10.00 ha area under soybean, respectively. The data further revealed that majority (60.00 %) of the respondents had medium experience in soybean cultivation i.e. 7 to 12 years followed by 30.00 per cent respondents had low experience in soybean cultivation i.e. up to 6 years. Only 10.00 per cent respondents had high experience in soybean cultivation i.e. above 12 years.

The data in Table 1 revealed that more than half of the respondents 56.67 per cent had obtained 7.51 - 12.50 q ha^{-1} productivity of soybean crop, followed by 24.16 per cent of the respondents had 2.50 to 7.50 q ha^{-1} productivity of soybean. The 15.84 per cent respondents had obtained 12.51 to 17.50 q ha^{-1} productivity and only 3.33 per cent of the respondents were obtained 17.51 to 22.50 q ha^{-1} productivity of soybean crop.

The data further noted that more than one third (42.50 %) of the respondents had no participation in any social organization followed by 37.50 per cent respondents were the members of informal organization like self help group, farmers club, youth club etc. Whereas, 10.00 per cent respondents were the members of formal organization like *Grampanchyat, Panchayat Samiti* followed by 6.67 per cent respondents were the office bearers of informal organization. Only 3.33 per cent respondents were the office bearers of formal organization

The data from Table 1 also observed that majority (71.66per cent) of respondents had medium category of extension contact followed by 16.67 per cent of respondents had low category of extension contact. Only 11.67 per cent respondent had low category of extension contact. The data further revealed that more than half of the respondents had medium category of economic motivation, followed by 23.34 per cent respondents had low category of economic motivation. Only 15.83 per cent respondents had high category of economic motivation.

Relationship between independent variables and adoption

The correlation coefficient was computed for the relationship between the overall adoption level of soybean farmers and the independent variables. The results are presented in Table 2 out of ten variable seven independent variables correlated significantly with the adoption of herbicide application practices. They were education land holding, annual income, area under soybean, experience in soybean cultivation, extension contact and economic motivation. Knowledge as the dependent variable also significantly correlated with overall adoption of herbicide application practices.

Table 2: Relationship between socio-economic characteristics of soybean farmers and their overall adoption of herbicide application practices

S. N.	Characteristics	Coefficient of correlation 'r' value
1	Age	-0.4807**
2	Education	0.5807**
3	Land holding	0.3094**
4	Annual income	0.2708**
5	Area under soybean	0.2575**
6	Experience in soybean cultivation	0.3985**
7	Productivity	-0.0309
8	Social participation	0.00211
9	Extension contact	0.4649**
10	Economic motivation	0.4497**
11.	Knowledge	0.6617**

** - Significant at 0.01 per cent level of probability

* - Significant at 0.05 per cent level of probability

Age and adoption

The correlation coefficient (r = - 0.4807**) indicate that the relationship between age of the respondents and their adoption level was negatively significant. This indicates that old age farmers were not found interested in the seeking the information about new technology i.e. herbicide application practices in soybean that leads to lower down the adoption of herbicide application practices.

Education and adoption

The correlation coefficient (r = 0.5807**) indicate that the relationship between education of the respondents and their adoption level was highly significant. It means that educated farmers were tried their best to get the knowledge about herbicide application practices and knowledge of farmer was resulted into increase in adoption.

Land holding and adoption

The correlation coefficient (r = 0.3094**) indicated that the relationship between land holding of the soybean farmers and their adoption level was highly significant. It can be inferred from the findings that land holding was contributed to improve adoption behavior of soybean farmers about herbicide application practices.

Annual income and adoption

The correlation coefficient (r = 0.2708**) indicate that the relationship between annual income of the respondents and their adoption level was highly significant. This leads to conclude that the annual income of the farmers plays a decisive role in moulding their adoption behavior. The farmer with higher income level able to invested on herbicide to get higher yields and in turn the higher income. So that increasing annual income increase the adoption of herbicide.

Area under soybean and adoption

The correlation coefficient (r = 0.2575**) indicate that the relationship between area under soybean of the respondents and their adoption level was highly significant. It means that the farmer possess more area under soybeancrop they adopt more herbicide in their field.

Experience in soybean cultivation and adoption

The correlation coefficient (r = 0.3985**) indicate that the relationship between experience in soybean cultivation of the respondents and their adoption level was highly significant. It can be inferred from the findings that when experience in soybean cultivation was more that experience gives the sufficient time to farmer to study and analysis the practicability and relative advantage of the recommended herbicide application practices, hence adoption was also increases with increase in experience.

Productivity and adoption

The correlation coefficient (r = - 0.0309) indicate that the relationship between productivity of soybean and the adoption level of the respondents was negative and non-significant. It can be inferred from the findings that decreases in adoption of herbicide lower down the productivity of soybean crop.

Social participation and adoption

The correlation coefficient (r = 0.00211) indicate that the relationship between social participation of the respondents and their adoption level of the respondents was non- significant. It means adoption level is not increases with increase in social participation of the respondents.

Extension contact and adoption

The correlation coefficient (r = 0.4649**) indicate that the relationship between extension contact of the respondents and their adoption level was positive and significant. The farmers who had greater extension contact might got more knowledge and information about herbicide application practices, which ultimately results in higher adoption.

Economic motivation and adoption

The correlation coefficient (r = 0.4497**) indicate that the relationship between economic motivation of the respondents and their adoption level was positive and significant. It can be inferred from the findings that the farmers with higher economic motivation who were enthusiastically motivated towards adopting the herbicide application practices.

Knowledge and adoption

The correlation coefficient (r = 0.6617**) indicate that the relationship between knowledge of the soybean farmers and their adoption level was positive and significant. The farmers with appropriate knowledge about herbicide application practices in soybean lead to increase in adoption behaviors of soybean farmers.

All the above findings were similar with findings of Jadhav (2008), Shinde (2000), Ashish kumar (2012), Mohite (2013) and Dhenge (2013).

CONCLUSIONS

From the study it is concluded that negative significant relationship was observed between age of the farmer and their adoption level. The education, land holding, annual income, experience in soybean cultivation, extension contact, economic motivation and knowledge of farmers showed positive significant relationship with adoption level of farmers.But, the productivity and social participation did not show any significant relationship with knowledge. That means among all independent variables education, land holding, annual income, area under soybean, experience in soybean cultivation, extension contact, economic motivation and knowledge were the most contributing variables for increasing adoption behavior of soybean farmers about herbicides application practices.

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Effect of Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) on Rural Communities in Eastern Vidarbha

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ABSTRACT

The present study was undertaken with an objective to assess the impact of Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) on rural communities in the four districts of eastern Vidarbha region of Maharashtra namely, Bhandara, Gondia, Gadchiroli and Chandrapur. For the study, total thirty two villages were selected and from each selected village, ten beneficiaries were selected randomly constituted a sample size of 320 beneficiaries. The results indicated that there was major labour scarcity in summer paddy (37.20 %) due to MGNREGA enlightened the adverse effect of the act. As far as benefit is concerned farmers felt very positive impact on increased water storage capacity, available water for livestock in summer due to the irrigation canal and repair of embankment through MGNREGA and also the improvement of socio-economic status of the beneficiaries. Majority (65.62%) of farmers strongly agree with wage employment as benefits due to MGNREGA activity, whereas 63.54 per cent farmers strongly agree with improved climate as benefit due to tree plantation through MGNREGA.

The Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) is an Indian job guarantee scheme, enacted by legislation on 25 August, 2005. The act has become operative in the notified districts from 2nd February 2006 with an objective of enhancing livelihood security of rural households by providing at least 100 days of guaranteed wage employment in every financial year to every household whose adult members volunteer to do unskilled manual work. In Maharashtra state, first phase of MGNREGA started in 12 districts since 2006.These districts were identified as poorest districts of Maharashtra (Source: www.nrega.nic.in). The present study was carried out amongst four districts namely Bhandara, Gondia, Gadchiroli and Chandrapur located in eastern Vidarbha region. The MGNREGA programme in selected districts aims to provide livelihood support for the families of landless labourers, small farmers and those from poor households who have irregular income and are often unable to have enough money to purchase their entire month's food quota at the fair price shop, all at once. It is therefore felt necessary to find out the effect of MGNREGA on the rural communities in the villages, where this act has been implemented to record the positive as well as negative effects of MGNREGA for better implementation of scheme.

MATERIAL AND METHODS

Locale of the study

The study was carried out in eastern Vidarbha region, which comprises the districts namely Bhandara, Gondia, Gadchiroli and Chandrapur. These four districts are well known for paddy growing belt of Vidarbha region.

Selection of tahsils

The higher number of registered persons since beginning of the scheme was the criterion for selection of the tahsils for the study. The talukas namely 1) Deori, 2) Sadak Arjuni, 3) Lakhandur, 4) Sakoli 5) Nagbhir 6) Brahmapuri 7) Kurkheda 8) Wadsa were observed having more number of registered persons on the job. Hence, these tahsils were selected for the study.

Selection of villages

From each selected tahsils, four villages were selected for the study based on higher number of beneficiaries under MGNREGA working in a selected village. Thus, total thirty two villages were selected.

Selection of beneficiaries

The list of beneficiaries who worked under MGNREGA since five years was obtained from Gram Panchayat of the selected villages and from each selected village ten beneficiaries were selected randomly to constitute a sample size of 320 beneficiaries. Extent of impact of MGNREGA on rural livelihood of individual beneficiary was worked out as the differences of rural livelihood between before and after working in MGNREGA by an individual beneficiary.

Research Design

An exploratory research design was used for the present study.

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Development of data collection instrument

Interview schedule was prepared and pre-tested with a great caution so that it becomes perfect as per the objective set for the investigation. Data were collected in face to face situation. The interview with the beneficiaries was conducted at their resident or place with comfort situation.

RESULTS AND DISCUSSION

Impact of MGNREGA on agriculture

The MGNREGA provides guarantee of 100 day wage employment in a year to every rural household who is willing to do unskilled manual work. This unique feature of the programme has absorbed not only the labour having no employment but also the labourers working earlier in the agricultural field, making it labour scarcity to carry out agricultural operation. But in other hand this flagship programme is much benefited to rural community that creates employment by creating productive durable assents at village level. These assets include road construction, irrigation canal, renovation of embankment, tree plantation and land development. These MGNREGA activities give direct benefits include increased productivity, improve socio-economic condition, enhanced rural infrastructure etc. Impact of MGNREGA on agriculture is delineated in following paragraphs.

Labour availability for agriculture: Agriculture is a backbone of India and rich source of livelihood to the labour and poor sector people. Agriculture occupation is totally depend on environment and labour, but after implementation of MGNREGA goal with provide 100 day employment to adult who willing to do unskilled manual work in a every financial year , making it difficult to carry out agricultural operations. This factor is important because MGNREGA is employment generating scheme, hence, it has been considered in the present study. The labour availability wise distribution of farmers is presented in Table 2.

It is evident from the Table 2 that for land preparation for kharif paddy crop, 2.3 person days of labour was required per acre, while labour availability before MGNREGA was 100.00 per cent, but after implementation of MGNREGA labour availability was 92.82 per cent it means that total scarcity of labour for land preparation was 7.17 per cent. Other operations of *Kharif* paddy like threshing and transplanting observed labour scarcity 3.0 and 2.5 per cent respectively. Total labour scarcity for the *Kharif* paddy was observed 12.72 percent due to implementation of MGNREGA. In respect of sugarcane only the operation like cutting of sugarcane had 8.02 per cent labour scarcity due to MGNREGA. Similarly major labour scarcity was observed in summer paddy crop due to MGNREGA. It is observed from Table 2, that there was 23.00 per cent labour scarcity in summer paddy threshing and transplanting. Whereas 7.95 per cent labour scarcity was observed in paddy harvesting and 6.23 per cent labour scarcity observed in land preparation and weeding for summer paddy.

It is observed from Table 2, that major labour scarcity was in summer paddy (37.20 %) due to MGNREGA. It might be due to the reason, that as per the provision of MGNREGA, works start from the month of December to January and end in June to July, due to large number of agricultural labour engage in MGNREGA work. Similarly summer paddy crop operations also carried out during this period. So it is very difficult for cultivators those having summer paddy crop to avail labourer due to MGNREGA implementation. Farmers have to do different operations by machine and old age labour due to which, the cost of summer paddy cultivation is increased. Harish et al (2011) also noticed that MGNREGA programme often poses the problem of labour scarcity for some of the agricultural operations linked to market wage rates. As a consequence, farmers have brought down their acreage under different crops, leaving the land fallow.

Benefit from MGNREGA activities: MGNREGA was started with objective provide guaranteed wage employment to adult who willing to do unskilled manual work and generating productive assets, protecting the environment. It means that MGNREGA definitely provide benefits to rural community include enhanced agricultural production, irrigation facilities, improved socio-economic condition and rural infrastructure etc. Keeping this in view, hence, it has been considered in the present study. The benefits accrued from MGNREGA activities as perceived by rural community are presented in Table 3.

The data recorded in Table 3 shows that, majority i.e. 76.04 per cent farmers had strongly agree with effect on education as benefit due to the road construction through MGNREGA followed by 72 .91 per cent farmers had strongly agree with health facilities in case of emergency as benefits. Whereas, 70.83 per cent farmers agreed that approach to main market as a benefit of road

Table 1: District wise MGNREGA beneficiaries and selected beneficiaries

S.N.	Districts	Total MGNREGA beneficiaries	No. of beneficiaries selected
1	Bhandara	31029	80
2	Chandrapur	42490	80
3	Gondia	46237	80
4	Gadchiroli	36018	80
	Total	**155774**	**320**

Table 2: Impact of MGNREGA on labour availability for agriculture

Season	Major crop	Major activity	Labour required (day/acre)	Labour availability before MGNREGA (day/acre)	Labour availability after MGNREGA (day/acre)	Labour scarcity before MGNREGA (per cent)	Labour scarcity after MGNREGA (per cent)	Absolute scarcity (per cent)
Kharif	Paddy	Land preparation	02.00	02.00	01.88	00.00	07.17	07.17
		Nusery bed preparation	01.00	01.00	01.10	00.00	00.00	00.00
		Transplanting	18.00	18.00	17.90	00.00	02.53	02.53
		Weeding	06.00	06.00	06.09	00.00	00.00	00.00
		Harvesting	14.0	13.00	13.98	00.00	00.00	00.00
		Threshing	09.00	09.00	08.39	00.00	03.00	03.00
		Total	50.00	50.00	48.66	00.00	12.72	12.72
Rabi	Sugarcane	Land preparation	04.01	01.01	01.01	00.00	00.00	00.00
		Planting	08.60	08.60	08.60	00.00	00.00	00.00
		Intercultural operation Cutting	14.94	14.94	14.94	00.00	00.00	00.00
		Total	60.01	60.01	57.40	00.00	08.02	08.02
Summer	Paddy	Land preparation	00.84	00.84	00.81	00.00	03.79	03.70
		Nursery bed preparation	00.46	00.46	00.46	00.00	00.00	00.00
		Transplanting	06.07	06.07	05.38	00.00	11.32	11.32
		Weeding	02.05	02.05	02.00	00.00	02.53	02.53
		Harvesting	04.84	04.84	04.45	00.00	07.95	07.95
		Threshing	03.03	03.03	02.67	00.00	11.68	11.68
		Total	**17.31**	**17.31**	**15.80**	**00.00**	**37.20**	**37.20**

construction, while 56.25 and 55.21 per cent farmers had strongly agree with sanitation and easy for movement to farm as benefit due to road construction respectively. 58.33 per cent respondents agreed that due to road construction under MGNREGA, there is increase in the frequency of government officer visits in the village.

The findings indicated that majority of farmers feel road construction activity through MGNREGA as most important benefit for education, availing health facility, approach to main market and easy for movement to farm.

The data recorded in Table 4 shows that, majority (79.16%) of farmers strongly agree with increased water store capacity as benefits due to MGNREGA activity, whereas 70.83 per cent farmers strongly agree with available water for livestock in summer as benefit due to repair of embankment through MGNREGA. While increased

Table 3: Benefits as perceived by rural communities due to road construction under MGNREGA

S. N.	Benefit from road construction	Respondents (n=96)		
		Strongly agree	Agree	Disagree
1	Approach to main market	68(70.83)	28(29.17)	00(00.00)
2	Frequently visit to government office	12(12.50)	56(58.33)	28(29.17)
3	Health facilities in case of emergency	70(72.91)	26(27.09)	00(00.00)
4	Effect on education	73(76.04)	23(23.96)	00(00.00)
5	Sanitation	54(56.25)	42(43.75)	00(00.00)
6	Easy for movement to farm	53(55.21)	27(28.13)	16(16.66)

(Figures in parenthesis indicate the percentage)

Table 4: Benefits as perceived by rural communities due to irrigation canals/ repair of embankment under MGNREGA

S. N.	Benefit from irrigation canals/ repair of embankment	Respondents (n=96)		
		Strongly agree	Agree	Disagree
1	Increased ground water level	45(46.87)	40(41.67)	11(11.46)
2	Increased water store capacity	76(79.16)	18(18.75)	02(02.09)
3	Increased irrigation source	12(12.50)	76(79.16)	08(08.34)
4	Shift of crop paddy to sugarcane	35(36.45)	00(00.00)	61(63.55)
5	Increase area under crops	35(36.45)	50(52.09)	11(11.46)
6	Increase productivity /yield	20(20.83)	42(43.75)	3435.42)
7	Improvement of socio-economic status	15(15.63)	67(69.79)	14(14.58)
8	Available water for livestock in summer	68(70.83)	28(29.17)	00(00.00)

(Figures in parenthesis indicate the percentage)

Table5: Benefits perceived by rural communities due to tree plantation under MGNREGA.

S. N.	Benefit from tree plantation	Respondents (n=96)		
		Strongly agree	Agree	Disagree
1	Wage employment	63(65.62)	33(34.38)	00(00.00)
2	Reduced evaporation from soil	02(02.08)	18(18.75)	76(79.17)
3	Reduced surface runoff	12(12.50)	76(79.17)	08(08.33)
4	Improved climate-	61(63.54)	35(36.46)	00(00.00)
5	Improvement in availability of water status	35(36.46)	50(52.08)	11(11.46)
6	Cultural and social benefits	38(39.58)	42(43.75)	16(16.67)

(Figures in parenthesis indicate the percentage)

irrigation source and improvement of socio-economic status as benefit due to MGNREGA activity 79.16 and 69.79 per cent farmers agree respectively. Similarly 63.55 per cent farmers disagree with shift of crop paddy to sugarcane due to MGNREGA activity. The findings indicate that the irrigation canal and repair of embankment through MGNREGA farmers feel very positive impact on increased water storage capacity, available water for livestock in summer and improvement of socio-economic status of the beneficiaries.

The figures presented in Table 5 shows that, over half (65.62 %) of farmers strongly agree with wage

employment as benefits due to MGNREGA activity, whereas 63.54 per cent farmers strongly agree with improved climate as benefit due to tree plantation through MGNREGA. While79.17 and 52.08 per cent farmers agreed reduced surface runoff and improvement in availability of water status as a benefit due to MGNREGA respectively. Nearly fifty per cent (43.75%) farmers agree with social and cultural benefit due to tree plantation. Similarly 79.17 per cent farmers disagree with reduced evaporation from soil due to MGNREGA activity tree plantation. The findings indicated that farmers feel very positive impact of MGNREGA on rural community in terms of improved climate; provide wage employment, improvement in availability of water status and social and cultural benefit due to tree plantation.

CONCLUSION

It is concluded from results of the study that, MGNREGA had very positive impact in terms of improved climate; provide wage employment, improvement in availability of water status as well as social and cultural benefit due to tree plantation. On other hand created problems of labourer in summer season due to engagement of labourer in MGNREGA.There is need to focus attention on this issue by the policy makers to find out alternative arrangements to overcome the problem of availability of farm labour during summer season in the villages.

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PKV Mini Dal Mill : A Boon for Agro Processing Centre

Mohini Dange[1], P. A. Borkar[2] and P. H. Bakane[3]

ABSTRACT

The study was conducted by All India Coordinated Research Project on Post Harvest Technology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola to enhance entrepreneurship in unemployed educated youths in Vidharbha region of Maharashtra. A new Agro Processing centre (APC) was established at Jamthi (Hatgaon), Tq. Murtizapur, Distt Akola (Maharashtra) for Farmer's cooperative society i.e. Krishi Vikas Shetkari Audhogik Sahakari Sasntha. PKV mini dal mill was installed at this APC. Panjabrao Deshmukh Krishi Vidyapeeth mini dal mill after processing tur/pegion pea gives the recovery of nearly 72 to 75per cent and 25 to 28 per cent byproduct (brokens+husk+powder).Also this dal mill was efficient in preparing mong dal (75-80per cent recovery) from Green gram and udad dal (75-80 per cent recovery) from Black gram. After installing of PKV mini dal mill at APC the centre generated an income of about Rs. 1,46,650/- and the profit gained was Rs. 1,32,318 during 2010. And during 2011 the centre generated an income of about Rs. 2,71,250 /- and the profit gained was Rs. 2,24,586. The study showed that the entrepreneur who is effectively maintaining PKV mini dal mill at his Agro Processing Centre (APC) had generated sufficient income by processing and value addition of pegion pea and this centre is now become an ideal for other farmers who are willing to become an entrepreneur.

Post harvest processing is one of the necessary steps in conversion, value addition and prevention of loss of agricultural produce. It is essential operation being carried out prior to consumption of agro produce. Most of the post harvest processing operations are performed at urban side resulting into increased cost of transportation and storage requirement besides loss of some important byproducts and post harvest losses. These operations include threshing, cleaning, grading, drying, and storage, which can be treated as primary processing of the farm produce. Operations like de-husking, grinding, de-cortication, milling, oil extraction, use of by- products etc. are the secondary processing operation. Primary or secondary processing of agricultural produce at village level will help to reduce the cost of processed material, giving additional income source to producer, employment generation among the rural youths and in situ value addition. As a result, processed product will be available at lower cost for the rural population also.

It is now necessary to assess the potential for these processing operations at village level. This will generate data for design of model pilot^{-1} plant agro^{-1} processing centre, which in turn can be installed befitting to the needs of the production locality. Such models pilot^{-1} plant agro^{-1} processing centre will attract the farmers village^{-1} artisans, villagers, unemployed youths and rural entrepreneurs to adopt by themselves for producing value added products. Therefore, the Agro Processing Centres are needed to be established at production catchments. The study was undertaken with the objectives to establish one new Agro-processing centre on cereals and pulses and for monitoring the performance of Agro Processing Centre.

MATERIAL AND METHODS

Project proposal was finalized and the beneficiary was selected. The selection committee had selected the Farmer's cooperative society i.e. Krishi Vikas Shetkari Audhogik Sahakari Sasntha, Jamthi (Hatgaon) Tq. Murtizapur Distt Akola (Maharashtra) for establishment of Agro Processing Centre (APC). About 4500 farmers from 155 villages of two districts are the member of the society. Total land holding of the group is about 40,000 ha and green gram, black gram, pigeon pea are the major crop grown. The society use to sell the farm produce to the organized group of marketing at Nanded. After doing the survey it was observed that, the group can fetch higher price to their produce merely by cleaning , grading and processing of pulses into dal thus enhancing the profit. Further, the seasonal activity of shevai making can generate employment and enhance income. As green gram, black gram, bengal gram and pigeon pea are the major crops grown and huge quantity is produced, thus, there is good scope for establishment of new Agro Processing centre. Crop wise production is shown below.

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Table 1. Cropwise production of farmer's cooperative society (2010)

S. N.	Crop	Production, q
1	Pigeon pea	35,000
2	Green gram	20,000
3	Black gram	100
4	Chick pea	10,000
	Total	**65,100**

According to the crop production shown in Table 1, the machineries were selected for establishment APC Plate 1, 2 and 3. Details of machineries are given in Table 2.

Plate 1. PKV mini dal mill at APC

Table 2. List of Machinery for Agro Processing Centre at Jamthi (Hatgaon)

S. N	Name of Technology	Name of Machinery	No. of units required	Capacity, q day^{-1}	Power required (HP)	Rate of units, Rs. (in lakh)	Total Cost, Rs. (in lakh)
1.	Cleaning/ grading	PKV cleaner/ grader cum polisher	03	30	1	0.30	0.90
2.	Dal milling	PKV mini dal mill	03	10	2	0.50	1.50
		Sheller	03	10	5	0.20	0.60
3.	Shevai	Shevai machine	03	01	2	0.30	0.90
		Plat form weighing balance	01			0.30	0.30
	Civil work (foundation and drying yard)						0.90
	Total		**13**			**-**	**4.50**

Plate 2. PKV cleaner cum grader at APC

Plate 3. Shevai machine at APC

RESULTS AND DISCUSSION

a) Monitoring Performance of Agro Processing Centre (Jamthi) during 2010 & 2011

As per the project report the machineries were procured and installed. The working of mini dal mill and shevai machine was explained. To built up working confidence, demonstration and training to the working persons and members of co-operative society was organized. Performance of APC during 2010 (Table 3) and 2011 (Table 4) and Plate 4.

Table 3. Performance of Activities at APC, 2010

S. N.	Machines	Commodity Processed		Quantity Processed, q	Charges, Rs/q	Amount collected, Rs.
1.	PKV mini dal mill	i)	Pigeon pea	381	350	1,33,350
		ii)	Black gram	17	200	3,400
		iii)	Green gram	32	200	6,400
		iv)	Bengal gram	-	-	-
2.	Sewai machine	i)	Sewai processing	5	700	3,500
	Total			**235**		**1,46,650**

Table 4. Performance of Activities at APC, 2011

S. N.	Machines	Commodity Processed		Quantity Processed, q	Charges, Rs/q	Amount collected, Rs.
1.	PKV mini dal mill	i)	Pigeon pea	682	350	2,38,700
		ii)	Black gram	-	-	
		iii)	Green gram	23	350	8,050
		iv)	Bengal gram	57	350	19,950
2.	Sewai machine	i)	Sewai processing	6.5	700	4,550
	Total			**768.5**		**2,71,250**

As the centre was newly established in 2010, the processing at the centre was below expectation level ,processed quantity is 235 q only and income earned was Rs. 1,46,650 (Table 3), and during this season progress is satisfactory, the processed quantity is 768.5 q only and income is Rs.2,71,250/- (Table 4) The centre was used to impart trainings and demonstrations to farmers and entrepreneurs to encourage them to establish such type of Agro Processing Centres in their respective production catchment. About 22 entrepreneurs and 77 farmers participated in 6 training programmes and nearly 123 farmers had participated in 6 demonstrations programs arranged at APC and Plate 5

Plate 4. Processed Dal at APC

Table 5. Operational performance and income generation at APC

S. N.	Activities	Processed material (q)		Cost of Process (Rs./q)		Expenditure incurred (Rs.)		Income (Rs.)		Profit/ Loss (Rs.)	
		2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
1	Pigeon pea	381	682	350	350	2263 (E) 3959(O) 5000 (L) 11,222	11,935 (E) 14,915 (O) 14,700 (L) 41,550	1,33,350	2,38,700	1,22,128	1,97,150
2	Black gram	17	-	200	-	213 (E) 372(O) 500 (L) 1,085	3,400	-	2,315	-	
3	Green gram	32	23	200	350	400 (E) 700 (O) 800 (L) 1,900	403 (E) 503 (O) 600 (L) 1,506	6,400	8,050	4500	6,544
4	Bengal gram	-	57	-	350		998 (E) 1,247 (O) 1,200 (L) 3445	-	19,950	-	16,505
5	Sewai Processing	5	6.5	700	700	125(E) 125	163 (E) 163	3,500	4,550	3,375	4,387
Total		**235**	**768.5**			**14,332**	**46,664**	**1,46,650**	**2,71,250**	**1,32,318**	**2,24,586**

(E – Electricity charges, L – Labour charges and O – Oil charges)

Plate 5. Training Programme at APC

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PKV Res. J. Vol. 40 (1), January 2016

Studies on Heat Pump Drying of Green Chilli

P. H. Bakane[1], M. R. Bari[2], H. M. Khobragade[3] and Manisha Khedkar[4]

ABSTRACT

The green chilli were dried ain dehumidified air dryer at 30, 40, 50°C with different pretreatments. The drying rate of green chilli was found to be increased with increase in drying temperature in all pretreatments. The moisture content of green chilli reduced exponentially with drying time. Drying of green chilli took place mainly under falling rate period. The KMS treated and blanched samples had higher drying rates and took less drying time as compared to control. Drying air temperature as well as pretreatment both play significant role in influencing the quality parameters of dehydrated chilli.

Chilli (*Capsicum annuum* L.) is a spice cum vegetable of commercial importance. It is most widely used spice all over the world as a condiment, culinary supplement or as a vegetable and virtually an indispensable item in the kitchen. The wide popularity of chilli is due to its wide range of shape, size and sensory attributes such as colour, pungency, taste and distinctive aroma that generally make insipid bulk nutritive flesh and cereal foods more appetizing. Both red and green chillies can be used as fresh but dried chillies are also used extensively.

India is the largest producer and exporter of chilli in the world. Chilli is cultivated on an area of 7.75 lakh ha and productivity of 1.9 MT ha^{-1} during the year 2013-14 (www.nhb.gov.in). In India, Andhra Pradesh is largest producer of chilli and Maharashtra is on third position. Murthy (1995) reported that around 97 per cent of total production of chilli is consumed within the country and only 3 per cent is exported.

The prices of chilli are fluctuating and it declined during post harvest season and increase in the off season. Preservation of seasonal gluts permits seasonal products to become available round the year as well as prevents post harvest losses. As far as preservation of vegetables is concerned, drying is the most widely used method for reducing the water activity of the perishable commodities to the safe storage level to prevent microbial infection. The chief benefits of drying of food stuffs are their prolonged preservation which allows them to be marketed and consumed outside their traditional season and reduction of their mass and volume which makes transportation cheaper. Among the various dehydration techniques, hot air circulation around the commodity is commonly used. This technique is energy intensive and characterized by low drying efficiency especially during last phases of drying cycle.

Heat pumps have been known to be energy efficient when used in conjunction with drying operations. The principal advantages of dehumidified air dryers emerge from the ability of heat pumps to recover energy from the exhaust as well as their ability to control independently the drying air temperature and humidity. Heat sensitive food products requiring low temperature drying, can take advantage of the heat pump drying technology in which the drying temperature can be adjusted from 20 °C to 60 °C with proper control, it is also possible for heat pump dryer to produce freeze drying conditions at atmospheric pressure (Prasertsan and Saen-Saby, 1998). In countries where the level of air humidity is high - high spoilage rates occur during the rainy season when the drying air is very moist. Heat pump dryer can reduce product spoilage by maintaining low humidity of drying air through the regulation of the latent heat removal at the evaporator.

The literature is available on dehydration of green chilli. Some researchershave studied the effect of pre-treatments and drying condition on drying characteristics and product quality. But the information pertaining to the effect of dehumidified air drying at near ambient temperature of fruits and vegetables in general and green chilli in particular and its effect on product quality is scare.

Therefore, present work on drying of green chilliin heat pump dryer was undertaken to study the drying characteristics of green chilli.

MATERIAL AND METHODS

Green chillies were washed, destalked andcut into 1 cm long pieces using stainless steel knife. The samples were divided into three lots, one lot was steam blanched,

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second lot was treated with 0.2 per cent KMS (Muhammad *et. al., 2015* and Phoungchandang and Saentaweesuk, 2011) and the third were used as control.

For blanching, the cut samples were placed into a stainless steel wire mesh basket and steam blanched for 2 min by direct steam injection. Blanched samples were immediately cooled in cold water to prevent further thermal stress. The water adhering on the surfaces of blanched and KMS treated samples were removed with tissue paper prior to drying.

Heat Pump Dryer

Dehumidified air dryer or Heat Pump Dryer is suitable for drying of heat sensitive material at low temperature. Lab model of dehumidified air dryer was used for the drying experiment. The dryer consist of compressor, evaporator, condenser, drying chamber and thermostat. The condenser and evaporator coil provide the required heating and cooling / dehumidification operation for the process air in the dryer. In order to maintain low relative humidity condition and prevent air exchange with outside, an external condenser has been employed to remove excess heat. The size of drying chamber was 73 x 51 x 56 cm. The aluminium wire mesh trays of size (50 x 48 cm) were kept one above the other. Drying of green chilly were carried out at 30 °C (35per cent RH), 40 °C (25per cent RH), 50 °C (15per cent RH) temperature. Moisture content of the sample was determined by standard hot air oven method.Chlorophyll and ascorbic acid content of green chilli was determined (AOAC, 1995).

RESULTS AND DISCUSSION

During drying process the observations were recorded at an interval of 1h. Dehumidified air dryer when operated with drying air temperatures at 30, 40, 50 °C took 34, 14, 10 to reduce the moisture content of green chilli from 493.11 to 6.7, 5.9, 5.7 per cent (d.b.) for control samples, respectively. Total drying time required to dry green chilli at different temperatures and treatments is given in Table 1.

Table 1. Time (hours) required to dry green chilly in Heat Pump Dryer

Treatment	Drying Temperature		
	30°C	40°C	50°C
Control	34	14	10
Sulphited	30	14	9
Blanched	30	13	9

Effect of drying air temperature

Moisture content vs. drying time

Air temperature has an important effect on the drying of green chilli. Increase in drying air temperature was observed to increase the drying rates which decreased total drying times.

Variation in moisture content with drying time at each of the drying air temperatures of 30, 40, 50 °C in dehumidified air dryer for green chilli (Fig.1). From the plot of moisture content against drying time, it is clearly evident that drying time decreased with increase in drying air temperature.

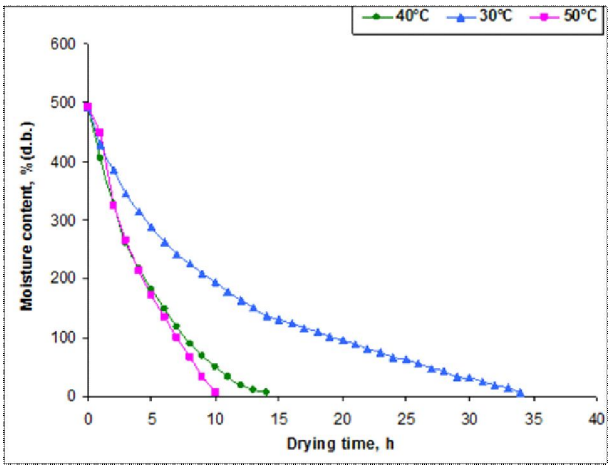

Fig. 1: Variation in moisture content of green chilli with drying time during drying

The dehumidified air dryer when operated with drying air temperature at 30 °C took 34 h to reduce the moisture content of green chilli from 493.11 to 6.7 per cent (d.b.) for control samples. Dehumidified air drying of green chilli at 30 °C took the longest time with lower drying rates. Whereas, KMS treated samples required 30, 14, 9 h at 30, 40 and 50°C temperature, respectively, to dry the samples. Blanched samples required 30, 13, 9 hat 30, 40, 50 °C temperature, respectively. This shows a significant reduction in drying time with increase in drying air temperature. Similar trends were also observed with KMS treated and blanched samples dried at different drying air temperature (Table 1).

Drying rate vs. moisture content

The relationship between drying rates and average moisture contents during drying process (Fig. 2), which shows that the lowest drying rates was mainly due to low drying temperature at 30 °C. Initially, when

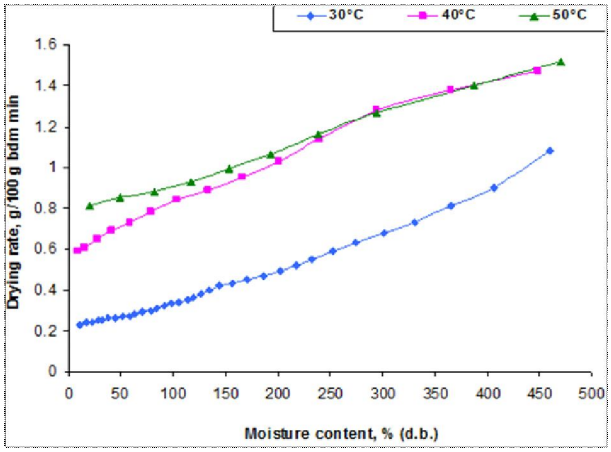

Fig. 2: Variation in drying rate with moisture content of green chilli at different temperature.

moisture content of the sample was high drying rate was found to be higher as compared last stage of drying. This might be due to initially free moisture were more as compared to later stage of drying. Drying of green chilli took place mainly under falling rate period and constant rate period was absent. During this period the migration of moisture occurred through the mechanism of diffusion. These results are in agreement with the observations of earlier researcher (Lahsasni*et al*., 2004).

Effect of pretreatment

The average initial moisture content of control, KMS treated and blanched samples were 493.11, 575.21, 548.50 per cent (d.b.) for green chilli. It can be observed from Table1 that the total drying time required for complete drying of KMS treated and blanched samples was less as compared to control. The decrease in total drying time due to treatment was found to be more at lower temperature level, but at higher temperature level the difference was not significant.

At drying air temperature of 50°C in dehumidified air dryer a clear difference in drying rates of control, KMS treated and blanched samples were observed. Steam blanched material had higher drying rates than control samples(Fig. 3). The higher drying rates in case of blanched samples could be attributed to the cell wall

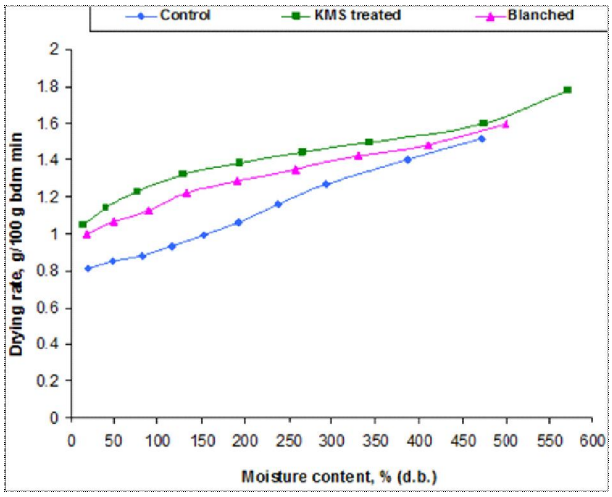

Fig. 3: Variation in drying rate with moisture content of green chilli at different pretreatments

Table 2.Dehydration and rehydration ratio of green chilli

Treatments	Drying Temperature			Drying Temperature		
	30°C	40°C	50°C	30°C	40°C	50°C
	Dehydration Ratio			Rehydration Ratio		
Control	5.55	5.59	5.61	4.6	4.4	4.3
Sulphited	6.39	6.39	6.39	4.9	4.7	4.6
Blanched	6.13	6.13	6.13	3.7	3.6	3.4

Table 3. Chlorophyll and ascorbic acid content of dried green chilli

Treatments	Drying Temperature			Drying Temperature		
	30°C	40°C	50°C	30°C	40°C	50°C
	Chlorophyll content (mg 100^{-1}g d.b.)			Ascorbic acid content (mg 100^{-1}g d.b.)		
Control	73	69	66	54.00	52.00	49.31
Sulphited	70	68	64	52.00	50.41	45.63
Blanched	58	54	51	57.00	55.00	52.11

destruction and lesser resistance to the moisture movement as reported (Ramesh *et al.*, 2001).

As there was no thermal treatment to the control samples the internal moisture was not increase whereas, blanching and KMS treatment increased the overall moisture of the blanched and KMS treated samples. This might be reason for higher drying rates of blanched and KMS treated samples.

The values of dehydration and rehydration ratio are depicted in Table 2.The dehydration ratio was found to be less in control sample as compared to treated sample this may be due to higher value of residual moisture content after drying which adds to the weight of the sample. The same effect is also reported for tomato slicesby Gupta *et al.* (2006). The dehydration ratios of KMS treated samples were observed to be highest. Dehydration ratio was found to be higher at higher drying temperature in both the drying method.

The rehydration ratios of green chilli were observed to be highest for KMS treated samples and lowest for blanched samples at all the drying air temperatures. The elasticity of cell walls and swelling power, which are important for good rehydration could be reduced during blanching, hence the lower rehydration ratios were found in blanched samples. The results are similar to the findings of Rama and John (2000) for dried mushrooms. It is clear that the rehydration ratios decreased with increased in drying air temperature. This may be due to that cell of product may damaged more at higher drying temperature.

The values of chlorophyll and ascorbic acid content are depicted in Table 3. It was observed that the chlorophyll and ascorbic acid content of dried green chilli decreased with increase in drying air temperature for all the samples because of its heat sensitiveness.

The retention of ascorbic acid was more in blanched samples as compared to KMS treated and control samples for all the drying air temperatures. Vitamin C is highly water soluble and there was no contact with water therefore, more amount of vitamin C was retained in blanched samples. The ascorbic acid content of KMS treated samples was observed to be less than that of blanched samples which might be due to leaching of the water soluble vitamin during treatment.

The chlorophyll content of control samples was observed to be highest followed with KMS treated and blanched samples at all drying temperatures. The blanched samples showed a significant loss of chlorophyll which might be due to change of the pigment to an olive green colour during steam blanching at higher temperature.

CONCLUSION

Heat pumps have been known to be energy efficient when used in conjunction with drying operations. The principal advantages of dehumidified air dryers emerge from the ability of heat pumps to recover energy from the exhaust as well as their ability to control independently the drying air temperature and humidity. Therefore, from the present study, it can be concluded that dehumidified air dryer with heat pump at 30°C can be successfully used for drying of green chilli with KMS treatment for producing good quality chilli.

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Cutting Force Requirement of Sorghum Cob Peduncles

Mrudulata Deshmukh[1], S. K.Thakare[2] and R. B. Ghorade[3]

ABSTRACT

Cutting of cobs is an important process in sorghum harvesting. The study was aimed to develop cutting mechanism for harvesting Sorghum. The experiments were conducted to determine force for cutting cob peduncles at different combinations of blade parameters. The minimum value of force (2.95 N) for cutting sorghum cob peduncle was observed at bevel angle of 45^0 for the variety CSH-9 while the maximum value (11.74 N) was observed at bevel angle of 35^0 for variety CSV-20. The minimum value of force (2.76 N) for cutting sorghum cob peduncle was observed at blade shear angle of 35^0 for the variety CSH-9 while the maximum value (10.34 N) was observed at blade shear angle of 25^0 for variety CSV-20. The force for cutting sorghum cob peduncle decreases with decrease in blade rake angle from 20^0 to 0^0 for selected three varieties. The force was maximum at 350 rpm for cutting cob peduncles of variety CSV-20 and obtained minimum for the variety CSH-9. Similar trend was also obtained as an effect of blade velocity of 500 and 650rpm.

Harvesting operation is achieved by four different actions, i) Slicing action with a sharp smooth edge; ii) Tearing action with a rough, serrated edge; iii) High velocity single element impact with sharp or dull edge and iv) A two element scissors type action. India covers 34 per cent of the total Sorghum area in the world and produces around 17 per cent of the world production of sorghum grain per annum. It is being cultivated in Maharashtra for both grain and fodder during K*harif* (area 13.84 lakh ha) and R*abi* (area 30.17 lakh ha). (http://vistar.nic.in/document/chapter/79.htm)

The present practice of harvesting is carried out using a mannually operated sickle. The total harvesting of Sorghum requires two stages cutting of plant, one at the top for separating cobs and second at the bottom for fodder. Hence double labour is required for harvesting of this crop and about 25 per cent of the total labour for grain production is consumed by harvesting operation alone.In case of hybrid Jowar when the crop attains maturity, the stand is erect and the cobs at the top of the plant are nearly at uniform height. This genetic factor is favourable for introducing a mechanical harvesting device. Thus mechanized harvesting of Sorghum is a need of a day which will reduce the drudgery and save the time. Hence the present study was aimed to develop cutting mechanism for harvesting Sorghum.

MATERIAL AND METHODS

The experimental material selected for the study was three different varieties CSV-20, CSV-23 and CSH-9 of sorghum planted in the year 2012 on the experimental field at Western Block of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. Physiologically matured sorghum plants were selected and the experiments were conducted to determine cutting force of cobs at different combinations of blade parameters.

Moisture content : The moisture content of the sorghum cob peduncles was measured according to ASAE Standard S.352 (ASAE Year Book 1979).

Cob peduncle diameter

The Sorghum cob peduncle diameter was determined with the help of a slide calliper having a least count of 0.01mm. Three repeated measurements were taken to get average value.

Experimental Techniques

The laboratory set up of cutting mechanism was developed to measure force required for cutting sorghum cobs of three selected varieties at different combinations of various blade parameters such as blade bevel angle; shear angle; rake angle and blade velocity (Plate 1). The plane blade having dimensions 230 x 60 x 10 mm was used for the experiment. Different parameters selected for the study are described herewith as follows.

Parameters selected for the study

Independent variables

I) Varieties – 3 (CSV-20, CSV-23 & CSH-9)

II) Blade bevel angles – 3 levels (25º, 35º, 45º)

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III) Blade shear angles – 3 levels (25º, 30º, 35º)

IV) Blade rake angles – 3 levels (20º, 0º, -20º)

VI) Blade velocity – 3 levels (350, 500, 650 rpm)

Dependent variables : Peak force

Replications : 3

Design : CRD

The developed laboratory set up of cutting mechanism had different components such as central shaft, rotating disc, torque sensor, electric motor with variable frequency drive (VFD) etc. Rotating disc was mounted on central shaft at lower end for cutting cob peduncles. The blades were fitted on the rotating disc with different shear angle and rake angle sims according to the treatment combinations. Torque sensor was mounted on the central shaft in between rotating disc and middle bearing. Torque sensor was used to measure the cutting torque (Plate 2). The power for operating set up was supplied by electric motor and the speed of rotation was varied with the help of variable frequency drive.

The samples for investigations were collected at random. The cob peduncles of an average equal diameter were selected for the experimentation. The experiment was planned on the same day to void the fluctuation in the moisture content of the cob peduncle. The samples of three varieties of sorghum cob peduncles were hold in the plant holder and the disc was rotated at three different speeds selected for study. The torque observations were noted for each speed separately from the excel sheet data of torque sensor. The trials were repeated thrice for different treatments selected.

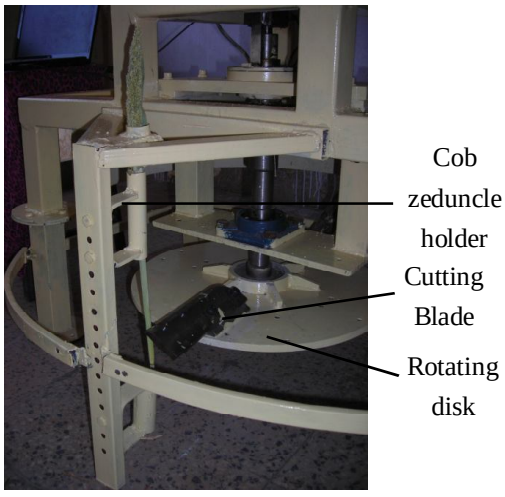

Plate 1 Laboratory set up of cutting mechanism

Plate 2 Torque sensor

RESULTS AND DISCUSSION

The effect of each parameter i.e.blade bevel angle, blade shear angle, blade rake angle and blade velocity on force for cutting sorghum cob peduncle of three selected varieties are tabulated in the following Tables.

Table 1. Effect of blade bevel angle on force for cutting cob peduncles of three sorghum varieties

S.N.	Bevel angle,	Force, N		
	(º)	CSV-20	CSV-23	CSH-9
1	25	6.72	6.73	3.06
2	35	11.74	6.70	5.47
3	45	5.24	4.82	2.95
	F-test	**S**	**S**	**S**
	SE(m) ±	0.612	0.392	0.033
	CD (5per cent)	2.633	1.687	0.142

S – significant

Effect of blade bevel angle

Table 1 revealed that the minimum value of force (2.95 N) for cutting sorghum cob peduncle was observed at bevel angle 45º for the variety CSH-9 while the maximum value (11.74 N) was observed at bevel angle 35º for variety CSV-20. However, significant difference amongst the value of force as an effect of blade bevel angle was observed in each selected variety. Fig 1 (a) shows that the force for cutting sorghum cob peduncle increases with increase in blade bevel angle from 25 to 35º and decrease with further increase in blade bevel angle from 35 to 45º for selected all

thee varieties. When the effect of blade bevel angle on each variety was compared, it was found that the force for cutting cob peduncle was maximum for variety CSV-20 and significantly decreases for variety CSV-23. The minimum values of force for cutting cob peduncle were observed for the variety CSH-9 for all three levels of blade bevel angle.

Effect of blade shear angle

Table 2 revealed that the minimum value of force (2.76 N) for cutting sorghum cob peduncle was observed at blade shear angle 35^0 for the variety CSH-9 while the maximum value (10.34 N) was observed at blade shear angle 25^0 for variety CSV-20. However, significant difference amongst the value of force as an effect of blade shear angle was observed in the varieties CSV-20 and CSH-9 whereas the variety CSV-23 recorded non significant difference. The data revealed that the force for cutting sorghum cob peduncle decreases with increase in blade shear angle 25^0 to 35^0 for selected three varieties (Fig 1b). When the effect of blade shear angle 25^0 was studied with respect to sorghum varieties, it was found that the maximum value of force obtained for variety CSV-20 whereas minimum was obtained for the variety CSH-9. The similar trend of force was observed with blade shear angle 30^0 whereas for blade shear angle 35^0, the maximum value of force was noted for the variety CSV-23 and minimum for the variety CSH-9. The variety CSV-20 having intermediate value.

Table 2 Effect of blade shear angle on force for cutting cob peduncles of three sorghum varieties

S.N.	Shear angle,	Force, N		
	(º)	CSV-20	CSV-23	CSH-9
1	25	10.34	6.44	5.24
2	30	8.30	5.99	3.48
3	35	5.06	5.82	2.76
	SE (m)±	0.612	0.392	0.033
	CD at 5%	2.633	1.687	0.142

S – significant

NS- nonsignificant

Table 3. Effect of blade rake angle on force for cutting cob peduncles of three sorghum Varieties

S.N.	Rake angle (º)	Force, N		
		CSV-20	CSV-23	CSH-9
1	20	12.53	7.98	6.29
2	0	4.32	4.56	2.44
3	-20	6.85	5.70	2.74
	SE (m)±	0.612	0.392	0.033
	CD at 0.05 %	2.633	1.687	0.142

S – significant

Effect of blade rake angle

Table 3 shows the effect of blade rake angles, 20^0, 0^0 and -20^0 on force for cutting sorghum cob peduncle using plane blade.The minimum value of force (2.44 N) for cutting sorghum cob peduncle was observed at rake angle 0^0 for the variety CSH-9 while the maximum value (12.53 N) was observed at rake angle 20º for variety CSV-20. However, the significant difference amongst the value of force as an effect of blade rake angle was observed in each selected variety. The data revealed that the force for cutting sorghum cob peduncle decreases with decrease in blade rake angle from 20º to 0º for selected three varieties whereas the force values increases with further decrease in rake angle to -20º. When the effect of blade rake angle -20º was studied with respect to sorghum varieties, it was found that the maximum value of force obtained for variety CSV-20 whereas minimum was obtained for the variety CSH-9 (Fig 1c). The similar trend of force was observed with blade rake angle 20º. At blade rake angle 0º, the force value was maximum for the variety CSV-23 and minimum for the variety CSH-9.

Effect of blade velocity

Table 4 represents the effect of blade velocities, 350, 500 and 650 rpm on force for cutting sorghum cob peduncle using plane blade. The analysis of data shows significant difference amongst the values of force for the variety CSH-9 whereas non significant difference amongst the values of force was observed for the varieties CSV-20 and CSV-23. The minimum value of force (3.45 N) for cutting sorghum cob peduncle was observed at velocity

of 650 rpm for the variety CSH-9 while the maximum value (8.31N) was observed at the velocity of 350 rpm for variety CSV-20. It was observed from the data that the value of force decreases with increase in blade velocity upto 500 rpm whereas the force value increases with further increase in velocity to 650 rpm for the varieties CSV-20 and CSV23. In case of variety CSH-9, continuous decreasing trend of force was observed with increase in velocity from 350 to 650 rpm. From the Fig 1(d) it was observed that the force was maximum at 350 rpm for cutting cob peduncles of variety CSV-20 and obtained minimum for CSH-9. Similar trend was also obtained as an effect of blade velocity of 500 and 650 rpm.

Table 4 Effect of blade velocity on force for cutting cob peduncles of three sorghum varieties

S.N.	Velocity(rpm)	Force, N		
		CSV-20	CSV-23	CSH-9
1	350	8.31	5.91	4.04
2	500	7.53	5.60	3.99
3	650	7.87	6.74	3.45
	SE(m)±	0.612	0.392	0.033
	CD at 0.05 %	2.633	1.687	0.142

S – significant NS- nonsignificant

CONCLUSIONS

1. The minimum values of force for cutting cob peduncle were observed for the variety CSH-9 for all three levels of blade bevel angle.
2. The force for cutting sorghum cob peduncle decreases with increase in blade shear angle from 25º to 35º for selected three varieties.
3. The variety CSH-9 required minimum values of force for cutting cob peduncle for all three levels of rake angles.
4. Force decreases with increase in blade velocity upto 500 rpm whereas increases with further increase in velocity to 650 rpm for the varieties CSV-20 and CSV23. At all levels of velocity, the force was maximum for cutting cob peduncles of variety CSV-20 and minimum for the variety CSH-9.

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Investigation on Thermal Performance of Solar Cabinet Dryer with and without Heat Storage System for Drying Tomato Slices

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ABSTRACT

The solar cabinet dryer was developed and evaluated its thermal performance with and without heat storage system for drying tomato slices. The loading capacity of the dryer was about 10 kg slices per batch. The drying characteristics of the dryer were studied and compared with open sun drying method. Drying time for drying tomato slices from initial moisture content of 94 per cent to final moisture content of 8.97 per cent (wb) was found to be 12.0 h and 12.5 h in the solar cabinet dryer without and with heat storage system, respectively whereas, it was found to be 15 h in the open sun drying method. The powder was prepared from tomato slices dried in dryer and which shows the dark red colour compared to OSD dried slices powder. It was found that the gravel with iron scrap heat storage system supplied heat to the drying chamber for about 3 h after sunset also.

Agriculture is considered to be the backbone of Indian economy as 65 to 70 per cent of the population depends on agriculture for employment and livelihood. But, yet the national food production could not meet the needs of the population. In India, sun drying is the most commonly used method to dry the agricultural material like grains, fruits and vegetables. In sun drying, the crop is spread in a thin layer on the ground and exposed directly to solar radiation and other ambient conditions. The rate of drying depends on various parameters such as solar radiation, ambient temperature, wind velocity, relative humidity, and initial moisture content of produce, type of crops, crop absorptive and mass of product per unit exposed area (Mohanraj and Chandrasekar, 2008; Mohanraj and Chandrasekar, 2009[a,b]). This form of drying has many drawbacks such as degradation by windblown, debris, rain, insect infestation, human and animal interference that will result in contamination of the product. Drying rate get reduced due to intermittent sunshine, interruption and wetting by rain. At the time of harvesting, most of the agricultural products have high moisture content. Agricultural products, if left as such will biologically degrade due to the growth of microorganisms. So, to preserve them for future purpose and to make it available throughout the year proper preserving technique is to be adopted (Umayal Sundari et *al*., 2013).

Solar energy is a time dependent energy resource. Energy storage provides means for improving the performance and efficiency of vide range of energy systems. Solar dryer reduces operating cost by input of solar heat energy as compared to the electrical dryers. Solar dryer reduces drying time as compared to the traditional open sun drying. In many cases continuous drying is preferred. However, solar dryers are operated only during day time for 8-9 h. The conventional source of energy is to be used to continue for drying after sun set. Normally thermal storage systems are employed to store the heat, which includes sensible and latent heat storage. Common systems used in storing thermal energy include gravel bed, rock beds, sand, concrete etc., where thermal energy is stored in the form of sensible heat (Ataer, 2006; Anuradha and Oommen, 2013; Ayyappan and Mayilsamy, 2012; Kamble *et al*. 2013). Use of gravel and iron scrap bed for the improvement of performance of solar air heater has been proposed by several investigators (Saravankumar and Mayilsamy, 2010). Energy storage is essential for places where the solar intensity is high and need to be stored to avoid over-drying of the product and to continue the drying operation in off sunshine hours also (Dhote and Thombre, 2013).

Solar energy is by far the most attractive alternative energy sources for the future. But the main problem of solar energy is its intermittent nature. Hence provision of some device which could store this energy and supply it during off sunshine hour was made. Utilization of solar thermal energy through solar dryer is relatively new technology for drying of agricultural produce. The use of heat storage material in solar cabinet dryer such as gravels, sand, iron scraps, etc. provide the

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heat after sun set also. Therefore, the study was undertaken to develop solar cabinet dryer with and without heat storage system and to evaluate its thermal performance for drying tomato slices.

MATERIAL AND METHODS

A solar cabinet dryer **of 10 kg per batch capacity** was developed and installed in Department of Unconventional Energy Sources and Electrical Engineering, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The performance of the dryer with and without heat storage syste was evaluated for drying of tomato slices. The schematic and sectional views of solar cabinet dryer integrated with heat storage system are shown in Fig.1

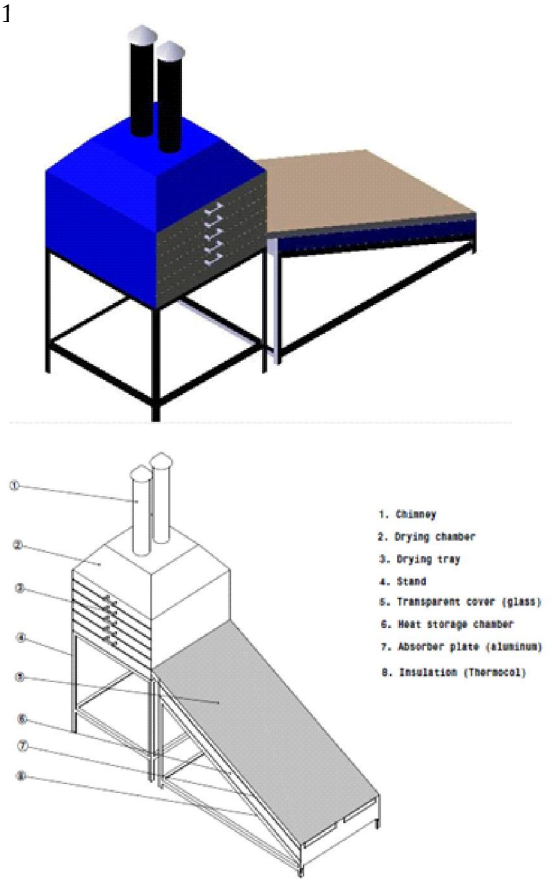

Fig.1 Schematic views of the solar cabinet dryer with heat storage system

Flat plate solar collector

A flat plate solar collector acts as solar air heater. The flat plate solar collector is directly connected to drying chamber. A natural air was circulated through the gap between transparent glass cover and absorber plate by simple thermo-syphon effect. The flat plate solar collector was placed on stand with an angle of 25° with respect to horizontal. The system was oriented to face south to maximize the solar radiation incident on the solar collector. To increase the temperature of air by greenhouse effect, toughen textured glass cover was used and it was placed on the top of the flat plate collector. The aluminum absorber sheet of 3 mm thick was used in solar air heater. The aluminum absorber sheet was coated with black paint in both sided to absorb the maximum incident solar radiation. The absorber plate was placed below the transparent cover with a layer of air separating it from the cover.

Heat storage system

A heat storage chamber was filled with heat storage materials like gravel and iron scrap to store heat during sunshine hours and to obtain hot air after sunset. The heat storage chamber was directly placed below the aluminum absorber plate. It acts as a heat exchanger and it was made up of 22 gauge GI sheet. To reduce heat losses the system was properly insulated using 5 mm thick thermocol. Insulation was provided below the heat storage chamber to avoid the heat losses from heat storage material.

Drying chamber

A drying chamber was designed for loading drying produce. The drying chamber was made up of 24 gauge CR sheet of 1.0 x 1.0 x 0.6 m. The holding capacity of drying chamber was 10 kg batch^{-1}. The drying chamber consists of five numbers of perforated mesh trays of size 1.0 x 1.0 m. It was made up of stainless steel wire mesh of 40 mesh per square inch and of 30 gauge. The holding capacity of each drying trays was about 2 kg. Two numbers of chimney with 0.15m in diameter and 0.75 m in length was provided on the top of drying chamber for release of moist exhaust air.

Ambient air, collector heat storage bed and drying chamber temperature solar cabinet dryer were measured with digital type RTD (resistance temperature detector) and 12 channel indicator. A solar radiation at the inclination of the dryer was measured with digital pyranometer with data logger. Relative humidity was monitored with digital hygrometer. A wind vane anemometer was used to measure the wind speed at the chimney of the dryer. The weight loss of tomato slices in the dryer and open sun drying method was measured

periodically by digital electronic weight balance. The moisture content of the slices was measured by oven drying method. The observations of the dryer were recorded at 30 min. intervals.

Performance evaluation of solar cabinet dryer

Fresh air entered in the air heater and gets heated when comes in contact with the absorber aluminium plate and proceed to the drying chamber. Just below the aluminium plate sheet a heat storage system containing gravels and iron scrap material which absorbed the heat when sun radiation strikes on the aluminium sheet through glass and this stored heat was supplied to the drying chamber after sunset. Freshly harvested tomatoes were properly washed in fresh running water and then they were cut into slices of 4 to 6 mm thickness of tomatoes manually.

The performance of solar cabinet dryer was carried out with and without heat storage system at full load condition. The drying trays were loaded with 10 kg tomato slices and spread over the drying trays. Drying was conducted between 08:30 to 17:30 h. The experiment was conducted in the month of April and May 2014 for drying tomatoes slices. The initial weight of the samples was recorded. Each sample of 100 gm was weighted regularly at an interval of 30 min. and simultaneously the temperature, relative humidity, solar radiation and wind velocity inside the solar cabinet dryer and ambient temperature was measured. The loading of heat storage material in heat storage system and loaded tomato slices are shown in Fig. 2 and 3, respectively.

Fig. 2 Heat storage material loading in heat storage system of solar cabinet dryer

Fig. 3 Tomato slices loaded in solar cabinet dryer

Drying characteristics of tomato slices

The drying depends on simultaneous heat and mass transfer phenomena and factors dominating each process determine the drying behavior of the product. The drying rates were computed from the experimental data and drying characteristics curves i.e. moisture content versus drying time, drying rate and moisture ratio versus drying time.

The moisture ratio of the produce is computed by following formula (Chakraverty, 1988).

$$\text{Moisture Ratio (M.R.)} = \frac{(M_t - M_e)}{(M_i - M_e)} = e^{-kt}$$

Where,

M_t - Moisture content (db), per cent

M_e - Equilibrium moisture content (db), per cent

M_i - Initial moisture content (db), per cent

k - Drying rate constant per minute

t - Drying time, min

The drying rate, (m_w) was determined from the mass of moisture removed and drying time and was determined by the following equation.

$$m_w = \frac{M_w}{t_d}$$

Where,

m_w - Drying rate, kg h^{-1}

M_w - Quantity of water evaporated from product, kg

t_d - Assumed drying time, h

RESULTS AND DISCUSSION

Full load testing of solar cabinet dryer without heat storage system for drying tomato slices

The solar cabinet dryer without heat storage system was evaluated for drying of tomato slices. The maximum temperature in the solar cabinet dryer was observed to be 53.2°C whereas, the maximum ambient temperature, relative humidity and solar intensity were observed to be 42.1°C, 20.6 per cent and 946.7 W/m^2, respectively (Fig. 4). Akachukwu, (2013[a,b]) has reported the average daily solar dryer temperature of 49.9°C while drying tomato slices in small scale direct mode natural convection solar dryer. The flow rate of air at ambient condition and at the exhaust chimney was observed in the range of 0.4 to 1.13 and 0.1 to 0.2 m/s respectively. From Fig.4. it is clear that the temperature inside the solar cabinet drying chamber was significantly higher than open sun drying (OSD). It migth be due to the better absorption of solar energy by product as most of the solar energy entering the cabinet is trapped inside the cabinet solar dryer facilitating absorption and the chimney facilitates the removal of moisture by natural circulation of atmospheric air. This explicity indicates that the drying rate of tomato slices in the solar cabinet dryer was higher than that of OSD experiment.

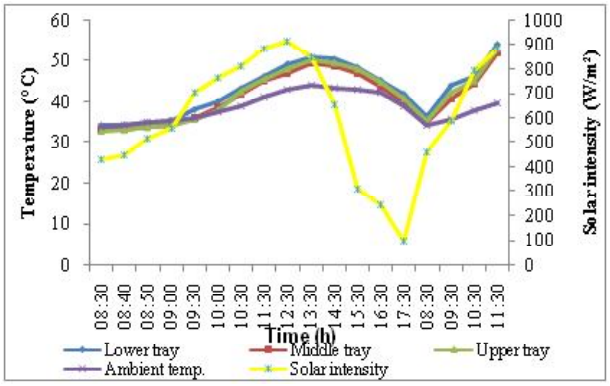

Fig. 4 . Temperature variation in the solar cabinet dryer without heat storage system during full load condition of tomato slices drying

From Fig.5 it is observed that the total drying time required for drying tomato slices was 12 h in solar cabinet dryer whereas, it was 15 h in OSD. The drying time was reduced to about 20per cent for drying tomato slices in solar cabinet dryer without heat storage system than OSD. From Fig.5 it depicted that the average moisture content of tomato slices placed in T1, T2, T3, T4 and T5 drying trays reduced from 1566.67 to 9.78per cent (db) was reached in 12 h. in solar cabinet dryer without heat storage system. Whereas, the average moisture content of tomato slices was reduced from 1566.67 to 12.91 per cent (db) in 15 h in OSD.

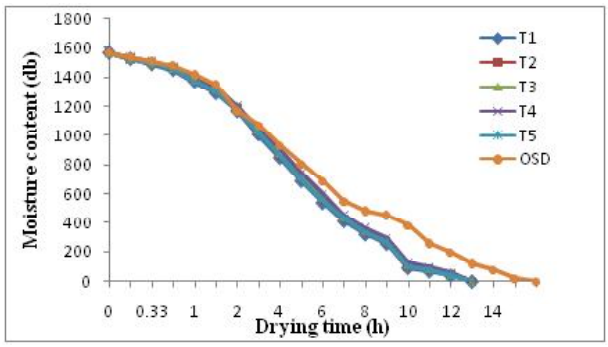

Fig. 5 Variation of moisture content of tomato slices in solar cabinet dryer without heat storage system and OSD

From Fig. 6 it is seen that the drying rate of tomato slices dried in trays T1, T2, T3, T4 and T5 of solar cabinet dryer without heat storage system varied from 4.167 to 0.024, 4.278 to 0.027, 3.889 to 0.032, 3.333 to 0.036 and 4.167 to 0.025 gm/100gm bdm min, respectively. The drying rate of tomato slices dried in OSD was found to be 2.722 to 0.007 gm/100gm bdm min.

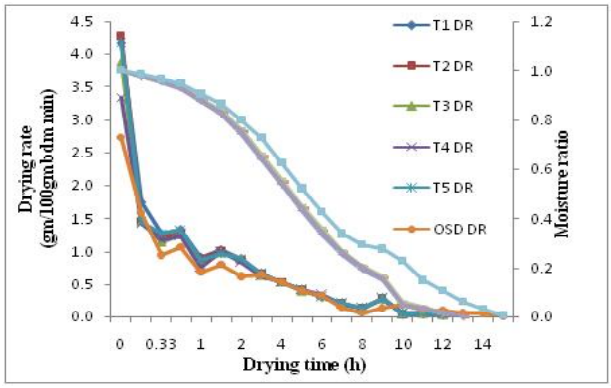

Fig. 6. Variation of drying rate and moisture ratio of tomato slices in solar cabinet dryer without heat storage system and OSD

Solar cabinet dryer with heat storage system

The solar cabinet dryer with heat storage system was tested for drying of tomato slices. The maximum temperature attained in solar cabinet dryer was 52.63 whereas, the maximum ambient temperature and solar intensity was recorded as 42.03°C and 991.70 W/m^2, respectively. It was observed that drying of tomato slices

in solar cabinet dryer took 12.5 h. From Fig.7 it is seen that the heat storage system supplied the heat after sunset hour also and remarkable difference in temperature of drying chamber and ambient was obsereved upto 20:30 h. and the drying of tomato slices was achieved in one day only (08:30 to 20:30 h).

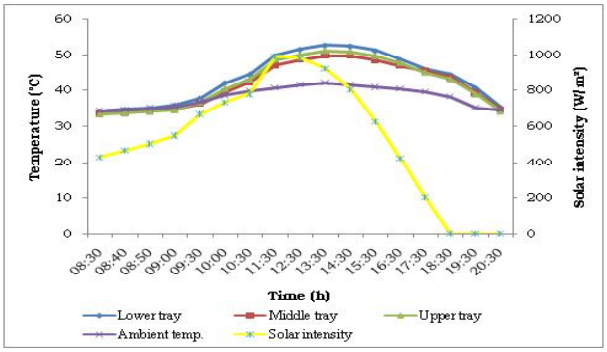

Fig. 7 Temperature variation in the solar cabinet dryer with heat storage system at full load condition

Tomato slices were dried in solar cabinet dryer and its drying characteristics were studied. Figure 8 revealed that the average moisture content of tomato slices samples placed in T1, T2, T3, T4 and T5 trays reduced from 1566.67 to 9.78 per cent (db) in 12.5 h in solar cabinet dyer with heat storage system. Whereas, the average moisture content of tomato slices sample reduced from 1566.67 to 12.91 per cent (db) in 15 h for open sun drying in the month of May 2014. Babagana *et al*. (2012) reported the drying time of 14 hrs for tomato slices in solar vegetable dryer with heat storage system.

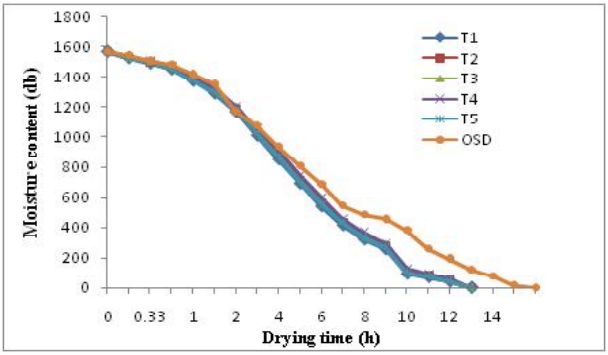

Fig.8 Variation of moisture content of tomato slices in solar cabinet dryer with heat storage system and OSD

Figure 9 revealed that the average drying rate of tomato slices dried in T1, T2, T3, T4 and T5 trays of solar cabinet dryer integrated with heat storage system was found to be 0.9233, 0.8821, 0.8390, 0.7889 and 0.8132 gm/100gm bdm min, respectively. The drying rate of open sun dried tomato sample (OSD) was found to be 2.3889 to 0.0111 gm/100gm bdm min.

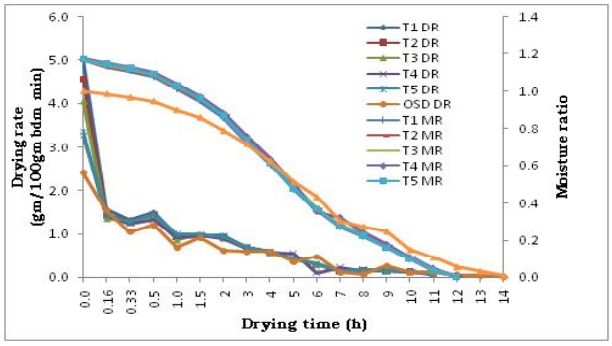

Fig.9 Variation of drying rate and moisture ratio of tomato slices in solar cabinet dryer with heat storage system and OSD

Temperature developed in heat storage system of solar cabinet dryer

The temperature developed in the heat storage system of solar cabinet dryer during day time and after sunset was measured at full load condition at upper and lower layer of heat storage system viz., bottom, middle and top. From Fig.10 it is seen that the maximum temperature in the heat storage system at its upper layer was observed to be 73.97°C while, the temperature in the heat storage system at its lower layer was observed to be 60.83°C. The maximum ambient temperature was observed to be 42.03°C and solar intensity was 991.70 W/m^2.

The maximum temperature difference between ambient and drying chamber was 10.83 during 08:30 to 17:30 h and it was observed 8.18 to 5.87°C during 17:30 to 20:30 h for tomato slices drying in solar cabinet dryer with heat storage system. Senthilkumar et al. (2013) reported to maintain consistent temperature inside the collector even during off shine hours (17:00 to 19:00h).

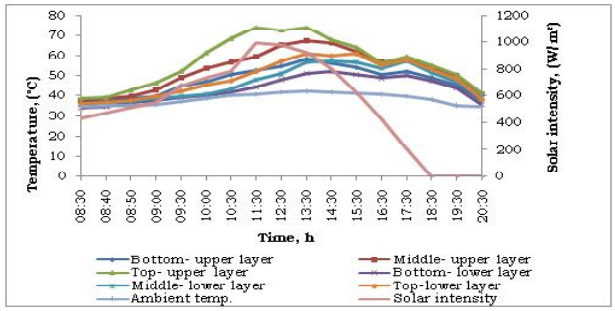

Fig.10 Temperature developed in the heat storage system at full load condition in May, 2014

Variation in moisture content in solar cabinet dryer and OSD method

The variation of moisture content (db) with drying time is illustrated in Fig. 11. Drying time for drying of tomato slices from initial moisture content of 94 to 8.91 per cent (wb) i.e. 1567 to 9.78per cent (db) was found to be 12.5, 12 and 15 h in solar cabinet dryer with heat storage system, dryer without heat storage system and OSD methods, respectively.

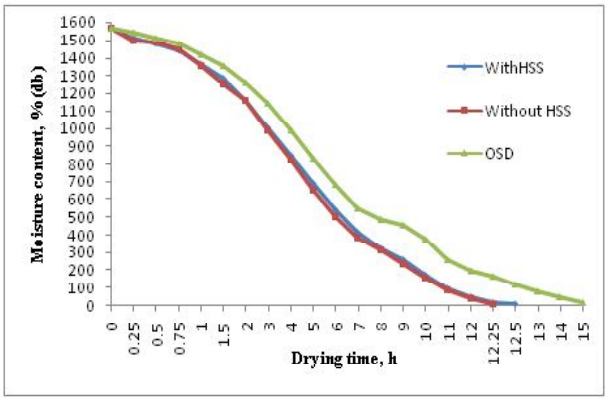

Fig.11 Variation in moisture content in solar cabinet dryer and open sun drying of tomato slices

Appearance of dried tomato slices and powder

The drying of tomato slices was carried out in solar cabinet dryer with heat storage system and in open sun drying method. The appearance of slice of tomato dried in dryer and OSD is shown in Fig.12 (a) and (b), respectively. From Fig. 12 it is clearly observed the remarkable difference between tomato slice dried in dryer and OSD. The powder was prepared from tomato slices dried in dryer and which shows the dark red colour compared to OSD dried slices powder (Fig. 13).

(a) Open sun dried tomato slices

(b) Solar cabinet dried tomato slices

Fig. 12. A view of dried tomato slices in open sun and solar cabinet dryer

Open sun dried tomato powder

Solar cabinet dried tomato powder

Fig. 13. A view of dried tomato slices powder in open sun and solar cabinet dryer

Economics of solar cabinet dryer for drying of tomato slices

The economic feasibility of solar cabinet dryer with and without heat storage system for drying of tomato slices was calculated by considering initial investment,

depreciation cost, annual interest, average repair and maintenance cost, cost of raw material and tomato powder.

Economics of solar cabinet dryer with and without heat storage system for drying of tomato slices using different economic parameters are summarized in Table 1. Around 270 drying days are available for drying in one year. As the drying of one batch was completed in one and half drying day in solar cabinet dryer without heat storage system and therefore, total 180 numbers of batches could be completed in 270 drying days. Whereas, the drying of tomato slices was completed in a single day in solar cabinet dryer with heat storage system and hence 270 batches of drying could be possible in a year.

The BC ratio of the solar cabinet dryer without heat storage system was worked out to be 1.40 whereas, it was found to be 1.45 for the solar cabinet dryer with heat storage system (Table 2.). The payback period of the of the solar cabinet dryer without heat storage system was estimated to be 16 months whereas, it was found to be 11 months in case of solar cabinet dryer with heat storage system.

CONCLUSIONS

Drying time for 10 kg of tomato slices for reducing its moisture content from 94 to 8.97per cent (wb) was found to be 12.0 h and 12.5 h in the solar cabinet dryer without and with heat storage system, respectively whereas, it was found to be 15 h in the open sun drying method. The BC ratio and payback period of the solar cabinet dryer without heat storage system was worked out to be 1.40 and 16 months and it was found to be 1.45 and 11 months for dryer with heat storage system. It was observed that the gravel with iron scrap heat storage system helped to continue the drying for about 3 h after sunset also.

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Table 2. Cost economics of solar cabinet dryer for drying tomatoes slices per year

S. N.	Description	without heat storage	With heat storage system
1	Life of dryer, Year	10	10
2	No. of drying days in a year	270	270
3	No. of drying batches per year	180	270
4	Tomato slices loading capacity, kg (10 kg/batch)	1800	2700
5	Initial investment for dryer, Rs.	30000	32000
6	Depreciation cost @ 10per cent per annum	3000	3200
7	Interest @ 10per cent per annum	3000	3200
8	Repairs and maintenance cost, Rs. (2per cent per year)	600	640
9	Cost of raw material i.e. tomatoes @ Rs. 8/kg (Rs yr^{-1})	14400	21600
10	Cost of labour for drying @ Rs180/day (Rs yr^{-1})	32400	48600
11	Total dried powder, kg per annum	216	324
12	Cost of grinding powder @ Rs 3 per kg	648	972
	Total Cost, Rs.	**54048**	**78212**
13	Total cost of finished product, Rs.	75600	113400
	(Average market value @ Rs 350/kg)		
	Net Benefit, Rs	21552	35188
	Benefit- cost ratio	1.40	1.45
	Payback period	16 months	11 Months

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Manual Detacher for Reducing Drudgery of Farm Women

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ABSTRACT

After harvesting Roselle from the plant, the calyses are separated / detached manually , these Roselle calyses are then used for preparing different value added products e.g. sharbat, Jam, syrup, pickle, Roselle supari etc. the manual method is laborious and time consuming. With the increasing demand of calyces for preparing various value added products there was an urgent need was to develop a detacher for calyces separation /detaching from Roselle fruit and hence manual operated Roselle calyces detacher (RCD) was developed. The developed detacher consist of cutting blade, cutting blade holder, spring and rivet arrangement. The Detacher is a manual hand operated tool with wt. of 125 g and overall dimensions of 225 mm x 105mm x 20mm .

The average percentage of calyces and seed capsule were found to be 50.64 (±2.726) and 49.36 (±2.726). The manual calyces detaching efficiency was observed to be 68.9 ± 4.51 per cent and by Roselle Calyces detacher (RCD) was observed to be 96.8 ± 1.23per cent. According to the the ergonomical observations it was observed that detaching of Roselle calyces falls under LIGHT WORKLOAD. It is recommended to use Roselle calyces detacher (RCD) for detaching calyces from Roselle fruit as the capacity of RCD is 5.62± 0.918 kg/h i.e. five times more then manual detaching capacity (0.96 ±0.275 kg/h)

Roselle *(Hibiscus sabdariffa* L.), is a member of malvacae family and it is a tropical plant of considerable economic potential. Roselle is quite hardy and grows well in most soils that are deep, fairly fertile and Roselle is a drought-tolerant crop. Roselle grows well in a wide range of climates except in the super-humid zones. The crop is cultivated extensively at present in India, Thialand, Germany, Senegal and Egypt for its pleasant red coloured calyces which are used for making jam, jelly and bottle drinks (Morton, 1987). Production of Roselle in Maharashtra is 0.39 lakh bales grown on 26000 ha (Indian Agril., 2003). In Maharashtra it is grown under mixed cropping pattern and the use is limited to unleavened bread and chutney. (Morton, 1987)

After harvesting Roselle from the plant, the calyses are separated manually, these Roselle calyses are then used for preparing different value added products e.g. sharbat, Jam, syrup, pickle, Roselle supari etc. There are two traditional methods by which the calyces are detached from the Roselle plant i) Dried roselle calyces are obtained either by harvesting the fruits fresh, decore them, and then dry the calyces; or the other way is by ii) leaving the fruits to dry on the plants to some extent, harvest the dried fruits, dry them further if necessary, and then separate the calyces from the capsules. Both the methods are laborious and time consuming. Thus, with the increasing demand of calyces for preparing various value added products there is an urgent need to develop a detacher for calyces separation from Roselle plant. The present study was undertaken with the objective to develop a detacher for Roselle calyces anf to test and evaluate Roselle calyces detacher (RCD) for detaching Roselle calyces from Roselle fruit. (Morton, 1987)

MATERIAL AND METHODS

A) Physical and mechanical properties of Roselle fruit

The Roselle fruits used for the study were obtained from local market of Akola district. The good healthy matured Roselle fruits were selected for the study. The 25 fruits were randomly selected for determination of physical properties. The measurements were carried out with three replications. Different physical properties of Roselle fruit (RF) and Roselle Seed Capsule (RSC) were determined by standard methods viz. length, width, thickness, geometric mean diameter, roundness, sphericity, surface area and moisture content. The volume, bulk density, true density and porosity of Roselle seed capsule (RSC) were determined.

B) Development of Detacher and calculation of Detaching Efficiency :

i) Observations with respect to efficiency of detacher for fresh calyces is calculated by the expression (Balasubramaniam *et al.* 1993)

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$$\text{Detaching Efficiency, DE (\%)} = \frac{W_T - W_D}{W_T} \times 100$$

where,

DE (%) = Detaching efficiency, per cent

W_T = Total weight of Roselle fruits, kg

W_D = Weight of damaged calyces, kg

C) Ergonomical observations

The ergonomical observations with respect to psychophysical response such as overall discomfort rating (ODR), body part discomfort (BPDS), heart rate, pulse rate and energy expenditure of operator while operating Roselle calyces detacher were taken. I) Test Conditions II) Body weight and height of the subject III) Measurement of Heart Rate IV) Energy Expenditure V) Classification of workload VI) BPDS (Gite , 1997)

Plate 1 : Female labour detaching with Roselle Calyces Detacher

RESULTS AND DISCUSSION

The Physical properties of Roselle fruits (RF) and Roselle seed capsule (RSC) are summarized where the avg. length of RF and RSC was 43.01 mm and 21.51 mm, respectively. The avg. width of RF and RSC was 18.03 mm and 14.12 mm, respectively. And the avg. thickness of RF and RSC was16.06 mm and 12.98 mm, respectively. The avg. weight of RF and RSC was 8.27 gm and 3.33 gm, respectively. The avg. moisture content of RF and RSC was 76.20 (per cent wb) and 22.8 (per cent wb), respectively. The geometric mean diameter of RF and RSC was 23.18 mm and 15.80 mm, respectively. Also the sphericity for RF and RSC was 53per cent and 73per cent, respectively.

The surface area covered by RF and RSC was calculated as 1838 mm^2 and 1002 mm^2. The volume of RSC was 6.31cm^3. The solid density of the RSC was calculated to be 1.208 g cc^{-1}. It shows that RSC was more compact and dense .The bulk density of the fruit was found to be 0.809 g cc^{-1}. The surface area for RF and RSC was found to be 1838 mm^2 and 1002 mm^2respectively. This might be because of the larger size of the RF and smaller size of RSC.

Since we are interested to develop a device for detaching calyces from seed capsule attached with epicalyx of fruit , the average diameter at this particular point was measured and found to be 13.58 $\pm$ 1.012 mm. Therefore, the length of opening of both jaws was kept 16 mm.

After harvesting Roselle fruit from plants, the operation of calyces detachment from Roselle fruit was carried out manually. This operation of detaching becomes a laborious job and hence considering the design parameters the Roselle calyces detacher was developed which helps in detaching the calyces from Roselle fruit.

The developed Roselle calyces detacher is shown in Plate 1. A special stainless steel (SS -304) cutting blades made for the purpose of detaching calyces from seed capsule attached with epicalyx were welded firmly to upper and lower jaw (blade holder). The jaws were riveted to mild steel handle. A spring arrangement was given at the point of rivet to keep the handle in released position and allows the cutting blades to be at a distance of 16 mm. The sharp edge of cutting blade was sufficient enough to produce cutting force more than 4 kg at the point where calyces are joined to seed capsule attached with epicalyx. Thus, Roselle calyces can be detached and held in one hand and epicalyces with seed capsule can be detached with the help of Roselle calyces detacher by the other hand.

The Roselle fruits were harvested from the STRU, Dr. PDKV, Akola field and brought to AICRP on PHTS lab. The erogonmical observations were taken at the temp of 25.6^{0}C and 35per cent humidity. Five female labours were selected for study and their weight and height was measured. The subjects (preferably those who participated in the physiological cost trials) were involved in this test. Each trial was conducted for two hour duration. During the two hour duration subject was not allowed for any

rest as such. The subjects in Table 1 were selected to perform detaching of Roselle calyces by manual method as well as by using Roselle calyces detacher.

Table 1 : List of Subjects/ female farmers used for ergonomical study

S N.	Code No.	Name of Subject
1	F	Sau. Savita More
2	G	Sau. Pushpa Chavan
3	H	Sau. Anita Sukdane
4	I	Sau. Varsha Phukat
5	J	Sau. Manda Dahatonde

The weight and height of the subjects were measured and the Body Mass Index (BMI) for female subject (Table 2) was measured as per caterorised presumptive diagnosis.

The data showed (Table 2) the presumptive diagnosis of female subjects as mesomorph and ectomorph i.e these subjects are normal and low weight (normal) and hence can perform the psychophysical work of detaching Roselle calyces. (Corllet ,1976)

Roselle calyces detaching was carried out manually and also with Roselle Calyces detacher with the help of five female subjects subjects as mentioned above and the performance for both (M & RCD) was studied with three replications as shown in Table 3. It was observed from Table 3 that the average working heart rate for manual Roselle calyces detaching was 95 ± 6.279 beats min^{-1} and with RCD it was 94.8 ± 6.603 beats min^{-1}, respectively. It was observed that the average work pulse (ΔHR) for manual Roselle calyces detaching was 11.33 ± 3.416 beats min^{-1} and for RCD it was 10.86 ± 2.774 beat min^{-1}, respectively. The average energy expenditure for manual Roselle calyces detaching was 6.385 ± 0.998 kJ min^{-1} and for RCD it was 6.353 ± 1.050 kJ min^{-1}, respectively. The output/capacity for manual Roselle calyces detaching was 0.95 ± 0.187 kg hr^{-1} and for RCD it was 5.37 ± 0.541 kg hr^{-1}, respectively.

Thus from the data (Table 3) given by Varghese *et al.,* (1994) the category of work load is falling under LIGHT WORKLOAD on the basis of energy expenditure (5.1-7.5 kJ min^{-1}) and heart rate data (91-105 beats min^{-1}).

Also, the psychophysical responses of female subject by performing the detaching operation manually and with Roselle Calyces Detacher was observed from Overall discomfort rating (ODR) and Body part discomfort score (BPDS) and is given in Table 4.

Thus, for Overall discomfort rating (ODR) it was observed that in case of manual detaching, the operator faces more than light discomfort is 3.76 ± 0.230 (i.e. VADS range 3-4) (Corllet , 1976) and while working with RCD the operator faces light discomfort is 2.02 ± 0.511 (i.e. VADS range 2-3). For, Body part discomfort score (BPDS) it was observed that, the operator has more BPDS while working manually (19.6 ± 0.834) as compared to working with Roselle calyces detacher (11.54 ± 0.508).

CONCLUSIONS

The capacity of Roselle calyces detacher (RCD) was found to be 5.62± 0.918 kg h^{-1}, which was five time more than manual detaching capacity (i.e.0.96 ±0.275 kg h^{-1}). The efficiency of RCD for detaching calyces from Roselle fruit was observed to be 96.8 ± 1.23 per cent as compared to manual detaching efficiency which was 68.9 ± 4.51 per cent. Detaching calyces by RCD was falling under LIGHT WORKLOAD on the basis of ergonomical observations like EE i.e 6.353± 1.05 kJ min^{-1} , WHR i.e 94.8 ± 6.6.3 beats min^{-1}, ODR i.e 2.02 ± 0.511 (VADS range 2-3) and BPDS i.e 11.54 ± 0.508.

Table 2 : BMI of the female subject

Subject	Age, yrs	Weight ,kg	Height, m	BMI	Category	Limits, yrs
F	49	60	1.625	22.718	mesomorph	20-25
G	28	51	1.524	21.958	mesomorph	20-25
H	41	57	1.651	20.91	mesomorph	20-25
I	35	49	1.575	19.758	ectomorph	0 20
J	38	58	1.600	22.650	mesomorph	20-25

Table 3 : Performance of manual detaching and detaching with Roselle Calyces detacher (Female subject) :

S.N.	Name of Subject	Replica-tions	Heart Rate (beats/min.) (HR)						Energy Expenditure (EE)(kJ min^{-1})		Output (kg h^{-1})		Category of work load on the basis of Heart Rate Data	
			Rest (RHR)		Working (WHR)		Work Pulse							
			M	RCD	M	RCD	M	RCD	M	RCD	M	RCD	M	RCD
1.	"F"	R1	81	81	89	88	8	7	5.431	5.272	0.980	4.200	Light	Light
		R2	83	82	88	88	5	6	5.272	5.272	0.880	4.850	work	work
		R3	81	80	89	88	8	8	5.431	5.272	0.800	4.765	load	load
2.	"G"	R1	94	96	107	106	13	10	8.293	8.134	0.870	5.800		
		R2	95	94	105	106	10	12	7.975	8.134	0.900	5.900		
		R3	97	92	104	104	7	12	7.816	7.816	1.000	5.360		
3.	"H"	R1	84	87	95	99	11	12	6.385	7.021	1.200	5.800		
		R2	82	84	96	97	14	13	6.544	6.703	1.400	6.000		
		R3	84	85	98	99	14	14	6.862	7.021	1.000	6.100		
4.	"I"	R1	81	80	95	92	14	12	6.385	5.908	0.800	4.900		
		R2	85	82	96	90	11	8	6.544	5.590	1.100	5.200		
		R3	81	84	94	94	13	10	6.226	6.226	1.000	5.600		
5	"J"	R1	79	79	89	89	10	10	5.431	5.431	0.600	5.200		
		R2	74	74	92	90	18	16	5.908	5.590	0.850	5.100		
		R3	74	79	88	92	14	13	5.272	5.908	0.910	5.700		
	Avg	**83.67**	**83.93**	**95**	**94.8**	**11.33**	**10.86**	**6.385**	**6.353**	**0.95**	**5.37**			
	SD(±)	**6.842**	**6.076**	**6.279**	**6.603**	**3.416**	**2.774**	**0.998**	**1.050**	**0.187**	**0.541**			

M – Manual detaching of Roselle Calyces
RCD – Roselle calyces detacher for detaching of Roselle Calyces

Table 4 : Psychophysical response of the female subject by performing the detaching operation manually and with Roselle Calyces Detacher :

S.N.	Name of Subject	Replica-tions	Overall Discomfortrating		Mean rating (ODR)		Body part discomfort score		Mean rating (BPDS)	
			M	RCD	M	RCD	M	RCD	M	RCD
1.	"F"	R1	3.8	2.6	4.0	2.6	20	10	19	11
		R2	4.1	2.5			19	11		
		R3	4.2	2.7			18	12		
2.	"G"	R1	3.5	1.5	3.7	1.2	18	12	19.7	11
		R2	3.7	1.0			21	10		
		R3	3.9	1.2			20	11		
3.	"H"	R1	3.1	2.2	3.4	2.2	20	11	21	11.7
		R2	3.5	2.5			21	13		
		R3	3.6	2.0			22	11		
4.	"I"	R1	3.7	1.5	3.8	2.0	19	12	19.3	12
		R2	3.9	2.4			20	13		
		R3	3.9	2.2			19	11		
5.	"J"	R1	3.8	2.1	3.9	2.1	20	13	19	12
		R2	4.0	2.2			18	11		
		R3	3.9	2.0			19	12		
AVG			**3.77**	**2.04**	**3.76**	**2.02**	**19.6**	**11.53**	**19.6**	**11.54**
SD (±)			**0.273**	**0.518**	**0.230**	**0.511**	**1.183**	**0.990**	**0.834**	**0.508**

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Research Notes

Character Association Studies in Mustard

Indian mustard (*Brassica juncea L*) called as 'rai', 'raya' or 'laha' is an important oil seed crop next to groundnut in India in respect of both area and production. The oil content in Indian mustard seed varies from 30 to 48%. In Maharashtra the sole crop of mustard is seldom grown but with its low cost of production and high yielding potential it can be adopted in Vidarbha. Breeding programme in mustard is oriented with an objective to develop new varieties with high yield potential, wider adaptability, disease resistance and optimum oil content. Designing efficient breeding programme requires an existence of genetic variability in the breeding material. Similarly, in order to incorporate desirable characters for maximization economic yield, the information on the nature and extent of genetic variability present in a population for desirable characters, their association and relative contribution to yield constitutes the basic requirement.

Correlation studies helps the breeder to decide which character should be chosen for selection to bring about the maximum increase in desirable traits. Correlation between seed yield and their related characters determine the traits significantly associated with this character.

The experimental material comprised of ten F_2 crosses selected on the basis of yield performance in F_1 generation and their eight parents viz., Rohini, JD-6, BIOYSR, BIO-902, Laxmi, GM-2, PCR-7, and Pusa bahar. Ten F_2 crosses, eight parents involved in the crosses and two checks (Shatabdi and Pusa bold) were grown during *rabi*, 2013-2014 in randomized complete block design with three replications. The seed material of each F_2 cross was hand dibbled in an individual plot which consisted of ten rows of three meter length, spaced 45 cm apart with an intra-row spacing of 15 cm. The parental seeds and that of checks were dibbled in an individual plot which consisted of two rows of three meter length with the same spacing of 45 X 15 cm. Recommended cultural practices and plant protection measures were undertaken as per the schedule to raise a healthy crop. Observations were recorded on 225 plants from each individual F_2 cross and five randomly selected plants in each parent for six characters i.e. days to maturity, plant height (cm), primary branches plant^{-1}, siliqua plant^{-1} and yield plant^{-1}. The data recorded were subjected to the statistical analysis. Analysis of variance was done by the method given by Panse and Sukhatme (1954) and correlation by Fisher (1958).

Seed yield is a complex character being dependent on a number of other component characters and the knowledge of association of different yield contributing components is of significant importance in breeding programme. This study provides reliable information on nature, extent and effectivity of selection.

Analysis of variance revealed that the mean squares due to genotypes (crosses + parents + checks) were significant for all the characters *viz.*, days to maturity, primary branches plant^{-1}, plant height (cm), siliquae plant^{-1}, and yield plant^{-1} indicating a substantial genetic variability among the genotypes. These results were in confirmity with that of Bansod *et al*. (2007) and Lole *et al*. (2012) who also reported significant variability among the genotype for all the characters under study in mustard.

The data regarding simple correlation coefficients (*i.e*. genotypic, phenotypic and environmental) between all possible combinations of traits are presented in table 2. In general, the genotypic correlation coefficients were higher than that of the phenotypic correlation coefficients.

At phenotypic and genotypic levels, yield plant^{-1} exhibited positive significant correlation with all

Table 1: Analysis of variance for six characters in mustard

Source of variation	d.f.	Mean Squares					
		Siliqua plant^{-1}	Days to first flower	Days to maturity	Branches plant^{-1}	Plant height (cm)	Yield plant^{-1} (g)
Replications	2	264.078	11.183	0.057	0.243	632.989	0.352
Genotypes	19	264.549**	38.707**	118.70**	0.304**	333.934**	0.582**
Error 38	74.602	0.242	0.192	0.037	67.498	0.105	

**Significant at 1%

Table 2: Estimates of genotypic , phenotypic and environmental correlation coefficients in mustard

Characters		Plant height	Siliquae plant^{-1}	Days to 50% flowering	Days to maturity	Branches plant^{-1}	Yield plant^{-1}
Plant height	G	1	0.739**	0.115	-0.279*	0.793**	0.836**
	P	1	0.565**	0.083	-0.205	0.595**	0.564**
	E	1	0.421**	-0.024	0.102	0.265*	0.201
Siliquae plant^{-1}	G		1	-0.303*	-0.030	0.849**	0985**
	P		1	-0.197	-0.023	0.622**	0.688**
	E		1	-0.072	-0.075	0.411**	0.393**
Days to 50% flowering	G			1	-0.011	0.106	0.066
	P			1	-0.010	0.093	0.044
	E			1	-0.012	0.059	-0.050
Days to maturity	G				1	-0.452**	-0.019
	P				1	-0.376**	-0.016
	E				1	0.057	-0.041
Branches plant^{-1}	G					1	0.790**
	P					1	0.670**
	E					1	0.472**
Yieldplant^{-1}	G						1
	P						1
	E						1

*, ** Significant at 5% and 1% level respectively 'r' value at 5%= 0.211 and at 1%= 0.369
G, P and E –Genotypic, Phenotypic and environmental correlation coefficient

the characters under study except days to 50 per cent flowering and maturity. Results of positive and significant association of yield with plant height was reported by Hasan *et al* (2014). Singh *et al* (2011) also reported positive and significant correlation of seed yield per plant with plant height and number of siliquae indicating that these are the main yield contributing traits The character, primary branches plant^{-1}, showed positive and significant association with siliquae plant^{-1}and plant height. Belet (2011) also reported significant positive association of primary branches with pods plant^{-1}. Days to maturity exhibited significant negative association with primary branches plant^{-1} and plant height and negative non significant association with days to 50 per cent flowering and siliquae plant^{-1}. Days to 50 per cent flowering showed significant and negative association with siliqua plant^{-1} and non significant but positive association with plant height. Belet (2011) reported significant positive association of days to flowering with days to maturity. Siliquae plant^{-1} showed significant and positive association with plant height. This results were in confirmity with Mekonnen *et al* (2013). They reported positive significant association of pods plant^{-1} with plant height.

In the present investigation, it could be concluded that the that proper selection procedure can be adopted to select genotypes for improvement of yield.

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Variability for Shootfly Resistance in Prebreeding Lines of Sorghum

Sorghum is the fifth most widely cultivated grain crop in the world after Wheat, Maize, Rice and Barley and the third most important cereal crop in India. The insect pests are the major biotic constraints for production and productivity. The sorghum shoot fly (*Antherigona soccata* (Rondani)) has become major seedling pests. In, India the losses due to shoot fly damage have been estimated to reach as high as 90 per cent of grain and 45 per cent of fodder yield (Jotwani 1982).

Conventional methods for the control of shoot fly are not practical or cost effective to subsistence farmers. Under this circumstance, resistance cultivars are realistic alternative to chemical control. At present situation there is need to increase productivity of sorghum by utilizing variability and heritability present in germplasm lines to develop high yielding and shootfly resistant varaeties.

The experiment was conduted in set A and set B for yield and yield contributing characters related to shootfly resistance which consists 19 germplasm lines, three resistant lines, three susceptible lines. (Table 1). Germplasm lines were sown in Randomized Block Design with three replications during kharif 2012 at Sorghum Research Unit, Dr. PDKV Akola.

The observations were recorded on five randomly selected plants from the net plot expect days to 50% flowering, dead heart count at 14 and 28 DAE and recovering of infested plant where the plant population per plot has been considered to study the variability for yield and yield contributing characters and shoot fly resistance for set A viz., days to 50 per cent flowering, Plant height, panicle length, 1000 seed weight, fodder yield per plant, grain yield per plant. In set B observations were recorded on six characters viz., number of eggs per plant (14 and 28 DAE), dead heart counts (24 and 28 DAE), recovery of infested plant, chlorophyll index, trichome density per $mm^{2,}$, seedling vigour (1-5), leaf glossiness (1-5).

The data were subjected to analysis of variance by Panse and Sukhatme (1988). The data obtained were further assessed for computation of genotypic, phenotypic coefficient of variation, heritability and genetic advance as per method suggested by Burton and Devane (1952), Lush (1949) and Johnson et al., (1955a).

The analysis of variance was carried out for all characters under study and is presented in Table 2 and 3. The data revealed highly significant differences among germplasm lines for characters related to yield and traits related to shoot fly resistance shoot fly resistance. It indicated the presence of sufficient amount of variability of these characters which provides ample scope for selection of superior and desirable germplasm lines for plant breeder for further genetic improvement.

Table 1: Mean performance of genotypes .

S. N.	Lines	Days to 50% flowering	Grain yield plant^{-1} (gm)	Dead heart count at 14 DAE (%)	Dead heart count at 28 DAE (%)
1	AKENT- 19	83.33	51.20	24.57(29.60)	51.23(45.70)
2	AKENT- 61	81.33	59.34	35.00(36.27)	69.96(56.83)
3	AKENT- 63	84.33	42.21	29.47(32.30)	62.06(52.53)
4	AKENT- 64	84.33	38.94	21.43(27.20)	49.84(44.93)
5	AKENT- 66	83.67	43.22	38.70(38.40)	74.44(60.03)
6	AKENT- 67	85.00	36.19	23.13(28.73)	50.14(44.07)
7	AKENT- 73	85.33	36.51	24.80(29.80)	51.44(45.80)
8	AKENT- 75	84.33	41.38	34.57(36.00)	67.62(55.33)
9	AKENT- 77	82.67	52.76	29.47(32.83)	59.10(50.30)
10	AKENT- 79	84.00	42.12	22.40(28.23)	47.80(43.73)
11	AKENT- 80	84.00	41.71	36.73(37.20)	71.77(58.70)
12	AKENT- 81	84.33	39.40	28.77(32.27)	59.66(50.87)
13	AKDL- 28-3-1	84.67	38.51	24.63(29.50)	53.35(47.00)
14	AKDL-26-2-1	86.67	29.97	23.17(28.73)	49.19(44.53)
15	AKENT-8-2XGJ-40-14-1111	84.67	37.14	29.73(32.87)	61.31(50.77)
16	RS-29 XIS-25017-35-2-1	84.67	43.54	24.90(29.80)	52.47(46.43)
17	SPV-669 X13R-1	86.33	30.48	33.97(33.27)	62.03(52.03)
18	2219BX42B-20-2	85.67	35.30	24.70(29.73)	51.61(45.93)
19	Kharif local-2-3	84.67	36.61	22.53(28.30)	48.40(44.07)
20	IS-18551(R)	85.00	40.41	20.43(26.63)	44.62(41.87)
21	IS-2205(R)	84.67	43.03	22.53(28.30)	58.29(49.83)
22	IS-2312(R)	84.67	39.95	13.27(21.30)	34.36(35.83)
23	MS-296B(S)	86.67	30.32	28.87(32.33)	58.29(49.83)
24	AKMS-14B(S)	86.33	33.61	34.37(35.87)	66.21(54.57)
25	DJ-6514(S)	86.00	33.05	34.37(35.87)	60.48(51.17)
	SE (m) ±	0.82	4.62	2.48	3.70
	CD at 5%	2.34	13.15	7.05	10.51
	CD at 1%	3.12	17.54	9.41	14.02

Components of Variation

In the present study, the variability parameters like genotypic variance, phenotypic variance, genotypic coefficients of variation (G.C.V.), Phenotypic coefficient of variation (PCV) and heritability estimates in broad sense (h^2b.s.) were estimated for yield and yield contributing characters and characters related to shoot fly resistance. The results are presented in Table 4 and 5.

Components of Variation for characters studied

Genotypic Variance

The fodder yield plant^{-1} among all characters exhibited highest genotypic variance (1408.48), followed by plant height (280.18). It is moderated for grain yield per plant (26.72), 1000 seed weight (10.23). It was low for days to 50 per cent flowering (0.83). The trait like trichomes density per mm^2 exhibited highest genotypic variance (112.24) followed by, recovery of infested plant (54.09). The genotypic variance moderated for dead heart counts at 28 DAE (19.61),dead heart counts at 14 DAE(9.38) and chlorophyll content index (4.98). It was low for number of eggs per plant at 14 DAE (0.09), number of eggs per plant at 21 DAE (0.12), glossiness (0.50), seedling vigour (0.53).

Phenotypic Variance

The phenotypic variance for all the characters under study was observed higher than genotypic variance. Fodder yield plant^{-1} (3206.23) showed highest phenotypic

Table 2: Analysis of variance for yield and yield contributing characters. (Set A)

Source	D. F.	Mean Sum of Squares						
		Days to 50% flowering	Plant height (cm)	Panical length(cm)	Panical breadth (cm)	1000 seed weight(gm)	Fodder yield plant^{-1} (gm)	Grain yield plant $^{-1}$ (gm)
Replication	2	1.97	935.78	9.30	0.048	28.24	1490.69	39.63
Genotypes	24	4.525**	1515.91**	21.45**	0.762**	46.99**	6019.20**	144.32**
Error	48	2.02	675.37	9.25	0.28	16.28	1799.75	64.14

Table 3: Analysis of variance for characters related to shootfly resistance.(Set B)

Source	D. F.	Mean Sum of Squares								
		No.of eggs plant^{-1} at 14 DAE	No. of eggs plant $^{-1}$ At 21 DAE	Chlorophyll Content index	Trichome Density /mm^2	Seedling Vigour (1-5)	Glossiness (1-5)	Recovery of infected plant(%)	Dead heart count at 14 DAE (%)	Dead heart count at 28 DAE(%)
Replication	2	0.59	0.54	29.28	0.85	0.33	0.093	33.25	36.21	73.23
Genotypes	24	0.54*	0.61**	26.49**	337.17**	2.10*	1.77*	193.50**	46.58**	99.84**
Error	48	0.26	0.24	11.53	0.44	0.52	0.27	31.21	18.45	40.98

Note: * Significant at 5% level of significance * * Significant at 1% level of significance

Table 4 : Estimates of genotypic and phenotypic variance.

S. N.	Characters	^6²G	^6²P
1	Days to 50% flowering	0.83	2.86
2	Plant height (cm)	280.18	955.56
3	Panicle length (cm)	4.06	13.32
4	Panicle breadth (cm)	0.16	0.44
5	1000 seed weight (gm)	10.23	26.52
6	Fodder yield/plant (gm)	1406.48	3206.23
7	Grain yield/plant (gm)	26.72	90.87
8	No. of eggs/plant at 14 DAE	0.09	0.36
9	No. of eggs/plant at 21 DAE	0.12	0.37
10	Chlorophyll index	4.98	16.52
11	Trichome Density/mm^2	112.24	112.69
12	Seedling vigour	0.53	1.05
13	Glossiness	0.50	0.77
14	Recovery of infected plant (%)	54.09	85.31
15	Dead heart count at 14 DAE (%)	9.38	27.83
16	Dead heart count at 28 DAE (%)	19.61	60.60

Table 5 : Estimates of Different Parameters in Sorghum

S. N.	characters	Range		Mean	GCV (%)	PCV (%)	Heriability (%)	(EGA) (%)
		Min	Max					
1	Days to 50% flowering	81.33	86.67	84.69	1.08	2.00	29.09	1.19
2	Plant height (cm)	128.35	214.35	164.92	10.15	18.74	29.32	11.32
3	Panicle length (cm)	13.50	24.84	19.21	10.49	19.00	30.51	11.94
4	Panicle breadth (cm)	2.68	4.81	3.75	10.69	17.73	36.38	13.28
5	1000 seed weight (gm)	15.17	32.89	23.05	13.88	22.34	38.60	17.76
6	Fodder yield/plant (gm)	127.67	315.0	201.97	18.57	28.04	43.87	25.33
7	Grain yield/plant (gm)	29.97	59.34	39.88	12.96	23.91	29.41	14.48
8	No. of eggs/plant at 14 DAE	0.40	2.33	1.34	22.76	44.56	26.10	23.95
9	No. of eggs/plant at 21 DAE	1.07	3.27	2.32	14.99	26.19	32.76	17.67
10	Chlorophyll index	28.03	41.36	35.45	6.29	11.47	30.17	7.13
11	Trichome Density/mm^2	0.52	43.75	5.42	195.46	195.85	99.60	401.85
12	Seedling vigour	1.00	5.00	3.78	19.16	27.11	49.95	27.90
13	Glossiness	1.00	5.00	3.02	23.37	29.07	64.63	38.71
14	Recovery of infected plant (%)	16.98	70.92	47.53				
		(24.30)	(57.57)	(43.34)	16.96	21.30	63.41	27.83
15	Dead heart count at 14 DAE (%)	13.27	38.70	27.63				
		(21.30)	(38.40)	(31.46)	9.73	16.76	33.70	11.64
16	Dead heart count at 28 DAE (%)	34.36	74.44	56.98				
		(35.83)	(60.03)	(49.11)	9.01	15.84	32.37	10.57

variance followed by plant height (955.56), grain yield plant^{-1} (90.87). The magnitude of phenotypic coefficient of variation was comparatively low for days to 50 per cent flowering (2.86). Trichome density per mm^2 exhibited highest phenotypic variance (112.69) followed by recovery of infected plant (85.31).The magnitude of phenotypic variance was comparatively low for number of eggs plant $^{-1}$at 14 DAE (44.56).

Godbharle *et al.* (2010) reported genotypic variance was lower than the phenotypic variance for all the characters studied. Ahmed *et al.* (2012) also reported the similar result that most of the characters under study had higher phenotypic and genotypic variance estimates than the environmental variance estimates.

Components of Variability

Genotypic Coefficient of Variation

It was observed from the Table 4 that the character studied for fodder yield per plant exhibited highest genotypic coefficient of variation (18.57%) followed by 1000 seed weight (13.88%). Moderated values of GCV were noticed for grain yield per plant (12.96%), panicle breadth (10.69%), where as the magnitude of GCV were comparatively low for panical length, (10.49%), plant height (10.15%) and days to 50 per cent flowering(1.08%). Trichome density per mm^2 exhibited highest genotypic coefficient of variation (195.46 %) followed by glossiness (23.37 %), number of eggs per plant at 14 DAE (22.76 %). The GCV value were moderated for recovery of infected plant (16.96%), seedling vigour (19.16%) and number of eggs per plant at 21 DAE (14.99 %) whereas, the magnitude of GCV were comparatively low for dead heart count at 14 DAE (9.73%), dead heart count at 28 DAE (9.01%) and chlorophyll content index (6.29 %).

Phenotypic Coefficient of Variation

It was observed from the Table 5 that the magnitude of PCV values were higher for characters fodder yield per plant (28.04%) followed by grain yield per plant (23.91%),1000 seed weight (22.34%). The magnitude of phenotypic coefficient of variation was comparatively low for days to 50% flowering (2.00%).

The magnitude of PCV was higher for the trichomes density per mm^2 (195.85 %) followed by number of eggs per plant at 14 DAE (44.56%). The PCV value were moderated for glossiness (29.07 %), seedling vigour (27.11%), number of eggs per plant at 21 DAE (26.19 %). whereas, the magnitude of PCV were comparatively low for dead heart count at 14 DAE (16.76 %). The research findings showed that there was low difference between GCV and PCV for all the characters studied. Kjein and Rosenow (2006), reported low GCV and PCV for days to 50 per cent flowering. Similar results were found by Mahajan et al (2011).

Heritability in Broad sense

In selection program, the success depends primarily upon the magnitude of heritable variability. The highest heritability were observed for fodder yield per plant (43.87%) followed by 1000 seed weight (38.60 %), panicle breadth (36.38 %). The heritability values moderately high for panicle length (30.51%), grain yield per plant (29.41%),plant height (29.32 %), while it was low for days to 50 per cent flowering (29.09 %). The highest heritability were found trichome density per mm^2(99.60%) followed by glossiness (64.63%), recovery of infested plant (63.41%). Heritability value was moderately high for dead heart count at 14 DAE (32.76%), while it was low for chlorophyll content heart count at 28 DAE (32.37%).

Heritability and Genetic Advance

Heritability and genetic advance are important selection parameters and after an idea about the gene action involved in the expression of various polygenic traits. Heritability estimates along with genetic advance are helpful in predicting the gain under selection than heritability estimates alone.

Genitic Advance for Characters Studied

Estimates of genetic advance help in understanding the type of gene action involved in the expression of various polygenic characters. It also helps in deciding a breeding procedure for the genetic improvement of various polygenic traits by determining the gene actions.

The highest genetic advance expressed in percentage was for fodder yield per plant (25.33%) followed by 1000 seed weight (17.76%), expected genetic advance over mean value was moderately high for grain yield per plant (14.48 %), panicle breadth (13.28 %), panicle length (11.94 %), plant height (11.32 %), while low for days to 50 per cent flowering (1.19 %). The highest expected genetic advance expressed in per cent was for trichomes density per mm^2 (401.85 %) followed by glossiness (38.71 %). Expected genetic advance over mean value was moderately high for seedling vigour (27.90 %), recovery of infected plant (27.83%), number of eggs per plant at 14 DAE (23.95 %) while low for chlorophyll content index (7.13 %), dead heart count at 28 DAE (10.57 %), dead heart count at 14 DAE (11.64 %) and number of eggs per plant at 21 DAE (17.67 %).

Hemlata et al. (2006) recorded more than 80% heritability. Also the study revealed that the high heritability estimates coupled with high genetic advance and genetic gain were found for grain yield per plant. Bello et al (2007) also observed high heritability estimates in characters such as plant height and days to 50 per cent flowering. Deepalakshmi and Ganeshmurthy (2007) reported that high heritability is accompanied with high GA as percent of mean and was observed for the characters days to 50 per cent flowering, hundred grain weight. Shinde et al. (2010) also reported high estimates of broad sense heritability for the characters viz., 50 per cent days to flowering, plant height, number of leaves, number of internodes, panicle length, panicle breadth, number of primaries per panicle of grain plant^{-1}.

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Introgression Analysis in BC_1 and BC_2 Populations for Shootfly Tolerance Traits in Sorghum

Sorghum is one of the most important cereal crop in the semiarid tropics (SAT) and are the fifth most important cereal crop worldwide after wheat, rice, maize and barley .Insect pests are the major biotic constraints for the production and productivity of sorghum causing economic losses over US $ 1 billion annually in the SAT. Among 100 insect pests that attack sorghum, one of the most important biotic constraints to sorghum production in India is the shoot fly (*Atherigona soccata Rond*.), which causes damage when sowings are delayed. The late sown crops tend to be affected by shoot fly damage as compared to the early sown crop. The infestation of shoot fly is high when sorghum sowings are staggered due to erratic rainfall distribution which is common in the SAT countries (Kumar *et al.*, 2008). Shoot flies of the genus Antherigona are known to cause 'dead hearts' in a number of tropical grass species (Deeming, 1971). Shoot fly attack sorghum 5–25 days after emergence. The shoot fly larvae cuts growing tip which results in dead heart formation. Infestation causes dead hearts in seedlings as well as in tillers of the old plants, resulting in to considerable damage to the crop (Aruna and Padmaja, 2009). Many approaches have been employed to minimize the losses caused by shoot fly. These include agronomic practices, natural enemies, synthetic insecticides and host plant resistance (Kumar *et al.*, 2008). However, it is not always feasible to implement all these approaches in practice. For example, early sowing is not always feasible due to short sowing window, whereas chemical control is a limiting factor for a large area. The seriousness of the shoot fly problem in sorghum, combined with the high costs and toxicity hazards of using chemical control render it necessary to develop new varieties or hybrids that are resistant to this pest. DNA marker-assisted breeding for a range of traits (particularly to overcome diseases and pests) has become one of the most important applications of biotechnology in recent times. Molecular markers are being used worldwide to tag specific chromosome segments containing the desired gene(s) to be introgressed into the breeding lines. In this way, indirect selection with co-dominant molecular markers (like SSR) tightly linked to gene(s) controlling characters of interest improves response to selection. DNA based marker-assisted selection (MAS) can supplement conventional breeding and therefore will become an integral part of the plant breeding practices in the coming years. Considering the economic importance of the pest, improving the genetic makeup of the plant is an important objective in the sorghum breeding programmes. Therefore, in order to better understand the inheritance of resistance, identification of QTLs and the linked markers are important. This will eventually help in successful introgression of the QTLs through marker-assisted breeding. QTL mapping is a highly effective approach for studying genetically complex forms of plant disease resistance. With QTL mapping, the roles of specific resistance genes can be assessed, and interaction between resistance genes, plant development, and the environment can be analyzed (Young, 1996). Studies carried out in the past on shoot fly resistance in sorghum suggests quantitative nature of the trait (Folkertsma et al. 2003). Satish *et al.* (2009) identified 29 QTLs for five component traits of shoot fly resistance with a varying degree of phenotypic variation in a 168 RIL mapping populations derived from the cross 296B × IS18551. In the present study, a mapping population derived from the cross of IS18551 × AKSV13R was used, first phenotyping and then genotyping of population was done.

Plant material

A mapping population, which was developed from a cross between genotypes IS18551 (shoot fly resistant) and AKSV-13R (shoot fly susceptible). (Satish, *et.al.* 2009) field experiment was conducted in late kharif (rainy) season at Sorghum Research Unit, Dr Panjabrao Deshmukh Agricultural University, Akola, India, during 2011-12. The experiment was carried out. Each entry was planted in a single row of 45cm × 45 cm length spaced at 40 cm apart .To attain uniform shoot fly pressure under field conditions, the fishmeal technique (Nawanze, *et.al.*, 1991) was adopted to ensure shoot fly infestation in the experimental material. Plant protection measures were strictly avoided.

Phenotyping and data analysis

Phenotypic data on shoot fly resistance was scored for both parental genotypes on different component traits viz., leaf glossiness, (pigmentation, oviposition (number of eggs laid on seedling at 14 and 21 days after seedling emergence (DAE)), dead hearts per cent (DH % recorded on 14th and 21st DAE), tiller dead heart and

trichome density on abaxial (lower) leaf surface. Leaf glossiness was visually scored on a scale of 1–5 scores at 10 DAE (1, highly glossy (light green, shinning, narrow and erect leaves) and 5, nonglossy (dark green, dull broad and dropping leaves), pigmentation was assessed at 5 DAE (where 1, plumule or leaf sheath with dark pigment and 5, plumule or leaf sheath with green colour) following Sharma and Nawanze (1997). Oviposition was recorded by taking an average of the total number of eggs laid on 10 seedlings in a row. The number of eggs per seedling were calculated at 14 and 21 DAE. To record data on DH per cent, the total numbers of plants were initially recorded and the numbers of plants with dead hearts were subsequently recorded on 14th and 21st DAE. The mean values of DH per cent (number of dead hearts / total number of plants × 100) were recorded on 14th and 21st DAE. As regards the trichome density was recorded at 14 DAE on the abaxial leaf surface on the central portion of the fifth leaf from the base, in three randomly selected seedlings in each row in each replication as per the procedure outlined by Sharma and Nawanze (1997). Briefly, the leaf segments (< 2 cm^2) were cleared in acetic acid: alcohol (2:1) and transferred to 90 per cent lactic acid in small vials. The leaf segments were then mounted on a slide in a drop of water and observed under stereomicroscope at a magnification of 40X. The number of trichomes on abaxial leaf surface was counted in three microscopic fields at random and expressed as trichome density (no./mm^2).

Phenotypic performance of parents

The resistant donor parent IS18551 recorded 2.37 leaf glossiness as compared to 2.32 leaf glossiness in parent AKSV-13 R on 1-5 scale. Similarly differences for mean performances for pigmentation was recorded in two parents IS18551 (2.37) and AKSV-13 R (2.72).The mean percent seedling with eggs recorded after 14th and 21st days after emergence were numerically higher in AKSV-13 R (4.0% and 3.91% on 14th and 21st DAE). Similarly dead heart per cent at 14th and 21st DAE varied in two parents AKSV-13 R (50% and 61% on 14th and 21st DAE) and IS18551 (28% and 32% on 14th and 21st DAE). Whereas, trichome density was higher in IS18551 (64/mm^2) as compared to AKSV-13 R (22/mm^2).

Correlation Coefficient in BC1

Pigmentation

Correlation of pigmentation was studied with different parameters such as leaf glossines, trichome density, seedling with egg, dead heart and yield per plant revealed that pigmentation was positively correlated with leaf glossiness, seedling with egg and dead heart at 14th and 21st DAE and negatively correlated with trichome density and yield $plant^{-1}$. Whereas pigmentation was significantly and moderately with correlated leaf glossiness (0.53*) seedling with egg at 14th DAE (0.50*) and highly correlated with dead heart at 14th DAE (0.62**)

Glossiness

Correlation revealed that glossiness was positively correlated with seedling with egg at 14th (0.92**) and 21st (0.28**) DAE, dead heart at 14th (0.83*)and and 21st (0.74*)DAE while it was negatively correlated with trichome density (-0.72**) and yield $plant^{-1}$ (-0.86**).

Trichome Density

Correlation reveled that trichome density was positively correlated with yield (0.68**) and negatively correlated with seedling with egg at 14th (-0.67**) and 21st (-0.20) DAE, dead heart at 14th (-0.68**) and and 21st (-0.53*) DAE.

Seedling with Egg

Correlation reveled that seedling with egg at 14th DAE was positively correlated with dead heart at 14th (0.77**) and 21st (0.73**) DAE and it was negatively correlated with trichome density (-0.72**) and yield $plant^{-1}$ (-0.86**). Seedling with egg at 21st DAE was also positively correlated with Dead heart at 14th (0.45*) and 21st (0.48*) DAE.

Dead Heart

Correlation of Dead heart with yield reveled that it was negatively correlated DH per cent at 14th (-0.80**) and 21st DAE (-0.72**)

Yield

Correlation with yield was also studied with different parameters and revealed that only trichome density exhibited positive and significantly correleated with yield while rest of the characters were negatively correlated viz. pigmentation (-0.68**), glossiness (-0.86**), seedling with egg 14th (-0.85**) and 21st (-0.34) DAE and Dead heart 14th (-0.80**) and 21st (-0.72**)

Correlation Coefficient in BC2

Pigmentation

Correlation of pigmentation was positively correlated with leaf glossiness(0.06),trichome density (0.28*) seedling with egg at 14th (0.03)DAE dead heart 14th (0.09) and negatively correlated with seedling with egg at

Table 1 . Mean phenotypic performance for shoot fly resistance component traits in the parents.

Character	AKSV– 13R(susceptible)	IS18551(resistant)
Leaf glossiness (1-5 scale)	2.32	2.37
Pigmentation (1-5 scale)	2.72	2.37
Seeding with egg% 14,21st DAE	4.0, 3.91	1.32, 1.86
Deadhearts % at 14, 21th	50, 61	28, 32
Trichome density(per mm^2)	22	64

Table 2. Phenotypic correlation coefficient among the six morphological traits in BC_1 derived from cross AKSV-13R X IS18551

	Pigment mean	Leaf glossiness	Trichome Density	Seedling with eggs (DAE)		Deadheart damage (DAE)		Seedling with eggs (DAE)
				14	21	14	21	
Pigmentation	1	0.53*	-0.44	0.50*	0.21	0.62**	0.27	-0.68**
Leaf glossiness		1	-0.72**	0.92**	0.28	0.83*	0.74*	-0.86**
Trichome Density			1	-0.67**	-0.20	-0.68**	-0.53*	0.68**
Seedling with egg 14 DAE				1	0.20	0.77**	0.73**	-0.85**
Seedling with egg 21 DAE					1	0.45*	0.48*	-0.34
Dead heart 14 DAE						1	0.57*	-0.80**
Dead heart 21 DAE							1	-0.72**
Yield plant^{-1}								1

** Significant at P= 0.01= highly significant,* Significant at P= 0.05 = significant,N.S = Non significant.

Table 3 Phenotypic correlation coefficient among the six morphological traits in BC_2 derived from cross AKSV-13R X IS18551

	Pigment mean	Leaf glossiness	Trichome Density	Seedling with Egg (DAE)		Dead heart (DAE)		Yield plant^{-1}
				14	21	14	21	
Pigmentation	1	0.06	0.28*	0.03	-0.14	0.09	-0.15	-0.07
Leaf glossiness		1	-0.09	0.01	0.03	0.03	0.15	-0.87**
Trichome Density			1	0.07	-0.03	-0.04	-0.14	0.10
Seedling with egg 14 DAE				1	0.08	0.28*	0.21	-0.07
Seedling with egg 21 DAE					1	0.02	0.43**	-0.08
Dead heart 14 DAE						1	0.09	-0.16
Dead heart 21 DAE							1	-0.22
Yield plant^{-1}								1

** Significant at P= 0.01= highly significant, * Significant at P= 0.05 = significant, N.S = Non significant

21st (-0.14), Dead heart 21st (-0.15) and yield plant-1 (-0.07). Whereas pigmentation was significantly and moderately with correlated with trichome density (0.28*).

Glossiness

Correlation revealed that glossiness was positively correlated with seedling with egg at 14th (0.01) and 21st (0.03)DAE Dead heart 14th (0.03) and 21st (0.15) while it was negatively correlated with trichome density (-0.09) and yield plant-1 (-0.87**)

Trichome Density

Correlation revealed that seedling with egg14th (0.07) and yield per plant (0.10) and trichome density was positively correlated with seedling with egg14th (0.07) and yield (0.10) while it was negatively correlated with seedling with egg at 21st (-0.03) DAE, dead heart at 14th (-0.04) and and 21st (-0.14)DAE

Seedling with Egg

Correlation revealed that seedling with at 14th DAE egg was positively correlated with dead heart (0.28)and and 21st (0.21)DAE and it was negatively correlated with yield plant-1 (-0.07). Seedling with egg at 21st (0.43**) DAE also positively correlated with Dead heart at 14th(0.02).

Dead Heart

Correlation of dead heart with yield It was observed that yield was negatively correlated with DH per cent at 14th (-0.16) and 21st DAE (-0.22).

Yield

Correlation with yield was also studied with different parameters and revealed that only trichome density (0.10) exhibited positive and significantly correlated with yield. While rest of the characters were negatively correlated with pigmentation (-0.07), negative correlated with leaf glossiness (-0.87**), seedling with egg and 14th (-0.07), 21st (-0.08), dead heart at 14th day (-0.16) and 21st (-0.22).

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Fertilizer Management Studies in Indian Mustard

Mustard (*Brassica jouncea*) is an important *Rabi* oilseed crop under irrigated and rainfed condition and widely grown on large area in India. In India area under this crop is 6.5 million ha producing about 7.67 million tons of seeds with an average productivity of 1179 kg ha^{-1}. Rajasthan is the largest producer of mustard seed in the country with a contribution of 54 per cent to the country's total mustard seed production followed by Punjab and Haryana, which together contributes 14 per cent , Now a day's mustard is spreading to non-traditional areas like Maharashtra, Andhra Pradesh, Tamilnadu and Karnataka. Area under cultivation in Maharashtra was 7700 hectare with production of 3000 tons and productivity of 383 kg ha^{-1} (Anonymous, 2012) and in Vidarbha area under this crop is 2200 hectare with production of 800 tons and productivity of 312 kg ha^{-1} (Anonymous, 2011).

The yield of mustard is very low in Maharashtra. The major cause for low productivity is the proper fertilizer management and suitability of cultivar for the region. Some promising entries are found for the zone IV comprising the Vidarbha area . The performance of such promising genotype need to be evaluated in the agronomic trial for zone under irrigated condition. With this objective in mind the present investigation was planned.

A field experiment was conducted at College of Agriculture, Nagpur during *Rabi* 2012-13 under irrigated condition in split plot design replicated thrice with objective of better utilization of resources for higher productivity. The main factor treatments were five mustard genotype viz.,Ag-1(SKM-815), Ag-2 (BIO-902), Ag-3-(GM-3), Ag-4 (Kranti) and Ag-5 (SKM-301) and sub plot treatments were four fertilizer management levels viz., F_{75}(75%RDF), F_{100}(100%RDF), F_{125}(125%RDF) and F_{150}(150%RDF). The recommended fertilizer dose i.e. 100 per cent% RDF was 50:40:0 NPK kg ha^{-1} under irrigated condition. The experiment was conducted on clayey texture soil with normal pH(7.6), medium soil organic carbon(5.36 g kg^{-1}), low available nitrogen (219.5 kg ha^{-1}), very low in available P_2O_5 (12.82 kg ha^{-1}) and very high in available K_2O (369.6 kg ha^{-1}). The observation on as reported in Table 1 were recorded with standard procedures. Uptake at harvest was estimated in dry matter of seed and straw separately by estimating available NPK content.

Performance of genotype : Plant height and days to physiological maturity were not influenced significantly by the different mustard genotypes(Table 1). However, the days to 50 per cent flowering were significantly higher in Ag-3 (GM-3), Ag-4 (Kranti) and Ag-5(SKM-301) over Ag-2 (BIO-902). The siliqua $plant^{-1}$(100.5), Yield $plant^{-1}$ (4.03 g) were maximum and significantly more in Ag-2 (BIO-902) and Ag-5 (SKM-301) was at par. The test weight (5.25 g) was also more in BIO-902. The genotype Ag-2 (BIO-902) also recorded maximum and significantly higher yield ha^{-1} (610 kg). This might be due to the growth contributing characters i.e. siliqua $plant^{-1}$ and yield $plant^{-1}$ due to BIO-902 cultivar as evidenced from the data shown in the Table 1. The same cultivar also recorded significantly more grass monetary return (GMR) of (Rs 18304 ha^{-1} and also net monetary returns (Rs 8142 ha^{-1}) and the highest B:C ratio (1.79) among the different mustard entries. The cultivar SKM-815 and SKM-301 also given significantly higher yield over the check Kranti. This might be due to more seed yield. Anonymous (2013) at Jobner also found SKM-301 superior in yield over Kranti which support the present findings. Dry matter at harvest was significantly influenced and the genotype Ag-2 (BIO-902) recorded maximum and significantly higher plant dry matter (2945 kg ha^{-1}) fallowed by SKM-815 and SKM-301 which were at par with it among the genotypes (Table 1). The nitrogen, phosphorus and potassium uptake was recorded maximum and significantly more due to the genotype Ag-2 (BIO-902) fallowed by SKM-815 and SKM-301 which were at par with it. This might be due to comparatively higher dry mater production and higher seed yield in BIO-902 as evidenced from the yield and dry matter data.

Effect of fertilizer levels : Among the fertilizer levels, plant height was maximum and significantly more when applied with F_{150}(150% RDF) and followed by F_{125}(125% RDF) which were at par with F_{100}(100% RDF).The days to 50 per cent flowering were significantly more due lower fertilizer dose i.e F_{75}(75% RDF). But the days to physiological maturity was not influenced by the fertilizer levels. Number of siliqua $plant^{-1}$ (92) and seed yield $plant^{-1}$ (3.8 g), were maximum and significantly higher due to F_{150}(150% RDF) level over F_{100}(100% RDF). The test weight was also higher due to the F_{150}(150% RDF). The same fertilizer level also recorded maximum and significantly higher yield ha^{-1} (543 kg), GMR (Rs 16287 ha^{-1}), NMR (Rs 4997 ha^{-1}) and the

Table1. Growth, Yield, yield attributes, uptake and economics of mustard as influenced by the various treatments

Treatments	Plant height (cm)	Siliqua plant^{-1}	Yield plant^{-1} (g)	Test Wt. (g)	Yield ha^{-1} (kg)	COC (Rs ha^{-1})	GMR (Rs ha^{-1})	NMR (Rs ha^{-1})	B:C ratio	Days to Phy. Maturity	Days to 50 % flowering	Plant dry matter (kg ha^{-1})	NPK uptake (Seed+Straw) (kg ha^{-1})		
													N	P	K
Main plot- Genotypes															
Ag-(SKM-815)	141	78.6	3.50	3.60	443	10163	13286	3123	1.30	97.0	37.8	2546	40.59	7.83	96.60
Ag-2(BIO-902)	135	100.5	4.03	5.25	610	10163	18304	8142	1.79	97.3	34.8	2945	50.40	11.42	120.18
Ag-3 (GM-3)	136	56.2	2.74	4.55	343	10163	10295	132	1.01	97.2	39.4	2210	35.49	9.81	76.04
Ag-4 (KRANTI)	129	59.9	2.37	2.40	341	10163	10227	65	1.00	96.0	39.3	1745	23.82	5.45	59.56
Ag-5(SKM-301)	139	92.9	3.53	3.55	443	10163	13297	3134	1.29	96.9	40.1	2440	42.66	9.73	94.28
SE(m)+	7.6	4.4	0.18	-	18.4	-	553	553	-	0.6	1.0	199	3.54	0.795	8.051
CD at 5%	NS	14.4	0.60	-	60.1	-	1804	1804	—	NS	3.2	648	11.56	2.591	26.251
Sub plot- fertility levels															
F_{75}(75%RDF)	129	66.6	2.51	3.84	356	9035	10665	1630	1.18	96.7	40.3	2057	26.48	6.30	66.36
F_{100}(100%RDF)	134	73.7	3.19	3.76	374	9787	11222	1435	1.15	96.6	38.7	2272	32.28	7.65	80.55
F_{125}(125%RDF)	138	78.0	3.44	3.84	479	10539	14153	3614	1.34	97.1	37.1	2484	42.83	9.55	96.70
F_{150}(150%RDF)	142	92.0	3.80	4.04	543	11290	16287	4997	1.44	97.1	37.1	2696	52.78	11.90	114.33
SE(m)+	3.0	2.4	0.12	-	12.8	-	383	383	-	0.4	0.7	160	2.81	0.606	5.965
CD at 5%	8.6	7.0	0.34	-	36.8	-	1105	1105	-	NS	1.9	463	8.12	1.750	17.225
Interactions															
SE(m)+	5.9	4.9	0.24	-	25.5	-	765	765	-	0.7	1.3	321	5.63	1.212	11.930
CD at 5%	NS	NS	NS	-	NS	-	NS	NS	-	NS	NS	NS	NS	NS	NS

Mustard Seed minimum support price Rs. 3000 q^{-1}

highest B:C ratio (1.44) over all other fertilizer levels. The higher GMR and NMR might be due to more seed yield due to the treatment. Anonymous (2013) reported more than 10 per cent yield increase by 125 per cent RDF and 7 per cent reduction by 75 per cent RDF at SKNagar and Jobner under the similar climatic condition. Patel *et. al*. (2012) at SKNagar and Meena *et. al*.(2012) at Kota also reported significantly lower mustard seed yield by 75 per cent RDF. Anonymous (2010) reported that 150 per cent RDF recorded maximum and significantly higher yield over 100 per cent RDF but 125 per cent RDF was at par with 150 per cent RDF which support the present findings. Application of 150 per cent RDF produced maximum plant dry matter production, but it was at par with 100 and 125 per cent RDF. Nitrogen, phosphorus and potassium uptake in plant was recorded maximum and significantly more due to the 150 per cent RDF application which might be due to the more seed yield, more plant dry matter production and more content of nutrient in plant compared to other fertilizer levels.

Interaction effects: The interaction effects in respect of all the character under study and also the uptake study were found non-significant.

CONCLUSIONS

Thus from the present experiment it can be concluded that for maximum yield and better economic return the genotype Ag-2 (BIO-902) among the different mustard genotype and the enhanced fertilizer dose of 150 per cent i.e. 75 kg N and 60 kg P_2O_5 can be used.

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Readability of Krishisanvadini Published by Dr. PDKV, Akola

The printed matter has a lasting power than spoken word or event the visual image. The use of printed material, as compared to other media, is more advantageous, because it can present more detailed information in a simple language, supported with illustrations or pictures and reach large number of readers. The printed material can also be preserved for future reference.

The effectiveness of printed materials depends largely on the extent to which they are readable. Any reading materials is readable, if it is easy and pleasant to read. According to UNESCO, a piece of writing is readable if it could be read and understood by the readers for whom it was intended (Anonymous 1963). Printed words are being widely used as communication medium in agricultural extension, extramural education of rural people and farmers mass training programme.

Considering the needs of the farmers, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola is publishing Annual publication i.e. Krishisanvadini in Marathi language. Directorate of Extension Education is communicating the latest farm information regarding new technology and research findings through Krishisanvadini.

Large number of farmers are taking advantage of the Krishisanvadini for knowing the technical know – how in agriculture and allied fields. Whether this material suits to the average readers? What is the readability level of the farm literature? In order to gather the scientific data on these aspects the present investigation was carried out.

OBJECTIVES

1. To measure the readability of the information published in Krishisanvadini.
2. To investigate the reading interest of readers towards various topics appeared in Krishisanvadini.
3. To obtain suggestions of the readers.

MATERIAL AND METHDS

The present study was conducted in Akola district of the Vidarbha region of Maharashtra State. Akot and Barshitakli taluka were selected From Akola district. Five villages were selected randomly. As a first step, the readers of Krishisanvadini were identified to obtain information. The officials like Extension Agronomist, Subject Matter Specialists, Agricultural Technology Information Centre and Extension Staff of State Agricultural department and were requested to point out the readers of Krishisanvadini. Thus a list of readers of Krishisanvadini in selected villages was prepared and 20 respondents were selected randomly from each village. Thus total number of 100 readers was selected for the study. The Research Technique named Shirke Formula was used for measuring the readability in marathi.

RESULTS AND DISCUSSION

1. Perceived Readability of Farm Information published Krishisanvadini

1.1 Words

On perusal of data from Table 1, it is clear that a majority of the respondents (52.00 %) expressed that the words were ‘very easy to read and understand’. Thirty nine percent of the respondents felt that the words were ‘easy to read and understand’, while only 9 percent of the respondents had ‘difficulty in reading and understanding’ the words. As the farm information included in krishisanvadini was specially published for the sake of farmers, the writers and editors seem to have been successful in using very simple words.

1.2 Technical words

Near about half of the respondents (49.00 %) felt that the technical words were ‘difficult to read and understand’, while 38.00 per cent of the respondents perceived technical words as ‘easily read and understand’. Only 13 per cent respondents could ‘very difficult to read and understand’ the technical words. Considering the level of literacy skills of the respondents, it is, quite natural that technical words were perceived as difficult to read and understand. The appropriate words as alternatives to technical words need to be used in writing for farmers. Giving meaning to the technical words may also help, to some extent, to improve readability.

1.3 Sentences (length)

Sentences were perceived ‘small in length’ by 45 per cent of farmer respondents, while 36 per cent perceived sentences as having ‘medium length’. Nineteen per cent

respondents felt that the sentences were 'lengthy'. The perception of the respondents as small and moderate sentences was correct as it was found in an attempt to calculate readability that the average sentence length was quite small i.e. 7 to 8 words per sentence.

Table 1. Readability level of Krishisanvadini as perceived by the readers.

S.N.	Components	Respondent (n = 100)	
		Frequency	Percentage
1	2	3	4
I.	**Words**		
	1. Difficult to read and understand	09	09.00
	2. Easy to read and understand	39	39.00
	3. Very easy to read and understand	52	52.00
II.	**Technical words**		
	1. Very difficult to read and understand	13	13.00
	2. Difficult to read and understand	49	49.00
	3. Easy to read and understand	38	38.00
III.	**Sentence length**		
	1. Long	19	19.00
	2. Medium	36	36.00
	3. Small	45	45.00
IV.	**Paragraph (size)**		
	1. Big	27	27.00
	2. Medium	52	52.00
	3. Small	21	21.00
V.	**Title or heading (appropriateness)**		
	1. Inappropriate	06	06.00
	2. Somewhat appropriate	31	31.00
	3. Appropriate	63	63.00
VI.	**Titles or heading (adequacy)**		
	1. Inadequate	10	10.00
	2. More than adequate	25	25.00
	3. Adequate	65	65.00
VII.	**Illustration (appropriateness)**		
	1. Inappropriate	22	22.00
	2. Some what appropriate	25	26.00
	3. Appropriate	62	62.00
VIII.	**Tables and charts (sufficiency)**		
	1. Too many	09	09.00
	2. Little more than sufficient	22	22.00
	3. Sufficient	69	69.00
IX.	**Type size**		
	1. Too small to be read	15	15
	2. Able to read with little difficulty	38	38
	3. Easy to read	47	47

1.4 Paragraph (size)

A majority of the respondents (52 per cent) expressed that the paragraphs were medium in size. Paragraphs were perceived to be big and small in size by 27 and 21 per cent of the respondents respectively.

The slow reading speed of farmers required more time to read. Therefore, they took more time to read a paragraph than other readers. The paragraph breaks monotony in reading. Hence, small paragraphs are required for farmer readers. As they have perceived paragraphs to be small and medium, it can be inferred that the paragraphs were really of suitable size.

1.5 Title or Headings (appropriateness)

More than half (63 per cent) of the respondents felt that the titles or headings were 'appropriate'. Thirty one per cent respondents perceived it to be 'somewhat appropriate' while only 6 per cent opinioned that the title or headings were 'inappropriate'.The heading, sub-headings and titles add to the better reading and comprehension of the subject matter.

1.6 Title or Headings (adequacy)

Majority of the respondents (65 per cent) felt that the title or headings were 'adequate'. Twenty five per cent respondents expressed that the titles or headings were 'more than adequate' while only 10 per cent respondents reported the headings were inadequate'. Adequate number of titles, headings and subheadings in a documents are necessary because they help in meaningful organization of farm information. The adequate number of headings/sub-headings add to readability in comprehension of information.

1.7 Illustration (appropriateness)

It is evident from Table 1 that 62 per cent of the respondents reported that the illustrations were 'appropriate', while, 26 per cent opined the illustrations to be 'somewhat appropriate'. Only 22 per cent readers opined that the illustrations were 'inappropriate'. It seems that the majority of the respondents wanted appropriate illustrations.

1.8 Table and charts (sufficiency)

Majority of the respondents (69 per cent each) expressed that the tables and charts were sufficient. while, 22 per cent of the respondents opined that the table and charts were 'little more than sufficient'. The reason for this might be that, it was easy to understand the tables and charts.

1.9 Type size

Table 1 elucidates that majority of the respondents (47 per cent) expressed that they were easily able to read the farm information. Thirty eight per cent respondents opined that they able to read with little difficulty, while 15 per cent of the respondents expressed that the type size was too small to read the farm information.

However, majority of the respondents still had some difficulty in reading on account of type size. The probable reasons might be the newness of the basic literacy skill, less reading experience and poor ability to identify the letters and words quickly.

2. Overall Perceived Readability level of Farm Information published in Krishisanvadini.

The respondents were classified into three groups of readability viz., low readability level, medium readability level and high readability level on the basis of their overall perceived readability scores, with the help of mean SD formula.

Table 2 depicts that 64 per cent of the respondents perceived farm information to be moderately readable followed by high readability level (24 per cent). Only 12 per cent of the respondents perceived the farm information to be less readable. Thus, it can be concluded

Table 2. Overall Perceived Readability level of the Krishisanvadini.

S.N.	Category	Respondents (n = 100)	
		Frequency	Percentage
1	Low readability level (Up to 20)	12	12.00
2	Medium readability level (21 to 32)	64	64.00
3	High readability level (33 and above)	24	24.00

that, about 88 per cent of the respondents expressed that the literature was moderately to highly readable. Perceived readability occurred more in medium readability level because more farmers were in the middle school category.

3. Reading Interest

Table 3 depicts that the respondents shown more reading interest towards information on Plant Protection, ranked 1st fallowed by fertilizer application Information(Rank 2nd). Information on Crop Cultivation, Important Machinery and Fruit and Vegetables were ranked 3rd, 4th and 5th respectively. It is also observed that the information on Irrigation Management, Floriculture, Animal Husbandry and Dairy Science and General Information were ranked 6th,7th, 8th and 9th, respectively.

4. Suggestions of the Respondents for improving Readability

It can be seen in Table 4 that majority of the respondents (52 per cent) suggested that the 'meaning of technical words must be written in the paragraph', while, 42 per cent of the respondents suggested that sentences must be small and easy in writing. Thirty per cent of the respondents suggested that illustration must be appropriate'.

Table 3 Distribution of the respondents according to Reading Interest of information published in Krishisanvadini

S.N.	Component	Reading Interest (n=100)				Rank
		More	Medium	Little	No	
1	Variety/ Hybrid (Crop Cultivation)	71 (71.00)	15 (15.00)	13 (13.00)	01 (01.00)	III
2	Fruit and Vegetables	61 (61.00)	27 (27.00)	09 (09.00)	03 (03.00)	V
3	Floriculture	50 (50.00)	30 (30.00)	15 (15.00)	05 (05.00)	VII
4	Animal Husbandry and Dairy Science	48 (48.00)	25 (25.00)	20 (20.00)	07 (07.00)	VIII
5	Plant Protection	78 (78.00)	12 (12.00)	10 (10.00)	00 (00.00)	I
6	Important Machinery	65 (65.00)	20 (20.00)	15 (15.00)	00 (00.00)	IV
7	Fertilizer Application	72 (72.00)	15 (15.00)	13 (13.00)	00 (00.00)	II
8	Irrigation Management	58 (58.00)	25 (25.00)	14 (14.00)	03 (03.00)	VI
9	General Information	20 (20.00)	26 (26.00)	29 (29.00)	24 (24.00)	IX

Table 4. Suggestions of the Respondents for improving Readability

S.N.	Category	Respondents	
		Frequency	Percentage
1	Meaning of technical words must be written in the paragraph	52	52.00
2	Sentences must be small and easy in writing	42	42.00
3	Paragraph must be small and attractive	20	20.00
4	Title must be easy and appropriate	18	18.00
5	Illustrations must be appropriate	31	31.00
6	Tables and chart musts be in sufficient numbers	21	21.00
7	Type size should be big	19	19.00

Nearly, equal percentages, i.e. 21 per cent and 20 per cent of the respondents expressed that 'Tables and chart musts be in sufficient numbers' and 'paragraph must be small and attractive', respectively. Some of the suggestions by the respondents for improving readability included, ', 'type size should be big' (19 percent), 'title must be easy and appropriate' (18 per cent).

CONCLUSION

It could be, thus concluded from the above findings that general words were easy to understand, while technical words were felt difficult by farmer readers. Length of sentences and size of paragraph were suitable. The titles and headings were appropriate. Tables and charts included were more than required and appropriate type size has not been used. The results provide feedback to writers and editors of farm information for farmers to select easy technical words, use appropriate type of size, make judicious use of illustrations and usage of tables and charts.

It is therefore, suggested that writers and extension workers should consider these variables while writing and providing farm information for farmers so that it will be more readable TO them. The farmers should be encouraged and motivated to read more literature.

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Studies on Total Serum Protein on Feeding of Complete and Conventional Diet to Calves

Animal husbandry is an integral part of crop husbandry. Animal rearing is not a separate activity but a subsystem within whole farming system. Livestock depends largely on crop residues and grazing either inside the forest or outside the forest. India contributes larger livestock population but the major constraints for economic animal production are chronic feed deficits and under nutrition of animals. It has been seen that more area is brought under crop cultivation, urbanization and industrialization in the country which has resulted in acute shortage of green fodder, dry fodder, grazing and browsing resources. The grazing resources are decline @ 1.5 million ha/year and only 4.4 per cent of cropped area is under fodder crops (Dhore and Ghule, 2010). In such situation there is necessity to accept the new feeding trends. Moreover there is unbridgeable gap between quality requirement of feed and there availability. The complete feed is the new approach feeding system in the diet of animals. In the Vidharbha region cotton is the major crop, after last picking of cotton usually it is thrown away from the field or use as fuel purpose. After chaffing and grinding it can be effectively use in the complete diet and improve its palatability and digestibility in the diet of animal and may be save the national income. Keeping these views in mind present study was undertaken to study on average total serum protein in blood of calves on different feeding system.

A batch of 15 crossbred calves ranging from 66 kg to 88 kg body weight was selected from the herd. The calves were divided in three groups on the basis of nearness in body weight and age. Complete feed was prepared by using cotton straw as a base material, the different ingredient of concentrate were mixed to it to form complete feed this complete feed prepared with different proportion of cotton straw i.e. 45 (T_1) and 30 (T_2) per cent was compared with control treatment diet (T_3). The control diet consisted feeding of wheat straw + concentrate mixture. Treatment T_4 consisted of same feed as that T_1 but offered 10 per cent extra DM allowances over requirement. While in treatment T_5 same feed as that of T_2

was offered with 10 per cent extra DM allowances. The concentrate mixture used in the control treatment was prepared by coarse grinding of Jowar, Tur, Wheat grains and mixing in the proportion of 40, 20 and 10 parts (W/W) respectively . In this mixture 25, 2 and 3 parts (w/w) of whole cotton seed, urea and mineral mixture were added and mixed manually. The requirement of nutrients in terms of DM, DCP and TDN were calculated for individual calves as per the ICAR feeding standards (1985) on the basis of body weight. The computation of ration was revised every week on the basis of body weight achieved in calves. Complete feed was offered as per treatment in the morning at 9.0 am hours and the left over was measured in next day in order to know the intake of feed by the calves. All the animals from each group were subjected to blood collection, 2 ml. of blood was collected from Jugular vein in sterile vial containing 1-2 drops of EDTA solutions at the rate of 5 ml. of blood. For separation of serum above 10-15 ml of blood was collected in sterile test tube without any anticoagulant. Collected blood was allowed to clot in the test tube in slanting position at room temperature for 24 hr. The clean serum was separated in oven dried vials. The samples were properly labelled and vials were stored in deep freezers at 20^0C until use for biochemical analysis. Total serum protein was estimated by using Auto Analyser in the laboratory. The data obtained was analysed statistically by applying FRBD design as per the procedure given by Amble (1975).

Chemical composition of feed stuffs

In the present study two complete feed were developed by using cotton straw as sole source of roughage. It seems, therefore necessary to discuss the composition of cotton straw. In view of this the data related to proximate principles of cotton straw, the basic ingredients of the complete feed and wheat straw + concentrate mixture (Conventional ration) are presented in Table 1 along with the composition of complete feed – I with 45 per cent of cotton straw and complete feed – II with 30 per cent cotton straw.

It is seen from the Table 1 that the C.P. contain (7.07% on D.M. basis) of cotton straw appeared to be substantially higher than that of the conventional roughages like Jowar straw, Wheat straw, Paddy straw and other dried grasses. Thus cotton straw could form a good source of fibrous component as well as protein source in the ration of animals. The chemical composition of cotton straw reported by Dani (2004) and Gangode and Fulpagare (2004) is supportive to present results. The complete feed prepared with the cotton straw was containing sufficient amount of crude protein (16.62 to 17.06 %) to support the maintenance and growth in calves.

Daily gain in body weights

The data on the daily gain in body weight of calves as influenced by the feeding treatment are tabulated in Table 2. It is seen from Table 2 that feeding treatments affected significantly the daily gain in calves. The calves from T_1 group maintained significantly higher daily gain of 380.333 gm as compared to rest of the treatments. The average daily gain in other feeding groups was 336.333, 227.66, 354.66 and 310.666 gm per calf in T_2, T_3, T_4 and T_5 groups respectively. However, the gain of T_2 and T_4 as well as T_3 and T_5, did not differ significantly. It is clear from this trend that there was no adverse effect of feeding complete diet – I with 45 per cent cotton straw to calves. However Gangode and Fulpagare (2004) noticed higher daily gain in body weight due to inclusion of 10 per cent cotton straw in the diet and increased level of cotton straw decreased in daily gain in calves while Reddy and Reddy (1985) reported higher growth rate on complete feed with NH_3 treated cotton straw than the feed with untreated cotton straw. In the present study untreated cotton straw was used in the formulation of complete feed and therefore the comparison can be made with their untreated group in respect of daily weight gain. However, the growth rate reported by Reddy and Reddy (1985) on feeding complete feed with untreated cotton straw appears to be slightly on higher side than the present values.

Table 2 : Effect of feeding treatments on daily gain in body weight of calves (g)

Treatments		Mean Daily gain in BW
T_1	Complete feed - I	380.333 a
T_2	Complete feed - II	336.333 b
T_3	Conventional feed	277.666 c
T_4	T_1 + 10% extra	354.666 b
T_5	T_2 + 10% extra	310.666 a
	S.E. (m) ±	14.477
	C.D. at 5%	40.130
	C.V. %	27.238
	G.M.	331.933

(Means with similar superscript/s do not differ significantly)

Table 1 : Average chemical composition of different types of feeds.(% D.M. Basis)

S. N.	Particulars	Conventional Diet		Complete feed		Cotton
		Conc. mixture	Wheat straw	45 % C.S. (I)	30 % C.S. (II)	straw
1.	D.M	90.12	90.13	90.50	90.20	91.10
2.	C.P.	21.37	2.48	17.06	16.62	7.07
3.	E.E.	3.12	1.10	3.45	3.50	1.67
4.	C.F.	6.36	40.03	27.10	25.65	49.74
5.	Ash	7.65	10.27	10.60	10.15	6.62
6.	N.F.E.	61.50	46.12	41.79	44.08	34.90

(C.S. - Cotton Straw, Conc. - Concentrate)

Total serum protein (TSP) content

The data on average total serum protein in the blood of calves on different feeding systems over a period of 90 days have been tabulated in Table 3. The results in Table 3 revealed that the average total serum protein value at the start of the trial was ranging from 4.533 to 4.667 gm dl^{-1} in the blood of calves. These values appeared within the normal range of 4-7 gm dl^{-1}. Bhikane (2002) reported the normal total serum protein in the range of 5.7 to 8.1 gm/dl. Therefore it appears that the total serum protein values may differ according to the age of the animal. Moreover the difference in values between the groups was non – significant, indicating that the calves from all the groups were equal with regards to total serum protein status at the beginning of the feeding trial. In general total serum protein (TSP) in blood of calves showed increasing trend over the experimental period. The values increased from 4.5667 to 6.467, 4.667 to 6.033, 4.533 to 5.367, 4.567 to 6.267 and 4.667 to 5.900 gm dl^{-1} in T_1, T_2, T_3, T_4 and T_5 groups, respectively.

The results further indicated that at all the intervals of testing the TSP levels were significantly higher in calves maintained on complete diet – I with 45 per cent cotton straw (T_1) than that of other feeding groups. In T_1 group, TSP levels increased to the tune of 41.60 per cent over the initial value of 4.567 gm dl^{-1}. In contrast. TSP levels were increased by 17.51 per cent when the calves received conventional diet (T_3). The rate of increase in TSP level in other feeding groups was 29.26, 37.22 and 26.41 per cent over their respective initial values under T_2, T_4 and T_5 group, respectively.

Table 3: Effect on average total serum protein on feeding complete and conventional diet to calves

Treatments		Mean values of TSP(g/dl)						
Days →		0	15	30	45	60	75	90
T_1	Complete feed - I	4.567	4.833 a	5.400 a	5.567 a	5.967 a	6.067 a	6.467 a
T_2	Complete feed - II	4.667	4.800 ab	4.933 b	5.133 b	5.467 b	5.633 b	6.033 b
T_3	Conventional feed	4.533	4.633 b	4.800 b	5.100 c	5.133 c	5.267 c	5.367 c
T_4	T_1 + 10% extra	4.567	4.667 ab	5.167 c	5.700 a	5.900 a	6.200 a	6.267 a
T_5	T_2 + 10% extra	4.667	4.700 ab	4.900 b	5.233	5.400 b	5.500 c	5.900 e
	S.E. (m) ±	0.0453	0.057	0.0236	0.0357	0.0641	0.0853	0.0650
	C D at 5%	N.S.	0.187	0.0769	0.1166	0.2091	0.2782	0.2119
	G.M.	4.600	4.727	5.040	5.347	5.573	5.733	6.007
	C.V.%	1.730	2.098	0.810	1.58	1.993	2.577	1.874

(Means with similar superscript/s in column do not differ significantly)

Ramkrishna (2003) observed non-significant difference among the most of blood chemical constituents under different management conditions. These observations do not agree with present trend as TSP values differ significantly between feeding groups. Beside this, Patil *et al.* (2000) opined that total serum protein increased up to 12 months of age in Gir calves and 9 months of age in crossbred calves. The increase in TSP was the indication of earlier physiological maturity in crossbred calves over Gir calves. It is pointed out that the calves in present study had age between 9 to 12 months and therefore on the basis of their logic the calves reared on complete diet – I with 45 per cent cotton straw (T_1) may attain physiological maturity earlier than the calves fed with conventional diet.

The calves reared on complete diet had significantly more level of TSP and plasma glucose than that of calves maintained on conventional diet. The levels of TSP and plasma glucose at the end of the trials were 6.467 gm dl^{-1} and 59.900 mg dl^{-1} in calves fed with complete diet – I with 45 per cent cotton straw. The corresponding values of the calves maintained on conventional diet were 5.367 gm/dl and 51.600 mg/dl respectively. Thus the results indicated that the calves were in normal health without any adverse influence of feeding complete diet containing cotton straw as roughage. On the other hand the increased values of TSP were the indication of possibility of earlier physiological maturity in crossbred calves fed with complete diet.

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