VOL. 25 NO. 1 JANUARY 2001

ISSN 0378-813 X

PKV RESEARCH JOURNAL

DR. PANJABRAO DESHMUKH KRISHI VIDYAPEETH,
(AGRICULTURAL UNIVERSITY)
AKOLA (MAHARASHTRA) INDIA

Dr. PANJABRAO DESHMUKH KRISHI VIDYAPEETH, AKOLA

RESEARCH JOURNAL

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Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola

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Relationship Between Forms of Sulphur and Yield Under Long Term Fertilization to Sorghum-Wheat Sequence on Vertisol

R.D. Muramkar[1], S.D. Zadode[2], H.N. Ravankar[3] and R.T. Patil[4]

ABSTRACT

An investigation was superimposed during 1998-99 on the long term experiment conducted at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola to study the relationship between forms of Sulphur and yield under long term manuring and fertilization to sorghum-wheat sequence on vertisol. Application of 100 per cent NPK alongwith 10 t FYM ha^{-1} was most significant treatment followed by 150 per cent NPK in respect to yield. The total S, organic S, sulphate S and adsorbed S, were found to be in higher amounts in 100 per cent NPK + 47.5 kg S ha^{-1} through gypsum. All the fractions except non-sulphate S were highly correlated with each other, S uptake and grain yield of sorghum. Use of S containing P fertilizer was significantly superior to S free.

Long-term of manure and fertilizer is known for maintaining productivity and soil fertility. Sulphur deficiency in crops is gradually becoming widespread in different soils particularly under intensive agriculture in several states of India. A knowledge of forms of sulphur and its relationship is essential for improving sulphur nutrition of crops. Long term fertilizer experiments usually provide the best practical test of sustainability of a crop management practices (Nambiar, 1994).

The complex problems of soil fertility management can only be studied by long-term field trials as it takes time for the crops, crop rotations, fertilizers and manures to have a reasonable effect on soil fertility. Hence present investigation was carried out after ten complete cycles to evaluate the S status of soil as influenced by various treatment conbinations.

MATERIAL AND METHODS

The present study was superimposed during 1998-99 on field experiment. "Monitoring long term changes in soil fertility and crop yield in sorghum-wheat sequence on vertisol", which been initiated since 1988 on the farm of Deptt. of Agril. Chemistry and Soil Science, Central Research Station, Dr. PDKV, Akola. The experiment was laid out in RBD with fourteen treatments replicated four times. The soil of experimental area was clay in texture, montmorillonitic type, isohyperthermic family of Typic Haplusterts. The treatment details are given in every table.

Plot wise surface (30 cm) soil samples were collected before sowing of sorghum. The soil samples were processed (<2 mm) and pH, EC, total N, available P ad K were determined as per standard methods described by Jackson 1967. The total S was estimated by using diacid extract (Chesnin and Yein, 1950). Organic S was determined by digesting soil with hydrogen peroxide and extraction with 1 per cent NaCl (Evans and Rost, 1945). Sulphate S was extracted with 0.15 per cent $CaCl_2$ (Palaskar and Ghose, 1982). Adsorbed S was extracted with 500 ppm P solution of KH_2PO_4 (Ensminger, 1954). Non Sulphate S was calculated by subtracting organic S and sulphate S from total S. Water soluble S was extracted as per the method given by Piper 1966. In all cases sulphur was determined turbidimentrically (Chesnin and Yein, 1950).

RESULTS AND DISCUSSION

The data pertaining to fertility status of soil is presented in Table 1. The availability of nutrients were highest in the treatment where 100 per cent NPK + 10 t FYM (T_{11}) was applied. It may be because of improvement in soil microbial activity, chelation etc. In general the nutrient availability seems to be improved with the application of sulphur and particularly application of S through S containing P fertilizer over the S free one. Similar the application of S and Zn improved their availability in the soil.

The grain and straw yield of sorghum was significantly affected due to various treatments with highest grain and fodder yield of sorghum to the extent of 40. 7 q ha^{-1} and 123.67 q ha^{-1} respectively at 100 per cent NPK + 10 t FYM (T_{11}) followed by 150 per cent NPK level (37.59 and 109.54 q ha^{-1}). The 100 per cent NPK + 10 t FYM (T_{11}) was significantly superior over 100 per cent NPK (T_4) alone and

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Table 1. Fertility status of soil before sowing of sorghum as under various treatments

Treatments		pH	Organic carbon (%)	Total nitrogen (%)	Available phosphorus (kg ha^{-1})	Available potassium (kg ha^{-1})
T_1	Control	7.83	0.308	0.0392	12.03	379.6
T_2	50 % NPK	7.86	0.528	0.0424	17.18	487.1
T_3	75% NPK	7.81	0.591	0.0445	22.34	517.4
T_4	100% NPK	7.89	0.611	0.0500	32.65	564.4
T_5	150% NPK	7.92	0.658	0.0520	40.39	624.8
T_6	100% N	7.91	0.490	0.0479	13.75	417.6
T_7	100% NP	7.87	0.583	0.0493	22.50	450.2
T_8	100 % NPK + 10 kg S ha^{-1} through gypsum	7.78	0.567	0.0508	25.78	511.7
T_9	100 % NPK + 10 kg $ZnSO_4$ ha^{-1}	7.83	0.585	0.0494	22.20	481.4
T_{10}	100 % NPK (S free)	7.92	0.596	0.0489	24.91	541.9
T_{11}	100 % NPK + 10 t FYM ha^{-1}	7.95	0.783	0.0581	44.69	692.1
T_{12}	10 t FYM ha^{-1}	7.82	0.703	0.0482	21.48	444.50
T_{13}	100% NPK + 47.5 kg S ha^{-1} through gypsum	7.75	0.567	0.0575	23.22	484.7
T_{14}	100% NPK + 20 kg $ZnSO_4$ ha^{-1}	8.01	0.533	0.0511	25.78	481.4
	SE m±	0.061	0.016	0.0064	1.970	11.65
	CD at 5%	0.172	0.049	0.0018	6.079	35.91

Table 2. Yield of sorghum and wheat (q ha^{-1}) as affected by various treatments

Treatments		Sorghum		Wheat	
		Grain	Fodder	Grain	Straw
T_1	Control	4.06	13.93	1.67	3.05
T_2	50 % NPK	13.22	43.94	13.20	24.30
T_3	75% NPK	21.22	62.29	16.53	29.97
T_4	100% NPK	28.23	81.70	26.63	48.88
T_5	150% NPK	37.59	109.54	35.71	64.73
T_6	100% N	17.06	47.66	11.54	21.34
T_7	100% NP	22.29	66.61	18.48	33.96
T_8	100 % NPK + 10 kg S ha^{-1} through gypsum	29.20	87.73	26.70	49.20
T_9	100 % NPK + 10 kg $ZnSO_4$ ha^{-1}	30.47	87.77	25.61	47.35
T_{10}	100 % NPK (S free)	26.51	77.50	25.08	45.92
T_{11}	100 % NPK + 10 t FYM ha^{-1}	40.70	123.67	41.78	77.00
T_{12}	10 t FYM ha^{-1}	8.72	28.60	4.08	6.78
T_{13}	100% NPK + 47.5 kg S ha^{-1} through gypsum	31.16	93.45	27.63	51.05
T_{14}	100% NPK + 20 kg $ZnSO_4$ ha^{-1}	33.29	105.35	27.20	50.23
	SE m±	0.965	1.897	0.544	0.951
	CD at 5%	2.300	4.524	1.297	2.268

increased grain yield by 44 per cent indicating the cumulative effect of and better fertilizer efficiency due to combined use of fertilizer and FYM. Sulphur application through SSP at 100 per cent NPK (T_4) level increased grain yield by 6.5 per cent over 100 per cent NPK S free (T_{10}), whereas no significant effect was noted on the fodder yield of sorghum. The results were confirmity with findings of Singh (1983).

The grain and straw yield of wheat was also higher (41.78 q ha^{-1} and 77 q ha^{-1} respectively) in the treatment 100 per cent NPK + 10 t FYM (T_{11}) followed by 150 per cent NPK level (T_5) (35.71 and 64.73 q

Table 3. Forms of sulphur (ppm) before sowing of sorghum

Treatments		Total S	Organic S	Sulphate S	Non sulphate S	Water soluble S	Adsorbed S
T_1	Control	299.25	91.75	36.37	171.12	20.32	40.12
T_2	50 % NPK	346.25	112.75	43.62	190.37	39.50	42.25
T_3	75% NPK	394.50	128.00	48.50	218.00	45.32	47.75
T_4	100% NPK	444.50	176.50	59.50	208.50	50.32	59.45
T_5	150% NPK	601.50	321.75	75.25	204.50	61.75	77.75
T_6	100% N	290.50	97.75	36.00	156.25	44.75	40.00
T_7	100% NP	363.75	161.25	53.65	148.85	41.65	55.87
T_8	100 % NPK + 10 kg S ha^{-1} through gypsum	576.25	333.25	67.50	175.50	61.32	72.75
T_9	100 % NPK + 10 kg $ZnSO_4$ ha^{-1}	506.75	309.50	62.25	136.50	50.82	68.87
T_{10}	100 % NPK (S free)	247.00	119.00	32.65	94.70	20.15	40.75
T_{11}	100 % NPK + 10 t FYM ha^{-1}	540.00	240.00	68.00	232.00	52.02	72.00
T_{12}	10 t FYM ha^{-1}	233.75	109.75	38.00	86.00	20.17	41.00
T_{13}	100% NPK + 47.5 kg S ha^{-1} through gypsum	608.25	364.00	77.50	166.75	73.82	80.50
T_{14}	100% NPK + 20 kg $ZnSO_4$ ha^{-1}	559.00	330.75	74.15	154.10	55.65	77.12
	SE m±	3.133	0.917	2.699	4.259	3.232	1.066
	CD at 5%	7.47	2.18	6.63	10.15	7.70	2.54

Table 4. Correlation of forms of sulphur (before sowing of sorghum) with grain yield and total S uptake by sorghum and wheat

	Sorghum yield	Wheat yield	Total S uptake by sorghum	Total S uptake by wheat
Total S	0.8068**	0.7758**	0.8492**	0.8129**
Organic S	0.7659**	0.7144**	0.7886**	0.7504**
Sulphate S	0.8104**	0.7708**	0.8432**	0.8060**
Non sulphate S	0.3860	0.4265	0.5450*	0.4428
Water soluble S	0.7367**	0.6822**	0.7667**	0.7039**
Adsorbed S	0.8356**	0.7991**	0.8699**	0.8383**

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

ha^{-1}). Sulphur application @ of 47.5 kg ha^{-1} entirely through gypsum (T_{13}) increased the grain yield by 3.4 per cent as compared to the same quantity of S when applied partly through gypsum and partly through SSP at similar NPK level (T_8). The similar trend was also found by Aulakh (1989).

The highest value of total S (608.25 ppm), organic-S (364.00 ppm), sulphate S (77.50 ppm), water soluble S (73.82 ppm), adsorbed S (80.50 ppm) was noted in treatment 100 per cent NPK + 47.5 kg S ha^{-1} (T_{13}). The non-sulphate fraction was highest in treatment 100 per cent NPK + 10 t FYM ha^{-1} (T_{11}). Application of FYM @ 10 t ha^{-1} in combination with 100 per cent NPK (T_{11}) showed an increase in total S and organic S by 21.4 per cent and 35 per cent, respectively over that of 100 per cent NPK (T_4) alone. P applied through SSP increased total S by 79.9 per cent over that of sulphur free treatment (T_{10}). Application of 10 and 20 kg $ZnSO_4$ in combination with 100 per cent NPK resulted 14 per cent and 25 per cent increase in total S and 75.3 per cent and 87.3 per cent increase in organic S, respectively, indicating synergistic effect of zinc with sulphur. Application of sulphur @ 47.5 S ha^{-1} (T_{13}) entirely through gypsum showed significant increase of 14.8 per cent in sulphate S over that of 100 per cent NPK + 10 kg S ha^{-1} through gypsum (T_8). The 100 per cent NPK level through SSP which supplied 37.5 kg S ha^{-1} increased the water soluble S by 30 ppm over that of S free treatment.

The application of zinc increased the adsorbed S and the higher dose being superior over lower one. Close examination of data reveals that the application of S through gypsum (T_{13}) was superior over S through SSP (T_8). The treatment 100 per cent NPK

(SSP, T_4) noted an increase in adsorbed S by 18.7 ppm over 100 per cent NPK (S free, T_{10}).

All fractions of sulphur except non-sulphate were signficantly and highly correlated with each other (Table 5). Similarly the S uptake and grain yield of sorghum and wheat were also highly and significantly correlated with fraction (Table 4).

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PKV Res. J. Vol. 25 (1) : 2001

Impact of Long Term Fertilization to Sorghum-Wheat Sequence in Vertisol on Distribution of Sulphur

R.D. Muramkar[1], S.D. Zadode[2], H.N. Ravankar[3] and R.T. Patil[4]

ABSTRACT

An investigation was superimposed during 1998-99 on the long term experiment conducted at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola to study the effect of long term fertilization on distribution of sulphur in sorghum-wheat sequence on vertisol. Highest content of total S, organic S, sulphate S, water soluble S and adsored S were noted in 100 per cent NPK + 47.5 kg S ha^{-1} through gypsum before sowing of sorghum as well as after harvest of sorghum and wheat. The use of S containing fertilizer was superior over S free. All the fractions of S except non-sulphate S were highly correlated with each other before sowing of sorghum and after harvest of sorghum, whereas all correlations including non-sulphate S significantly correlated with each other after harvest of wheat.

Distribution of different forms of sulphur and their interrelationship with some important soil characteristics decides the sulphur supplying capacity of soil by influencing its release and dynamics in soils. Cultivation of high yielding varieties of crops particularly the cereals in multiple cropping system and use of non sulphur containing fertilizers results in exhaustion of soil sulphur. A knowledge of the forms of sulphur in soils and their distribution helps in managing the sulphur nutrition of crops. The present investigation was carried out with a view to study the S fractions as influenced by long term fertilizer application.

MATERIAL AND METHODS

The present study was superimposed in 1998-99 on field experiment "Monitoring Long Term Changes in Soil Fertility and Crop Yield in Sorghum-Wheat Sequence" initiated since 1988 at Department of Agricultural Chemistry and Soil Science, Dr. PDKV, Akola. The experiment was laid out in RBD with fourteen treatments replicated four times. The soil of experimental area is clay in texture, montomorillonitic type, isohyperthermic family of Typic Haplusterts. The treatments details are given in every table.

The surface (30 cm) soil samples from each plot were collected before sowing of sorghum and after harvest of sorghum and wheat. The total S was estimated by using diacid (HNO_3-$HCLO_4$) extract (Chesnin and Yien, 1961). Organic S was determined by digesting the soil with hydrogen peroxide and extraction with 1 per cent NaCl (Evans and Rost 1945). Adsorbed S was extracted with 500 ppm P solution of KH_2PO_4 (Ensminger 1954). Water soluble S was extracted as per the method given by Piper (1966). Non sulphate S was worked out by subtracting organic and sulphate S from total S (Virmani and Kanwar, 1971).

RESULTS AND DISCUSSION

Distribution of sulphur before sowing of sorghum :

The data pertaining to various fractions of S before sowing of sorghum is given in Table 1. The highest value of total S (608.25 ppm), organic S (364.00 ppm), sulphate S (77.50 ppm), water soluble S (73.82), adsorbed S (80.50 ppm) was noted in treatment 100 per cent NPK + 47.5 kg S ha^{-1} (T_{13}). Application of FYM @ 10 tonnes ha^{-1} in combination with 100 per cent NPK (T_{11}) showed an increase in total S and organic S by 21.4 per cent and 35 per cent, respectively, over that of 100 per cent NPK alone (T_8). P applied through SSP (T_4) increased total S by 79.97 per cent over that of S free treatment (T_{10}). Similar trend was also found by Tanawade *et al.*, (1976).

Application of 10 and 20 kg $ZnSO_4$ in combination with 100 per cent NPK increased the total S by 14 and 25 per cent and organic S by 75 per cent and 87 per cent over 100 per cent NPK (T_2) respectively, indicating synergistic effect of zinc.

Application of sulphur @ 47.5 kg S ha^{-1} entirely through gypsum (T_{13}) showed a significant increases of 14.81 per cent in sulphate S over that of 100 per cent NPK + 10 kg S ha^{-1} through gypsum (T_8). The 100 per cent NPK level through SSP (T_4) which supplied 37.5 kg S ha^{-1} recorded an increase of about 30 ppm in water soluble S content over that of S free treatment (T_{10}), whereas 100 per cent NPK + 47.5 kg S ha^{-1} (T_{13}) increased the water soluble S by 12.5 ppm

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Table 1. Forms of sulphur (ppm) before sowing of sorghum

Treatments		Total S	Organic S	Sulphate S	Non sulphate S	Water soluble S	Adsorbed S
T_1	Control	299.25	91.75	36.37	171.12	20.32	40.12
T_2	50 % NPK	346.25	112.75	43.62	190.37	39.50	42.25
T_3	75% NPK	394.50	128.00	48.50	218.00	45.32	47.75
T_4	100% NPK	444.50	176.50	59.50	208.50	50.32	59.45
T_5	150% NPK	601.50	321.75	75.25	204.50	61.75	77.75
T_6	100% N	290.50	97.75	36.00	156.25	44.75	40.00
T_7	100% NP	363.75	161.25	53.65	148.85	41.65	55.87
T_8	100 % NPK + 10 kg S ha^{-1} through gypsum	576.25	333.25	67.50	175.50	61.32	72.75
T_9	100 % NPK + 10 kg $ZnSO_4$ ha^{-1}	506.75	309.50	62.25	136.50	50.82	68.87
T_{10}	100 % NPK (S free)	247.00	119.00	32.65	94.70	20.15	40.75
T_{11}	100 % NPK + 10 t FYM ha^{-1}	540.00	240.00	68.00	232.00	52.02	72.00
T_{12}	10 t FYM ha^{-1}	233.75	109.75	38.00	86.00	20.17	41.00
T_{13}	100% NPK + 47.5 kg S ha^{-1} through gypsum	608.25	364.00	77.50	166.75	73.82	80.50
T_{14}	100% NPK + 20 kg $ZnSO_4$ ha^{-1}	559.00	330.75	74.15	154.10	55.65	77.12
	SE m±	3.133	0.917	2.699	4.259	3.232	1.066
	CD at 5%	7.47	2.18	6.63	10.15	7.70	2.54

Table 2. Forms of sulphur (ppm) after harvest of sorghum

Treatments		Total S	Organic S	Sulphate S	Non sulphate S	Water soluble S	Adsorbed S
T_1	Control	293.25	119.00	23.82	150.42	9.40	27.87
T_2	50 % NPK	310.50	128.00	41.65	140.85	10.40	43.50
T_3	75% NPK	365.00	158.25	49.62	157.12	11.45	54.00
T_4	100% NPK	488.75	255.50	53.87	179.37	20.70	59.62
T_5	150% NPK	567.00	353.50	63.50	150.00	55.32	72.37
T_6	100% N	307.75	128.00	26.50	152.62	18.50	30.87
T_7	100% NP	390.75	227.75	50.25	112.75	20.67	56.00
T_8	100 % NPK + 10 kg S ha^{-1} through gypsum	574.50	343.75	58.82	171.92	57.82	62.37
T_9	100 % NPK + 10 kg $ZnSO_4$ ha^{-1}	520.75	300.50	54.50	167.75	42.17	61.12
T_{10}	100 % NPK (S free)	275.75	125.00	23.65	127.10	7.57	28.37
T_{11}	100 % NPK + 10 t FYM ha^{-1}	507.25	257.00	63.50	186.75	29.32	68.62
T_{12}	10 t FYM ha^{-1}	325.00	112.75	33.15	179.10	8.02	37.62
T_{13}	100% NPK + 47.5 kg S ha^{-1} through gypsum	605.75	380.50	66.50	158.75	56.20	74.25
T_{14}	100% NPK + 20 kg $ZnSO_4$ ha^{-1}	555.75	321.75	60.02	173.97	47.82	68.62
	SE m±	2.744	2.657	2.329	4.528	0.820	1.672
	CD at 5%	6.54	6.33	5.55	10.79	1.95	3.98

over that of 100 per cent NPK (SSP) + 10 kg S ha^{-1} (T_8). The treatment 100 per cent NPK (T_4) noted an increases of 18.7 ppm in adsorbed over 100 per cent NPK (S free, T_{10}).

Distribution of sulphur after harvest of sorghum :

The data pertaining to various fractions of S after harvest of sorghum are presented in Table 2. The highest values of total S (605.75), organic S (380.50 ppm) and adsorbed S (74.25 ppm) were noted in 100 per cent NPK + 47.5 kg S ha^{-1} (T_{13}), whereas non sulphate S (186.75 ppm) and water soluble S (57.82 ppm) was highest in the treatment 100 per cent NPK + 10 t FYM ha^{-1} (T_{11}) and 100 per cent NPK + 10 kg S

Table 3. Forms of sulphur (ppm) after harvest of wheat

Treatments		Total S	Organic S	Sulphate S	Non sulphate S	Water soluble S	Adsorbed S
T_1	Control	261.25	152.25	27.65	80.85	21.17	32.00
T_2	50 % NPK	316.25	167.25	31.12	117.87	34.77	37.25
T_3	75% NPK	372.00	188.50	36.15	147.35	41.62	43.50
T_4	100% NPK	474.25	235.50	53.00	185.75	48.07	59.00
T_5	150% NPK	572.00	309.50	64.57	198.05	58.07	70.12
T_6	100% N	256.00	158.25	29.90	67.85	34.12	35.50
T_7	100% NP	441.25	206.25	53.62	181.37	35.62	59.37
T_8	100 % NPK + 10 kg S ha^{-1} through gypsum	554.50	317.50	57.50	179.50	56.65	64.25
T_9	100 % NPK + 10 kg $ZnSO_4$ ha^{-1}	513.75	279.25	55.75	178.75	50.25	60.37
T_{10}	100 % NPK (S free)	230.75	143.00	23.40	64.35	19.82	32.75
T_{11}	100 % NPK + 10 t FYM ha^{-1}	500.75	257.00	59.12	184.62	50.06	63.12
T_{12}	10 t FYM ha^{-1}	259.75	158.25	28.70	72.80	20.82	34.25
T_{13}	100% NPK + 47.5 kg S ha^{-1} through gypsum	597.00	348.15	74.65	173.60	63.52	76.62
T_{14}	100% NPK + 20 kg $ZnSO_4$ ha^{-1}	543.75	310.00	59.00	174.75	55.97	67.12
	SE m±	3.801	2.062	1.184	4.047	0.802	1.501
	CD at 5%	9.06	4.91	2.82	9.65	1.91	3.58

Table 4. Correlation between different forms of sulphur before sowing of sorghum

	Total S	Organic S	Sulphate S	Non-sulphate S	Water soluble S	Adsorbed S
Total S	1	0.9388**	0.9777**	0.5150	0.9163**	0.9708**
Organic S		1	0.9409**	0.1898	0.8391**	0.9676**
Sulphate S			1	0.4315	0.8935**	0.9885**
Non-sulphate S				1	0.5233	0.3493
Water soluble S					1	0.8675**
Adsorbed S						1

Table 5. Correlation between different forms of sulphur after harvest of sorghum

	Total S	Organic S	Sulphate S	Non-sulphate S	Water soluble S	Adsorbed S
Total S	1	0.9823**	0.9227**	0.4693	0.9430**	0.9434**
Organic S		1	0.8936**	0.3043	0.9571**	0.9207**
Sulphate S			1	0.3842	0.7920**	0.9964**
Non-sulphate S				1	0.3010	0.3783
Water soluble S					1	0.8252**
Adsorbed S						1

Table 6. Correlation between different forms of sulphur after harvest of wheat

	Total S	Organic S	Sulphate S	Non-sulphate S	Water soluble S	Adsorbed S
Total S	1	0.9697**	0.9780**	0.9357**	0.9547**	0.9855**
Organic S		1	0.9491**	0.8230**	0.9490**	0.9548**
Sulphate S			1	0.9003**	0.9238**	0.9946**
Non-sulphate S				1	0.8642**	0.9137**
Water soluble S					1	0.9305
Adsorbed S						1

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

ha^{-1} (T_8) respectively. The treatment 100 per cent NPK (containing S) was significantly superior over 100 per cent NPK (S free, T_{10}) and showed a significant increase in all S fractions over S free treatment.

The treatment 100 per cent NPK + 20 kg $ZnSO_4$ ha^{-1} (T_{14}) showed 6.60 per cent increase in organic S fraction over 100 per cent NPK + 10 kg $ZnSO_4$ ha^{-1} (T_9).

Distribution of sulphur after harvest of wheat :

The data pertaining to various sulphur after harvest of wheat (Table 3) indicates the highest values of total S (597.00 ppm), organic S (348.75 ppm), sulphate S (74.65 ppm), water soluble S (63.52 ppm), adsorbed S (76.62 ppm) were noted in treatment 100 per cent NPK + 47.5 kg S ha^{-1} (T_{13}). The non sulphate S was highest in 150 per cent NPK level (T_5). The treatment 100 per cent NPK (T_4) (containing S) was found to be superior over that of 100 per cent NPK (S free, T_{10}) exhibiting significant increase in all S fractions. The treatment 100 per cent NPK + 47.5 kg S ha^{-1} (T_{13}) was significantly superior over 100 per cent NPK (SSP) + 10 kg S ha^{-1} (T_8) showing an increase in organic S, sulphate S, water soluble S and adsorbed S by 9.84 per cent, 29.82 per cent, 12.82 per cent and 19.25 per cent, respectively indicating the significance of gypsum over SSP.

The 100 per cent NPK + 20 kg $ZnSO_4$ ha^{-1} (T_{14}) level was significantly superior over 100 per cent NPK + 10 kg $ZnSO_4$ ha^{-1} (T_9) showing significant increase in total S, water soluble S, organic S, sulphate S and adsorbed S.

The treatment 100 per cent NPK + 47.5 kg S ha^{-1} (T_{13}) was significantly superior over all other treatments in respect of all S fractions except non sulphate S which was highest in 150 per cent NPK (T_5).

Correlation :

All the fractions of S except non-sulphate S were highly correlated with each other before sowing of sorghum and after harvest of sorghum, whereas all correlations including non-sulphate S were significantly with each other after harvest of wheat.

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PKV Res. J. Vol. 25 (1) : 2001

Characterization and Classification of Soils of Varkhed Watershed in Akola District of Vidarbha Region of Maharashtra

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ABSTRACT

Eight pedons of Varkhed watershed in Akola district of Vidarbha region of Maharashtra were studied to characterise and classify the soils of watershed area. The soils, in general, were shallow to deep, non to slightly eroded to severely eroded, well to moderately well drained, gravelly clay to clay in texture, slightly acidic to moderately alkaline in reaction, low to moderately high in organic carbon content with calcium as the dominant cation among the major exchangeable cations. The ESP of soils was less than 0.37, indicating that these soils are free from sodicity. The bulk density of soils ranged from 1.06 to 1.28 Mg m^{-3} and the hydraulic conductivity was 0.08 to 0.91 cm hr^{-1} and it decreased with increase in clay content. These soils were classified as Typic Ustorthents, Vertic Ustochrepts and Typic Haplusters, based on the variations in their morphological and physico-chemical properties, as per the guidelines in Keys to Soil Taxonomy.The basic data obtained in present investigation may be useful to suggest the capability and suitability of soils for obtaining the potential yields on a sustainable basis.

The ever increasing demand for food to feed the growing population of the country calls for a rational use of finite soil and water resources so as to ensure towards increased and sustainable agricultural production. One of the most scientific and efficient ways to achieve this is by adopting watershed based land use planning approach.

Watershed management has been defined as rational utilization of land and water resources for optimum and sustained production with minimum hazards to natural resources. It essentially relates to the soil and water conservation and leads to proper land use as per the capability or suitability of soils, protection of land against degradation, maintenance of soil fertility and increasing productivity from all land uses.

At present there is an extreme inadequancy of basic data or resources for preparation of scientifically sound watershed development plans. Keeping in view the importance of basic data of soils and site characteristics, the present investigation was undertaken in the Varkhed watershed of Akola district in Vidarbha region of Maharashtra.

MATERIAL AND METHODS

The Varkhed watershed is about 32 km south east of Akola and 12 km from Barshitakli township. It extends from 77°7'00" to 77°10'00" E longitudes and 20°32'30" to 20°35'00" N latitudes, covering an area of about 198 ha. The relief ranges from 320 to 340 m above MSL with mean elevation of 325 m above MSL. Physiographically the watershed area is very gently sloping to gently sloping undulating landscape with the average slope of 1-3 per cent (class - B). The drainage pattern of the area is dendritic with moderately well to well drained soils. The geological formations in the area include the deccan traps with intertrappean beds of cretaceous eocene period. The geology of the area comprises predominantly of volcanic rocks, which consists chiefly of basalt.

Agro-ecologically the watershed area lies in 10.3 (K_5 DM_4) subregion (Eastern Maharashtra, plateau, hot moist semi arid with medium and deep clayey black soils, medium to high available water capacity and LGP 120-150 days). The climate is semi - arid monosoonic characterized by three distinct seasons viz. *summer* with hot and dry weather from March to May; monsoon, warm and rainy from June to October and winter, dry mild from November to February. The average annual rainfall is about 825 mm and mean annual maximum and minimum temperatures are 34.2 and 19.2°C respectively. The temperature regime is hyperthermic and soil moisture regime is ustic.

The major three species observed in the area are *Acacia arabica* (Babool), *Azadirachta indica* (Neem), *Butea frondosa* (Palas) and the dominant crops grown are cotton, sorghum, pigeonpea etc.

The detailed soil survey of the watershed area was carried out with the help of survey of India toposheet (1:50,000) and a cadastral map (1:10,000). After traversing the area, based on variations in soil-site characteristics, eight typifying pedons were identified and described (Soil Survey Staff, 1951). Horizonwise soil samples were collected and the processed soil samples (< 2 mm) were analysed for

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various physico-chemical properties following standard methods (Black, 1965, Jackson, 1966). Soils were classified using standard technique (Soil Survey Staff, 1998). In the present study, the land capability classification has been done upto capability class and subclass levels based on kind and degree of limitations which provide the information about the degree of limitations and kinds of problems involved to plan cropping pattern and conservation measures.

RESULTS AND DISCUSSION

Morphological characteristics :

The morphological characteristics of the soils (Table 1) showed that most of the soils were shallow to deep with colour in the hue 10 YR, value ranging from 3 to 4 and chroma of 1 to 3. The data presented in Table 1 indicate that the soils were very dark grayish brown to dark brown in colour. The surface soils had subangular blocky structure while pedons 7 & 8 had well developed angular blocky structure in subsurface horizons. In addition to angular blocky structure, the vertisols (pedon 8) showed well developed intersecting slickensides. This slickensided zone had wedge shaped structural aggregates and angular blocky structure. This may be due to the swell - shrink phenomenon of smectitic clay observed in such soils resulting in the development of slickensides (Ahmad, 1983).

Physical characteristics :

From the data presented in Table 2, it is observed that most of the soils were clay in texture, with clay content ranging from 49.68 to 70.34 per cent and it increased with depth in all the pedons except AC horizons. Similar trend of gradual increase in clay content with depth was also observed by Puranik *et al.*, (1972).

The silt content of the different soils under study from 23.42 to 33.16 per cent. The sand content in general was less than 20 per cent. The bulk density of soils ranged from 1.05 to 1.28 Mgm^{-3} and the hydraulic conductivity ranged from 0.08 to 0.91 $cmhr^{-1}$ and it decreased with depth. The slightly higher values of hydraulic conductivity at surface layers might be because of porous nature as a result of continuous tillage operations and comparatively higher organic matter status. The gravimetric water retention of soils at 33 kPa and 1500 kPa tension varied from 18.32 to 33.99 and 9.22 to 16.76 per cent respectively and the available moisture content in soils ranged from 8.71 to 17.23 per cent. In general, the moisture content was higher in subsurface horizon as compared to the surface horizon.

The soils were slightly acidic to moderately alkaline in reaction (pH 6.51 to 7.91). In general pH of the soils increased with depth. The electrical conductivity (EC) of soils ranged from 0.15 to 0.36 dSm^{-1}, which is well with in the acceptable limit of EC range designated for normal soils (Richards, 1954) and it increased with depth in vertisols (pedon 8). This may be due to leaching of salts from the surface to the subsurface horizons through pedogenic processes. The organic carbon content of the soils varied from 0.42 to 0.69 per cent it decreased with depth. Calcium carbonate content of the soils ranged from 2.0 to 23.5 per cent and it increased with depth. This could possibly be due to the accumulation of displaced calcium from the exchange complex from the upper layer or due to the precipitation of $CaCO_3$. The soils were dominant in calcium followed by magnesium on the exchange complex, indicating the dominance of calcium bearing minerals in the parent rock. The exchangeable calcium varied from 31.20 to 41.82 cmol (p^+) kg^{-1} and exchangeable magnesium 9.60 to 12.88 cmol (p^+) kg^{-1}. The exchangeable sodium and potassium ranged 0.16 to 0.19 and 1.46 to 2.31 cmol ($p+$) kg^{-1}, respectively. The cation exchange capacity of soils varied from 43.72 to 59.57 cmol(p^+) kg^{-1}. Generally the soils which had lower amount of clay content had lowest CEC values. Since the CEC is the change behaviour of soils where clay is the fundamental block contributing towards its cation exchange, the high CEC of these black soils is attributed to its smectitic clay mineralogy (Pal and Deshpande, 1987). The soils exhibit slight variation in their per cent base saturation and it varied from 91.03 to 98.73 per cent (Table 3).

Taxonomical classification :

Soils were classified as per soil taxonomy (Soil Survey Staff, 1998) and in all the cases the mineralogy and temperature regime are montmorillonitic and hyperthermic respectively at the series level.

The soils of the Varkhed watershed area developed basically from basaltic rock, vary in depth,, colour, texture, structure, consistency and other morphological characteristics. The examination of soil profiles revealed different degree of weathering of relatively uniform parent material due to active influences of climate and topography. The effect of vegetation appears to be secondary. Based on the morphological characteristics, three soil series (VI to V3) and eight mapping units have been identified, classified and mapped.The details about the mapping units, taxonomical classification is presented in Table 4.

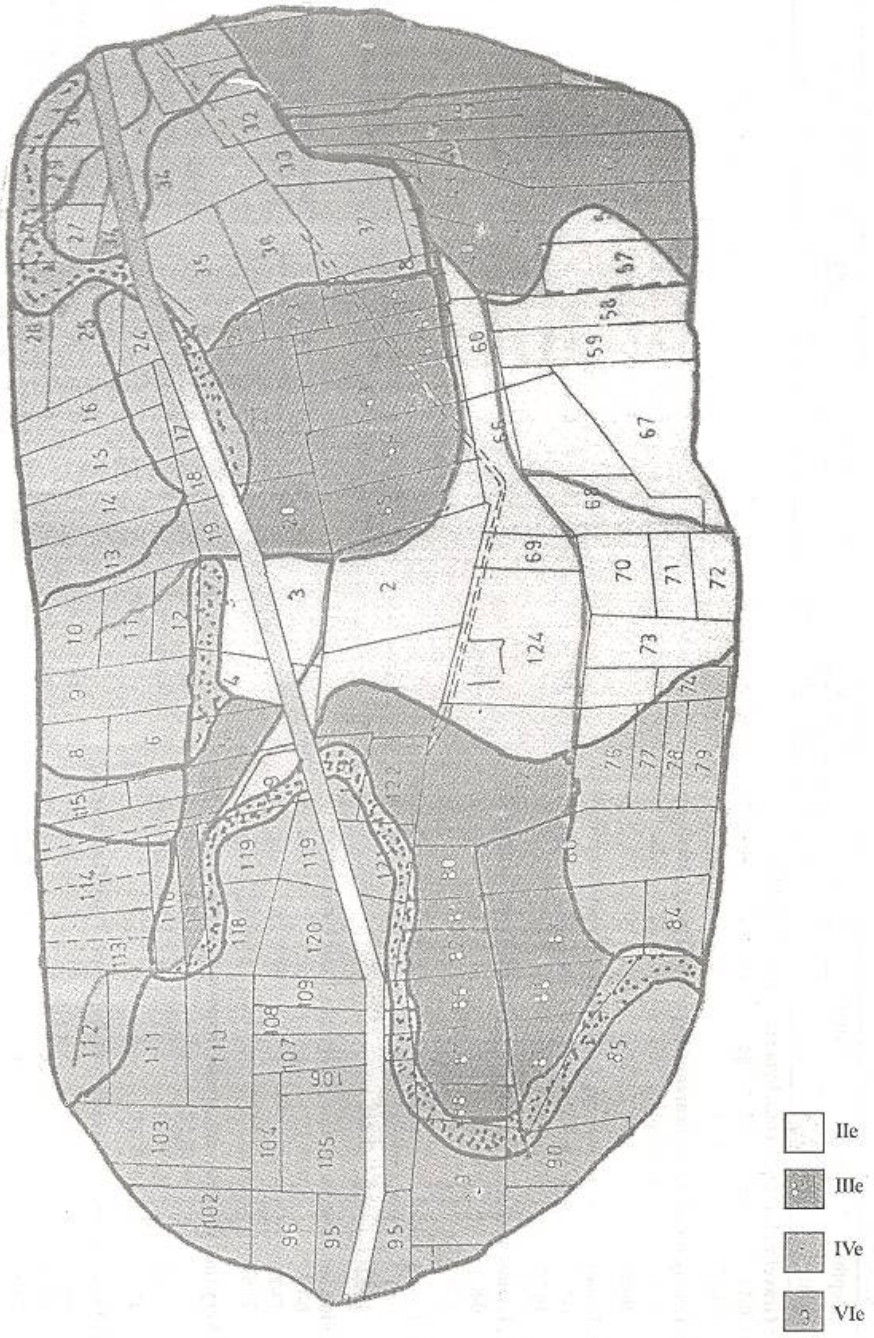

Fig. 1 Land capability classification of Varkhed watershed

Table 1. Morphological characteristics of the soil

Horizon	Depth (cm)	Munsell colour	Texture	Structure S	Structure G	Structure Ty	Consistence D	Consistence M	Consistence W	Effective cence	Roots S	Roots Q	Boundary D_1	Boundary Ty	Special features
Pedon P1 : Gravelly clay, calcareous, hypermic, Typic Ustorthents															
Ap	0-14	10 YR 4/2	gc	m	2	sbk	h	fr	sp	ev	f	c	c	s	
C	14-27	10 YR 4/3													
Pedon P2 : Loamy, mixed, non-calcareous, hypermic, Typic Ustorthents															
Ap	0-16	10 YR 3/4	cl	m	2	sbk	sh	fr	ssps	-	f	f	c	s	
Cr	16-30	10 YR 5/6													
Pedon P3 : Loamy, mixed, non-calcareous, hypermic, Typic Ustorthents															
Ap	0-19	10 YR 3/2	c	m	2	sbk	h	fr	sp	-	f	c	c	s	
Cr	19-37	10 YR 5/6													
Pedon P4 : Loamy, mixed, non-calcareous, hypermic, Typic Ustorthents															
Ap	0-8	10 YR 3/3	c	m	1	sbk	sh	fr	ssps	-	f	f	c	s	
Cr	8-29	7.5 YR 4/4													
Pedon P5 : Loamy, mixed, non-calcareous, hypermic, Typic Ustorthents															
Ap	0-11	10 YR 4/4	cl	m	2	sbk	h	fr	ssps	-	f	c	c	s	
Cr	11-32	7.5 YR 4/4													
Pedon 6 : Fine, smectitic, calcareous, hypermic, Typic Ustochrepts															
Ap	0-17	10YR 3/2	c	m	2	sbk	sh	fr	sp	es	m	c	c	s	Weathered calcic material
A	17-38	10 YR 3/2	c	m	2	sbk	h	fi	sp	es	f	c	a	w	in AC horizon
ACrk	38-67	10 YR 7/1								ev	f	f			
Pedon 7 : Very fine, smectitic, calcareous, hypermic, Vertic Ustochrepts															
Ap	0-19	10 YR 3/2	c	m	2	sbk	h	fi	sp	es	f	c	c	s	Cracks 1 cm wide upto 30
A	19-47	10 YR 3/1	c	m	2	abk	h	fi	vsvp	es	f	f	c	s	cm depth; pressure faces
ACrk	47-71	10 YR 7/2								ev					in B horizon
Pedon P8 : Very fine, smectitic, calcareous, hypermic, Typic Haplusterts															
Ap	0-17	10 YR 3/2	c	m	2	sbk	h	fi	sp	e	f	c	c	s	Cracks 1-2 cm wide upto
A	17-38	10 YR 3/2	c	m	2	sbk	h	fi	sp	e	f	c	c	s	75 cm depth; slickensides
Bss1	38-67	10 YR 3/1	c	m	2	abk	h	fi	vsvp	e	f	f	c	s	in IIIrd & IV th horizon.
Bss2	67-104	10 YR 3/1	c	m	2	abk	h	fi	vsvp	es	f	f	a	w	
BCk	104-115	10 YR 7/1								ev					

S - Size, G - Grade, Ty - Type, D - Dry, M - Moist, W - Wet, Q - Quantity, D_1 - Depth

Table 2. Physical characteristics of soils

Horizon	Depth (cm)	BD Mg m^{-3}	HC cm hr^{-1}	Sand (%)	Silt (%)	Clay (%)	Water retention		AWC (%)
							33 kPa	1500 kPa	
Pedon 1									
Ap	0-14	1.28	0.91	19.62	30.70	49.68	19.09	9.52	9.57
C	14-27								
Pedon 2									
Ap	0-16	1.26	0.49	15.94	30.06	54.00	19.48	9.88	9.60
Cr	16-30								
Pedon 3									
Ap	0-19	1.25	0.90	15.62	33.16	51.22	20.52	10.14	10.38
Cr	19-37								
Pedon 4									
Ap	0-8	1.28	0.48	14.50	32.06	53.44	18.32	9.22	9.10
Cr	8-29								
Pedon 5									
Ap	0-11	1.22	0.10	13.84	28.40	57.76	23.56	12.15	11.41
Cr	11-32								
Pedon 6									
Ap	0-17	1.18	0.33	8.26	27.40	64.34	23.41	11.56	11.85
A	17-38	1.30	0.08	7.50	26.40	66.10	29.59	14.63	14.96
ACrk	38-67	1.05	0.16	12.19	30.21	57.60	26.97	13.69	13.28
Pedon 7									
Ap	0-19	1.17	0.12	4.84	29.80	65.36	24.42	12.40	12.02
Bw	19-47	1.21	0.12	2.96	28.78	68.26	19.09	10.03	9.06
Ck	47-71								
Pedon 8									
Ap	0-17	1.18	0.49	7.60	29.68	62.72	22.53	13.82	8.71
A	17-38	1.19	0.15	7.18	26.06	66.76	25.21	14.37	10.84
Bss1	38-67	1.10	0.15	7.36	26.06	66.58	33.99	16.76	17.23
Bss2	67-104	1.06	0.12	6.24	23.42	70.34	26.59	12.40	14.19
BCk	104-115								

Table 3. Chemical characteristics of soils

Horizon	Depth (cm)	pH (1:2.5)	EC (dS m^{-1})	O.C. (%)	CaCO3 (%)	Exchangeable cations Ca	Mg	Na	K	CEC	BS	ESP
						[cmol (p+) kg^{-1}]						
Pedon 1												
Ap	0-14	6.98	0.20	0.53	2.2	38.42	9.60	0.16	1.59	51.90	95.89	0.31
C	14-27	7.14										
Pedon 2												
Ap	0-16	6.51	0.17	0.68	1.5	31.20	9.60	0.18	1.74	43.72	97.68	0.41
Cr	16-30											
Pedon 3												
Ap	0-19	6.7	0.23	0.67	3.2	34.21	10.80	0.17	1.59	49.14	95.18	0.35
Cr	19-37											
Pedon 4												
Ap	0-8	6.68	0.16	0.50	2.2	37.36	9.84	0.17	1.46	50.18	97.31	0.34
Cr	8-29											
Pedon 5												
Ap	0-11	7.92	0.20	0.66	2.0	36.84	11.76	0.17	2.08	53.29	95.42	0.33
Cr	11-32											
Pedon 6												
Ap	0-17	7.76	0.30	0.62	13.2	40.27	12.00	0.18	2.17	55.32	98.73	0.33
A	17-38	7.75	0.29	0.61	17.0	41.82	12.88	0.19	2.21	59.17	96.50	0.32
ACrk	38-67	7.72	0.25	0.25	22.0	39.41	10.56	0.19	1.67	54.92	94.37	0.34
Pedon 7												
Ap	0-19	7.37	0.21	0.53	20.7	39.72	12.44	0.19	2.31	56.72	96.37	0.34
Bw	19-47	7.49	0.36	0.46	23.0	40.69	11.04	0.20	2.28	57.10	94.94	0.35
Ck	47-71											
Pedon 8												
Ap	0-17	7.81	0.24	0.69	15.5	37.12	9.60	0.19	1.57	50.62	95.77	0.37
A	17-38	7.77	0.25	0.43	23.5	40.22	11.20	0.18	1.78	57.12	93.45	0.32
Bss1	38-67	7.75	0.28	0.49	7.5	40.32	10.56	0.18	1.99	58.64	91.03	0.30
Bss2	67-104	7.91	0.32	0.43	9.2	42.68	10.45	0.17	1.60	59.57	92.18	0.29
BCk	104-115											

Table 4. Taxonomical classification of soils

	Mapping unit	Taxonomical classification at family level	LCC
1.	V1-d2-gc-A-el	Gravelly clay, calcareous, mixed, hyperthermic family of Typic Ustorthents	IVes
2.	V1-d2-f-B-e2	Loamy, mixed, hyperhermic family of Typic Ustorthents	IVes
3.	V1-d2-f-C-e3	Loamy, mixed,hyperthermic family ot Typic Ustorthents	IVes
4.	V1-d2-m-A-el	Fine, smectitic, hyperthermic family of Typic Ustorthents	IVes
5.	V1-d2-m-B-e2	Fine, smectitic, hyperthermic family of Typic Ustorthents	IVes
6.	V2-d3-m-A-el	Fine, smectitic, calcareous, hyperthermic family of Typic Ustochrepts	IIIes
7.	V2-d4-m-A-el	Very fine, smectitic, calcareous, hyperthermic family of Vertic Ustochrepts	IIe
8.	V3-d5-m-A-el	Very fine, smectitic, calcareous,hyperthermic, family of Typic Haplusters	IIe

Land capability classification :

The results indicated that the soils of the Varkhed watershed are grouped into four capability classes viz. IIe, IIIes, IVes and VIes (Fig. 1), indicating that most of the soils are suitable for cultivation.

1. **Capability subclass IIe** :

The following units are included under this subclass.

Mapping units - V3-m-d5/A-el, V2-m-d4/A-el. These are deep to very deep soils on very gentle to gentle slopes subjected to water erosion. The main constraints are high clay content, slow to very slow permeability and compaction and hard setting.

2. **Capability subclass IIIes :**

(Mapping units -V2-m-d3/A-el). These are moderately deep to deep soils having clay to clay loamy texture, occurring on gentle slopes with moderate erosion and slow permeability.

3. **Capability subclass IVes :**

(Mapping unit - V1-m-d2/B-e2, V1-m-d2/A-el, V1-f-d2/B-e2 and V1-gc-d2/A-el). These are very shallow to shallow soils, gravelly clay to clay loam in texture and moderate medium subangular blocky in structure, occur on gentle slopes. These soils are moderately well drained to well drained. Shallowness, low water holding capacity and erosion hazards are the limitations of these soils.

4. **Capability subclass VIes :**

(Mapping unit - V1-f-d2/C-e3). These are very shallow soils with texture ranging from gravely clay to clay loam, occuring on scap slopes with very severe erosion hazards and are well drained. Low water holding capacity, shallowness, scarp slope and severe erosion hazards are the major limitations of these soils.

The capability classification, however, does not suggest the most profitable use of soils. The results obtained in the present investigation not only suggests the capability and the suitability of soils for crops but also helps in efficient soil based agro-technology transfer for better harvest of these crops on similar soils under similar agroclimatic conditions elsewhere on a sustainable basis.

ACKNOWLEDGEMENT

The authors are thankful to the National Agriculture Technology Project on "Land Use Planning for Management of Agricultural Resources," (NATP-LUP-MM-III-28) for prividing the funds.

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PKV Res. J. Vol. 25 (1) : 2001

Distribution of Organic Matter in Vertisols Under Long Term Fertilization to Sorghum-Wheat Cropping Sequence

H.N. Ravankar[1], Sujata Pothare[2], P.A. Sarap[3] and S.S. Hadole[4]

ABSTRACT

An investigation (2000-2001) was conducted on the long term fertilizer experiment started since 1988 at Dr. PDKV, Akola. There were 14 treatments comprised of NPK levels with and without FYM, S and Zn (replicated 4 times in RBD). The results indicated that the organic matter fractions are significantly affected by the treatments. Higher fulvic acid, humic acid and humin content were recorded with the application of 100 per cent NPK + 10 t FYM ha^{-1}. Higher values of all organic matter fractions were observed with the application of FYM alone over control. Further, it is observed that the ratio of organic matter fractions were also favourably influenced with the application of FYM indicating the significance of FYM in IPNS. The yield of crops was significantly correlated with organic matter and its fractions.

Soil organic matter is key to soil fertility and productivity. It includes plant and animal residues at various stages of decomposition, microbes and substances synthesized by soil population. Any change in organic matter content does have its own reprecussion on crop yield. Various fractions of organic matter have been isolated on the basis of solubility and named as humic acid, fulvic acid, humin and hymatomelonic acid (Kononova, 1966). The organic matter, many a times is classified as specific (humin substances) and non-specific (non-humid fractions) substances. Non-specific materials provide short range effects such as sources of food and energy for micro-organism. However, specific substances (humic fractions) provide long range effect such as maintaining CEC, buffering capacity and water holding capacities. Hence, an attempt has been made to study the effect of long term manuring and fertilization on organic matter and its fractions after 12 years of cropping.

MATERIAL AND METHODS

The present investigation was undertaken during the year 2000-2001 on the long term fertilization experiment started since 1988.There were fourteen treatments replicated four times in a randomised block design comprised of NPK levels with the without FYM, S and Zn as given in Table 1.

Table 1. Details of treatments

	Treatments	NPK (kg ha^{-1})		Fertilizer source
		Sorghum	Wheat	
T_1	Control	-	-	-
T_2	50% NPK	50:25:20	60:30:30	Urea, SSP, MOP
T_3	75% NPK	75:37.5:30	90:45:45	Urea, SSP, MOP
T_4	100% NPK	100:50:40	120:60:60	Urea, SSP, MOP
T_5	150% NPK	150:75:60	180:90:90	Urea, SSP, MOP
T_6	100% NPK (S free)	100:50:40	120:60:60	Urea, DAP, MOP
T_7	100% NPK + 10 kg S ha^{-1} (gypsum)	100:50:40	120:60:60	Urea, SSP, MOP
T_8	100% NPK + 47.5 Kg S ha^{-1} (gypsum)	100:50:40	120:60:60	Urea, DAP, MOP
T_9	100% NPK + 10 kg ZnSO ha^{-1}	100:50:40	120:60:60	Urea, SSP, MOP
T_{10}	100% NPK + 20 kg $ZnSO_4$ ha^{-1}	100:50:40	120:60:60	Ures, SSP, MOP
T_{11}	100% N	100:0:0	120:0:0	Urea
T_{12}	100 % NP	100:50:0	120:60:0	Urea, SSP
T_{13}	100% NPK + 10 t FYM ha^{-1} (*kharif*)	100:50:40	120:60:60	Urea, SSP, MOP
T_{14}	FYM 10 t ha-1 (*kharif*)	-	-	-

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The soil of the experimental site was characterized as - vertisols, particularly montmorillonitic type, hyperthermic family of Typic Hapluster. The soil was slightly alkaline in reaction, medium in organic carbon, low in available nitrogen and phosphorus and high in available potassium. The soil was analysed for different physicochemical properties as described by (Piper 1966, Jackson 1967, Subbaiah and Asija 1956). The different fraction of soil organic matter were estimated as per the procedures described by Stevenson (1982).

RESULTS AND DISCUSSION

Fractions of organic matter :

The organic matter content was significantly higher with all the treatments over control and the highest being with 100 per cent NPK + 10 t FYM ha^{-1} followed by 150 per cent NPK.

The fulvic acid (FA) content was significantly influenced by the addition of FYM which is evident from T_{13} (100% NPK + 10 t FYM ha^{-1}) and T_{14} (FYM alone) treatments. The percentage of FA in organic matter ranged from 23.49 to 27.78. Prasad *et al.*, (1991) also reported higher value of fulvic acid in treatment wherein FYM was used.

Humic acid (HA) content of organic matter differed significantly and ranged from 0.19 to 0.26 per cent. The highest HA content (0.26%) was observed in 100 per cent NPK + 10 t FYM ha^{-1} as well as with 100 per cent NPK alongwith higher levels of S and Zn. Significantly higher value of humic acid was observed in FYM treated plot (T_{14}) as compared to control.

Table 2. Organic matter fractions (%) in soil as influenced by fertilization under sorghum-wheat cropping sequence

S.N.	Treatments		FA	HA	HyA	Hn insoluble
1.	T_1	Control	0.23 (28.26)	0.19 (23.23)	0.043 (5.21)	0.35 (42.88)
2.	T_2	50 % NPK	0.26 (26.84)	0.23 (23.99)	0.056 (5.68)	0.42 (42.39)
3.	T_3	75% NPK	0.27 (27.46)	0.21 (21.84)	0.092 (9.35)	0.40 (41.26)
4.	T_4	100% NPK	0.27 (26.61)	0.23 (21.45)	0.074 (6.80)	0.49 (44.06)
5.	T_5	150% NPK	0.32 (27.78)	0.25 (21.72)	0.037 (3.30)	0.55 (47.20)
6.	T_6	100% NPK (S free)	0.28 (27.51)	0.23 (22.76)	0.056 (5.41)	0.43 (44.30)
7.	T_7	100% NPK + 10 kg S ha^{-1} (gypsum)	0.27 (27.03)	0.25 (25.14)	0.056 (5.60)	0.46 (42.21)
8.	T_8	100% NPK + 47.5 kg S ha^{-1} (gypsum)	0.26 (24.51)	0.26 (23.83)	0.062 (5.69)	0.50 (45.95)
9.	T_9	100% NPK + 10 kg $ZnSO_4$ ha^{-1}	0.30 (25.74)	0.21 (18.27)	0.075 (6.36)	0.59 (49.60)
10.	T_{10}	100% NPK + 20 kg $ZnSO_4$ ha^{-1}	0.31 (27.01)	0.26 (22.58)	0.037 (3.19)	0.56 (47.21)
11.	T_{11}	100% N	0.25 (37.13)	0.21 (22.63)	0.056 (5.97)	0.41 (43.46)
12.	T_{12}	100% NP	0.28 (29.19)	0.22 (22.97)	0.062 (6.30)	0.39 (40.76)
13.	T_{13}	100% NPK + 10 t FYM ha^{-1} (*kharif*)	0.34 (24.8)	0.26 (18.63)	0.055 (3.94)	0.73 (52.57)
14.	T_{14}	FYM 10 t ha^{-1} *kharif*	0.28 (23.49)	0.25 (22.78)	0.050 (4.41)	0.53 (47.77)
	SE m±		0.018	0.014	0.010	0.39
	CD at 5%		0.0513	0.042	0.030	1.17

Figures in parenthesis indicates the per cent content in organic matter

Table 3. Organic matter, organic carbon, total N in soil and ratios between organic matter fractions.

S.N.	Treatments	O.C. (%)	O.M. (%)	Total N (%)	HA : FA	HA:HyA	A:Humin
1.	T_1 Control	0.47	0.83	0.035	0.8	4.4	0.5
2.	T_2 50% NPK	0.56	0.98	0.040	0.9	4.1	0.5
3.	T_3 75% NPK	0.57	0.98	0.042	0.8	2.3	0.5
4.	T_4 100% NPK	0.62	1.08	0.044	0.9	3.1	0.5
5.	T_5 150% NPK	0.67	1.16	0.047	0.8	6.8	0.5
6.	T_6 100% NPK (S free)	0.60	1.04	0.042	0.8	4.1	0.5
7.	T_7 100% NPK + 10 kg S ha^{-1} (gypsum)	0.58	1.01	0.043	0.9	4.5	0.6
8.	T_8 100% NPK + 47.5 kg S ha^{-1} (gypsum)	0.63	1.10	0.046	1.0	4.2	0.5
9.	T_9 100% NPK + 10 kg $ZnSO_4$ ha^{-1}	0.68	1.19	0.043	0.7	2.8	0.4
10.	T_{10} 100% NPK + 20 kg $ZnSO_4$ ha^{-1}	0.68	1.18	0.045	0.8	7.0	0.5
11	T_{11} 100% N	0.54	0.93	0.043	0.8	3.8	0.5
12.	T_{12} 100% NP	0.55	0.96	0.045	0.8	3.5	0.6
13.	T_{13} 100% NPK + 10 t FYM ha^{-1} (*kharif*)	0.81	1.40	0.051	0.8	4.7	0.4
14.	T_{14} FYM 10 t ha^{-1} *kharif*	0.64	1.12	0.055	0.9	5.0	0.5
	SE m±	0.021	0.037	0.00073	-	-	-
	CD at 5%	0.060	0.10	0.0030	-	-	-

Table 4. Yield of sorghum and wheat (q ha^{-1})

Treatment		Sorghum		Wheat	
		Grain	Fodder	Grain	Fodder
T_1	Control	4.12	9.61	0.45	0.635
T_2	50% NPK	25.56	62.55	5.90	8.38
T_3	75% NPK	36.11	87.81	9.01	12.80
T_4	100% NPK	46.91	114.55	21.34	30.31
T_5	150% NPK	54.00	131.40	26.92	38.25
T_6	100% NPK (S free)	34.42	83.57	20.65	29.32
T_7	100% NPK + 10 kg S ha^{-1} (gypsum)	44.5	108.57	21.86	30.78
T_8	100% NPK + 47.5 kg S ha^{-1} (gypsum)	48.51	116.47	23.17	32.88
T_9	100% NPK + 10 kg $ZnSO_4$ ha^{-1}	48.26	116.35	21.27	30.01
T_{10}	100% NPK + 20 kg $ZnSO_4$ ha^{-1}	49.61	118.12	22.51	31.82
T_{11}	100% N	20.13	48.42	5.01	7.12
T_{12}	100% NP	35.66	87.00	9.72	13.77
T_{13}	100% NPK + 10 t FYM ha^{-1} (*kharif*)	58.60	143.40	27.52	39.15
T_{14}	FYM 10 t ha^{-1} (*kharif*)	10.30	24.82	1.32	1.85
	SE m±	0.396	1.192	0.290	0.428
	CD at 5%	1.11	3.35	0.816	1.204

Percentage of HA in organic matter ranged between 18.27 to 23.99. Similar results were recorded by Kononova (1966).

Hyamatomelanic acid (HyA) content in organic matter varied between 0.037 to 0.092 per cent. FYM application along with inorganic fertilizer did not enhance HyA content over other treatments but it was significantly higher with FYM application over control. HyA per cent in the organic matter varied between 3.19 to 9.35.

Highest humin content was recorded in the treatment with the application of 100 per cent NPK + 10 t FYM ha^{-1}. Application of FYM alone also showed significantly higher humin content than control indicating the role of FYM in improving humin conent in soil. Humin per cent in organic matter ranged from 40.76 to 52.57. Biswas and Mukherjee (1995) also reported 40 to 60 per cent humin content in organic matter.

Organic carbon, organic matter and total N content were significantly affected by different treatment combinations. Application of 100 per cent

NPK + 10 t FYM ha^{-1} showed highest values of organic carbon, organic matter and total N content in soil. Application of FYM alone gave significant increase over control. Ravankar *et al.*, (1998) also reported similar results with combined application of inorganics and organics in sorghum wheat sequence on vertisols.

Grain and fodder yield :

The manuring and fertilization treatments significantly influenced grain and fodder yield of sorghum. The highest grain and fodder yields of sorghum were obtained with the application of 100 per cent NPK+ 10 t FYM ha^{-1} followed by 150 per cent NPK which were significantly superior over 100 per cent NPK alone. Lowest yield was obtained under control. Significantly increase in the grain and fodder yield was found when 47.5 kg S ha^{-1} was applied with 100 per cent NPK over 100 per cent NPK (S free). There were no significant effect of the application of FYM alone over 100 per cent NPK but it was significant superior over control. This indicates that for yield sustainability in sorghum, fertilization is essential. Ravankar *et al.*, (1998) also reported the advantage of conjunctive use of FYM and NPK for achieving higher productivity.

The treatment of 100 per cent NPK + 10 t FYM ha^{-1} was significantly superior for grain and straw yield of wheat. It was followed by treatment T_5 (150% NPK). Use of recommended NPK through sulphur free fertilizer decreased the grain and straw yield of wheat significantly over recommended NPK containing sulphur. Furher sulphur application enhanced the wheat yield significantly. The lowest grain and straw yield was recorded in control plot. The treatment 10 t FYM ha^{-1} recorded significantly higher yield over control but was inferior to 100 per cent NPK.

The yield of *kharif* sorghum and *rabi* wheat were subjected to correlation studies with different organic matter fractions and it was found that sorghum and wheat yields were highly and significantly correlated with organic matter and their fractions FA and humin.

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Dynamics of Potassium Fractions Under Long Term Fertilization to Sorghum-Wheat Sequence in Vertisols

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ABSTRACT

The study on distribution of different forms of potassium and their relationship with yield of sorghum and wheat crop was conducted during 2001-2002 on old long term experiment started from 1988. Water soluble, exchangeable, available, non-exchangeable, lattice and total K were affected significantly with the different levels of fertilizers. Relative abundance of K fractions follwoed the order lattice K > non-exchangeable K > available K > exchangeable K > water soluble K which contributed 92.83-93.08 per cent , 5.76-6.02 per cent, 1.12-1.13 per cent, 1.07 to 1.08 per cent and 0.050 per cent , respectively. The status of K fractions was improved particularly with the application of NPK in combination with FYM, zinc and sulphur. All the fractions of K evaluated showed an appreciable build up under 100 per cent RD NPK with 10 t FYM ha^{-1}. The highest yield of sorghum and wheat and uptake of nutrients were recorded by 100 per cent RD NPK with 10 t FYM ha^{-1} and the lowest under control. Application of 100 per cent RD NPK with FYM recorded highest amount of O.C., total N, available N, P, K and S in soil followed by 150 per cent NPK level. All the forms of K showed highly significant correlation with yield.

Various forms of K viz. water soluble, exchangeable, available, non-exchangeable, lattice and total K in soil exist in equillibrium and depletion of one form is replenished from other forms. Generally, 92 per cent of total K occurs in structural form, 6.3 per cent as non exchangeable, 1.6 per cent as exchangeable and only 0.2 per cent as water soluble K (Tandon and Sekhon, 1988). The present study was undertaken to study distribution of different forms of potassium under long term fertilization and their relationship with yield.

MATERIAL AND METHODS

The field experiment was monitoring long term changes in soil fertility and crop yields under sorghum-wheat cropping sequence in vertisols is being continued at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola since 1988. At the start of experiment the soil (Vertisols) was slightly alkaline in reaction (8-8.1) medium in organic carbon (0.46%), total N (0.044%), available N (120) ha^{-1}, low in available P (8.4 kg ha^{-1}) and very high in available potassium (358 kg ha^{-1}). The soil samples were analyzed before sowing of sorghum for O.C., total N, available N, P, K and S (Jackson, 1967). Plant samples were analyzed for their total N, P and K (Piper, 1966). Water soluble K was estimated by extracting with distilled water 1:5 (USSLS, 1954), exchangeable K by extracting with 1 N NH_4OAC 1:5 (Knudsen, 1982), non-exchangeable K by extracting with 1 N NHO_3 in 1:10 ratio (Wood and Deturk, 1941) total K by digesting with HF-$HCLO_4$ (Jackson, 1967) and K determined by flame photometer and lattice K calculated by substracting the sum of above three forms of K from the total K content. Simple correlation and multiple regression co-efficient were calculated for different forms of K with yield adopting statistical procedure.

RESULTS AND DISCUSSION

Fertility status :

The data regarding fertility status of soil before sowing of sorghum are given in Table 1. The nutrient contents in soil were highest in 100 per cent RD NPK with 10 t FYM ha^{-1} followed by 150 per cent RD NPK level. Similar results were also reported by Ravankar *et al.*, (1998). Application of 100 per cent RD NPK through S containing fertilizer increased the O.C., available N, P, K and S over 100 per cent RD NPK through S free fertilizer. Application of Zn in combination with RD NPK increased total N, available P and K over 100 per cent RD NPK.

Crop yield :

Continuous manuring and fertilization at the same site for long period affected the dynamics of nutrient availability as well as yield of crops (Table 2). Highest grain and fodder yield of crop was obtained with application of 100 per cent RD NPK + 10 t FYM ha^{-1} followed by 150 per cent RD NPK level and the lowest in the control plot. According to Ravankar *et al.*, (1998), the productivity of cereal-cereal cropping sequence could only be increased

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Table 1. Fertility status of soil before sowing of sorghum (2001)

Treatments		Organic carbon (%)	Total N (%)	Available Nutrient (Kg ha^{-1}) N	P	K	Sulphur (ppm)
T_1	Control	0.247	0.0368	184	11.27	212	13.47
T_2	50% RD NPK	0.485	0.0385	233	14.64	285	16.82
T_3	75% RD NPK	0.496	0.0428	248	18.38	325	20.35
T_4	100% RD NPK	0.597	0.0472	283	22.54	366	22.54
T_5	150% RD NPK	0.612	0.0531	303	24.96	428	24.72
T_6	100% RD NPK (S free)	0.532	0.0487	268	19.72	355	15.38
T_7	100% RD NPK + 10 kg S ha^{-1} (gypsum)	0.573	0.0470	274	20.41	361	27.64
T_8	100% RD NPK + 47.5 kg S ha^{-1} (gypsum)	0.551	0.0475	277	21.43	358	28.29
T_9	100% RD NPK + 10 kg $ZnSO_4$	0.582	0.0485	258	22.17	416	18.74
T_{10}	100% RD NPK + 20 kg $ZnSO_4$	0.586	0.0494	271	23.27	400	19.45
T_{11}	100% RD N	0.532	0.0416	229	15.72	353	15.45
T_{12}	100% RD NP	0.568	0.0428	255	17.65	375	18.57
T_{13}	100% RD NPK + 10 t FYM ha^{-1} (*kharif*)	0.655	0.0575	313	25.35	454	28.87
T_{14}	FYM 10 t ha^{-1} (*kharif*)	0.541	0.0430	223	16.43	316	21.48
	SE m±	0.01	0.00016	1.20	0.19	1.58	0.46
	CD at 5%	0.03	0.00045	3.36	0.52	4.44	1.29
	Initial values	0.46	0.044	120	8.4	358	11.8

Table 2. Yield of sorghum and wheat (q ha^{-1}) as affected by various treatments (after 13th cycle i.e. 2001-2002)

Treatments		Sorghum		Wheat		Total
		Grain	Fodder	Grain	Straw	productivity
T_1	Control	2.16	4.70	0.75	1.09	2.91
T_2	50% RD NPK	15.69	34.65	8.24	11.87	23.93
T_3	75% RD NPK	20.94	46.48	11.94	17.21	32.88
T_4	100% RD NPK	27.52	61.45	23.19	33.44	50.71
T_5	150% RD NPK	32.41	72.10	25.59	37.25	58.00
T_6	100% RD NPK (S free)	24.30	48.65	21.67	31.24	45.97
T_7	100% RD NPK + 10 kg S ha^{-1} (gypsum)	26.34	58.53	25.04	36.11	51.38
T_8	100% RD NPK + 47.5 kg S ha^{-1} (gypsum)	29.67	65.50	26.12	37.67	55.79
T_9	100% RD NPK + 10 kg $ZnSO_4$	29.60	65.85	24.54	34.89	54.14
T_{10}	100% RD NPK + 20 kg $ZnSO_4$	30.15	67.23	24.90	35.91	55.05
T_{11}	100% RD N	12.02	31.05	7.74	11.15	19.76
T_{12}	100% RD NP	20.90	46.30	16.76	24.15	37.66
T_{13}	100% RD NPK + 10 t FYM ha^{-1} (*kharif*)	34.98	77.70	29.21	42.13	64.19
T_{14}	FYM 10 t ha^{-1} (*kharif*)	5.95	12.95	2.10	3.03	8.05
	SE m±	0.84	1.43	0.55	1.33	-
	CD at 5%	2.37	4.00	1.53	4.02	-

significantly with conjunctive use of NPK and FYM or organics.

Nutrient uptake :

The uptake of N, P and K in both crops were highest with 100 per cent RD NPK + 10 t FYM followed by 150 per cent RD NPK. Similar results were recorded by Bharadwaj *et al.*, (1994) who revealed that the addition of FYM to 100 per cent RD NPK increased the uptake of nutrients. Lowest uptake of N, P and K by crops was in control plot. Significantly higher uptake of NPK was observed with the application of S to 100 per cent RD NPK than 100 per cent RD NPK (S free). Application of 20 kg Zn along with 100 per cent RD NPK also significantly increased the uptake over 100 per cent RD NPK.

Forms of potassium :

The data on the various forms of K as

Table 3. Total uptake of NPK and S (kg ha^{-1}) by sorghum and wheat crop

Treatments		Sorghum			Wheat		
		N	P	K	N	P	K
T_1	Control	4.12	1.34	6.86	1.80	0:43	2.25
T_2	50% RD NPK	33.60	10.49	53.62	21.75	4.31	20.40
T_3	75% RD NPK	47.78	14.99	75.30	30.91	7.30	33.65
T_4	100% RD NPK	66.88	21.42	100.73	61.88	16.14	67.18
T_5	150% RD NPK	85.84	29.09	128.42	74.58	18.64	77.31
T_6	100% RD NPK (S free)	54.41	18.20	82.67	55.26	13.20	60.93
T_7	100% RD NPK + 10 kg S ha^{-1} (gypsum)	61.47	20.29	100.23	69.58	16.69	74.34
T_8	100% RD NPK + 47.5 kg S ha^{-1} (gypsum)	62.58	21.72	102.29	72.61	14.93	75.77
T_9	100% RD NPK + 10 kg $ZnSO_4$	71.91	23.61	107.02	66.75	16.09	71.95
T_{10}	100% RD NPK + 20 kg $ZnSO_4$	73.65	23.52	109.79	67.92	17.24	73.51
T_{11}	100% RD N	26.96	8.50	48.61	20.40	4.24	21.43
T_{12}	100% RD NP	46.00	14.44	76.36	44.00	10.24	47.23
T_{13}	100% RD NPK + 10 t FYM ha^{-1} (*kharif*)	99.92	34.35	145.18	84.76	21.59	90.88
T_{14}	FYM 10 t ha^{-1} (*kharif*)	13.28	4.08	20.14	8.61	1.75	9.90
	SE m ±	1.83	0.58	2.82	1.95	0.65	1.70
	CD at 5%	5.13	1.63	7.91	5.52	1.85	4.82

Table 4. Fractions of potassium (ppm) as influenced by long-term fertilization before sowing of sorghum

Treatments		X_1 Water soluble K	X_2 Exch. K	X_3 Avail. K	X_4 Non-exch. K	X_5 Lattice K	X_6 Total K
T_1	Control	6.08	88.56	94.64	700.0	11455.36	12250
		(0.049)	(0.72)	(0.77)	(5.71)	(93.51)	
T_2	50% RD NPK	6.58	120.65	127.23	750.0	11872.77	12750
		(0.051)	(0.94)	(0.99)	(5.88)	(93.11)	
T_3	75% RD NPK	6.81	138.27	145.08	776.5	12328.42	13250
		(0.051)	(1.04)	(1.09)	(5.86)	(93.04)	
T_4	100% RD NPK	7.04	156.35	163.39	802.3	12784.31	13750
		(0.051)	(1.13)	(1.18)	(5.83)	(92.97)	
T_5	100% RD NPK	7.68	183.39	191.07	863.0	14445.93	15500
		(0.049)	(1.18)	(1.23)	(5.86)	(93.19)	
T_6	100% RD NPK (S free)	6.92	151.56	158.48	800.0	13291.52	14250
		(0.048)	(1.06)	(1.11)	(5.61)	(93.27)	
T_7	100% RD NPK + 10 kg S ha^{-1}	7.00	154.16	161.16	804.0	13534.84	14500
	through gypsum	(0.048)	(1.06)	(1.11)	(5.54)	(93.34)	
T_8	100% RD NPK + 47.5 kg S ha^{-1}	7.16	152.66	159.82	794.0	13046.18	14000
	through gypsum	(0.051)	(1.09)	(1.14)	(5.67)	(93.18)	
T_9	100% RD NPK + 10 kg $ZnSO_4$	7.24	178.47	185.71	848.0	13716.29	14750
		(0.49)	(1.20)	(1.25)	(5.74)	(92.99)	
T_{10}	100% RD NPK + 20 kg $ZnSO_4$	7.19	171.38	178.57	820.0	13001.43	14000
		(0.051)	(1.22)	(1.27)	(5.85)	(92.86)	
T_{11}	100% RD N	6.92	150.66	157.58	787.0	11555.42	12500
		(0.55)	(1.20)	(1.26)	(6.29)	(92.44)	
T_{12}	100% RD NP	7.14	160.27	167.41	812.9	13519.69	14500
		(0.049)	(1.10)	(1.15)	(5.60)	(93.23)	
T_{13}	100% RD NPK + 10 t FYM ha^{-1} (*kharif*)	8.16	194.51	202.67	895.0	14902.33	16000
		(0.051)	(1.21)	(1.26)	(5.59)	(93.13)	
T_{14}	FYM 10 t ha^{-1} (*kharif*)	6.77	134.3	141.07	767.0	11841.93	12750
		(0.053)	(1.05)	(1.10)	(6.01)	(92.87)	
	Mean	7.04	152.51	159.56	802.83	12949.74	13910.71
	SE m ±	00.11	6.54	6.22	7.40	8.10	79.62
	CD at 5%	0.32	18.41	17.50	20.82	22.78	223.98

Figures in parenthesis indicates contribution of different fractions of K towards total K

Table 5. Correlation between K-fraction and yield of sorghum and wheat (2001-2002)

	Sorghum		Wheat	
	Grain	Fodder	Grain	Straw
Water soluble K	0.810**	0.838**	0.847**	0.849**
Exchangeable K	0.849**	0.875**	0.928**	0.929**
Available K	0.850**	0.876**	0.927**	0.928**
Non-exchangeable K	0.841**	0.863**	0.897**	0.899**
Lattice K	0.861**	0.850**	0.853**	0.854**
Total K	0.866**	0.857**	0.942**	0.943**

** - Significant at 1 per cent level

influenced by long term fertilization are presented in Table 4. The maximum content (ppm) of water soluble (8.16), exchangeable (194.51), available (202.67), non-exchangeable (895), lattice (14902.33) and total K (16000) were found in treatment T_{13} (100% RD NPK + 10 t FYM ha^{-1}). Similar results are also obtained by Kadrekar (1976). In relation to the total potassium content in soil, the water soluble, exchangeable, available, non-exchangeable and lattice K forms accounted for 0.048 to 0.055, 0.72 to 1.22, 0.77 to 1.27, 5.54 to 6.29 and 92.44 to 93.51 per cent, respectivley. The results are in agreement with those of Sharma and Dubey (1988). These forms are found lower in control plot. Inclusion of S or Zn in the treatment with 100 per cent RD NPK was found to be significantly superior over 100 per cent RD NPK alone.

Correlation between K fractions and yield of sorghum and wheat were worked out and presented in Table 5. All the fractions of K showed high significant positive correlation with the yield of sorghum and wheat crop. Therefore, multiple regression equation were worked out to find out the best predictive equation for different forms of K and crop yield. Multiple regression studies indicated that exchangeable K was the dominant form of K which mainly contributed for potassium nutrition of sorghum and wheat. The multiple regression equations are given below.

$$Y_1 = 54.89 + 6.34_{X1} - 1.06_{X2} + 1.65_{X3} - 0.382_{X4} + 0.0041_{X5} + 0.0059_{X6}$$

$R^2 = 0.931$

$$Y_2 = 75.07 + 8.75_{X1} - 1.72_{X2} + 2.56_{X3} - 0.540_{X4} + 0.0059_{X5} + 0.0084_{X6}$$

$R^2 = 0.937$

Where,

Y_1 and Y_2 - yield of sorghum and wheat

X_2 - exchangeable K

It may be concluded that application of inorganics in combination with organics increased the availability of nutrients, uptake of nutrients and yield of crops. Hence, use of inorganics is essential in association with organics be made for high productivity on sustainable basis maintenance of soil health.

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PKV Res. J. Vol. 25 (1) : 2001

Management of Bud Borer and Fruit Borer of Chilli Crop Through Integrated Approach

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ABSTRACT

The studies on management of bud borer *Eurytoma* spp. and *Goethella* spp. and fruit borer *Helicoverpa armigera* (Hubner) and *Spodoptera litura* F. of chilli crop were conducted for two years at Central Research Station, Dr. PDKV, Akola during 1996-97 and 1997-98. Fifteen modules comprising seedling dip and field sprays with bio-rational materials viz. cowdung, cowurine, turmeric, tumeric + cowurine and neem seed extract each at 5 per cent in complete crop growth stage and *Btk* 1000 g ha^{-1} during flowering phase of the crop either alone or in alternation with monocrotophos, a treatment of monocrotophos and an untreated control were evaluated. The module No. 15 having all applications of monocrotophos 0.05 per cent was found most effective in minimising bud borer and fruit borer infestation. The next best module was No. 3 (use of NSE 5 % in alternation with monocrotophos 0.05 per cent) which was at par with module 4 (NSE 5 % in combination with 1/2 dose of monocrotophos 0.05 per cent (0.025%)) in case of bud borer and followed by module 14 in case of fruit borer. The use of biorational materials did not show encouraging results. However, the use of monocrotophos in alternation with each of them improved the efficacy of the module. Highest yield was recorded in module 15 and found to be the most economically viable module. The use of NSE 5 per cent appeared promising in getting the desirable yield level and ICBR as well.

Chilli, one of the important condiment crops is grown on an area of 9,56,500 hectare with an annual production of 9,45,500 tonnes of chilli in the country. In Maharashtra, it is being cultivated on an area of 1,08,200 hetare with an annual production of 59,600 tonnes contributing 11.31 and 6.30 per cent area and production, respectively at national level (Singhal, 1999). This crop is infested with as many as 55 species of insect and non-insect pests that influence the crop productivity. Of these, bud and fruit borers are threatening the yield potentiality of chilli crop. The damages due to bud borers is reported to the extent of 13 per cent (Ukey, *et al.*, 1989) and fruit damage due to lepidopteran pest, *Euproctis cervina* to 26.01 per cent in buds, flowers and younger as well as matured fruits (Anonymous, 1994).

The continuous sprays of chemical insecticides arose the problems like development of resistance in targeted species, collapse of biotic natural balance, toxic residues in commodity and harm to the consumers (Lal, 1996). Moreover, the increasing concern of the environment and ever rising prices of insecticides necessitated to search upon environmentally safe and eco-friendly alternative to combact the situation through use of bio-rational materials and hence the investigation was undertaken to find out the alternative means.

MATERIAL AND METHODS

A field experiment on chilli crop (var. CA-960) was conducted for two successive years at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during 1996-97 and 1997-98. Sixteen treatments as detailed in Table 1 were replicated thrice in randomised block design having plost size 3.6 x 4.5 m^2. The various modules evaluated against bud and fruit borer of chilli were No. 1 to 15 (Table 1). The seeds were sown in beds treated with phorate 10 G @ 10 kg ha^{-1}. The seedlings of 45 days old were used for transplanting and were dipped in the solution as per treatment for 10 minutes before transplanting. The spraying commenced on 10th day after transplanting and continued at an interval of 10 days till final harvest. Five plants were randomly selected in each plot and the number of healthy and infested flower buds were counted on 10th day after each spraying starting from flowering phase of the crop and the per cent infestation in buds due to bud borer was worked out. Similarly, the healthy and damaged fruits due to fruit borer were separated out at each picking from five selected plants in each plot and accordingly per cent infestation due to fruit borer was calculated. The picking of red ripe chilli was done periodically and yields were recorded accordingly which were further converted in to q ha^{-1}. The data obtained were subjected to statistical analysis.

The incremental cost benefit ratio (ICBR) of each module was calculated based on the yield of red ripe chilli fruits and cost of treatment.

RESULTS AND DISCUSSION

Efficacy against bud borer :

The pooled data presented in Table 1 revealed that module 15 comprising of all applications

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with monocrotophos 0.05 per cent recorded the lowest infestation of bud borer (0.99%) and was found significantly superior over rest of the modules and untreated control. The performance of monocrotophos 0.05 per cent against bud borer of chilli is in conformity with the results reported by Ukey *et al.*, (1991). The next best module was No. 3, comprising of the seedlings dip in NSE 5 per cent with its subsequent spraying in alternation with monocrotophos 0.05 per cent and it was at par with module 4 comprising of seedling dip in NSE 5 per cent + 1/2 dose of monocrotophos 0.05 per cent (0.025%) with its subsequent all spray applications. In module No. 3 and 4 infestation of bud borer was recorded to the extent of 1.42 and 1.60 per cent, respectively.

Similarly, module 1, a schedule of all applications of NSE 5 per cent also found promising in minimising the bud borer infestation (2.21%), which ranked 4th in order of efficacy. These findings revealed that NSE 5 per cent certainly has impact against bud borer by keeping the incidence in check. However, its efficacy was found increased when it was used either in alternation with monocrotophos 0.05 per cent or combined with 1/2 dose of monocrotophos 0.05 per cent (0.025%). Module 13 comprising of seedling dip and spray upto flower initiation with monocrotophos 0.05 per cent followed by *Btk* spraying during flowering phase of the crop failed to provide desirable protection against bud borer infestation (4.73%). However, in module 14 when it was alternated with monocrotophos during flowering phase of the crop improved the efficacy and recorded bud borer infestation to the extent of 2.45 per cent. The module 2, application of *Btk* in alternation with NSE 5 per cent during flowering phase of the crop also could not help much against bud borer (3.93%).Thus, the results indicated that application of *Btk* either alone or in alternation with NSE 5 per cent did not exhibit any positive performance against bud border.

The efficacy of indigenous materials against bud borer revealed that module No. 6, 8, 10 and 12 comprising of the seedlings dip in cowdung suspension 5 per cent, cowurine 5 per cent, turmeric 5 per cent and turmeric 5 per cent + cowurine 5 per cent and the spray of these respective materials in alternation with monocrotophos 0.05 per cent was observed to be relatively promising in checking the bud borer infestation (2.51 to 3.18 %) as compared to their sole applications i.e. in module No. 5, 7, 9 and 11 (5.30 - 6.12 %) being almost similar to an untreated control (6.26%).

Efficacy against fruit borer :

The lowest fruit borer infestation of 5.22 per cent was obtained in module 15 comprising of all applications of monocrotophos 0.05 per cent and it proved to be the most effective. However, it was at par with module 14 comprising of application of monocrotophos upto flowering and its sprays in alternation with *Btk* @ 1000 g ha^{-1} (5.66 %) and module 3 consisting of NSE 5 per cent in seedling dip and its field sprays in alternation with monocrotophos 0.05 per cent (5.79%). The results regarding the efficacy of monocrotophos against fruit borer are supported with observations of earlier workers like Manisegaran *et al.*, (1995) and Anonymous (2000). Module 13 consisting of seedling dip and sprays up to flowering with monocrotophos 0.05 per cent followed by *Btk* application during flowering phase had registered 6.48 per cent infestation indicating the slight reduction in the efficacy. Module 1 (sole application of NSE 5 %) and module 2 (NSE 5 % as seedling dip as well as spraying upto flowering and NSE 5 % spraying in altrnation with *Btk* during flowering phase of the crop) noticed 7.73 and 8.55 per cent fruit borer infestation, respectively. Whereas, module 4 i.e. use of NSE 5 per cent + 1/2 dose of monocrotophos 0.05 per cent (0.025%) in all applications exhibited 7.50 per cent fruit borer infestation. In light of the above, it is evidenced that NSE 5 per cent has good impact against fruit borer infestation. However, when it was sprayed either in alternation with monocrotophos 0.05 per cent or combined with 1/2 dose of monocrotophos (i.e. 0.025%) improved its efficiency. The results on the efficacy of neem products against fruit borer are supported by Rajasri *et al.*, (1991).

The module No. 6, 8, 10 and 12 comprising of indigenous materials i.e. cowdung suspension 5 per cent, cowurine 5 per cent, turmeric 5 per cent and turmeric 5 per cent + cowurine 5 per cent in alternation with monocrotophos 0.05 per cent performed comparatively better against fruit borer (8.65 to 11.32 %) over the respective sole application in module No. 5, 7, 9 and 11 (17.84 to18.93) which were ineffective similar to that of untreated control (18.97%). Thus, it is evident that an application of monocrotophos as alternative spray with indigenous material could improve the efficacy of modules to more considerable extent. These findings, however, differ with the opinion of earlier workers like Sombatsiri and Pathumchartpat (1979), Snoek (1984), Peries (1985) and Rankin (1986), who reported the effectiveness of these indigenous materials against lepidopteran pests.

Table 1. Effect of various modules on bud borer and fruit borer infestation and yield of chilli fruits

S.N.	Module numbers	Treatments		Infestation (%)		Yield of red ripe chilli fruits (q ha^{-1})
		Seedlings dip	Field sprays after transplanting	Bud borer	Fruit borer	
1.	1	NSE 5 %	NSE 5% (All)	2.21 (1.6422)*	7.73 (2.7668)*	40.60
2.	2	NSE 5 %	NSE 5 % upto flowering, followed NSE 5% alt. *Btk* 1000 g ha^{-1}	3.93 (2.0988)	8.55 (2.9184)	37.16
3.	3	NSE 5 %	NSE 5 % alt. Monocrotophos 0.05%	1.42 (1.3798)	5.79 (2.3938)	43.68
4.	4	NSE 5% + Monocrotophos 0.025% (1/2 dose)	NSE 5% + Monocrotophos 0.025% (1/2 dose) (All)	1.60 (1.4420)	7.50 (2.7326)	46.67
5.	5	Cowdung suspension 5%	Cowdung suspension 5 % alt. (All)	5.38 (2.4093)	18.57 (4.2964)	18.83
6.	6	Cowdung suspension 5%	Cowdung suspension 5% alt. Monocrotophos 0.05%	3.04 (1.8709)	11.32 (3.3342)	35.11
7.	7	Cowurine 5%	Cowurine 5% (All)	5.82 (2.5062)	18.93 (4.3427)	18.77
8.	8	Cowurine 5%	Cowurine 5% alt. Monocrotophos 0.05%	2.62 (1.7553)	10.35 (3.1939)	30.73
9.	9	Turmeric 5%	Turmeric 5% (All)	6.12 (2.5700)	18.86 (4.3301)	20.82
10.	10	Turmeric 5%	Turmeric 5% alt. Monocrotophos 0.05%	2.51 (1.7210)	10.12 (3.1652)	32.99
11.	11	Turmeric 5% + Cowurine 5%	Tumeric 5% + Cowurine 0.05% (All)	5.30 (2.3986)	17.84 (4.2108)	23.13
12.	12	Turmeric 5% + Cowurine 5%	Tumeric 5% + Cowurine 5% alt. Monocrotophos 0.05%	3.18 (1.9123)	8.65 (2.9097)	35.83
13.	13	Monocrotophos 0.05%	Monocrotophos 0.05% upto flowering, followed *Btk* 1000 g ha^{-1}	4.73 (2.2815)	6.48 (2.5404)	26.87
14.	14.	Monocrotophos 0.05%	Monocrotophos 0.05% upto flowering, followed Monocrotophos 0.05 % alt. *Btk* 1000 g ha^{-1}	2.45 (1.7100)	5.66 (2.3692)	42.88
15.	15	Monocrotophos 0.05%	Monocrotophos 0.05% (All)	0.99 (1.2052)	5.22 (2.2750)	48.26
16.	-	Untreated control		6.26 (2.5655)	18.97 (4.3454)	15.75
		'F' test		Sig.	Sig.	Sig.
		SE (m) ±		0.0575	0.0913	0.92
		CD at 5%		0.1660	0.2636	2.65
		C.V. %		7.16	6.86	6.94

* Figures in parenthesis are corresponding $\sqrt{n + 0.50}$ values

Table 2. Incremental cost benefit ratio of treatments on chilli crop

S.N.	Module No.	Cost of treatments (In Rs.)			Yield (q ha^{-1})	Increase in yield over control (q ha^{-1})	Value of increased yield (Rs. ha^{-1}) (B)	Increment benefit (B - A)	ICBR	Rank
		Cost of insecticides (16 sprays)	Labour cost and machinery charges (16 sprays)	Total cost (A)						
1.	1	3031.50	3120	6151.50	40.60	24.85	24850	18698.50	1:3.04	3
2.	2	17494.00	3120	20614.00	37.16	21.41	21410	796.00	1:0.04	10
3.	3	3569.00	3120	6689.00	43.68	27.93	27930	21241.00	1:3.18	2
4.	4	4912.75	3120	8032.75	46.67	30.92	30920	22887.25	1:2.85	4
5.	5	537.50	3120	3657.50	18.83	3.08	3080	(-) 577.50	1:-0.16	11
6.	6	2150.00	3120	5270.00	35.11	19.36	19360	14090	1:2.67	5
7.	7	537.50	3120	3657.50	18.77	3.02	3020	(-) 637.50	1:(-)0.17	12
8.	8	2150.00	3120	5270.00	30.73	14.98	14980	9710	1:1.84	6
9.	9	13781.50	3120	16901.50	20.82	5.07	5070	(-)11831.50	1:(-)0.70	15
10	10	8944.00	3120	12064.00	32.99	17.24	17240	5176	1:0.43	8
11.	11	14319.00	3120	17439.00	23.13	7.38	7380	(-)10059	1:(-)0.58	13
12.	12	9212.75	3120	12332.75	35.83	20.08	20080	7747.25	1:0.63	7
13.	13	31937.50	3120	35057.50	26.87	11.12	11120	(-) 23937.50	1:(-)0.68	14
14.	14	17850.00	3120	29070.00	42.88	27.13	27130	6160	1:0.29	9
15.	15	3762.50	3120	6882.50	48.26	32.51	32510	25627.50	1:3.72	1
16.	-	-	-	-	15.75	-	-	-	-	-

Influence of treatments on yield of chilli fruits :

The data on the yield of red ripe chilli fruits (Table 1) revealed that all the modules were observed to be statistically superior over untreated control. Module 15 with all application of monocrotophos 0.05 per cent and module 4 comprising of NSE 5 per cent + 1/2 dose of monocrotophos 0.05 per cent (0.025 %) contributed the maximum yields of 48.26 and 46.67 q ha^{-1} of red ripe chilli fruits, respectively and both the treatments were at par with each other. The next promising module was No. 3 consisting of seedlings dip in NSE 5 per cent with its subsequent sprays in alternation with monocrotophos 0.05 per cent and module 14 consisting of seedling dip in monocrotophos 0.05 per cent and its sprays upto flowering and further sprays of the same in alternation with *Btk* @ 1000 g ha^{-1} during flowering phase of the crop contributing the yield of 43.68 and 42.88 q ha^{-1} chilli fruits, respectivley and had statistically similar effect. The module 1, schedule of NSE 5 per cent with its sole application was also found promising recording 40.60 q ha^{-1} yield of chilli fruits. The study, therefore, indicated that NSE had shown good influence on increasing chilli yield and is supported by observations of Rajasri *et al.*, (1991).

In module 13 where the application of *Btk* alone in flowering phase of the crop were done, considerably reduced the yield level (26.87 q ha^{-1}). But, when it was alternated either with NSE 5 per cent in module 2 or monocrotophos 0.05 per cent in module 14 during flowering phase of the crop increased the yield level.

The treatment schedule of indigenous materials like cowurine 5 per cent, cowdung suspension 5 per cent, turmeric 5 per cent and turmeric 5 per cent + cowurine 5 per cent as seedling dip as well as their sprayings in alternation with monocrotophos 0.05 per cent included in module 6, 8, 10 and 12 performed well and obtained the yield in the range of 30.73 to35.83 q ha^{-1}. But the sole application of the indigenous materials included in module 5, 7, 9 and 11 exerted a marginal influence on the yield level (18.77 to 23.13 q ha^{-1}) as against untreated control (15.75 q ha^{-1}).

Incremental cost benefit ratio of treatments :

Module 15 consisting of insecticidal schedule of monocrotophos 0.05 per cent was found economically viable treatment giving the highest incremental cost benefit ratio (ICBR) of 1:3.72. The similar higher ICBR was also reported by Bodhade *et al.*, (1985) and Kandasamy *et al.*, (1990). The module 3 consisting of treatment schedule of NSE 5 per cent as seedling dip and field sprays in alternation with monocrotophos 0.05 per cent was found to be the next profitable schedule as it gained the ICBR of 1:3.18. This is by virtue of the yield potentiality of treatment next to sole insecticidal schedule and reduced cost of the treatment. The module 1 consisting of schedule of NSE 5 per cent was also found relatively economical having ICBR of 1:3.04. Similar, module 4 consisting of the treatment schedule of NSE 5 per cent + 1/2 dose of monocrotophos 0.05 per cent (0.025 %) also proved economical as it gained compratively better ICBR of 1:2.85 than remaining treatments.

The schedules of indigenous materials of cowdung 5 per cent, cowurine 5 per cent, turmeric 5 per cent + cowurine 5 per cent and turmeric 5 per cent used in alternation with monocrotophos achieved ICBR of 1:2.67, 1:1.84, 1:0.63 and 1:0.43, respectively (module 6, 8, 12 and 10). Whereas, in the sole treatment of turmeric, cowdung and cowurine and tumeric + cowurine, the ICBR was negatively worked out as 1:(-) 0.16 to 1:(-) 0.70 for the obivious reasons of low produce and turmeric being highly priced material. Similarly, in the treatment schedule where *Btk* was applied during flowering phase had provided either very meagre ICBR or the negative ICBR.

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Probability Estimation of Water Requirement of Major Crops of Akola Region

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ABSTRACT

The average weekly values of reference evapotranspiration were calculated by modified Penman formula and distribution was fitted for the same. The 70 per cent probability value of ET, crop for sugarcane, cotton, wheat and *summer* groundnut was found out to be 2065.30, 856.63, 528.71 and 777.29 mm, respectively. The total deficit of water requirement were found for each crop and observed to be 1633.41, 503.58, 528.71 and 777.29 mm for sugarcane, cotton, wheat and *summer* groundnut, respectively. If total excess rainfall is harvested, stored and utilized for further use the irrigation water could be saved considerably, thereby increasing the irrigation potential in the region.

A step towards the better planning and efficient designing of an irrigation system calls for estimation of total precipitation during crop period, the computation of water requirement of major crop of the region by using detailed data of crop evapotranspiration and effective rainfall. Data must be available on daily or weekly basis. Number of experiments need to be conducted for several years to obtained this data (Dastane *et al.*, 1970) but these experiments are time consuming, expensive and expansive also. Therefore, it is essential to determine the irrigation requirement from available climatic data an area, to work out an excess or deficit of rainfall and to decide either for storage of excess precipitation for further use or to supplement the deficit by irrigation during the dry spell at some probability level.

MATERIAL AND METHODS

Akola station is situated in subtropical zone at an altitude of 307.41 m above mean sea level (MSL) at an intersection of 20° 70' North latitude and 77° 00' East longitude. Weekly values of rainfall, temperature (maximum and minimum), relative humidity, wind speed and cloudiness were collected from Indian meterological department, Pune for the year 1970 to 1995. Date were used for estimation of reference evapotranspiration by modified Penman formula which is most accurate and reliabe method of estimating reference evapotranspiration (Subramanian and Rao 1985 ad Mohan, 1991).

The probability of weekly rainfall was estimated by Weibull's plotting position (Tambile *et al.*, 1991 and Ray *et al.*, 1980). The 70 per cent probability value of rainfall were worked out and are used for estimating effective rainfall at same probability level i.e. at 30 per cent risk level which is generally used for planning of ririgation and cropping system (Darbal and Rao, 1997) to reduce the risk in planning of excess rainfall. Calculated values of reference evapotranspiration were further statistically analyzed by probability distribution using normal and lognormal distribution, distribution was fit by chi-square at 5 per cent significance level and ETo values were read at 70 per cent probability from the best fit distribution.

Crop coefficient curves were developed as suggested by Dorrenbos and Pruitt (1977), for four major crops of the region viz. sugarcane, cotton, wheat and *summer* groundnut. Weekwise effective rainfall at 70 per cent probability was estimated by pricipitation and reference evapotranspiration method at 70 per cent probability to work out the deficit weeks and rainfall values at 70 per cent probability were used for estimating excess rainfall.

RESULTS AND DISCUSSION

From Table 1 it is observed that water requirement of sugarcane during first half season absolutely needs to be satisfied by supplementary irrigation. The moisture sensitive period of sugarcane consisting of establishment and stem elongation falls between 1st to 33rd S. met. week and shortage of moisture during this period retards the crop growth and yield, but up to 23rd S. met. week there is no rainfall. Therefore these weeks need supplementary irrigation to have better production. After 23rd S. met. week and up to 33rd S. met. week appreciable amount of rainfall is expected but still there are 4 to 5 weeks, which do not satisfy the water requirement (WR) of sugarcane that calls for protective irrigation during these weeks of deficit.

In general, the sugarcane needs the irrigation throughout the season even though the mid and late season of crop comes under monsoon period, the deficit of water for sugarcane was found to be 1633.41

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Table 1. Weekly irrigation requirement of sugarcane at 70 per cent probability level

S. Met. week	ETo (70%) (mm day^{-1})	Kc	ET crop (mm day^{-1})	Effective rainfall (70%) (mm)	Deficit IWR (70%) (mm)	Excess rainfall (70%) (mm)
1.	4.45	0.45	2.00	-	2.00	-
2.	4.60	0.50	2.30	-	2.30	-
3.	5.12	0.56	2.87	-	2.87	-
4.	5.50	0.57	3.14	-	3.14	-
5.	6.43	0.57	3.67	-	3.67	-
6.	6.67	0.58	3.87	-	3.87	-
7.	5.90	0.59	3.48	-	3.48	-
8.	5.54	0.60	3.32	-	3.32	-
9.	6.31	0.61	3.85	-	3.85	-
10.	6.78	0.63	4.27	-	4.27	-
11.	7.37	0.63	4.79	-	4.79	-
12.	7.66	0.67	5.13	-	5.13	-
13.	8.40	0.70	5.88	-	5.88	-
14.	7.10	0.72	5.11	-	5.11	-
15.	7.98	0.75	5.99	-	5.99	-
16.	9.78	0.78	7.63	-	7.63	-
17.	10.12	0.80	8.10	-	8.10	-
18.	10.46	0.84	8.79	-	8.79	-
19.	11.10	0.87	9.66	-	9.66	-
20.	10.97	0.90	9.87	-	9.87	-
21.	10.21	0.94	9.60	-	9.60	-
22.	8.50	0.96	8.16	-	8.16	-
23.	7.67	1.00	7.67	0.52	7.15	-
24.	6.72	1.02	6.85	7.12	-	2.65
25.	8.90	1.05	9.35	3.07	6.27	-
26.	5.36	1.08	5.79	13.79	-	12.61
27.	4.80	1.08	5.18	2.87	2.32	1.22
28.	5.10	1.10	5.61	6.90	-	9.79
29.	4.24	1.12	4.75	6.99	-	10.85
30.	5.10	1.14	5.81	5.20	0.62	5.79
31.	4.00	1.15	4.60	4.43	0.17	4.00
32.	4.00	1.17	4.68	5.41	-	5.82
33.	4.72	1.18	5.57	11.33	-	16.43
34.	4.50	1.20	5.40	2.06	3.34	-
35.	4.44	1.21	5.37	13.04	-	10.53
36.	4.38	1.21	5.30	2.62	2.68	-
37.	4.51	1.24	5.59	0.00	5.59	-
38.	4.30	1.25	5.38	1.48	3.90	-
39.	5.16	1.25	6.45	0.82	5.63	-
40.	5.17	1.24	6.41	-	6.41	-
41.	5.50	1.24	6.82	-	6.82	-
42.	5.20	1.23	6.40	-	6.40	-
43.	6.80	1.22	8.30	-	8.30	-
44.	5.20	1.20	6.24	-	6.24	-
45.	5.80	1.15	6.67	-	6.67	-
46.	4.90	1.10	5.39	-	5.39	-
47.	6.00	1.05	6.30	-	6.30	-
48.	4.98	0.92	4.58	-	4.58	-
49.	4.85	0.90	4.37	-	4.37	-
50.	5.45	0.85	4.63	-	4.63	-
51.	5.30	0.83	4.40	-	4.40	-
52.	4.60	0.81	3.73	-	3.73	-
Annual (mm)	2272.20		2065.30	87.66	1633.41	79.68

Total expected rainfall at 70 per cent probability = 148.7 mm

Table 2. Weekly irrigation requirement of cotton at 70 per cent probability level

S. Met. week	ETo (70%) (mm day^{-1})	Kc	ET crop (mm day^{-1})	Effective rainfall (70%) (mm)	Deficit IWR (70%) (mm)	Excess rainfall (70%) (mm)
21.	10.21	0.50	5.11	-	5.11	-
22.	8.50	0.51	4.34	-	4.34	-
23.	7.67	0.51	3.91	0.52	3.39	-
24.	6.72	0.53	3.56	7.12	-	5.94
25.	8.90	0.57	5.07	3.07	2.00	-
26.	5.36	0.62	3.32	13.79	-	15.08
27.	4.80	0.68	3.26	2.87	0.40	3.14
28.	5.10	0.77	3.93	6.90	-	11.47
29.	4.24	0.85	3.60	6.99	-	12.00
30.	5.10	0.92	4.69	5.20	-	6.91
31.	4.00	0.98	3.92	4.43	-	4.68
32.	4.00	1.03	4.12	5.41	-	6.38
33.	4.72	1.06	5.00	11.33	-	17.00
34.	4.50	1.08	4.86	2.06	2.80	-
35.	4.44	1.09	4.84	13.04	-	11.06
36.	4.38	1.09	4.77	2.62	2.15	-
37.	4.51	1.08	4.87	0.00	4.87	-
38.	4.30	1.06	4.56	1.48	3.08	-
39.	5.16	1.04	5.37	0.82	4.55	-
40.	5.17	1.01	5.22	-	5.22	-
41.	5.50	0.97	5.34	-	5.34	-
42.	5.20	0.93	4.84	-	4.84	-
43.	6.80	0.87	5.92	-	5.92	-
44.	5.20	0.81	4.21	-	4.21	-
45.	5.80	0.73	4.23	-	4.23	-
46.	4.90	0.66	3.23	-	3.23	-
47.	6.00	0.59	3.54	-	3.54	-
48.	4.98	0.55	2.74	-	2.74	-
Annual (mm)	1093.12			87.66	503.58	93.66

Total expected rainfall at 70 per cent probability = 148.7 mm

mm, whereas the seasonal crop water demand was 2065.30 mm at 70 per cent probability level. If alone sugarcane is cultivated and excess rainfall, which is about 79.68 mm, is harvested, stored and utilized, the supplementary irrigation needs of sugarcane could considerably be reduced in the region.

The weekwise irrigation requirement of cotton is shown in Table 2. It is seen from table that even though crop water requirement is met by effective rainfall for cotton during its mid and late season, there is still deficit of rainfall for the same crop for rest of the season i.e. initial and development stage, since the effective rainfal is available during 23rd to 36th S. met. week only. The total excess rainfall available for cotton crop was found out to be 93.66 mm and if this excess rainfall is utilized for further use for irrigating the cotton crop by properly harvesting, the cotton crop could be irrigated in the rest of the season. The critical period of cotton lies between 29th to 41st S. met. week consisting of flowering and boll development, which coincides with the rainfall period of region.

From Table 3 and Table 4, it is seen that the seasonal crop water requirement of wheat and *summer* groundnut was found to be 528.71 mm and 777.29 mm, respectively. The rainfall season is not available for wheat and *summer* groundnut as wheat is sown as *rabi* crop and groundnut as a hot weather crop in the region.

The water requirement during critical stages of wheat was found to be 306.25 mm, out of this 48 per cent water requirement during critical stage can be fulfil by excess rainfall of other season, if excess rainfall is properly harvested, stored and utilized. The water requirement during moisture sensitive period of *summer* groundnut consisting of flowering, pegging and pod development was found to be 434.91 mm. It is further seen that 34 per cent water

Table 3. Weekly irrigation requirement of wheat at 70 per cent probability level

S. Met. week	ETo (70%) (mm day^{-1})	Kc	ET crop (mm day^{-1})	Effective rainfall (70%) (mm)	Deficit IWR (70%) (mm)	Excess rainfall (70%) (mm)
44.	5.20	0.49	2.55	-	2.55	-
45.	5.80	0.50	2.90	-	2.90	-
46.	4.90	0.57	2.79	-	2.79	-
47.	6.00	0.72	4.32	-	4.32	-
48.	4.98	0.88	4.38	-	4.38	-
49.	4.85	1.00	4.85	-	4.85	-
50.	5.45	1.07	5.83	-	5.83	-
51.	5.30	1.11	5.88	-	5.88	-
52.	4.60	1.13	5.20	-	5.20	-
1.	4.45	1.13	5.03	-	5.03	-
2.	4.60	1.11	5.11	-	5.11	-
3.	5.12	1.07	5.48	-	5.48	-
4.	5.50	0.99	4.45	-	5.45	-
5.	6.43	0.88	5.66	-	5.66	-
6.	6.67	0.73	4.87	-	4.87	-
7.	5.90	0.55	3.25	-	3.25	
8.	5.54	0.36	1.99	-	1.99	-
Seasonal (mm)	639.03		528.71	0.00	528.71	0.00

Total expected rainfall at 70 per cent probability =148.7 mm

Table 4. Weekly irrigation requirement of *summer* groundnut at 70 per cent probability level

S. Met. week	ETo (70%) (mm day^{-1})	Kc	ET crop (mm day^{-1})	Effective rainfall (70%) (mm)	Deficit IWR (70%) (mm)	Excess rainfall (70%) (mm)
5.	6.43	0.45	2.89	-	2.89	-
6.	6.67	0.45	3.00	-	3.00	-
7.	5.90	0.48	2.83	-	2.83	-
8.	5.54	0.55	3.05	-	3.05	-
9.	6.31	0.66	4.16	-	4.16	-
10.	6.78	0.77	5.22	-	5.22	-
11.	7.37	0.88	6.49	-	6.49	-
12.	7.66	0.96	7.35	-	7.35	-
13.	8.40	1.00	8.40	-	8.40	-
14.	7.10	1.02	7.24	-	7.24	-
15.	7.98	1.02	8.14	-	8.14	-
16.	9.78	0.99	9.68	-	9.68	-
17.	10.12	0.95	9.61	-	9.61	-
18.	10.46	0.90	9.41	-	9.41	-
19.	11.10	0.83	9.21	-	9.21	-
20.	10.97	0.73	8.01	-	8.01	-
21.	10.21	0.62	6.33	-	6.33	-
Seasonl (mm)	971.46		777.29	0.00	777.29	0.00

Total expected rainfall at 70 per cent probability = 148.7 mm

requirement of *summer* groundnut during its critical period can be satisfied by excess rain of other season at Akola, if properly planned. At least half of total water requirement of wheat and 34 per cent of *summer* groundnut during its critical stage can be fulfilled by excess rain available in other season is harvested.

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Effect of Planting Dates on Growth, Flowering and Seed Yield of Aster (*Callistephus chinensis* L. Ness)

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ABSTRACT

The effect of different dates of planting on various aspect like growth, flowering and seed production of aster cv. local was studied and it was observed that planting of aster seedlings done as late as 1st November resulted in better vegetative growth, early emergence and opening of flower buds, more longevity of flowers, higher yield of better quality flowers (53.51 lakh ha^{-1}) and increased seed production (155.83 kg ha^{-1}). Whereas early planting on 1st August resulted on poor vegetative growth, flowering, lowest flower yield and seed production.

Aster (*Callistephus chinensis* L. Ness) is one of the most important garden annual flower commercially grown in India and throughout the world. Aster is a half hardy annual having many colours like blue, lavender, rose, white etc. The area under this crop is increasing day by day in Vidarbha region, and it's cultivation is on comparatively valuable land nearer to the cities. Therefore, proper agro-techniques are considered most important for the cultivation of this crop. The farmers in this region generally raise this crop in *rabi* season. However, due to lack of standard production technology, the yield of quality flowers and seed per unit area is low and therefore, the planting of aster at suitable time is considered most important. The importance of cultural practices for increasing the yield of quality flowers and seed is well known. The planting of seedlings at proper time has pronounced effect on vegetative growth, flowering, flower quality, yield and seed production. Delay or early planting may adversely affect the yield of quality flowers and seed production. It is, therefore, essential to find the most suitable planting time for raising of aster. In view of this an experiment was conducted to find out suitable time of planting for higher production of quality and seed of aster.

MATERIAL AND METHODS

The study was undertaken at Horticultural Botanical Garden, Deptt.of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the year 1997-98. The field experiment as laid out in RBD with four replicatios. The treatments comprised of seven different dates of planting starting from 1st August to 1st November at an interval of fifteen days. The seedlings of aster were planted in the plot when they had three or four leaves. These seedlings were transplanted in flat beds on different dates at fortnight interval from 1st August to 1st November 1997 at spacing of 30 x 30 cm in plot size of 1.8 to 1.8 m^2 while transplanting the soil was pressed firmly around the seedlings and watered thoroughly. The crop was applied 50 tonnes of FYM, 300 kg N, 200 kg P_2O_5 and 200 kg K_2O ha^{-1}. Half dose of nitrogen, full dose of P and K was given at the time of transplanting and remaining half dose of nitrogen was applied 30 days after transplanting. A well decomposed FYM was applied at the rate of 5 kg sq. m^{-1} to each of the plots two days prior to transplanting. Gap filling was done whenever necessary during to first two weeks after transplanting. Intercultural operations, irrigation and plant protection measures were done as and when required. The observations on growth, flowering, yield of flower and seed production were taken and data was statistically analysed.

RESULTS AND DISCUSSION

The data presented in Table 1 indicated that different planting dates appreciably influenced the vegetative growth viz. height of plant, spread of plant, basal diameter of main stem of plant, total number of primary branches $plant^{-1}$, fresh and dry weight of plant. It is revealed from the data in general that maximum plant height (69.42 cm), spread of plant (31.10 cm), stem diameter (1.707 cm)., number of primary branches (18.66), fresh weight of plant (168.62 g) and dry weight of plant (42.87 g) were noticed in last date of planting on 1st November followed by planting on 15th October. However, minimum vegetative growth and fresh and dry weight of plants were noticed in first planting date (1st August). Patil *et al.*, (1987) in China aster reported that the planting of seedings done in November produced more vegetative growth than planting done in October,

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Table 1. Effect of different planting dates on vegetative growth and flowering of aster

Treatments	Plant height (cm)	Plant spread (cm)	Stem diameter (cm)	No. of primary branches plant^{-1}	Fresh weight of plant (g)	Dry weight of plant (g)	Days required for emergence of flower	Days required for flower opening from bud emergence	Longevity of intact flower
T_1 (1 Aug.)	50.30	26.07	1.400	11.85	147.27	27.95	78.10	27.05	24.80
T_2 (15 Aug.)	56.50	26.45	1.517	12.12	150.03	29.42	74.85	25.10	27.22
T_3 (1 Sept.)	57.82	28.10	1.527	13.90	156.27	33.16	70.89	23.38	28.05
T_4 (15 Sept.)	60.67	28.25	1.608	14.25	162.55	38.10	68.95	21.15	30.00
T_5 (1 Oct.)	63.37	29.65	1.657	14.85	162.70	39.02	65.21	19.90	32.92
T_6 (15 Oct.)	68.45	29.75	1.665	16.66	164.31	40.85	63.08	17.12	34.90
T_7 (1 Nov.)	69.42	31.10	1.707	18.66	168.62	40.87	60.42	14.07	37.72
F test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE m±	0.42	0.46	0.008	0.79	1.69	0.86	1.10	0.98	0.71
CD at 5%	1.27	1.36	0.022	2.28	4.90	2.49	3.21	2.77	2.07

Table 2. Effect of different planting dates on flower and seed yield of aster

Treatments	Diameter of flower (cm)	Length of peduncle (cm)	Total number of flower plant^{-1}	Total number of flowers ha^{-1} (lakhs)	Weight of seed ha^{-1} (kg)	Weight of 1000 seed (g)
T_1 (1 Aug.)	4.23	16.34	35.22	39.13	92.22	1.60
T_2 (15 Aug.)	5.27	18.78	36.02	40.03	100.27	1.79
T_3 (1 Sept.)	6.12	20.02	39.91	44.35	127.22	1.84
T_4 (15 Sept.)	6.52	23.85	40.58	44.65	131.11	1.94
T_5 (1 Oct.)	6.99	25.96	44.62	49.58	142.77	2.07
T_6 (15 Oct.)	7.08	27.42	45.25	50.29	148.33	2.11
T_7 (1 Nov.)	7.71	30.28	48.25	53.61	155.83	2.40
F test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE m±	0.17	0.95	0.20	0.22	2.07	0.03
CD at 5%	0.50	2.76	0.59	0.65	6.01	0.10

December and September under Pune conditions. Similar results were observed by Dombhare (1995) in China aster.

The better vegetative growth of aster plants was obtained in plants of first November planting date. This may be due to favourable growing conditions available during the period from November to February. During this period the minimum and maximum temperatures were 12.1°C and 32.2°C, respectively. Likewise, the relative humidity was also found to be maximum (96 %) during this period. This congenial temperature and humidity might have helped the plants to acquire more vegetative growth. However, during the period from August to October the minimum and maximum temperatures, were 23.5°C and 34.8°C respectively. The atmospheric humudity was 89 per cent. The higher temperature and lower humidity prevailed during this period would have reduced the vegetative growth of plants.

In respect of flowering (Table 1), it is revealed that different planting dates appreciably influenced number of days required for emergence of flower bud, days required for flower bud opening and the longevity of intact flowers in aster plants. The planting date (1st November) significantly reduced the number of days required for emergence of flower buds (60.42) and number of days required for opening of the flower buds (14.07). The longevity of intact flowers was found significantly more in 1st November planting than the other planting dates. Maximum days for flowering were recorded in planting on 1st August followed by 15th August, 1st September, 15th September, 1st October, 15th October and 1st November planting. The results are in agreement with the findings of Mohanty *et al.*, (1993) in marigold and Mishra (1993) in gladiolus.

Aster being a short day plant, short photoperiod and moderate temperature prevealing during 1st November planting date promoted earlier flower bud emergence, flower bud opening and more longevity of flower. The response in this regard was intermediate during 15th September, 1st October planting, whereas during 1st August, 15th August and 1st September planting dates prevalence of high temperature delayed flower bud emergence, flower bud opening and less longevity of flower. The flower quality parameters like diameter of fully opened flower and peduncles length of flower were significantly affected by different planting dates.

Data presented in Table 2 indicated that flower quality viz., diamter of flower (7.71 cm) and peduncle length (30.28 cm) of flower was found maximum in 1st November planting followed by 15th October and 1st October planting. This research findings are in agreement with the finding of Patil *et al.*, (1987) and Gowda (1990) in China aster. It is seen that the vegetative growth of plants was found more in last date of planting (1st November). This increased vegetative growth of plants having sufficient food materials might be helpful in increasing the diameter and peduncle length of flower. Moreover, the lower temperature and higher humidity prevailed during the period from November to February were favourable from the production of better size flower and larger peduncle length.

The yield contributing characters viz. total number of flowers plant^{-1}, total number of flowers ha^{-1} and seed yield ha^{-1} were significantly influenced by treatment of different planting dates.

Data presented in Table 2 indicates that the highest number of flowers plant^{-1} (48.25) and ha^{-1} (53.61 lakh) were recorded in last date of planting (1st November) followed by 15th October, 1st October, 15th September, 1st September, 15th and 1st August planting.

This results are in close confirmity with the findings of Patil *et al.*, (1987) in aster, Saini *et al.*, (1988) in gladiolus, Yadav (1983) in aster, Mohanty *et al.*, (1990) in marigold and Dombhare (1995) in aster.

During last planting date when plants were grown from November to February the range of minimum and maximum temperature were 12.18°C and 32.20°C, respectively and atmospheric humidity was also found maximum (96 %). These climatic conditions viz. optimum temperature and more humidity were favourable for promoting the vegetative growth of plants thus it was helpful in producing more number of flowers and seed yield unit^{-1} area and weight of thousand seed.

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Performance of Onion Bulb Cultivars in Seed Production

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ABSTRACT

Twelve cultivars of onion were evaluated in a randomized block design with three replications during 1995-96, 96-97 and 97-98 at the Regional Research Station (OUAT), Bhawanipatna. The pooled data revealed that maximum seed yield was harvested from the variety Agrifound Light Red (11.38 q ha^{-1}) which was at par with Punjab Red Round (11.18 q ha^{-1}), Nasik Red (10.48 q ha^{-1}), N 2-4-1 (9.98 q ha^{-1}) and Pusa Red (9.87 q ha^{-1}). The higher seed yield in these cultivars was related to higher number of seed stalks $plant^{-1}$, taller and wider umbels with more number of flower $umbel^{-1}$ and heavier seeds. It was concluded that, selection of varieties on the basis of number of seed stalks $plant^{-1}$ either independently or in combination with 1000 seed weight and umbel diameter would be useful for amelioration of seed yield in onion.

About 3000 tonnes of certified seeds of onion (*Allium cepa* L. var. *cepa*) are required annually for bulb production in the country but only about 750 tonnes are produced and distributed by private and public sector seed agencies. Rest of the seed is being produced and distributed by the farmers themselves (Singh, 1998). As a result quality seeds of improved varieties are not availble with the farmers for commercial cultivation of onion. It necessitates a well organized seed production programme of different high yielding varieties in different regions of the country to meet the demand. Keeping this in view, an experiment was conducted to find out the seed producing potential of some improved varieties of onion and to identify the suitable one for the region.

MATERIAL AND METHODS

The experiement was conducted in a randomized block design with three replications at the Regional Research Station, Bhawanipatna during winter season of 1995-96, 1996-97 and 1997-98 with twelve cultivars of onion collected from various institutes. Medium size healthy bulbs of each cultivar were planted on flat beds during second week of October every year at a spacing of 60 cm x 30 cm in a plot of 3.0 m x 3.0 m. Standard agronomic package were adopted to raise the crop successfully. Observations were recorded on number of seed stalks $plant^{-1}$ and flower $umbel^{-1}$, height and diameter of umbel and 1000 seed weight form 5 randomly selected plants in each plot every year. The seed yield was accounted on plot basis. The mean data were statistically analysed by following standard procedure.

RESULTS AND DISCUSSION

Pooled analysis of variance (Table 1) revealed significant mean square estimates for all the characters indicating sufficient diversity among the cultivars. The mean square due to environment were significant for all the traits except the height of umbel, which suggest wide differences between the years of testing. The mean squares due to the interaction effects of the genotypes with the environment were also significant for all the attributes except the height of umbel which explained differential response of varieties to environmental fluctuations.

The observations recorded on yield and it's contributing character over the years are presented in Table 2. Considerable variation (5.89 to 9.80) was encountered for number of flower stalks $plant^{-1}$. The variety Agrifound Light Red produced the highest number of seed stalks $plant^{-1}$ (9.80) which was at par with Arka Kalyan (9.64), N 2-4-1 (9.41), Punjab Red Round (9.20), Pusa Red (8.72) and Nasik Red (8.69), while Arka Niketan was a shy producer of seed stalk $plant^{-1}$ (5.89) followed by Pusa Ratnar (6.24) and Arka Pitamber (6.53). The cultivar Agrifound Light Red produded the tallest umbel (117.30 cm) closely followed by N 2-4-1 (112.40 cm), Arka Kalyan (110.50 cm), Punjab Red Round (109.10 cm) and Pusa Red (106.30 cm). On the contrary, Arka Niketan attained the shortest umbel (91.73 cm) alongwith least number of flowers $umbel^{-1}$ (312.60), minimum seed weight (2.46 g 1000^{-1} seeds) and lowest seed yield (5.36 q ha^{-1}). Naik and Srinivas (1992), reported that the number of seed stalks $plant^{-1}$ in onion varied from 1 to 12, while Shinde and Sontakke (1986) mentioned its variation form 1 to 20 with the height ranging from 90 to 120 cm.

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Table 1. Pooled analysis of variance for quantitative characters of onion cultivars in seed production

Source	Degrees of freedom	Mean square					
		No. of seed stalk umbel^{-1}	Height of umbel (cm)	No. of flowers umbel^{-1}	Diameter of umbel (cm)	1000 seed weight (g)	Seed yield (q ha^{-1})
Environment	2	18.81**	42.70	66489.26**	32.67**	7.14**	62.28**
Replication in environment	6	10.72**	497.15**	8930.52**	12.73**	2.05**	21.07**
Genotype	11	10.47**	1057.80**	26457.34**	13.02**	2.91**	24.69**
Genotype x Environment	22	3.27**	29.52	11502.76**	5.43**	0.87**	10.74**
Pooled Error	66	1.39	208.26	3033.23	1.48	0.33	2.89

Significant at * P = 0.05, ** P = 0.01

Table 2. Mean performance of bulb onion cultivars in seed production (pooled)

Cultivar	Character					
	No. of seed stalk plant^{-1}	Height of umbel (cm)	No. of flowers umbel^{-1}	Diameter of umbel (cm)	1000 seed weight (g)	Seed yield (q ha^{-1})
Nasik Red	8.69	104.86	412.29	7.39	3.50	10.48
N 2-4-1	9.41	112.40	427.44	8.53	3.46	9.98
Agrifound Dard Red	8.10	103.20	389.62	6.87	2.48	7.29
Agrifound Light Red	9.80	117.30	385.69	6.42	3.58	11.38
N 53	7.07	99.63	432.43	7.94	3.07	7.46
Punjab Red Round	9.20	109.10	410.67	7.80	3.78	11.18
Arka Pitamber	6.53	95.60	314.58	4.04	2.71	6.24
Arka Kalyan	9.64	110.50	396.64	6.53	3.48	9.49
Arka Niketan	5.89	91.73	312.60	5.48	2.46	5.36
Pusa Madhavi	7.33	105.67	391.83	7.13	3.37	9.09
Pusa Red	8.72	106.30	427.91	7.53	3.53	9.78
Pusa Ratnar	6.24	98.64	316.93	5.42	2.78	6.49
SE (m)±	0.39	4.00	18.36	0.41	0.19	0.57
CD at 5%	1.11	11.31	51.92	1.15	0.54	1.60

The number of flowers umbel^{-1} varied from 312.60 to 432.43. Maximum number of flowers umbel^{-1} were produced by N 53 which was at par with Pusa Red, N 2-4-1, Nasik Red, Punjab Red Round, Arka Kalyan, Pusa Madhavi, Agrifound Dark Red and Agrifound Light Red. Globerson *et al.*, (1981) noticed 200-1000 flowers umbel^{-1}, whereas, Shinde and Sontakke (1986) and Naik and Srinivas (1992) pointed out 50-2000 flowers umbel^{-1} in onion. The largest umbel of 8.53 cm diameter was produced by the cultivar N 2-4-1 colsely followed by N 53, Punjab Red Round, Pusa Red and Nasik Red, while Arka Pitambar gave smallest umbel of 4.04 cm diameter.

The weight of 1000 seeds ranged form 2.46 g to 3.78 g. Maximum weight of 3.78 g 1000^{-1} seeds was registered by Punjab Red Round followed by Agrifound Light Red, Pusa Red, Nasik Red, Arka Kalyan, N 2-4-1 and Pusa Madhavi. Since the heavier seeds germinate earlier and grow better than the lighter seeds (Shinde *et al.*, 1992), the above varieties are likely to perform better than others and amenable to quality seed production in common onion.

The seed yield showed a wide range of variation (5.36 to 11.38 q ha^{-1}). The highest yield was produced by the variety Agrifound Light Red (11.38 q ha^{-1}) which was at par with Punjab Red Round (11.18 q ha^{-1}), Nasik Red (10.48 q ha^{-1}), N 2-4-1 (9.98 q ha^{-1}) and Pusa Red (9.78 q ha^{-1}). On the otherhand, Arka Niketan gave the lowest yield (5.36 q ha^{-1}) followed by Arka Pitamber (6.24 q ha^{-1}) and Pusa Ratnar (6.49 q ha^{-1}). An average seed yield of 8-10 q ha^{-1} was reported by Shinde and Sontakke

(1986) and Naik and Srinivas (1992). Dhillon and Arora (1980-81) expected a seed yield of 5.0 - 7.5 q ha^{-1} in Punjab. However, the highest seed yield of 11.0 q ha^{-1} was obtained with variety Punjab Naroya (Sidhu *et al.*, 1994) and Punjab Red Round (Sidhu *et al.*, 1996) at Ludhiana. Similarly, a seed yield of 7-10 q ha^{-1} was recorded in Gujrat (Singh, 1998).

It was observed that, the cultivars which produced significantly higher seed yield also exhibited significantly higher number of seed stalk plant^{-1}, taller and larger umbels with more numbers of flowers umbel^{-1} and heavier seeds. Similar positive association of component characters with seed yield of onion was also reported earlier (Sandhu and Korla, 1976, Shinde *et al.*, 1992 and Sidhu *et al.*, 1996). Further analysis indicated that, among the yield traits studied the number of seed stalk plant^{-1} was the most essential character related to seed yield of onion followed by 1000 seed weight and diameter of umbel. It was inferred that besides yield selection of cultivars on the basis of number of seed stalks plant^{-1} either alone or in combination with 1000 seed weight and diameter of umbel would be rewarding to circumvent the seed yield of onion. The present study depicted that out of the twelve cultivars, Agrifound Light Red, Punjab Red Round, Nasik Red, N 2-4-1 and Pusa Red would be beneficial for the region and might be advocated for commercial cultivation.

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PKV Res. J. Vol. 25 (1) : 2001

Performance of Onion Varieties in *Kharif* Season

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ABSTRACT

Performance of 12 varieties of onion was studied during *kharif* season of 1996 to 1998 at the Regional Research Station, Bhawanipatna. Pooled analysis revealed that Pusa Madhavi, Arka Niketan, Punjab Red Round, grifound Dark Red, Arka Pitamber and Agrifound Light Red produced small to medium bulb with thinner neck denoting better storage quality. The cultivar Arka Kalyan and N 53 recorded significantly higher bulb yield (229.60 and 218.53 q ha^{-1}, respectively) than other varieties but were poor storers. It was found that *rabi* varieties if grown in *kharif* season could also confer good bulb yield. Arka Kalyan showing higher yield, thinner neck and resistance to leaf blight was proposed for production of fresh bulbs during *kharif* season. However, Agrifound Dark Red and Arka Niketan with better keeping quality, medium bulb and moderately high yield was suggested as substitute to N53 and Arka Kalyan for commercial cultivation in rainy season.

India is the second largest producer of onion in the world. The annual production is about 44.29 lakh tonnes from an area of 4.10 lakh hectares (Singhal, 1996). Out of the total production , 30 per cent account for the *kharif* and the late *kharif* season and 70 per cent to *rabi* season. Cultivation of *kharif* onion has helped to meet the need of fresh onion bulbs in off season. However, unlike winter season crop, very little information is available on rainy season crop. It was worthwhile to assess the response of available improved varieties of onion (*Allium cepa* L. var. *cepa*) in rainy season under Orissa conditions as a basic step.

MATERIAL AND METHODS

Twelve varieties of onion collected from various sources were evaluated in a randomized block design with four replications, at the Regional Research Station, Bhawanipatna during *kharif* season of 1996 to 1998. Eight weeks old healthy seedlings of each variety were transplanted in flat beds at spacing of 15 x 10 cm in a plot size of 3.0 x 3.0 m during first week of August every year. Recommended package of practices were followed during experimentation to raise the crop successfully. Observations were recorded on plant height, number of leaves $plant^{-1}$, neck thickness, diameter and weight of bulb from ten randomly selected plant in each plot every year. Bulb yield was worked out on plot basis. Progeny means pooled over the years were statistically analyzed as per standard procedure.

RESULTS AND DISCUSSION

Pooled analysis of variance (Table 1) revealed significant mean square estimates for all the characters indicating sufficient variation among the varieties. The mean squares due to environment were significant for all the traits except neck thickness which suggested considerable differences between the years of investigation. Signaficant mean square due to genotype x environment interaction for all the attributes except diameter of bulb explained differential response of varieties to environmental fluctuation.

The mean performance of varieties over the year is presented in Table 2. The tallest plant of 42.80 cm height was produced by the variety N 53 closely followed by Nasik Red and Pusa Madhavi, where as Arka Niketan registered shortest plant of 30.57 cm height. Similarly the cultivar N 53 also produced the maximum number of leaves $plant^{-1}$ (15.37) which was at par with Pusa Ratnar, Pusa Red, Pusa Madhavi and Arka Kalyan. On the contrary, minimum number of leaves $plant^{-1}$ was noted in Arka Pitamber (7.50) followed by Agrifound Light Red and N 2-4-1.

Widest neck of 1.13 cm was noticed in cultivars N 53 which was at par with Pusa Red (1.07), while Pusa Madhavi showed the narrow neck of 0.57 cm. the varieties Arka Niketan (0.67 cm), Arka Kalyan (0.77 cm), Punjab Red Round (0.77 cm), Agrifound Dark Red (0.77), Arka Pitamber (0.83 cm) and Agrifound Light Red (0.87 cm) also exhibited thinner neck than other varieties, there by establishing that they could complete their growth during *kharif* season, Bhonde *et al.*, (1992) obtained thinner neck for Arka Niketan and Agrifound Light Red in a late *kharif* season trial.

The diameter of bulb was maximum (5.63 cm) for Pusa Ratnar and minimum (4.57 cm) for Arka Pitamber. The remaining varieties manifested moderate

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Table 1. Pooled analysis of variance for quantitative characters of onion during rainy season

Source	d.f.	Mean Square					
		Plant height (cm)	No. of leaves plant^{-1}	Neck thickness (cm)	Diameter of bulb (cm)	Weight of bulb (g)	Bulb yield (q ha^{-1})
Environment	2	1108.62**	52.70**	0.12	2.41**	106.69**	8604.75**
Replication in environment	9	0.43	5.11	0.01	0.23	51.42*	531.80*
Genotype	11	152.69**	202.99**	0.36**	0.90**	1203.70**	7209.12**
Genotype x Environment	22	27.29**	30.02**	0.04**	0.14	142.88**	2704.82**
Pooled error	99	9.89	11.16	0.01	0.14	22.69	240.25

Significant at * P = 0.05, ** P =0.01

Table 2. Mean performance of onion varieties during rainy season (Pooled)

Cultivars	Character					
	Plant height (cm)	No. of leaves plant^{-1}	Neck thickness (cm)	Diameter of bulb (cm)	Weight of bulb (g)	Bulb yield (q ha^{-1})
Nasik Red	41.34	11.83	1.00	5.07	64.67	184.57
N 2-4-1	35.19	9.30	1.00	4.17	49.33	159.63
Agrifound Dark Red	39.50	11.93	0.77	4.83	68.63	203.07
Agrifound Light Red	33.50	8.60	0.87	4.97	61.10	175.17
N 53	42.80	15.37	1.13	5.23	69.90	218.53
Punjab Red Round	37.70	11.61	0.77	4.93	60.77	179.15
Arka Pitamber	33.53	7.50	0.83	4.57	47.51	155.07
Arka Kalyan	37.10	13.50	0.77	5.10	75.93	229.60
Arka Niketan	30.57	10.60	0.67	4.33	61.67	204.50
Pusa Madhavi	40.34	13.50	0.57	5.03	52.53	191.73
Pusa Red	37.53	14.50	1.07	5.23	48.13	158.10
Pusa Ratnar	38.10	14.92	1.00	5.63	49.30	166.27
SE (m) $\pm$	0.91	0.97	0.03	0.11	1.38	4.45
CD at 5%	2.57	2.73	0.08	0.30	3.89	12.66

diameter of bulb. The largest bulb (75.93 g) was noticed in cultivar Arka Kalyan, where as the smallest bulb (45.51 g) was observed in case of Arka Pitamber followed by Pusa Red, Pusa Ratnar and N 2-4-1. Rest of the varieties expressed moderate weight of the bulb. The thin neck trait coupled with small to medium size of bulb was detected for Pusa Madhavi, Arka Niketan, Punjab Red Round, Agrifound Dark Red, Arka Pitamber and Agrifound Light Red elucidating their potentiality for extended storage life (Kale *et al.*, 1992). Agrifound Dark Red. Agrifound Light Red and Arka Niketan have already proved their potential storage quality (Pandey, 1989 and Bhonde, 1998).

The bulb yield ranged from 155.07 to 229.60 q hq^{-1}. The highest yield was realized from Arka Kalyan (229.60 q ha^{-1}) which was at par with N 53 (218.53 q ha^{-1}), while moderately high yield of 204.50 and 203.07 q ha^{-1} was achieved by Arka Niketan and Agrifound Dark Red, respectively. Bhagchandani *et al.*, (1972), Pandey (1989) and Singh *et al.*, (1991) reported better performance of N 53 and Agrifound Dark Red than other varieties, whereas Bhonde *et al.*, (1992) did not found significant differences in performance among these varieties in *kharif* season. Out of these varieties, Arka Kalyan, N 53 and Agrifound Dark Red are recommended for cultivation in rainy season, while Arka Niketan is recommended for winter season cultivation. This illustrated that *rabi* varieties if grown in *kharif* season chould also produce good bulb yield. Similar observation were also obtained by Bhonde, *et al.*, (1992).

Among the two high performing varieties, Arka Kalyan showed larger bulb depicting poor storage life (Somkumar, *et al.*, 1997), whereas N 53 possessed thicker neck reflecting incomplete growth and poor keeping quality (Kale *et al.*, 1992). During last few years it has been noticed that the proportion of bolters, twins and small bulbs has increased considerably in N 53 due to which yield and quality of bulbs are seriously affected (Lawande and Kale, 1986). On the other hand, Arka Kalyan is moderately resistant to purple blotch disease which has created a serious concern now a days (Singh, 1999). Keeping in view the higher yield, thinner neck and resistance to leaf blight, Arka Kalyan was suggested for *kharif* cultivation to meet the demand of fresh bulbs. Since both the high yielding varieties appeared to be poor storer, Agrifound Dark Red and Arka Niketan with better keeping quality, medium bulb and moderately high yield might be appreciated over N 53 and Arka Kalyan and advocated for large scale cultivation during rainy season.

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To Assess the Optimum Plant Density for Obtaining Higher Yield in Papaya Variety CO-2 (*Carica papaya* L.)

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ABSTRACT

Plant density trial of papaya was conducted during the year 1995-96, 97-98 and 98-99 with five spacings 1.80 x 1.80 m² (3086 plants ha⁻¹), 2.00 x 2.00 m² (2500), 2.20 x 2.20 m² (2066), 2.40 x 2.40 m² (1736) and 2.50 x 2.50 m² (1600 plants ha⁻¹) variety CO-2. It is concluded from the findings that for an increased yield ha⁻¹, a spacing 2.00 x 2.00 m² with 2500 number of plant ha⁻¹ is most profitable. It is therefore recommended to undertake planting of papaya variety CO-2 at the spacing of 2.00 x 2.00 m² for maximum fruit yield under Vidarbha condition.

Papaya (*Carica papaya* L.) is an important fruit of Vidarbha region of Maharashtra state. Area under cultivation of this fruit crop is increasing due to its short duration nature, nutritious value and high yield potential. Cultivators are adopting various spacings for planting papaya, which effects on yield and quality of fruit. Planting distance of 2.4 m apart each way for papaya was recommended by Purohit and Singh (1978). Camejo and Alverez (1986) conducted a trial on papaya planting density and they noted that yield plant⁻¹ decreased as planting density was increased. However, yield hectare⁻¹ was the highest in intermediate planting density followed by the highest density. There is no any recommendation of spacing for papaya for Vidarbha region. Hence spacing trial on papaya was undertaken during the year 1995-96, 97-98 and 98-99.

MATERIAL AND METHODS

Field experiment was conducted during the year 95-96, 97-98 and 98-99 at Fruit Research Unit, Central Research Station, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The soil of the research unit was sandy loam and fertility status was available nitrogen 0.3 per cent, phosphorus 17.95 kg and potassium 376 kg ha⁻¹. The soil pH 7.7 was analysed. Trial was conducted in randomized block design with five spacings 1.80 x 1.80 m² (3086 plants ha⁻¹) 2.00 x 2.00 m² (2500), 2.20 x 2.20 m², (2066), 2.40 x 2.40 m² (1736) and 2.50 x 2.50 m² (1600 plants ha⁻¹). Experimental plot was prepared properly. Pits of 0.45 x 0.45 x 0.45 m³ were dug and filled with soil and FYM in equal proportion. The sixty days old seedlings of variety CO-2 were transplanted in the month of September 95, 97 and 98. Three seedlings pit⁻¹ were planted. Only one plant was retained after flower initiation. Five plants in net plot treatment⁻¹ were maintained. FYM @ 20 kg plant⁻¹ was applied, fertilizer 200:200:200 N :P_2O_5:K_2O g plant⁻¹ was applied in four equal splits i.e. one month after planting and thereafter third, fifth and seventh months after planting. Irrigation, intercultural operations and plant protection measures were adopted as and when required. Vegetative growth parameters such as plant height, basal girth, number of leaves plant⁻¹, spread of plant and yield contributing characters, average weight of fruit, number of fruits and fruit yield plant⁻¹ were recorded.

RESULTS AND DISCUSSION

Growth Parameters :

It is revealed from the data presented in Table1 that plant density significantly influenced growth characters of papaya variety CO-2 during all the years of the experimentation. Pooled mean clearly indicated that maximum plant height (256.0 cm) and leaves plant⁻¹ (127.3) were produced in closer spacing (1.80 x 1.80 m²), while minimum height (212.4 cm) and number of leaves (82.2) plant⁻¹ were recorded in wider spacing (2.50 x 2.50 m²). These results are in close conformity with Biswas *et al.*, (1989) and Kumar *et al.*, (1989). Deshmukh *et al.*, (1981) has also reported that increased plant height was recorded by Nagpur mandarin plants, planted at closer spacing as compared to wider spacing. Same trends of results were recorded by Yadav *et al.*, (1981) in guava fruit crop. Reverse results were obtained in respect of basal girth and spread of papaya plant. From pooled mean it is seen that maximum basal girth (42.1 cm) and spread (194.1 cm) was recorded under wider spacing (2.50 x 2.50 m²) while minimum basal girth (35.1cm) and spread of plant (150 .6 cm) was produced under closer spacing (1.80 x 1.80 m²). Same trend of results were reported by Biswas *et al.*, (1989) and Kumar *et al.*, (1989) in trial with papaya. Deshmukh *et al.*, (1981) in experiment with Nagpur mandarin and Yadav (1981) in trial with guava fruit crop.

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Table 1. Effect of plant density on growth of papaya variety CO-2

Spacings	Plant height (cm)			Pooled	Basal girth of plant (cm)			Pooled	No. of leaves plant^{-1}			pooled	Average
	95-96	97-98	98-99	mean	95-96	97-98	98-99	mean	95-96	97-98	98-99	mean	spread of plant (cm) pooled mean
1.80 x 1.80 M	205.9 (1)	279.6 (1)	282.5 (1)	256.0 (1)	34.0	35.2	36.3	35.1	103.0 (1)	140.4 (1)	138.5 (1)	127.3 (1)	150.6
2.00 x 2.00 M	190.7 (2)	252.4 (2)	270.6 (2)	237.9 (2)	34.9	38.0	37.5	36.8	87.9 (2)	116.0 (2)	115.5 (2)	106.5 (2)	167.4
2.20 x 2.20 M	108.2	247.6	256.2	228.0	36.5	39.0	39.3	38.3	76.2	104.2	104.8	95.0	179.9
2.40 x 2.40 M	172.5	240.2	245.0	219.2	38.5 (2)	40.8 (2)	40.5 (2)	39.9 (2)	68.2	98.2	97.6	87.9	184.0 (2)
2.50 x 2.50 M	162.8	238.0	236.4	212.4	40.1 (1)	43.0 (1)	43.3 (1)	42.1 (1)	61.8	91.8	93.0	82.2	194.1 (1)
F test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE m±	1.488	3.98	8.866	4.032	0.580	0.85	0.895	0.556	1.046	1.86	1.303	1.054	2.24
CD at 5%	4.310	11.51	25.679	11.770	1.681	2.45	2.565	1.624	3.030	5.38	3.789	3.078	6.55

(1) First rank (2) Second rank

Table 2. Effect of plant density on fruit yield of papaya variety CO-2

Spacings in meter (No. of plants ha^{-1})	Av. Wt. of fruit (kg) pooled mean	No. of fruits plant^{-1}			Pooled mean	Yield plant^{-1}(kg)			Pooled mean	Yield plant^{-1} (tonnes)			Pooled mean
		95-96	97-98	98-99		95-96	97-98	98-99		95-96	97-98	98-99	
1.80 x 1.80 m^2	0.793	48.0	58.2	62.2	56.1	40.800	43.650	48.510	44.320	125.91	134.70	149.70	136.77
(3086)												(2)	(2)
2.00 x 2.00 m^2	0.830	74.0	73.8	75.6	74.4	65.240	61.250	63.460	63.317	163.1	153.12	158.65	158.29
(2500)		(1)	(1)	(1)	(1)					(1)	(1)	(1)	(1)
2.20 x 2.20 m^2	0.870	69.6	70.6	72.4	70.8	62.640	60.010	62.090	61.580	129.41	123.98	128.27	127.22
(2066)		(2)	(2)	(2)	(2)					(2)	(2)		
2.40 x 2.40 m^2	0.902	65.2	68.4	69.8	67.8	61.940	59.850	61.780	61.190	107.53	103.89	107.25	106.22
(1736)	(2)												
2.50 x 2.50 m^2	1.080	61.6	66.6	67.2	65.1	67.760	68.260	74.930	70.316	108.42	109.22	119.89	112.51
(1600)	(1)												
F test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE m $\pm$	0.012	3.329	1.136	1.129	1.58	2.444	1.172	0.680	1.184	4.06	3.909	1.603	2.764
CD at 5%	0.035	9.979	3.9	3.267	4.61	7.328	3.394	1.972	3.450	14.409	11.321	4.644	8.068

(1) First rank, (2) Second rank

Yield parameter :

From data presented in Table 2 it is observed that average weight of fruit was increased with decrease in plant population. Maximum heavier fruit (1.080 kg) obtained under wider spacing 2.50 x 2.50 m^2 (1600 plants ha^{-1}). Same trend of results were reported by Biswas *et al.*, (1989) and Kumar *et al.*, (1989). Significantly maximum number of fruits (74.4 $plant^{-1}$) were harvested from the plants planted at 2.00 x 2.00 m^2. Same trend of the results were reported by Biswas *et al.*, (1989) and Kumar *et. al.*, (1989) in trial with papaya. Significantly maximum fruit yield $plant^{-1}$ (70.316 kg) was produced under wider spacing 2.50 x 2.50 m^2 (1600 plant ha^{-1}) while lowest fruit yield (44.320 kg) was obtained under closer spacing 1.80 x 1.80 m^2 (3086 plants ha^{-1}). Although this yield $plant^{-1}$ was more under wider spacing 2.00 x 2.00 m^2 (2500 plants ha^{-1}), the same trend of results were reported by Biswas *et al.*, (1989). Bose *et al.*, (1992) also reported that maximum fruit yield (95 tonnes ha^{-1}) was produced under plant density of 2500 plants ha^{-1}, where as Kumar *et al.*, (1989) obtained highest fruit yield with the spacing 1.5 x 1.5 m^2 (4444 plant ha^{-1}) under climatic conditions of Kalyani, Nandia in West Bengal.

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PKV Res. J. Vol. 25 (1) : 2001

Evaluation of Fungicides and Botanicals for the Management of Early Blight (*Alternaria solani*) of Tomato

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ABSTRACT

The efficacy of two fungicides viz., carbendazim 0.05 per cent, mancozeb 0.25 per cent, the botanicals i.e. neem seed and leaf extract each at 5 per cent concentration and tobacco decoction at 2 per cent concentration was evaluated in the field trial for the management of early blight of tomato caused by *Alternaria solani*. The lowest per cent disease incidence was observed in the treatment of carbendazim (13.93) and mancozeb (15.46). Similarly, the highest yield of tomato fruits was recorded in the treatment of carbendazim (200.86 q ha^{-1}) followed by mancozeb (179.10 q ha^{-1}) when sprayed five times at an interval of 15 days starting from the initiation of the disease. The plant products namely neem seed extract 5 per cent (19.75 PDI), neem leaf extract 5 per cent (20.36 PDI) and tobacco decoction 2 per cent (23.87 PDI) also proved effective in reducing the disease incidence and obtaining the fruit yield to the tune of 168.56, 156.43 and 147.66 q ha^{-1}, respectively. Highest cost benefit ratio was obtained from the spraying with carbendazim @ 0.05 per cent (1:10.95) followed by neem seed extract 5 per cent (1:9.95), however, neem leaf extract, 5 per cent and mancozeb 0.25 per cent were found promising in getting higher return to the extent of 1:8.01 and 1:6.25, respectively.

Tomato (*Lycopersicon esculentum* Mill) is one of the most important "Protective foods" because of its excellent nutritive value and also due to the wide spread production. Maharashtra is the most popular tomato growing state having total area under this crop around 30,000 hectares (Anonymous, 1998).

Early blight of tomato is caused by *Alternaria solani* (Ellt and Mart), Jones and Grout. It causes severe damage and occupies an important position among the diseases (Lodha, 1977). The yield losses may be as high as 50 per cent under favourable conditions (Ramkrishnan *et al.*, 1971). It is more severe in *kharif* season than in *rabi*. The present investigations were undertaken with a view to manage the disease through use of either chemicals or botanicals.

MATERIAL AND METHODS

The experiment was carried out in Chilli and Vegetable Research Unit, Central Research Station, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.) during three consecutive *kharif* seasons of 1996, 1997 and 1998. The trial was laid out in a randomized block design with four replications having each plot size of 3 x 4.80 m^2 with a variety Dhanashri at a spacing of 45 cm within row and 60 cm between plants. Two fungicides and three plant extracts along with an untreated control were tried. Thirty five days old seedlings raised on seed bed treated with phorate granules 10 per cent @ 10 kg ha^{-1} were used for transplantation and the seedings were dipped into the solution of monocrotophos 0.05 per cent. The recommended fertilizer dose (100:60:50 NPK kg ha^{-1}), half of the nitrogen along with total phosphous and potash were applied at the time of transplanting and the remaining nitrogen was given at 30 days after transplanting.

Required quantity of fungicides and plant extract was sprayed five times at 15 days interval from the first appearance of the disease in the field. The observations on the disease incidence on the leaves due to *Alternaria* blight was recorded on the basis of relative per cent leaf area covered by the disease (Table 1). The yield of marketable ripe fruits were recorded and are presented in Table 2.

RESULTS AND DISCUSSION

It is revealed from the pooled data of three years (Table 1) that all treatments were significantly superior over untreated control. Five foliar sprays of carbendazim 0.05 per cent and mancozeb 0.25 per cent were found to be effective in reducing the disease intensity as 13.93 and 15.46 per cent blight intensity was recorded. These results confirms the findings reported by Bhardwaj *et al.*, 1995 and to that of mancozeb with the results of Fugro and Mandokhot (2002).

Neem seed extract 5 per cent (19.75) and neem leaf extract 5 per cent (20.36) were at par with each other but superior to tobacco decoction 2 per cent and control. The present results are in conformity with the findings of Bambode and Shukla (1973) and Vyas (1997).

The data presented in Table 2 showed the

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significant differences in fruit yield of tomato due to application of chemicals and botanicals. Maximum fruit yield was obtained in carbendazim (200.86 q ha^{-1}) followed by mancozeb (179.10 q ha^{-1}). Sprays of neem seed extract also recorded higher yield (168.56 q ha^{-1}) however, all three botanicals were at par with each other. Chhabra *et al.*, (1999) reported the potentiality of botanicals i.e. neem based pesticide for decreasing per cent disease intensity (PDI) and obtaining the desirable fruit yield whereas, the other botanicals i.e. neem leaf extract and tobacco decoction and exerted marginal influence against disease and on yield.

The highest cost benefit ratio was obtained when five foliar sprays of carbendazim @ 0.05 per cent (1:10.95) was applied at an interval of 15 days starting from the first initiation of disease and it exhibited 50.40 per cent disease reduction. However, neem seed extract 5 per cent also exhibited (1:9.95) CBR with 29.69 per cent disease reduction followed by neem leaf extract 5 per cent (1 : 8.01) and mancozeb 0.25 per cent (1:6.25) with 27.51 and 44.96 per cent disease reduction, respectively. The lowest CBR and disease reduction (15.13%)was achieved in tobacco decoction 2 per cent (1: 4.13). Thus it is indicated that the foliar spray of neem seed extract 5 per cent could reduce blight with higher fruit yield and blight was reduced from 28.09 to 19.75 per cent and hence

Table 1. Effect of different fungicides and botanicals on *Alternaria* blight of tomato

S.N.	Treatments	Conc. %	Per cent disease intensity (145 DAS)			Mean	Per cent disease reduction
			1996-97	1997-98	1998-99		
1.	Carbendazim	0.05	13.90 (3.72)	13.88 (3.72)	14.00 (3.74)	13.93 (3.72)	50.40
2.	Mancozeb	0.25	14.80 (3.84)	15.99 (3.99)	15.60 (3.94)	15.46 (3.92)	44.96
3.	Neem seed extract	5	19.20 (4.38)	21.85 (4.67)	18.20 (4.26)	19.75 (4.44)	29.69
4.	Neem leaf extract	5	16.00 (4.00)	22.68 (4.76)	22.40 (4.73)	20.36 (4.50)	27.51
5.	Tobacco decoction	2	22.30 (4.72)	23.61 (4.85)	25.70 (5.06)	23.87 (4.88)	15.13
6.	Control	-	25.20 (5.01)	29.07 (5.39)	30.00 (5.47)	28.09 (5.29)	-
	SE (m)±		0.12	0.09	0.08	0.10	-
	CD at 5%		0.36	0.27	0.23	0.31	

Figures in parenthesis are square root transformed values.

Table 2. Effect of different fungicides and botanicals on tomato yield (q ha^{-1})

S.N.	Treatments	Conc. %	Yield q ha^{-1}			Mean	Cost benefit ratio
			1996-97	1997-98	1998-99		
1.	Carbendazim	0.05	236.69	180.21	185.69	200.86	1:10.95
2.	Mancozeb	0.25	198.75	167.92	170.62	179.10	1:6.25
3.	Neem seed extract	5	179.79	165.69	160.21	168.56	1:9.95
4.	Neem leaf extract	5	178.96	134.58	155.76	156.43	1:8.01
5.	Tobacco decoction	2	151.94	145.97	145.08	147.66	1:4.13
6.	Control		138.19	90.62	90.21	106.34	
	SE m±		8.54	3.61	5.56	7.22	
	CD at 5%		24.79	10.42	16.11	20.97	

in order to minimize pesticidal residues botanicals are safer for vegetable crops.

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PKV Res. J. Vol. 25 (1) : 2001

Body Measurements of She Buffaloes at Field Conditions

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ABSTRACT

Body measurements of she buffaloes at field conditions which includes chest girth, abdominal girth, body length, height at withers, face length, face width, hip width were studied. Means and measures of dispersion of physical measurement of body size are calculated. correlation study indicate that there is positive correlation among face length with body length and height at wither, face width with height at wither and face length, hip width with face length are non significant. Remaining measurements are highly positively and significantly correlated with each other. Interdependance of the character can be utilised in selection programmes for buffaloes.

Breeds of buffaloes are described on basis of body coat, colour, horn pattern, shape of face etc. A little information is available on body measurements. The present studies were undertaken to find variation in physical measurements of body size in local Surti graded she buffaloes.

MATERIAL AND METHODS

The data comprised of observations recorded on 100 locally available Surti graded she buffaloes at Malkapur tahasil of Buldana district. The animals which have completed at least one lactation were considered for oblservation from period of August 98 to September 98. The measurements were taken with calibrated tepe. All observations were recorded in centimeters.

Of the measurements included -

1. Chest girth (X_1)
2. Abdominal girth (X_2)
3. Body length (X_3) (From Poll to Pin-bone)
4. Height at withers (X_4)
5. Face length (X_5) (From Poll to Nostril)
6. Face width (X_6) (From Left eye to Right eye)
7. Hip width (X_7)

Data is analysed for correlation studies as per Amble (1975).

RESULTS AND DISCUSSION

The means for the various body measurements are presented in Table 1.

The coefficients of variation indicated that face length and face width measurement was more variable than othe rmeasurement traits. Their results are varied with the observation of Mangrurkar and Desai (1978) who recorded, chest girth, abdominal girth, body length, height at wither, hip width as 200.97 cm, 225.96 cm, 197.95 cm, 134.51 cm, 53.60 cm, respectively in Nili grade she buffaloes.

Interrelationship among body measurements -

Correlation coefficients of various characters studied are presented in Table 2.

From the Table 2 it is observed that there is positive correlation among face length with body length and height at wither, face width with height at wither and face length, hip width with face length are non significant. Remaining measurements are highly positively and significantly correlated with each other. Interdependance of the character can be utilized in selection programes for buffaloes.

Table 1. Means and measures of dispersion of physical measurements of body size in she buffaloes.

Measurement	Mean (cm)	SE	SD	CV%
Chest girth (X_1)	177.26	1.01	10.14	5.72
Abdominal girth (X_2)	182.87	1.18	11.89	6.50
Body length (X_3)	152.44	1.04	10.42	6.83
Height at wither (X_4)	122.07	0.56	5.68	4.65
Face length (X_5)	44.95	0.30	3.05	6.78
Face width (X_6)	20.11	0.18	1.85	9.19
Hip width (X_7)	48.03	0.39	3.98	8.28

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Table 2. Correlation coefficient for various characters

Characters	X_1	X_2	X_3	X_4	X_5	X_6	X_7
Chest girth (X_1)	1	0.62**± 0.06	0.36 **± 0.08	0.47**± 0.07	0.26*± 0.09	0.29**± 0.09	0.49**± 0.07
Abdominal girth (X_2)	-	1	0.34**± 0.08	0.30**± 0.09	0.29**± 0.09	0.24**± 0.08	0.56**± 0.06
Body length (X_3)	-	-	1	0.43**± 0.08	0.03**± 0.10	0.26*± 0.09	0.37**± 0.08
Height at wither (X_4)	-	-	-	1	0.06± 0.09	0.18± 0.09	0.54**± 0.07
Face length (X_5)	-	-	-	-	1	0.05± 0.10	0.17± 0.09
Face width(X_6)	-	-	-	-	-	1	0.35**± 0.08
Hip width(X_7)	-	-	-	-	-	-	-

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

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RESEARCH NOTES

Feasibility of Liquid Fertilizer Through Drip Irrigation to Cotton

Cotton plays an important role in national economy which is grown in almost all the part of India. India stands first in cotton area of about 80 lakhs hectare followed by China, U.S.A., U.S.S.R., Brazil and Pakistan. However, in respect of production, the country with its present production of about 100 lakh bales stands fourth in the world. In order to increase the cotton production, irrigated cotton is grown in some part of India. Due to scarcity of water drip irrigation method for cotton production is being introduced in arid and semiarid tropics. Area under drip irrigation in India is 10,000 hectare and in Maharashtra it is 700 hectare only (Sivanappan, 1987). To increase the production level, now a days soluble fertilizer is applied to crop through drip irrigation. The application of liquid fertilizer through drip irrigation system is more efficient than conventional method of ferilizer application (Fabry, 1978). It affords the opportunity of better adjusting water and nutrients supplies to crop as a more balanced feeding which results in high production and best product quality (Gagnard *et al.*, 1983). The application of fertilizer through drip increases the fertilizer efficiency and flexibility of fertilizer application with reduction in the labour cost (Haynes, 1985). Fertigation saves 40 per cent of fertilizer application over application method of solid fertilizer (Magar, 1988).

In order to study the effectiveness and efficiency of liquid fertilizer through drip irrigation, the field experiment was conducted at highway block of Central Research Station Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during 1995-96. The experiment was planned in randomized block design in four replications and five treatments i.e. drip irrigation with liquid fertilizers @ 100 per cent of recommended dose, drip irrigation with liquid fertilizers @ 75 per cent of recommended dose, drip irrigation with liquid fertilizers @ 50 per cent of recommended dose, drip irrigation with liquid fertilizer @ 25 per cent of recommended dose and drip irrigation with solid fertilizers 100 per cent of recommended dose in black cotton soil with variety PKV-Hybrid 4. The sowing was done on May 28, 1995 and irrigation through drip was applied daily, equivalent to previous day evapotranspiration. The spacing was 15 x 75 cm.

The maximum water use efficiency was found in the treatment of drip irrigation with liquid fertilizer 100 per cent of recommended dose, (34.21 kg ha^{-1} cm), followed by treatment 75 per cent recommended dose of liquid fertilizer. Lowest water use efficiency was found in the treatment drip irrigation with liquid fertilizers 25 per cent of recommended dose. The application efficiency and distribution efficiency were found to be 95.35 per cent and 95.84 per cent, respectively.

The treatment of drip irrigation with 100 per cent recommended dose of liquid fertilizer was found significantly superior in average plant height, average boll weight and number of bolls $plant^{-1}$ over all other treatments. However significant difference in biometric characters was not found in nuber of monopodia and sympodia. The weight of boll and number of bolls were maximum in the treatment of liquid fertilizer with 100 per cent of recommended dose (4.8 g and 60.29, respectively). However, the boll weight and number of bolls were at par in the treatment of liquid fertilizer with 50 per cent recommended dose and solid fertilizer with 100 per cent recommended dose. The results are given in the Table 1. The maximum yield was found in the treatment of liquid fertilizer with 100 per cent recommended dose (32.16 q ha^{-1}) and significantly superior over all the treatments followed by the treatment of liquid fertilizer with 75 per cent recommended dose, solid fertilizer

Table 1. Biometric characters observed under drip irrigation influenced by different levels of liquid fertilizer

Treatments	Average plant height (cm)	No. of mono-podia	No. of sympodia	Average weight of boll (g)	No. of bolls	Water use efficiency (kg ha^{-1} cm)	Yield (q ha^{-1})
L.F. of 100 % R. dose	88.17	17.50	16.30	4.8	60.29	34.21	32.16
L.F. of 75 % R. dose	83.87	16.80	14.60	4.6	53.80	29.25	27.50
L.F. of 50 % R. dose	77.81	16.75	13.45	4.3	51.61	26.23	24.66
L.F. of dose 25% R. Dose	70.27	15.00	10.00	4.0	43.97	20.78	19.54
Solid F. of 100 % R. dose	77.96	16.00	12.97	4.3	52.69	26.77	25.17
"F" test	Sig.	NS	NS	Sig.	Sig.	-	Sig.
SE m±	1.088	1.043	2.089	0.128	1.274	-	0.643
CD at 5%	3.355	3.214	6.438	0.592	3.928	-	1.983

with 100 per cent of recommended dose and liquid fertilizer with 50 per cent recommended dose. The significantly lowest yield was recorded in the treatment of liquid fertilizer with 25 per cent recommended dose (19.54 q ha^{-1}). The yield recorded in the treatment of liquid fertilizer with 50 per cent recommended dose and solid fertilizer with 100 per cent recommended dose were at par. The treatment of 100 per cent liquid fertilizer has given 28 per cent more yield over solid fertilizer treatment.

The Table 2 shows that the highest net return was found in the treatment of liquid fertilizer with 100 per cent recommended dose (Rs. 38914 ha^{-1}) with benefit cost ratio of 1:2.35 followed by the treatment of liquid fertilizer with 75 per cent recommended dose. The benefit cost ratio was found same in the treatment of liquid fertilizer with 50 per cent recommended dose and solid fertilizer with 100 per cent recommended dose thus 50 per cent fertilizer saves with fertigation.

About 28 per cent yield was increased by using 100 per cent recommended dose of liquid fertilizer over solid fertilizer treatment. The benefit cost ratio was same in the treatment of liquid fertilizer with 50 per cent recommended dose and solid fertilizer with 100 per cent recommended dose. Thus saving of 50 per cent fertilizer was obtained through fertigation.

Table 2. Total return, total cost, net return and benefit cost ratio

Treatments	Crop yield (q ha^{-1})	Total return (Rs. ha^{-1})	Total cost (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Benefit cost ratio
L.F. of 100 % R dose	32.16	67536	28622	38914	1:2.35
L.F. of 75% R dose	27.50	57750	27313	30437	1:2.11
L.F. of 50 % R dose	24.66	51786	26003	25783	1:1.99
L.F. of 25 % R dose	19.54	41034	24694	16340	1:1.66
Solid F of 100 % R dose	25.17	52857	26447	26410	1:1.99

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Soil Irrigability Classification of Akola District

Soil and water are two important natural resources for increasing agricultural production. Soil irrigability classification deals with evaluation of soils (profile features) for their suitability to irrigation on the basis of quantitative limits of soil characteristics pertinent to irrigation. There are five soil irrigability classes recognized for flow irrigation and aerable cropping. These irrigability classes are decided by considering different soil charactristics (soil profiles) such as effective soil depth, soil textural group, soil structure, available water capacity in effective profile depth, basic infiltration rate saturated hydraulic conductivity, soil salinity, soil sodicity, erosion, surface cover etc.

Sixteen representative soil samples (two from each location) were collected in the month of December, 94 from both Katepurna and Morna commands of Purna basin. The samples collected were of varying depth i.e. 0-25 cm and 25-50 cm. These soil samples were analyzed for their chemical properties such as EC, pH, ESP, Organic carbon, CEC (Cation Exchange Capacity) etc. as per U.S.S.L. methods (Richards, 1954). Also these samples were tested for various physical properties viz. saturated moisture content, field capacity, hydraulic conductivity, infiltration rate, drainable porosity etc. as per standard methods (Misra and Ahmed, 1990). After completion of analysis, soil samples were classified on the basis of soil irrigability classification. Soil irrigability classes are established without regard to availability of irrigation water, water quality, land preparation costs, availability of drainage outfalls and other non soil related factors. (Palaskar and Varade, 1985 and WALMI 1985).

Nearly twenty five per cent of the soil samples from both commands comes under class "C" of soil irrigability classification (Table 1). It means that twenty five per cent soil have severe soil limitations for sustained use under irrigation. While seventy five per cent of the soil samples comes under class "B" of soil irrigability classification. It means that seventy five per cent soil from these commands have moderate soil limitations for sustained use under irrigation (Rege *et al.*, 1974). As most of the area from both these commands have moderate soil limitations for sustained use under irrigation, some reclaimative measures such as leaching drainage or addition of amendments like gypsum are required to bring this soil under irrigation so as to avoid salt accumulation on the surface of the soil.

Table 1. Classification of soil on the basis of soil irrigation classification

S.N.	Locations	Aggregate index	Soil irrigability class
1.	Dahigaon	3.125	"B"
2.	Dhotardi	3.250	"B"
3.	CDF-37	3.250	"B"
4.	CDF-36	3.250	"B"
5.	Hingana	3.125 & 3.000	"B" & "C"
6.	Somthana	3.000	"C"
7.	Nimbi	3.125	"B"
8.	Mhaispur	3.000 & 3.125	"C" & "B"

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Insect Pests of Field Bean and Tolerence of Its New Genotypes to Pod Borers

Field bean *Dolichos lablab* (Linn) a minor pulse crop of Central Vidarbha is gaining importance in recent years especially after introduction of promising genotypes like Konkanbhushan. Further improvement in genotypes and management practices is being duly attended by research workers. However, information on insect pests of field bean in the zone is limited though pod borers are known to cause substantial damage (Nair, 1986). Therefore, present study was aimed to survey insect pests of field bean and evaluate few new genotypes for tolerance to pod borers in field conditions.

The experiment was laid out at Regional Research Station, N.A.R.P., Yavatmal with eight genotypes (Table 1) which were replicated thrice in a randomised block design. Each plot was 4.0 x 2.4 m size and sowing was done at 30 x 10 cm distance on September 9, 1997. After germination, five plants were selected randomly from each plot and observed frequently for the pests. Insect pests were recorded with intensity irrespective of the genotypes. At pod formation stage (November 1st week) total pods and damaged pods by pod borers were counted on selected plants. Percentage of damaged pods in each genotype was worked out and tolerance was judged on the basis of percentage of damaged pods.

Field bean raised in September was almost free from pests for a month but later on the crop was infested by pests listed in Table 2. Leaf folder, aphids, plume moth, *lablab* pod borer and *H. armigera* were predominent among 13 pests. Data regarding infestation of pod borers on selected genotypes (Table 1) revealed that Konkanbhushan recorded least infestation followed in ascending order by AKW 9305, AKW 9304 and AKW 9301 and they were at par with each other. Genotypes AKW 9306, AKW 9303, AKW 9311 and AKW 9312 had significantly high infestation than Konkanbhushan.

Table 1. Infestation of podborers on fieldbean as influenced by genotypes

Name of genotypes	Infested pods (%)
Konkanbhushan	32.62
AKW 9301	43.73
AKW 9303	47.73
AKW9304	39.53
AKW 9305	37.56
AKW9306	47.20
AKW 9311	50.98
AKW9312	55.35
S.E. ±	3.70
C.D. at 5%	11.21
C.V.%	14.51

Table 2. Insect pests of field bean in central Vidarbha

Name of pests	Plant portion damaged	Period of major activity and intensity
Grasshopper *Colemania sphenariodies* Bol.	Foliage	November, rare
Leaf miner *Cosmopteryx phaeogastra* Meyer	Foliage	November, 4 per cent leaflets.
Leaf folder *Hedylepta indicata* Fabr	Foliage	November to January, 10 per cent leaves
Hairy caterpillar *Euproctis subnotata* Wlk.	Foliage, buds, flowers, pods	January, 3 per cent plants
Jassids *Empoasca* spp.	Foliage	November, rare
Aphids *Aphis craccivora* Koch.	Tender shoots, foliage, inflorescence, pods	November-January 6.7 per cent plants
Thrips *Megalurothrips usitatus* (Bagnall)	Buds, flowers	November-January
Plume moth *Sphenarches anisodactylus* Wlk.	Pods	Nov., 5.5 larvae 10 plants^{-1}
Lablab pod borer *Adisura atkinsoni* (Moore)	Pods	Nov. 4.5 larvae 10 plants^{-1}
Pod borer *Helicoverpa armigera* (Hubner)	Buds, flowers, pods	Mid Nov. to Jan., 24 per cent pods in January
Spotted pod borer *Maruca testulalis* (Geyer)	Buds, flowers	November, rare
Pod bug *Riptortus linearis* Fab.	Pods	Nov.-Jan. 1 bug 20 plants^{-1}
Green stink bug *Nezara viridula* (L.)	Foliage, pods	Nov to Jan. rare

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Field Evaluation of Some Cotton Genotypes For Ovipositional Preference of *Helicoverpa armigera* (Hubner)

In India *Helicoverpa armigera* (Hubner) causes severe loss of cotton requiring rupees 250 crores worth of pesticides to control every year (Mehrotra, 1988). In another estimate more than 53 per cent share of yearly pesticides usage in the country is utilized for control of cotton pests (Basu, 1994). Therefore, research workers suggested integrated approach including use of tolerant varieties for its effective and ecofriendly management. Hence this study was aimed to evaluate certain genotypes of *arboreum* and *hirsutum* cotton for ovipositional preference of the pest under field conditions.

Two separate experiments were conducted at Regional Research Station, NARP, Yavatmal. Both experiments were laid out in a randomised block design with three replications and sown on June 26,1997. First experiment comprised of eight hybrids and two varieties of *arboreum* and one variety (Rajat) of *hirsutum* cotton as checks (Table 1 A). Each plot was 6.0 x 2.4 m^2 in size and spacing 60 x 60 cm. Second experiment comprised of twenty genotypes of *hirsutum* cotton including two recommended varieties as checks (Table 1 B). Each plot was 7.2 x 3.6 m^2 in size and spacing was 60 x 30 cm. Two plants were selected randomly from each plot and observations were recorded when crop was at full bloom (October 1st week). All tender shoots, leaves, squares, flowers and bolls on selected plants were observed through hand lens and number of eggs of *Helicoverpa* noticed were counted. The data were subjected to statistical analysis and ovipositional tolerance of genotypes was judged on the basis of number of eggs noticed i.e. genotypes having less eggs were considered as tolerant one and vice-versa.

The data (Table 1 A) revealed that all *arboreum* hybrids and varieties under study recorded significantly less number of eggs than *hirsutum* check Rajat. Among *arboreum* hybrids AKDH 3 had

Table 1. Ovipositional preference of *H. armigera* as influenced by cotton genotypes

A. Preference on *arboreum* cotton			B. Preference on *hirsutum* cotton		
Genotypes	No. of eggs plant^{-1}		Genotypes	No. of eggs Plant^{-1}	
AKDH 3	1.00	(1.22)*	AKH 8828	15.00	(3.93)*
AKDH 4	2.33	(1.68)	AKH 8801	17.00	(4.17)
AKDH 5	2.00	(1.56)	AKH 8940	7.67	(2.85)
AKDH 6	3.00	(1.86)	AKH 9015	9.33	(3.11)
AKDH 9	3.33	(1.93)	AKH 8627	5.33	(2.38)
AKDH 17	7.00	(2.71)	AKH 9312	13.00	(3.66)
AKDH 24	1.33	(1.34)	AKH 8740	8.33	(2.92)
AKDH 7	1.67	(1.46)	AKH 8649	10.33	(3.27)
AKA 8401 (Ch)	2.67	(1.77)	AKH 9131	1.33	(1.34)
AKA 5 (Ch)	3.00	(1.86)	AKH 8829	3.67	(2.00)
Rajat (*Hirs.* Ch)	14.67	(3.89)	AKH 8931	2.33	(1.64)
			AKH 8263	2.00	(1.56)
S.E. ±		0.156	AKH 8362	3.33	(1.85)
C.D. at 5%		0.46	AKH 8708	3.33	(1.95)
C.V. %		14.00	AKH 8928	6.00	(2.51)
			AKH 9119	1.33	(1.34)
			AKH 9340	4.00	(2.11)
			AKH 8935	6.33	(2.60)
			Rajat (Ch)	6.67	(2.67)
			DHY 286 (Ch)	10.00	(3.23)
			S.E. ±		0.24
			C.D. at 5%		0.70
			C.V. %		16.59

Ch = Check, (.....)* $= \sqrt{x + 0.5}$

significantly less eggs than both checks AKA 8401 and AKA 5. Though at par with AKA 8401, AKDH 24 recorded significantly less egg than AKA 5. Hybrids AKDH 7, AKDH 5, AKDH 6 and AKDH 9 were at par with both checks AKA 8401 and AKA 5. However, AKDH 17 had significantly more number of eggs than all *arboreum* hybrids as well as checks and stood only next to Rajat in ovipositional preference.

The data regarding number of eggs on *hirsutum* genotypes (Table 1B) revealed that AKH 9131 and AKH 9119 recorded least eggs followed by AKH 8263, AKH 8931, AKH 8362 and AKH 8708. They were at par with each other but significantly less preferred than both checks Rajat and DHY 286. Genotypes AKH 8829, AKH 9340, AKH 8627 and AKH 8928 were as preferred as Rajat, but significantly less preferred than DHY 286. Genotypes AKH 8935, Rajat, AKH 8940, AKH 8740, AKH 9015, DHY 286 and AKH 8649 were at par among themselves but had significantly increased number of eggs than former genotypes. AKH 9312 and AKH 8828, though at par with DHY 286, had significantly still more eggs than all former genotypes. AKH 8801 recorded highest number of eggs, but appeared to be as preferred as AKH 9312 and AKH 8828. Thus AKDH 3 and AKDH 24 from *arboreum* group and AKH 9131, AKH 9119, AKH 8263, AKH 8931, AKH 8362 and AKH 8708 from *hirsutum* group were less preferred by *H. armigera* for ovipositon than respective checks.

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collected from meteorological observatory, Nagpur situated at latitude of 21° 06' N and longitude of 79° 03' E. The data were arranged in twelve sets, corresponding to each month where every month has 24 rainfall events. Monthly and yearly events were then classified as drought, normal and abnormmal, as suggested by Sharma *et al.*, 1979.

Estimation of mean, standard deviation and coefficient of variation for monthy and annual rainfall series have been worked out and shown in Table 1. July is the wettest month (average rain = 292.20 mm) and April is driest month with average rainfall of just 8.00 mm. The wettest month next to July is August, which has lowest coefficient of variation i.e. have consistent rainfall. June and July have nearly 47 per cent coefficient of variation indicating good regularity of rains. December month has highest coefficient of variation i.e. 222.39 indicating irrigularity of rains in the month. January, February, March, April, May, October and November show C.V. greater than 100. Assured rainfall may be expected in the month of June to September only. Out of 288 months in 24 years drought, normal and abnormal months have found to be 37.15, 5.43 and 10.42 per cent, respectively. That is the expected number of drought, normal and abnormal months in a year are 5.08, 5.5 and 1.42, respectively. Table 2 shows probability of distribution of drought, normal and abnormal months in a year.

Rank correlation test for randomness (Kanji, 1995) has been applied for detecting trend in annual series. Analysis of data does not reject the hypothesis of no correction. Hence, we conclude the absence of trend in the annual rainfall series.

Monthly distribution of drought, normality and abnormality and percentage of total years having a given month as a drought, normal and abnormal is shown in Table 3. Information provided by this analysis may be used for planning of various crops. The command area of this observatory covers Nagpur and nereby part of Central India in which citrus (Nagpur Mandarin), cotton etc. are main crops.

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Screening of Cotton Genotypes Against *Alternaria* Leaf Spot and Bacterial Blight

Alternaria leaf spot caused by *Alternaria macrospora* Zimm and bacterial leaf blight caused by *Xanthomonas axonopodis* pv. *malvacearum* (Smith) Dowson are an important foliar diseases of cotton in Vidarbha region of Maharashtra as it causes extensive damage to the crop. The yield losses due to *Alternaria* spot incombination with bacterial blight were upto 10-20 per cent (Allayyanavarmath and Padaganur, 1977). Although many fungicides are reported for control of these foliar diseases, host plant resistance is an economical means to their management. The present study was therefore undertaken to find out new resistant sources.

A total twenty eight cotton varieties/ genotypes from *arboreum* and *hirsutum* group were tested for their reaction against *Alternaria* leaf spot and bacterial blight under natural field conditions during 1999-2000 and 2000-2001 at NARP farm, Yavatmal. Each test variety/genotype was planted in two rows of 6 m length. Ten plants were randomly selected from each variety and tagged for recording observations. Severity of foliar diseases were recorded at square-flowering stage. Six leaves per plant were observed for disease intensity and grading was done according to prescribed grading scale for *Alternaria* leaf spot and bacterial blight diseases, respectively (Mayee and Datar, 1986). PDI was calculated and the varieties were grouped into respective categories as 0 - immune, upto 5 per cent infection - resistant, 6-10 per cent infection - moderately resistant, 11-20 per cent infection - moderately susceptible, > 20 per cent infection - susceptible.

The results (Table 1) revealed that varieties/ genotypes screened, none was found immune i.e. for both the diseases. Fifteen varieties were found resistant to *Alternaria* blight while remaining 13 varieties showed moderately resistant reaction. As regards bacterial blight, 15 entries exhibited resistant reaction, seven moderately resistant and six moderately susceptible. Patil and Ghoderao (1998) reported highly susceptible reaction of var. AKH-84635 and AKH-081 to *Alternaria* blight under artificial inoculation. However, in the present studies both the cultivar showed moderately resistant reaction against the disease.

The exhibited resistance of genotypes against *Alternaria* leaf spot and bacterial blight useful in breeding programme.

Table 1. Reaction of cotton genotypes against *Alternaria* leaf spot and bacterial blight (1999-2001)

Diseases	Reaction	Variety/Genotype
Alternaria blight	Resistant	AKA-8401, 9004, AKH-4, AKA-9409, 9611, 9105, 9009, 9106, 9624, 8617, 9618, 8404, DHY-286, AKH-8362
	Moderately resistant	AKH-8427, 8649, 84635, 8829, 8931, 8940 9015, 9119, 9340, 9601, 8801, 8628, AKH-081
Bacterial blight	Resistant	AKA-9409, 9611, 9105, 9106, 9004, 9006, AKH-8362, 8627, 8649, 8801, 8628, 84635, 8940, 9601, DHY-286
	Moderately resistant	AKH-4, AKA-8404, 9009, 8617 AKH-081, 8829, 8931
	Moderately susceptible	AKA-8401, 9624, 9618 AKH-9015, 9119, 9340

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Response of Okra Genotypes to Varying Plant Density

Okra (*Abelmoschus escunlentus*) is an annual vegetable crop grown in tropical and sub-tropical regions. The tender green fruits of okra are cooked in curry and soup. The roots and stem are used for cleaning cane juice in preparation of "Gur". The dry seed contain 13-22 per cent good edible oil and 20-24 per cent protein. The crushed seed is feed to cattle for more milk production and the fiber is utilized in juice, textile and paper industry (Anon, 2001).

Plant density spacing^{-1} is an important factor which influences the yield of various crops considerably. The most appropriate spacing is one that enable the plant to take the best advantage of best condition at there disposal as it is intimately connected with root development as well as shoot growth and fructification. In a high plant density, the crop does not show good response with respect to growth and yield due to competition involved for nutrition, moisture, light, air, etc. resulting in reduction in yield. However, the crop yield can be compensated due to more number of plants on unit area. The concept of high density is increasingly gaining acceptance to optimize productivity. Keeping in view the above situation, a field investigation was conducted to find out optimum spacing and plant density for okra genotype.

The field experiment was carried out on the farm of Department of Agornomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *kharif* 2001-2002. The investigation comprised of four levels of spacing and three varieties were studies in split plot design repeated thrice. The main plot consisted of four levels of spacing while three verieties constituted the three sub-plot treatments.
The details of the treatments were.

Treatments

A) Main plot treatments
Spacings

S_1	60 x 30 cm^2	(55555 plant ha^{-1})
S_2	60 x 22.5 cm^2	(74074 plant ha^{-1})
S_3	45 x 45 cm^2	(50000 plant ha^{-1})
S_4	45 x 30 cm2	(74074 plant ha^{-1})

B) Sub plot treatments
Okra genotypes

V_1	AKOV-97-16 (pre release)
V_2	Parbhani Kranti
V_3	Arka Anamika

The soils of the experimental site was medium black clay loam in texture having 11.55 per cent sand, 34.30 per cent silt and 54.51 per cent of clay and slightly alkaline in reaction (pH 7.8), low in total nitrogen (0.035 %) and organic carbon (0.53 %), medium in available phosphorus (26.10 kg ha^{-1}) and high in available potassium (264.85 kg ha^{-1}).

The data on growth characters of okra as influenced by different treatments are presented in Table 1 indicated that the mean height of okra crop progressively increased with advanced age of crop the maximum height of 86.01 cm was noticed at 120 DAS. Plant height was significantly influenced by spacing at 120 DAS. A spacing of 45 x 30 cm (7404 plants ha^{-1}) recorded significantly more height at than spacing at 60 x 30 cm (55555 plant ha^{-1}) and 45 x 45 cm (50000 plant ha^{-1}) but was at par with spacing of 60 x 22.5 cm (74074 plant ha^{-1}). This might be due to comparatively less competition for light interception, moisture, space, nutrient in case of lower plant density. These findings are in conformity with those reported by Naik *et al.*, (1994).

All the yield contributing parameters i.e. number of leaves, number of fruits, length and diameter of fruits and weights of fruits plant^{-1} were significantly more due to 60 x 30 cm and 45 x 45 cm spacing than the higher plant spacing of 60 x 22.5 cm and 45 x 30 cm (Table 1 and 2). Plant density of 74074 ha^{-1} (60 x 22.5 cm and 45 x 30 cm) recorded higher dry matter weight and yield. The less per plant in case of high density was compensated be increased number of plants.

Therefore, the higher plant density i.e. 74074 plants ha^{-1} (spacing of 60 x 22.5 cm and 45 x 30 cm) was found to give 31.70 per cent higher yield as compared to 55555 plants and 50000 plants ha^{-1}. These results are in conformity with those reported by Patel and Singh (1991) and Raghav (1996).

Effect of variety on growth and yield contributing parameters and yield of *kharif* okra are presented in Table 1 and 2. The okra Parbhani Kranti variety (V_2) recorded significantly more plant height, number of leaves and leaf area than variety AKOV-97(V_1) and Arka Anamika (V_3). This might be due to genetic characters of the variety. Among the varieties significantly more dry matter was produced by Parbhani Kranti (V_2) which was followed by Arka Anamika (V_3) and AKOV-97(V_1). The results can be attributed due to more plant height, number of branches, number of leaves and leaf area attained by variety Parbhani Kranti as compared to Arka Anamika and AKOV-97. These results are in line with those reported by Choudhary *et al.*, (1995) and Anonymous (2002).

Table 1. Effect of plant density on growth characters of okra genotype

Treatments	Leaf area plant^{-1} ($dm^2 m^{-1}$) 120 DAS	Plant height(cm) 120 DAS	Number of branches plant^{-1} 120 DAS	Dry matter (g) plant^{-1} 120 DAS
Spacings				
S_1 60 x 30 cm^2	19.13	85.94	4.33	61.98
S_2 60 x 22.5 cm^2	18.00	89.71	3.52	54.82
S_3 45 x 45 cm^2	19.32	81.02	4.58	63.01
S_4 45 x 30 cm^2	18.31	90.11	3.80	56.69
SE (m)±	0.14	0.42	0.069	0.56
CD at 5%	0.47	1.37	0.22	1.80
Varieties				
V_1 AKOV-97-16	18.42	83.20	4.28	56.66
V_2 Parbhani Kranti	18.92	88.22	4.08	60.62
V_3 Arka Anamika	18.74	86.53	3.80	60.10
SE (m)±	0.98	0.28	0.069	0.39
CD at 5%	0.28	0.82	0.20	1.16
Interaction (S x V)				
SE (m)±	0.19	0.56	0.13	0.79
CD at 5%	-	-	-	-
GM 18.69	86.01	4.05	59.12	

Table 2. Effect of plant density on yield attributes and yield of okra genotypes

Treatments	Number of fruits plant^{-1}	Length of fruits (cm)	Diameter of fruits (cm)	Weight of fruits plant^{-1} (g)	Yield plant^{-1} (kg)	Yield ha^{-1} (q)
Spacings						
S_1 60 x 30 cm^2	17.10	14.16	1.46	103.41	5.27	32.63
S_2 60 x 22.5 cm^2	13.69	12.17	1.44	78.66	6.60	40.76
S_3 45 x 45 cm^2	18.15	14.23	1.50	104.37	4.89	30.20
S_4 45 x 30 cm^2	14.14	12.80	1.41	79.38	6.81	42.04
SE (m)±	0.54	0.16	0.024	1.23	0.067	0.43
CD at 5%	1.73	0.52	0.078	3.94	0.22	1.38
Varieties						
V_1 AKOV-97-16	14.22	12.72	1.43	84.87	5.41	33.40
V_2 Parbhani Kranti	16.59	13.46	1.47	95.48	6.16	38.04
V_3 Arka Anamika	16.50	13.86	1.45	94.02	6.11	37.78
SE (m)±	0.36	0.12	0.025	0.66	0.063	0.39
CD at 5%	1.07	0.36	0.073	1.93	0.18	1.16
Interaction (S x V)						
SE (m)±	0.73	0.25	0.050	1.32	0.12	0.79
CD at 5%	-	-	-	-	-	-
GM	15.77	13.34	1.45	91.45	5.89	36.40

Variety Parbhani Kranti (V_2) recorded significantly more number of flowers (16.69), green fruits (16.59) and fruit weight (95.48 g) than variety AKOV-97 (V_1) but was at par with Arka Anamika (V_3). Significantly more fruit length (13.86 cm) was recorded by variety Arka Anamika (V_3) followed by Parbhani Kranti (V_2) and AKOV-97(V_1). Varieties did not differ in respect of diameter of fruits. All these characters might have been governed by the genetical characters of the varieties. The variety Parbhani Kranti (V_2) produced significantly higher green fruits yield (6.16 kg) over AKOV-97(V_1) and also closely followed by Arka Anamika (V_3) (6.11 kg). The Arka Anamika (V_3) was also significantly superior over AKOV-97 (V_1) in respect of yield. Variety Parbhani Kranti (V_2) recorded 0.68 and 13.89 plant^{-1} more yield than the varieties Arka Anamika (V_3) and AKOV-97 (V_1), respectively. Similar observations were recorded by Choudhary *et al.*, (1995) and Anon, (2002).

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Particulars about PKV Research Journal
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FORM IV

1.	Place of Publication	:	Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola
2.	Periodicity of Publication	:	Six monthly
3.	Printers Name	:	Sau. Sunita Thakre
4.	Nationality	:	Indian
5.	Address	:	Pooja Prints, Raut wadi, Akola
6.	Publishers Name	:	Dr. S.V. Sarode
7.	Nationality	:	Indian
8.	Address	:	Director of Research, Dr. PDKV, P.O. Krishi Nagar, Akola
9.	Editor-in-Chief	:	Dr. S.V. Sarode
10.	Nationality	:	Indian
11.	Address	:	Editor-in-Chief Dr. PDKV, P.O. Krishi Nagar, Akola - 444 104 (Maharashtra)
12.	Owners Name	:	Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola

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