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DR. PANJABRAO DESHMUKH KRISHI VIDYAPEETH, AKOLA

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Research Note

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Yield and Uptake of Nutrients by *Kharif* Sorghum as Influenced by Integrated Nutrient Management

N.D. Bhande[1], P.S. Naphade[2], S.S. Hadole[3], K.J. Kubde[4] and S.T. Dangore[5]

ABSTRACT

A field experiment on "yield and uptake of nutrient by *kharif* sorghum as influenced by integrated nutrient management" was conducted at Central Research Station, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *kharif* season of 2000-01. The results of present investigation revealed that maximum yield of sorghum grain (47.06 q ha^{-1}) was obtained due to 100 per cent RDF (80 kg N + 40 kg P_2O_5 ha^{-1}) + *Azospirillum* application of inorganic in combination with organic and biofertilizer increased the availability of nutrients in soil after harvest. Thus, integrated use of inorganic and organic fertilizer is essential to obtain maximum yield of sorghum and to maintain soil fertility.

Integrated plant nutrient management is one of the key components of intensive Agriculture. The chemical fertilizers are no doubt, important sources of nutrients which can meet the nutrient requirements of plants but their unbalanced and continuous use leads to environmental, pollution and deterioration of soils physico-chemical properties.

Sorghum (*Sorghum bicolor* L. Moench) is a major source of food for million of people in the semiarid tropics. In tropical areas sorghum grain is an important food and livestock feed. India has the largest share (32.2%) of world in sorghum area and ranks second in production after U.S.A. In India, area under sorghum during 2000-2001 was 10.39 million hectares with a production of 8.86 million tonnes (FAO, 2001). It is a stable food of the people of Maharashtra. In Maharashtra, *kharif* sorghum was cultivated on about 19.07 lakh hectare area with an annual production of 23.95 lakh tonnes during the year 2000-2001 (Anonymous, 2001).

Considering the significance of integrated use of plant nutrients in increasing their efficiencies and crop productivity, the present study was under taken to study the effect of

Table 1. Details of treatments

S.N.	Treatment details	Symbol
1.	Control	T_1
2.	50 % RDF @ 40:20 kg N + P_2O_5 ha^{-1})	T_2
3.	50 % RDF + *Azospirillum* + Phosphate solubilizing bacteria	T_3
4.	100 % RDF @ 80 : 40 kg N + P_2O_5 ha^{-1}	T_4
5.	100 % RDF + *Azospirillum* + Phosphate solubilizing bacteria (250 g 10 kg^{-1} seed)	T_5
6.	Farm yard manure @ 5 t ha^{-1}	T_6
7.	FYM @ 5 t ha^{-1} + *Azospirillum* + Phosphate solubilizing bacteria @ 250 g 10 kg^{-1} seed) seed treatment	T_7
8.	FYM @ 5 t ha^{-1} + *Azospirillum* + Phosphate solubilizing bacteria 50% RDF	T_8
9.	Vermicompost @ 2.5 t ha^{-1}	T_9
10.	Vermicompost @ 2.5 t ha^{-1} + *Azospirillum* + Phosphate solubilizing bacteria + 50 % RDF	T_{10}
11.	Vermicompost @ 2.5 t ha^{-1} + *Azospirillum* + Phosphate solubilizing bacteria	T_{11}
12.	Sheep manure @ 1.25 t ha^{-1}	T_{12}
13.	Sheep manure @ 1.25 t ha^{-1} + *Azospirillum* + Phosphate solubilizing bacteria	T_{13}
14.	Sheep manure @ 1.25 t ha^{-1} + *Azospirillum* + Phosphate solubilizing bacteria + 50% RDF	T_{14}
15.	Poultry manure @ 1.5 ha^{-1}	T_{15}
16.	Poultry manure @ 1.5 ha^{-1} + *Azospirillum* + phosphate solubilizing bacteria	T_{16}
17.	Poultry manure @ 1.5 t ha^{-1} + *Azospirillum* + Phosphate solubilizing bacteria + 50% RDF	T_{17}

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Table 2. Nutrient content of organic manures and chemical fertilizers

S.N.	Particulars	N (%) (Piper, 1966)	P_2O_5 (%) (Jackson, 1967)	K_2O (%) (Jackson, 1967)
1.	Vermicompost	1.56	0.87	0.96
2.	Poultry manure	2.87	2.54	1.2
3.	Sheep manure	2.67	1.00	1.82
4.	Farm yard manure	0.49	0.2	0.5
5.	Urea	45.46	-	-
6.	Single super phosphate	-	16.28	-

Table 3. Sorghum yield (q ha^{-1}) as influenced by different treatments

	Treatments	Sorghum yield (q ha^{-1})	
		Grain	Straw
T_1	Control	16.33	36.82
T_2	50 % RDF @ 40:20 kg N + P_2O_5 ha^{-1}	22.95	47.49
T_3	50% RDF + *Azosirillum* + Phosphate solubiling bacteria	25.32	52.11
T_4	100 % RDF@ 80:40 kg N + P_2O_5 ha^{-1}	43.71	91.80
T_5	100 % RDF + *Azospirillum* + Phosphate solubiling bacteria (250 g 10 kg^{-1} seed)	47.06	95.54
T_6	Farm yard manure @ 5 t ha^{-1}	21.89	45.12
T_7	FYM @ 5 t ha^{-1} + *Azospirillum* + Phosphate solubilizing bacteria @ 250g 10 kg^{-1} seed (Seed treatment)	2340	47.85
T_8	FYM @ 5 t ha^{-1} + *Azospirillum* + Phosphate solubilizing bacteria 50% RDF	26.46	55.71
T_9	Vermicompost @ 2.5 ha^{-1}	23.51	48.79
T_{10}	Vermicompost @ 2.5 t ha^{-1} + *Azospirillum* + Phosphate solubilizing bacteria + 50 % RDF	26.49	54.89
T_{11}	Vermicompost @ 2.5 t ha^{-1} + *Azospirillum* + Phosphate solubilizing bacteria	33.94	69.84
T_{12}	Sheep maniure @ 1.25 t ha^{-1}	21.49	43.13
T_{13}	Sheep manure @ 1.25 t ha^{-1} + *Azospirillum* + Phosphate solubilizing bacteria + 50 % RDF	23.55	49.08
T_{14}	Sheep manure @ 1.25 t ha^{-1} + *Azospirillum* + Phosphate solubilizing bacteria + 50 % RDF	26.36	54.56
T_{15}	Poultry manure @ 1.5 ha^{-1}	23.53	49.69
T_{16}	Poultry manure @ 1.5 t ha^{-1} + *Azospirillum* + Phosphate solubilizing bacteria	25.57	51.22
T_{17}	Poultry manure @ 1.5 t ha^{-1} + *Azospirillum* + Phospate solubilizing bacteria + 50% RDF	28.46	57.78
	SE m $\pm$	0.64	1.25
	CD at 5%	1.80	3.74

organic manure, inorganic fertilizer and biofertilizer.

MATERIAL AND METHODS

The experiment was laid out in randomized block design (RBD) with seventeen treatment combination comprising of the levels of organic, inorganic and biofertilizer which were replicated thrice during.

The soil of the experimental site was characterized as - Vertisols, particularly montmorillonitic type, Hyperthermic family of Typic Haplusterts. The soil was slightly alkaline in reaction, medium in organic carbon, low in available nitrogen and phosphorus and high in

Table 4. Uptake of nutrients (Kg ha^{-1}) by sorghum crop as influenced by different treatments

Symbol	Treatment details	N uptake			P uptake			K uptake		
		Straw	Grain	Total	Straw	Grain	Total	Straw	Grain	Total
T_1	Control	10.94	23.94	34.89	5.79	4.63	10.42	20.64	4.89	25.54
T_2	50 % R.D.F. @ 40 : 20 Kg N + P_2O_5 ha^{-1})	15.19	36.97	49.16	7.91	7.03	14.95	28.33	7.49	35.83
T_3	50 % R.D.F. + *Azospirillum* + Phosphate solubilizing bacteria	17.35	37.73	55.09	9.19	8.01	17.21	31.79	8.52	40.31
T_4	100 % R.D.F. @ 80 : 40 Kg N + P_2O_5 ha^{-1})	36.96	66.00	99.96	18.36	14.85	33.21	65.80	15.58	81.38
T_5	100 % R.D.F. + *Azospirillum* + Phosphate solubilizing bacteria (250 g 10 kg^{-1} seed)	35.99	71.84	10.78	19.74	16.31	36.06	70.09	17.25	87.35
T_6	Far, yard manure @ 5 t ha^{-1}	15.65	32.98	48.64	8.14	6.93	15.07	26.92	7.22	34.15
T_7	FYM @ 5 t ha^{-1} + *Azospirillum* + Phosphate solubilizing bacteria @ 250 g 10^{-1} kg seed) (seed treatment)	17.55	35.57	53.12	8.93	7.65	16.59	29.03	7.88	36.92
T_8	FYM @ 5 t ha^{-1} + *Azospirillum* + Phosphate solubilizing bacteria 50 % R.D.F.	22.84	40.39	63.24	11.70	8.99	20.70	35.66	9.26	44.92
T_9	Vermicompost @ 2.5 t ha^{-1}	17.07	35.74	52.82	9.11	7.53	16.64	30.41	7.91	38.32
T_{10}	Vermicompost @ 2.5 t ha^{-1} + *Azospirillum* + Phosphate solubilizing bacteria + 50 % R.D.F.	21.41	40.79	62.21	10.98	8.99	19.97	35.13	9.10	44.23
T_{11}	Vermicompost @ 2.5 t ha^{-1} + *Azospirillum* + Phosphate solubilizing bacteria	28.18	52.94	81.12	15.38	11.99	27.37	46.11	12.56	58.68
T_{12}	Sheep manure @ 1.25 t ha^{-1}	13.66	32.45	46.12	8.05	6.66	14.72	21.16	7.16	33.33
T_{13}	Sheep manure @ 1.25 t ha^{-1} + *Azospirillum* + Phosphate solubilizing bacteria	15.71	36.44	52.15	9.66	7.46	17.12	21.42	8.02	39.45
T_{14}	Sheep manure @ 1.25 t ha^{-1} + *Azospirillum* + Phosphate solubilizing bacteria + 50 % R.D.F.	17.64	41.13	58.77	11.45	8.60	20.06	35.81	9.31	45.13
T_{15}	Poultry manure	16.39	36.47	52.87	10.27	7.76	18.03	30.95	8.00	38.95
T_{16}	Poultry manure @ 1.25 t ha^{-1} + *Azospirillum* + Phosphate solubilizing bacteria	18.26	39.97	58.24	11.09	8.60	19.06	32.61	9.12	41.73
T_{17}	Poultry manure @ 1.5 t ha^{-1} + *Azospirillum* + Phosphate bacteria + 50% R.D.F.	23.11	45.16	68.27	14.44	10.15	24.59	38.71	10.62	49.33
	SE (m)±	0.94	2.45	3.20	0.97	0.46	1.4	2.22	1.17	3.16
	CD at 5 %	2.88	7.34	9.58	2.94	1.42	3.92	6.63	3.46	9.45

available potassium. The soil was analysed for different physico-chemical properties as described by Piper 1966, Jackson 1967 and Subbaiah and Asija 1956.

Inorganic fertilizers viz. urea, single super phosphate of commercial grade, organic manures viz, vermicompost, poultry manure, sheep manure and farm yard manure and biofertilizers viz, *Azospirillum*, phosphate solubilising bacteria (PSB) were used in the present investigation. Prior to the application, organic and inorganic fertilizers were analysed for N, P and K contents. The analytical results are presented in Table 2.

RESULTS AND DISCUSSION

Grain and straw yield of sorghum

It is observed from the Table 3 that the application of recommended dose of fertilizer and biofertilizer (100 % RDF + AZO + PSB) (T_5) and (T_4) had significantly increased the grain yield over all treatments. Further, it was followed by 100 per cent RDF (T_4) and vermicompost @ 2.5 t ha^{-1} in combination with *Azospirillium* + PSB + 50 per cent RDF (T_{11}). These results are in agreement with the findings of Kundu and Gaur (1980) and Algawadi and Gaur (1992) who have reported 13.0 to 15.8 per cent increase in grain yield with the seed or soil inoculation. The highest grain and straw yields were observed due to the combined effect of nitrogen and phosphorus. However, the lowest grain and straw yields were noticed in control treatment. These results are also supported by Ravankar *et. al.* (1998) and Selvakumari *et. al.* (2000).

Uptake of nutrients

It is observed from the data presented in Table 4 that the uptake of NPK at the harvest stage were significantly increase due to application of organic, inorganic and biofertilizers and the highest uptake of NPK was recorded with the application of RDF + biofertilizers (T_5) and RDF alone (T_4). No significant difference were observed in uptake of NPK due to organic manures and biofertilizers applied alone or combinations. The total uptake at harvest stage was also highest due to application of 100 per cent RDF and seed treatment with biofertilizers (T_5) followed by T_4. Rest of the treatments were found at par. Naphade *et. al.*(1993) also recorded increased uptake of nutrients due to fertilizer application.

Application of 100 per cent RDF and seed treatment with biofertilizers might have resulted in more and easy availability of nutrients and recorded higher uptake of NPK. More and Ghoniskar (1984) noticed that increasing level of N increased the N content and its uptake.

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Studies on the Yield Potential of Different Cotton Genotypes in Different Agro-Climatic Zones of Maharashtra under Rainfed Condition

V.M. Solanke[1], A.B. Turkhede[2], S.T. Wankhade[3], R. N. Katkar[4] and B.A.Sakhare[5]

ABSTRACT

A field experiment was carried out during *kharif* seasons of 1998-99 to 2000-01 to study the yield potential of different cotton genotypes under rainfed condition at four locations. The results revealed that deshi varieties recorded better seed cotton yield (1093 kg.ha^{-1}) than *hirsutum* varieties (964 kg ha^{-1}) and hybrids (646 kg ha^{-1}) at Akola. At Yavatmal, *G.arboreum* (1279 kg ha^{-1}), *G. hirsutum* (1311 kg ha^{-1}) and *G. hirsutum* hybrids (1420 kg ha^{-1}) were found to be at par. At Buldana maximum seed cotton yield was recorded by *G. hirsutum* hybrid (875 kg ha^{-1}) followed by *G. arboreum* (733 kg ha^{-1}). At Achalpur, *G. arboreum* cotton group gave more seed cotton yield (1026 kg ha^{-1}) than *G. hirsutum* (625 kg ha^{-1}) and *G. hirsutum* hybrid (571 kg ha^{-1}). On the basis of location pooled, preference should be given to the cultivation of deshi cotton varieties AKA – 5 (1119 kg ha^{-1}) and AKA –7 (1141 kg ha^{-1}) over hybrids and *hirsutum* varieties because of lower cost of cultivation and high monetary returns in deshi varieties.

Virtually all the cotton varieties in India originated from four cultivated species i.e. *Gossypium arboreum, G. herbaceum, G. barbadense* and *G. hirsutum, Gossypium arboreum* is indigenous to the Indian Sub- Continent having short staple length with coarse fibres. The second asiatic type *G. herbaceum* was introduced from the middle east. Cultivation is centered in the central and western parts of India. Varieties from this species possess a medium long finer fibre than *arboreum* types. The cotton belonging to the American or Cambodia types *(G. hirsutum / barbadense)* constitute the prime source of medium and longer staple cotton of 26.8 mm and more. Only relatively small quantities of cotton growth in India, however, are longer than 30.4 mm.

Present improved varieties of American cotton are generally susceptible to the sucking pests and bollworms. On the other hand, the Asiatic types called the deshi cottons, are relatively free from sucking pests and tolerant to bollworms due to this cotton yield are directly affected.

Cotton growing seasons vary in India, and seed cotton yields are unstable and vary as per agro-climatic situation. The rainfall in most of the areas are uneven therefore, it directly affect the yield especially of *hirsutum* groups. So, keeping these points in view the present study was undertaken with the object to evaluate yield potential of different genotypes under rainfed conditions.

MATERIAL AND METHODS

The rainfed field experiments were carried out at four locations situated in different agro – climatic zones viz., Cotton Research Unit, Akola., National Agriculture Research Project, Yavatmal, Buldana, and Achalpur under the jurisdiction of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. (M.S.) during 1998-99 to 2000-01. The soil of the experimental sites were medium deep black with medium status of available nitrogen and phosphorus and high in available potassium. The trial was laid out in Randomized Block Design with three replications. The experiments consisted of 9 genotypes as detailed in Table 1.

RESULTS AND DISCUSSION

A. Seed cotton yield

a. Akola : Data reported in Table 1 indicates that during 1998-99 deshi varieties (*arboreum*) recorded significantly more seed cotton yield than American varieties and hybrids except AKH-081. Differences among the three deshi varieties and AKH-081 were not significant. Seed cotton yield among the three hybrids did not differ significantly. While in *hirsutum* varieties AKH-081 produced significantly more seed cotton yield than DHY – 286 and PKV Rajat.

During 1999 – 2000 on an average seed cotton yield potential of American varieties and hybrids was more than deshi varieties. Maximum seed cotton yield was produced by American

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Table 1. Seed cotton yield (kg ha^{-1}) as influenced by various treatments

Treatments	Akola				Yavatmal				Buldana				Achalpur		
	1998-99	1999-00	2000-01	Pooled mean	1998-99	1999-00	2000-01	Pooled mean	1998-99	1999-00	2000-01	Pooled mean	1999-00	2000-01	Pooled mean
A. Hybrids															
PKV Hy–2	637	1326	663	875	1385	1317	1902	1535	556	1065	810	809	141	694	417
PKV Hy–4	635	1406	554	865	1594	1516	1497	1535	718	1219	671	869	429	781	605
NHH–44	627	972	723	774	1144	1041	1387	1191	601	1358	887	948	468	916	692
Mean	633	1235	646	838	1374	1291	1595	1420	625	1214	789	875	346	797	571
B. American varieties															
DHY–286	514	1438	939	964	848	771	1497	1039	347	524	448	439	112	710	411
PKV Rajat	529	1419	1063	1004	1311	1125	2275	1570	463	977	588	676	424	1022	723
AKH - 081	873	1108	891	957	868	835	2276	1326	424	861	563	616	468	1013	741
Mean	638	1321	964	974	1009	910	2016	1311	411	787	533	577	335	915	625
C. Deshi varieties															
AKA–8401	812	867	1384	1021	739	263	1247	749	424	699	668	597	116	1235	819
AKA–5	873	1038	1430	1114	1144	1125	2417	1562	540	979	799	773	980	1263	1122
AKA–7	875	1049	1510	1145	1263	1234	2089	1528	579	1064	848	831	839	1444	1139
Mean	853	985	1441	1093	1048	874	1917	1279	514	914	772	733	645	1304	1026
S.E. m±	42.2	77.2	59.4	35.5	88.0	91.0	40.1	72.2	36.1	91.1	25.5	36.1	33.4	25.7	157.3
C.D. at 5%	126.6	231.5	178.2	100.6	265.0	272.0	120.4	204.6	108.4	264.9	76.5	104.9	100.1	77.2	471.6
C.V. %	10.3	15.1	10.1	-	13.4	15.4	16.6	-	12.2	16.2	6.35	-	13.1	16.3	-

Table 2. Seed cotton yield (Location pooled) net monetary returns, C:B ratio and B:C ratio as influenced by various treatments

Treatments	Seed cotton Yield (kg ha^{-1})	Net monetary returns (Rs ha^{-1})	C:B ratio	B:C ratio
PKV Hy –2	946	10075	1:1.95	0.95
PKV Hy –4	999	11242	1:2.07	1.07
NHH – 44	909	8134	1:1.77	0.77
Mean	951	9817	1:1.19	0.93
DHY – 286	726	6590	1:1.71	0.71
PKV Rajat	996	11978	1:2.35	1.30
AKH - 081	908	9809	1:2.14	1.06
Mean	876	9459	1:1.20	1.02
AKA – 8401	759	7853	1:2.13	1.07
AKA – 5	1119	15127	1:3.14	2.07
AKA – 7	1141	15532	1:3.20	2.12
Mean	1006	12837	1:1.28	1.42
S.E.m±	89.1	1979.5	-	-
C.D. at 5%	267.0	5934.7	-	-

cotton variety DHY-286, PKV Rajat, PKV Hy-4, PKV Hy-2 but significantly superior over rest of the varieties and hybrids. During 2000-2001 deshi varieties recorded significantly more seed cotton yield than Amrerican cotton varieties and hybrids. Three cotton hybrids produced significantly lowest yield.

Pooled data reported in Table – 1 indicated that a newly released deshi cotton genotype AKA – 7 produced maximum seed cotton under rainfed situation which was at par with AKA – 5 and both these deshi varieties recorded significantly more than other hybrids and varieties under study. On an average, among the three groups of varieties, hybrids and deshi varieties performed better than American genotypes and hybrids. Hybrids group was lowest in yield.

b. Yavatmal : At Yavatmal during 1998-99 and 1999-2000 on an average hybrids recorded higher seed cotton yield than American and deshi varieties. While during 2000-2001 American varieties and deshi varieties were found to be comparable and recorded considerable higher seed cotton yield than hybrids. Pooled data indicated that hybrids group had, on an average more yield potential than American and deshi varieties.

Among the hybrids, PKV Hy-2 and PKV Hy-4 gave 28.9 per cent more yield than NHH-44. In American varieties, PKV Rajat Produced significantly maximum seed cotton yield than DHY-286 and AKH-081. DHY-286 was observed to be lowest in yield. In *arboreum* genotypes. AKA –5 and AKA-7, being at par gave 813 and 779 kg ha^{-1} more seed cotton yield than AKA – 8401.

c. Buldana : During 1998-99, PKV Hy-4 recorded significantly maximum seed cotton yield over all the varieties and hybrids under study. In American varieties, PKV Rajat produced higher seed cotton yield than DHY – 286 and at par with AKH – 081, deshi varieties viz, AKA – 5 and AKA – 7 being at par gave 27.4 and 36.6 per cent more seed cotton yield, respectively, than AKA – 8401.

During 1999 – 2000, hybrids recorded more yield potential followed by deshi group cotton hybrid NHH – 44 which gave significantly superior yield than PKV Hy – 2 and at par with PKV Hy – 4. In deshi varieties AKA – 8401 was lowest in yield, and AKA – 7 and AKA – 5 were at par. In American cotton varieties PKV Rajat and AKH – 081 being at par showed significantly superior yield than DHY – 286.

During 2000-2001, *hirsutum* hybrid and deshi varieties on an average recorded higher seed cotton yield than American varieties. Maximum seed cotton yield was produced by the cotton hybrid NHH-44 which was at par with AKA – 7, PKV Hy- 2 and AKA – 5 and significantly superior over rest of the varieties and hybrids. PKV Hy-4, DHY – 286, and AKA – 8401 were lowest in seed cotton yield among their respective groups.

Pooled data indicated that on an average cotton hybrids recorded maximum seed cotton yield than pure line genotypes from *arboreum* and

Table 3. Ancillary information (Av. of three years)

Treatments	No.of bolls plant^{-1}	Yield Plant^{-1} (g)	PP ha^{-1} (000')	Plant Height (cm)	Sympodia Plant^{-1}	Dry Matter (g)	C : B Ratio			
							Akola	Yavatmal	Buldana	Achalpur
A. Hybrids										
PKV Hy –2	21.3	54.9	17.83	75.3	18.0	144.9	1:1.78	1:2.87	1:1.66	1:0.91
PKV Hy –4	14.8	38.4	25.46	81.7	19.5	117.4	1:1.77	1:2.87	1:1.77	1:1.28
NHH – 44	19.6	49.6	17.55	85.5	20.6	107.2	1:1.61	1:2.33	1:1.92	1:1.45
B. American varieties										
DHY – 286	8.5	21.2	49.50	63.5	15.6	88.5	1:2.22	1:2.36	1:1.10	1:1.03
PKV Rajat	9.1	22.6	49.55	73.1	18.7	84.7	1:2.29	1:3.29	1:1.63	1:1.73
AKH - 081	5.6	10.4	101.03	55.3	15.0	69.5	1:2.20	1:2.88	1:1.51	1:1.76
C. Deshi varieties										
AKA – 8401	10.4	22.5	49.82	100.5	21.5	51.3	1:2.85	1:2.21	1:1.82	1:2.38
AKA – 5	5.9	11.8	101.61	80.6	18.7	37.9	1:3.05	1:3.92	1:2.27	1:3.06
AKA – 7	6.1	12.4	100.81	72.5	18.3	45.4	1:3.11	1:3.86	1:2.41	1:3.10

hirsutum group. American varieties recorded lowest seed cotton yield. Hybrid NHH-44 showed maximum yield potential. Seed cotton yield recorded by this hybrid was at par with PKV Hy-4 and significantly superior to the rest of the hybrid and genotypes. In deshi varieties AKA – 7 and AKA – 5 being at par produced 39.2 and 29.5 per cent increased seed cotton yield over AKA – 8401.

d. Achalpur : During 1999 – 2000, AKA–5 and AKA–7 being at par, recorded significantly more seed cotton yield than all others hybrids and varieties. During 2000–2001, AKA–7 recorded significantly higher seed cotton yield (1444 kg ha^{-1}) than rest of the improved deshi, *hirsutum* varieties and *hirsutum* hybrids. In two years pooled data, it was seen that *arboreum* genotypes (deshi) performed better than *hirsutum* varieties and hybrids. Maximum seed cotton yield was given by AKA–7, followed by AKA–5. These two varieties were found to be at par.

On the basis of location pooled it was observed that deshi cotton recorded highest seed cotton yield (1006 kg ha^{-1}) followed by *hirsutum* hybrids (951 kg ha^{-1}) and American varieties (876 kg ha^{-1}). Statistically seed cotton yield differences between *G. arboreum, G. hirsutum* varieties and *G. hirsutum* hybrids were found to be at par. However, Wankhade and Meshram (1994) reported that the impact of improved package of practices was 31.4, 42.4 and 38.8 per cent in deshi, American varieties and *hirsutum* hybrids respectively and recommended agro – techniques recorded maximum increase in yield in H-4 cotton (74.7 %) and minimum in deshi cotton AKA – 5 (20.5%).

B. Economics : On the basis of location pooled highest net monetary returns were recorded in deshi group (Rs ha^{-1} 12837/-), followed by *hirsutum* hybrid (Rs ha^{-1} 9817/-) and *hirsutum* varieties (Rs. ha^{-1} 9459/-). C : B ratio and B:C ratios were also higher in deshi followed by American varieties and *hirsutum* hybrids. More or less similar results were recorded by Suryavanshi *et. al.* (1992).

C. Growth and yield parameters : On the basis of three years average, it showed that hybrid group recorded maximum bolls and yield per plant. Plant height and sympodia per plant were maximum in AKA – 8401, followed by NHH- 44, PKV Hy-4. In respect to dry matter accumulation deshi group recorded lowest and hybrid showed maximum dry matter per plant. American varieties exhibited an intermediate value of dry matter per plant except *hirsutum* dwarf variety AKH-081.

Thus, it could be concluded that at Akola deshi varieties performed better than American varieties and hybrid recorded less seed cotton yield. At Yavatmal, PKV Rajat, PKV Hy-4, PKV Hy-2 and AKA – 7 showed better yield performance than other varieties and hybrids. At Buldana, maximum seed cotton yield was recorded by hybrid NHH- 44, followed by PKV Hy-4, AKA – 7 and AKA – 5. At Achalpur, deshi cotton group gave more seed cotton yield than American varieties and hybrids. So under rainfed condition on the basis of economics it is recommended to give preference to the cultivation of deshi cotton varieties (AKA – 5 and AKA - 7) over hybrids and American varieties because of lower cost of cultivation and high monetary returns in deshi varieties.

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Vertical Distribution of Organic Carbon and Total NPK as Influenced by Long Term Application of Manures and Fertilizers Under Sorghum Wheat Sequence

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ABSTRACT

A study on vertical distribution of pH, EC, organic carbon and total N, P, K as influenced by manures, gypsum and fertilizers at different levels in long term experiment during 1998-99 revealed that long term manuring and fertilization in vertisol did not exert any significant effect on pH, however, EC of soil was influenced slightly, while organic carbon and total NPK were significantly influenced by various treatments. Application of 100 per cent NP K + 10 ton FYM ha^{-1} recorded highest organic carbon and total NPK, followed by 150 per cent NPK. Application of FYM alone did not increase much total N, P and K as compared to other treatments but its application showed 2-3 fold increase in organic carbon over control. Organic carbon and total NPK decreased with increase in soil depth irrespective of treatments. However, pH and EC values tended to increase with soil depth, though the increment were non-significant. Thus, conjunctive use of recommended dose of NPK + FYM (10 t ha^{-1}) in sorghum-wheat sequence proved superior in buildup of organic carbon, total N, P and K in soil (upto 60 cm depth).

Long term application of fertilizer and FYM alter the fertility status of soil. In respect of nitrogen, there is substantial removal by the crops besides losses due to volatilization, denitrification and leaching. Various soluble nitrogenous compounds are translocated in different depths of the soil. Phosphatic fertilizer when added to the soil, undergoes various reactions rendering some of the added phosphate unavailable to the plants. In Vertisol, about 75 to 80 per cent of applied phosphate is fixed mainly in the form of Ca-P(Bapat *et al.,* 1965). The mobility of phosphorus is very low as compared to N and K and therefore, its vertical distribution in intensive cropping system will throw light on nutrient management. Similarly, K is largely utilized by cereal crops as compared to the amount of K added through fertilizers and therefore, K reserves get depleted. In this situation, it will be of great significance to asses the vertical distribution of organic carbon, N, P and K in Vertisols subjected to long term manuring and fertilization for over 10 years. Keeping this in view, the present investigation was carried out to find the effect of continuous use of manures and fertilizers on vertical distribution of organic carbon and total NPK in Vertisols under sorghum-wheat sequence.

MATERIAL AND METHODS

A long term field experiment was started in the year 1988 at Central Research Station, Dr. PDKV, Akola with sorghum-wheat sequence. The soil of experimental site was clayey, fine, montmorilliontic, hyperthermic family of Typic Haplusterts having pH range (8.0-8.1), EC (0.31 dS m^{-1}), medium in organic carbon (0.46%) total N (0.044%), low in available N and P content (120 and 8.4 kg ha^{-1}, respectively) and high in available K (358 kg ha^{-1}). The experiment was initiated during kharif 1988 and present investigation was conducted during 1998 in a Randomised Block Design replicated 4 times. The treatment details are given in Table 1.

The NPK nutrients were applied in the form of urea, SSP, DAP and MOP as per treatments, sulphur through gypsum and zinc through $ZnSO_4.7H_2O$. Entire dose of P and K was given as a basal dose, while nitrogen was applied in two splits i.e. half at the time of sowing and remaining half dose 21 days after sowing of crop. FYM was applied 30 days before sowing of *kharif* crop. After completion of 10 cycles of sorghum wheat sequence, soil samples from total 56 plots were collected depth wise i.e. 0-15, 15-30, 30-45 and 45-60 cm. Standard

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methods as out lined by Black (1965) and Jackson (1967) were followed for analysis of pH, EC, organic carbon, total N,K and total P, respectively.

RESULTS AND DISCUSSION

pH

The data presented in Table 2 clearly indicated that there was no significant effect of various treatments on soil pH of surface and subsurface layers upto 45 cm depth. This may be attributed to the restricted vertical translocation of soluble fertilizer ingredient and humic substances. Similar results were also reported by Tyagi and Bhardwaj (1994) and Sinha *et al.* (1997). Treatment T_7 and T_8 which received gypsum (10 and 47.5 kg S ha^{-1}, respectively) showed lowest pH (7.78 and 7.75, respectively) than other treatments which might be due to incorporation of gypsum which helps to reduce pH. The treatment T_{14} (FYM @ 10 tons ha^{-1}) showed comparatively less pH (7.82) than treatment receiving inorganic fertilizer which might be attributed to production of acids during the process of decomposition of organic matter supplied through FYM (Chaudhari *et al.*, 1981).

EC

Long term manuring and fertilization significantly influenced salt content of Vertisols in surface layers (upto 30 cm). The significant changes in EC in surface layers may be attributed to the long term addition of NPK fertilizers mainly. However, total soluble salt content was not influenced significantly below 30 cm depth. Among the various treatments, a significantly maximum increase in EC (0.29 dS m^{-1}) observed in T_6 (100 % NPK S free) followed by treatment T_5(150 % NPK) over control which may be due to the amount of salt added through long term application of NPK fertilizers. Results throw light on the fact that by addition of fertilizers, the salt content of soil increased as compared to control. Even, continuous use of FYM and gypsum also showed higher values of EC than control might be ascribed due to solubilizing effect of organic acids on various compounds on soil and slight solubility of gypsum which increased total content of ions in the soil water (Shainberg *et al.*,1982) and inadequate drainage of these soils or improper leaching of salts beyond rootzone. However, these treatments showed less value of EC as compared to other treatments receiving chemical fertilizers. In general, the EC values were not so high that they could adversely affect the crop yield. Sharma *et al.* (1980) and Chaudhari *et al.*(1981) also reported that EC of soil had remained more or less unaffected under long term application of organic and inorganic fertilizers.

Organic carbon

The results revealed that the various fertilizers and FYM treatments have significantly increased organic carbon content of soil over control in all soil depths. Maximum amount of organic carbon

Table 1. Details of treatments

Sr. No.	Treatments	$N : P_2O_5 : K_2O$ Kg ha^{-1}		Source of fertilizer
		Sorghum	Wheat	
1	Control	-	-	-
2	50 % NPK	50 : 25 : 20	60 : 30 : 30	-
3	75 % NPK	75 : 37.5 : 30	90 : 45 : 45	Urea, SSP, MOP
4	100 % NPK	100 : 50 : 40	120 : 60 : 60	Urea, SSP, MOP
5	150 % NPK	150 : 75 : 60	180 : 90 : 90	Urea, SSP, MOP
6	100 % NPK (S free)	100 : 50 : 40	120 : 60 : 60	Urea, DAP, MOP
7	100% NPK + 10 kg S ha^{-1} through gypsum	100 : 50 : 40	120 : 60 : 60	Urea, DAP, MOP
8	100% NPK + 47.5 kg S ha^{-1} through gypsum	100 : 50 : 40	120 : 60 : 60	Urea, DAP, MOP
9	100% NPK + 10 kg $ZnSO_4$ 7 H_2O	100 : 50 : 40	120 : 60 : 60	Urea, SSP, MOP
10	100% NPK + 20 kg $ZnSO_4$ 7 H_2O	100 : 50 : 40	120 : 60 : 60	Urea, SSP, MOP
11	100% N	100 : 00 : 00	120 : 00 : 00	Urea
12	100 % NP	100 : 50 : 00	120 : 60 : 00	Urea, SSP
13	100% NPK + FYM 10 t ha^{-1} (*kharif*)	100 : 50 : 40	120 : 60 : 60	Urea, SSP, MOP
14	FYM 10 t ha^{-1} (*kharif*)			

Table 2. Vertical distribution of pH, EC and organic carbon as influenced by long term manuring and fertilization

	Treatments	pH (1:2.5)				EC (dSm^{-1})				Organic carbon (%)			
		0-15	15-30	30-45	45-60	0-15	15-30	30-45	45-60	0-15	15-30	30-45	45-60
		cm				cm				cm			
T_1	Control	7.83	7.96	8.16	8.23	0.16	0.18	0.25	0.28	0.308	0.278	0.252	0.201
T_2	50 % NPK	7.86	7.94	8.14	8.20	0.20	0.23	0.28	0.30	0.528	0.488	0.408	0.315
T_3	75 % NPK	7.81	7.83	8.19	8.33	0.22	0.24	0.28	0.34	0.591	0.521	0.484	0.370
T_4	100 % NPK	7.89	8.13	8.29	8.47	0.22	0.22	0.29	0.35	0.611	0.527	0.407	0.372
T_5	150 % NPK	7.82	8.09	8.22	8.49	0.28	0.31	0.31	0.35	0.658	0.556	0.490	0.393
T_6	100 % NPK (S free)	7.92	8.03	8.19	8.34	0.29	0.32	0.37	0.36	0.596	0.487	0.437	0.388
T_7	100% NPK + 10 kg S ha^{-1} through gypsum	7.78	7.94	8.12	8.25	0.26	0.26	0.31	0.36	0.567	0.483	0.461	0.362
T_8	100% NPK + 47.5 kg S ha^{-1} through gypsum	7.75	7.89	8.02	8.12	0.25	0.21	0.28	0.30	0.567	0.501	0.384	0.314
T_9	100% NPK + 10 kg $ZnSO_4$ 7 H_2O	7.83	8.08	8.18	8.26	0.25	0.24	0.34	0.38	0.585	0.512	0.402	0.333
T_{10}	100% NPK + 20 kg $ZnSO_4$ 7 H_2O	8.01	8.16	8.24	8.44	0.20	0.23	0.29	0.36	0.633	0.547	0.445	0.355
T_{11}	100% N	7.91	8.06	8.16	8.28	0.21	0.24	0.27	0.34	0.490	0.457	0.373	0.318
T_{12}	100 % NP	7.87	8.03	8.15	8.24	0.29	0.30	0.33	0.35	0.563	0.479	0.437	0.325
T_{13}	100% NPK + FYM 10 t ha^{-1} (*kharif*)	7.95	8.05	8.15	8.26	0.24	0.29	0.35	0.38	0.783	0.647	0.563	0.464
T_{14}	FYM 10 t ha^{-1} (*kharif*)	7.82	8.08	8.16	8.30	0.22	0.24	0.26	0.30	0.703	0.582	0.465	0.398
	Mean	7.86	8.01	8.16	8.30	023	0.25	0.30	0.33	0.584	0.504	0.431	0.350
	SE (m) $\pm$	-	-	-	0.052	0.018	0.023	-	-	0.016	0.025	0.031	0.027
	CD at 5%	-	-	-	0.146	0.051	0.065	-	-	0.049	0.077	0.046	0.083

Table 3. Vertical distribution of N, P and K as influenced by long term manuring and fertilization

Treatments	Total N (ppm)				Total P (ppm)				Total K (ppm)			
	0-15	15-30	30-45	45-60	0-15	15-30	30-45	45-60	0-15	15-30	30-45	45-60
	cm				cm				cm			
T_1 Control	294	217	168	125	1199	1117	945	840	5250	4597	3250	3250
T_2 50 % NPK	476	405	273	168	1462	1297	1192	1102	6750	6062	5562	5562
T_3 75 % NPK	539	497	316	245	1560	1425	1253	1207	7500	6275	6000	6000
T_4 100 % NPK	602	518	349	266	1702	1552	1350	1230	8062	6812	5687	5687
T_5 150 % NPK	689	615	504	413	1867	1642	1432	1380	9494	8625	6750	6750
T_6 100 % NPK (S free)	532	371	357	238	1499	1372	1305	1327	6437	6375	5875	5875
T_7 100% NPK + 10 kg S ha^{-1} through gypsum	560	497	434	280	1454	1335	1312	1282	7062	6562	5625	5625
T_8 100% NPK + 47.5 kg S ha^{-1} through gypsum	574	532	405	369	1522	1380	1304	1117	6750	6250	5687	5687
T_9 100% NPK + 10 kg $ZnSO_4$ 7 H_2O	553	553	335	294	1380	1312	1199	1110	7187	6568	5625	5625
T_{10} 100% NPK + 20 kg $ZnSO_4$ 7 H_2O	588	469	350	301	1477	1327	1177	1102	6875	6131	5000	5000
T_{11} 100% N	560	404	336	266	1282	1193	1087	997	5750	5375	4937	4937
T_{12} 100 % NP	574	509	299	259	1537	1427	1362	1229	6187	5250	4937	4937
T_{13} 100% NPK + FYM 10 t ha^{-1} (*kharif*)	722	635	539	403	1920	1687	1515	1432	12000	10062	9125	9125
T_{14} FYM 10 t ha^{-1} (*kharif*)	518	343	280	175	1234	1355	1177	1064	6875	6312	5125	5125
Mean	555	468	353	271	1506	1386	1258	1173	7299	6525	6010	5662
SE (m)±	25.01	38.43	50.79	46.76	125.58	55.06	64.75	50.95	394.40	429.28	499.07	499.07
CD at 5%	77.09	118.44	156.50	144.10	355.53	154.65	181.87	143.10	1107.73	1205.69	1401.21	1401.21

was recorded in 0-15 cm layer, and it decreased with soil depth. The higher organic carbon in surface layer may be attributed to the addition of plant biomass by way of roots and crop residues as well as application of FYM for over 10 years. Highest organic carbon (0.783%) was recorded in treatment T_{13} (100% NPK + FYM 10 t ha^{-1}) which was significantly superior over all other treatments involving organic and inorganic. This treatment was followed by T_{14} (10 t FYM ha^{-1}) where organic carbon of soil was quite high (0.703%). Bhandari *et al.*(1992) and Ravankar *et al.* (1998) observed build up in organic content due to application of NPK + FYM. This might have been due to the consistent higher yields obtained in this treatment. The relative increase in organic carbon due to FYM can be attributed to direct supply of organic matter through FYM alongwith recommended dose of NPK (Bharadwaj and Omanwar, 1994; Santhy *et. al.*,2001).

Total N

It is observed from the N values (Table 3) that the total N content of soil decreased with increasing soil depth irrespective of treatments. It may be ascribed to the reduction in the organic carbon content in the lower layers. As regards the total N content of surface layer (0-15cm), maximum total N content (722 ppm) was recorded in treatment T_{13} which was significantly superior to all other treatments except treatment T_5 (150 % NPK) which was at par. The results of the present study are in accordance with those of Sheeba and Chellamuthu (1996) and Ravankar *et. al.* (1998). Build up of total N status was more (689 ppm) in treatment with 150 per cent NPK and was significantly superior amongst fertilizers alone treatments. Singh and Faroda (1987) and Verma and Yadav (1988) recorded similar findings. It is noteworthy to mention that the long term application of FYM 10 t ha^{-1} alone to *kharif* crop showed almost 76 per cent build up in total N applied FYM in enhancing N status as well as improving soil health. It is further seen that due to continuous cropping without manuring and fertilization, the initial total N status of soil was markedly reduced (294 ppm) as compared to its initial levels (439 ppm). There was conspicuous effect of long term application of manures and fertilizers in enhancing the total N status of lower layers as compared to control, which may attributed to translocation of organic matter and soluble inorganic and organic N compounds to lower depths.

Total P

Vertical distribution of total P was significantly influenced by various manuring and fertilization treatments and its content in soil was found to decrease with depth. There appears less mobility of P due to fixation in surface layer. The depthwise distribution showed a decline trend in the concentration of total P with depth. The trend of total P was similar under all treatments. Highest total P content (1390 ppm) was observed in treatment T_{13} which was significantly superior over other treatments except T_4 (100% NPK) and T_5 (150% NPK). Graded levels of NPK linearly increased the total P (22 to 50 % over control) reserve of the soil. There was conspicuous effect of organics. FYM applied in conjunction with recommended dose of NPK level for 10 years in sorghum wheat sequence enhanced total P content of soil by 60,13 and 2 per cent over control (T_1), 100 per cent NPK (T_4) and 150 per cent NPK (T_5), respectively. Similar findings have been reported by Bhriguvanshi (1988) and Sheeba and Chellamuthu (1996) who reported considerable build up of total P due to 100 per cent NPK + FYM. Use of organics i.e. application of 10 t FYM ha^{-1} in *kharif* for 10 years revealed that the total P status of soil was not markedly affected and was at par with control in respect of surface and subsurface layers. It may be attributed to the greater uptake of P from the surface layer by the crops grown, although FYM added is a poor source of P. The order of total P build up in some of the prominent treatments were : 100 per cent NPK + FYM > 150 per cent NPK > 100 per cent NPK. However, total P build up in soil dose not necessarily indicate the greater availability of phosphorus to crops. Integrated use of fertilizers and FYM is the better preposition for augmenting the total P reserve of Vertisols.

Total K

As regards to total K content, various manuring and fertilizer treatments have significantly influenced total K status of Vertisols in surface and sub-surface layers. It decreased with soil depth. Highest total K (12000 ppm) was recorded in treatment T_{13} as against control (5250 ppm) and was significantly superior to all other treatments. Application of FYM alone for over 10 years has showed significant build up in total K content (6875 ppm) over control (5250 ppm). It seems that FYM application registered little build up of total K in soil as compared to treatments involving K fertilizers

application. The present findings are in consonance with those of Dhanorkar *et. al.* (1994) who studied the K dynamics in Vertisols under manuring and fertilization. The treatments where K was deleted (T_{11} and T_{12}) showed non significant build up in total K than control. Thus total K status of soil will get depleted with continuous sorghum-wheat cropping as these crops have very high requirement of K and hence high level of total K should be maintained in soil for satisfactory K availability and higher crop yield.

From the results of the present investigation, it is seen that the conjunctive use of recommended dose of NPK + FYM (10 t ha^{-1}) in cereal-cereal cropping sequence proved superior in build up of organic carbon, total N, P and K in soil indicating the significance of integrated nutrient management.

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Land Evaluation for Land Use Planning of a Watershed in Rainfed Area

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ABSTRACT

Ten pedons of Bhandaraj watershed in Akola district of Vidarbha region of Maharashtra were studied to assess and evaluate the soil and land resources for suitability of different crops. The soils were non to slightly eroded to severally eroded, well to moderately well drained, clayey in texture, neutral to moderately alkaline in reaction, low to moderately high in organic carbon content, low to medium in available nitrogen and phosphorus and moderate to high in potassium contents. CEC of soils was largely dependent on clay content. These soils were classified as Typic Haplusterts, Vertic Ustochrepts, Typic Ustochrepts and Typic Ustorthents. The land suitability evaluation revealed that generally, the soils of Typic Haplusterts and Vertic Ustochrepts were found to be moderately suitable for cotton, sorghum and pigeonpea. Soils of Typic Ustochrepts and Typic Ustorthents were marginally suitable to not suitable for cotton and pigeonpea. The results obtained in present study may be useful to cotton and pigeonpea and thereby also helpful to suggest the soil based agrotechnology transfer for better harvest of these crops on similar soils occurring in the same agroclimatic region elsewhere.

Soil, water , vegetation and climate are considered to be the most basic natural resources for agricultural growth and development. These natural resources are subjected to various kinds of deterioration and indiscriminate exploitation. In order to use the land resources optimally on sustainable basis it is necessary to have an up to date and precise information of existing natural resources.

The increasing need for food to support the growing population demands systematic appraisal of soil and water resources. For increasing agricultural production on sustainable basis the importance of rational use of soil and water resources with minimum soil and water loss is needed. This can be achieved by adopting watershed management approach.

At present there is an extreme inadequacy of basic data or resources for preparation of scientifically sound watershed development plans . Keeping in view the importance of the study of land resources by evaluating soil and site characteristics for proper land use planning, the present study was undertaken in Bhandaraj watershed in Patur Tehsil of Akola district in Vidarbha region of Maharashtra.

MATERIAL AND METHODS

The Bhandaraj watershed comprises the major portion of the village Bhandaraj and part of Belura (buzruk) and Tandli (Khurd) of Patur Tehsil, Akola district. The watershed is located between 76°52′ to 76°57′ E longitude and 20°31′ to 20° 34′ N latitude covering an area of 2238 ha. It is about 40 km South-West of Akola city. Geologically it comprises predominantly of volcanic rocks, which consist chiefly of basalt. The climate of area is semi-arid, monsoonic. The total rainfall received during the year 2001-2002 was 731.2 mm as against normal rainfall of 818.6 mm during last 30 years (1971 to 2000). The mean annual maximum and minimum temperatures were 33.9 °C and 19.6 °C respectively. Commonly occurring species of trees and grasses are Babool (*Acacia arabica*), Neem (*Azadirachta indica*), palas (*Butea frondosa*), Anjan grass (*Cenchrus cilliaris*), Kans (*Sacharum spontanum*).

The detailed soil survey of the watershed area was carried out with the help of Survey of India toposheet (1:50,000) and a geocoded LISS III satellite imagery. After traversing the area, based on variations in soil-site characteristics, ten pedons were identified and described (Soil Survey Staff, 1951). Processed soil samples (< 2 mm) were analysed for various physico-chemical properties following standard methods (Black, 1965; Jackson, 1967). Soils were classified using standard technique (Soil Survey Staff, 1994) and the soil-site suitability evaluated for some major rainfed crops using standard procedures (Sys, 1985).

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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 ranging from 2.5YR to 10 YR, value ranging from 3 to 6 and chroma of 1 to 3. The hue denotes the dominant spectral colour, value is the lightness or darkness of a colour and chroma strength of colour. The data presented in Table 1 indicate that the soils were very dark grayish brown to dark brown as well as reddish in colour. The shallow soil pedons 4, 5 and 10 had subangular blocky structure whereas the surface soils of all the remaining pedons had subangular blocky structure with well developed angular blocky structure in subsurface horizons. In addition to angular blocky structure the Vertisols (Pedon 2 and 6) showed well developed intersecting slickensides and wedge shaped structural aggregates. This may be due to swell and shrink phenomenon of smectite clay observed in such soils resulting in the development of slickensides (Ahmad, 1983).

Physico-chemical 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 40.8 to 72.4 per cent and it increased with depth in all the pedons except AC horizon. 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 ranged from 23.6 to 34.8 per cent. The sand content of the soils ranged between 1.2 to 35.6 per cent. The bulk density of the soils under study ranged from 1.40 to 1.59 Mgm^{-3} and it increased with depth . which may be sue to the compact nature of soil in the subsurface horizons and low organic matter content. Similar observations were also reported by Bharambe *et al.*(1990). These soils had hydraulic conductivity varying from 0.42 to 1.14 cm hr^{-1}. The shallow and moderately deep soils had higher hydraulic conductivity as compared to deep to very deep soils. The water retention at 33 kpa and 1500 kpa varied from 30.4 to 45.6 and 19.9 to 30.6 per cent respectively and the available moisture content in soils ranged from 8.6 to 19.2 per cent. In general , the moisture content was higher in subsurface horizons as compared to the surface horizons.

The soils were neutral to moderately alkaline (pH 7.28 to 8.00) in reaction and it increased with depth. The organic carbon content in soils of study area ranged from 0.31 to 0.72 per cent and it decreased with depth. This may be due to the higher rate of decomposition in the surface horizons as compared to subsurface horizons.Calcium carbonate content of the soils ranged from 4.5 to 18.5 per cent. Data represented in Table 3 indicate that the $CaCO_3$ content in the subsurface horizon was higher as compared to surface layers. 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 cation exchange capacity of soils varied. The perusal of data on exchangeable cations indicates that calcium is the dominating cation followed by magnesium, sodium and potassium suggesting dominance of calcium bearing minerals in the parent material. The exchangeable calcium varied from 36.98 to 44.92 cmol (p+) kg^{-1} and exchangeable magnesium 9.12 to 19.12 cmol (p+) kg^{-1}. The exchangeable sodium and potassium content ranged from 0.10 to 0.19 and 0.19 to 0.80 cmol (p+) kg^{-1} respectively. Generally the soils which had lower amount of clay content had lowest CEC values. Since the CEC is the charge behavior of soils where clay is the fundamental block contributing towards its cation exchange the high CEC of these black soils is attributed to its smectite clay mineralogy (Pal and Deshpande, 1987). The data on the base saturation indicates that the soils exhibit slight variation in their percent base saturation. The soils of Bhandaraj watershed are highly saturated with bases and it varied from 91.01 to 99.24 per cent.

Site characteristics

The site characteristics such as elevation, slope, erosion and drainage vary with the microtopographic situations of the soils, indicating the important role of land forms responsible for various sites. Slope is an important parameter in deciding suitable land use as the degree and direction of the slope decide the land use it can support, also very important while determining the land capability classification and has direct bearing on the runoff. The general slope of study area is gently sloping (1-3%) with moderate to well drained drainage conditions (Table 4). Drainage acts as an important criteria for evaluating soil suitability not only for annual but also perennial crops too. The drainage conditions in the studied area have been classified into two classes i.e. moderately well drained soils of pedon 2 and 6 and well drained soils of remaining pedons.

Table 1. Morphological characteristics of the soils

Horizon	Depth (cm)	Munsell colour (Moist)	Texture	Structure			Consistence			Efferve scene	Concretions		Roots		Boundary		Special features
				S	G	Ty	D	M	W		S	Q	S	Q	D	T	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Pedon P_1 : Typic Ustochrepts																	
Ap	0-24	10YR3/2	c	m	2	sbk	sh	fr	sp	e	f	c	f	c	c	s	-
A_1	24-45	10YR3/6	c	m	2	sbk	sh	fr	sp	es	f	c	f	c	a	w	
A_2	45-80	10YR3/6	c	m	2	sbk	sh	fi	sp	es	f	f	f	f	c	s	
Bw	80-108	10YR3/6	c	m	2	sbk	h	fi	sp	ev	f	f	f	f			
Pedon P_2 : Typic Haplusterts																	
Ap	0-20	10YR3/2	c	m	2	sbk	sh	fr	sp	es	f	c	f	c	c	s	Pressure faces in
A	20-41	10YR3/2	c	m	2	sbk	h	fi	sp	es	f	f	f	c	c	s	II^{nd} and III^{rd} horizon
Bw	41-70	10YR3/1	c	m	2	abk	h	fi	vsvp	es	vf	f	f	f	g	w	and slickensides
Bss	70-110	10YR3/1	c	m	2	abk	h	fi	vsvp	es	vf	f	f	f			from IV^{th} horizon
Pedon P_3 : Typic Ustochrepts																	
Ap	0-19	10YR3/2	c	m	2	sbk	h	fr	sp	e	f	c	f	c	c	s	
A_1	19-43	10YR3/2	c	m	2	sbk	sh	fr	sp	es	f	f	f	c	c	s	
A_2	43-67	10YR3/2	c	m	2	sbk	sh	fr	sp	es	f	f	f	f	a	w	
Bw	67-105	10YR3/1	c	m	2	sbk	sh	fr	sp	es	f	f	f	f			
Pedon P_4 : Typic Ustorthents																	
Ap	0-22	2.5YR3/4	c	m	2	sbk	sh	fr	sp	-	f	f	f	c	c	w	
C	22-40	2.5YR3/6								-	f	f	f	f			
Pedon P_5 : Typic Ustorthents																	
Ap	0-16	10YR3/3	c	m	2	sbk	sh	fr	sp	es	f	c	f	c	c	w	
C	16-35	10YR5/2								ev	f	c	f	f			
Pedon P_6 : Typic Haplusterts																	
Ap	0-18	10YR3/2	c	m	2	sbk	sh	fr	sp	e	f	f	f	c	c	s	Slickensides in
A_1	18-33	10YR3/2	c	m	2	sbk	sh	fi	sp	es	f	f	f	c	c	s	IV^{th} and V^{th}
A_2	33-55	10YR3/2	c	m	2	sbk	h	fi	sp	es	f	c	f	f	g	s	horizon
Bss_1	55-80	10YR3/2	c	m	2	abk	h	fi	vsvp	es	f	f	vf	f	g	w	
Bss_2	80-130	10YR3/1	c	m	2	abk	h	fi	vsvp	ev	f	c	vf	f			

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Pedon P_7 : Vertic Ustochrepts																	
Ap	0-16	10YR3/2	c	m	2	sbk	sh	fi	ssps	e	-	-	f	c	c	s	Cracks 1-2 cm
					wide upto 25 cm depth,pressure faces in IIIrdand IVth horizon.												
A	16-32	10YR3/2	c	m	2	sbk	sh	fi	ssps	e	-	-	f	c	c	s	
Bw_1	32-55	10YR3/2	c	m	2	sbk	sh	fi	ssps	e	-	-	f	c	c	s	
Bw_2	55-76	10YR3/1	c	m	2	abk	sh	fi	sp	e	-	-	f	f	c	w	
C	76-90	10YR6/4	c	m	2	abk	h	fi	sp	e	-	-	vf	f	c	s	
Pedon P_8 : Vertic Ustochrepts																	
Ap	0-18	10YR3/2	c	m	2	sbk	sh	fr	ssps	e	f	c	f	c	c	s	Few cracks 1-
					2cmwide upto 22 cm depthpressure faces inIIIrd and IVth horizon.												
A	18-38	10YR3/2	c	m	2	sbk	sh	fi	ssps	e	f	f	f	c	c	s	
Bw_1	38-59	10YR3/1	c	m	2	sbk	h	fi	sp	e	f	f	f	f	c	s	
Bw_2	59-80	10YR3/1	c	m	2	abk	h	fi	sp	es	-	-	f	f	c	w	
C	80-96	10YR6/4								es	-						
Pedon P_9 : Typic Ustochrepts																	
Ap	0-20	10YR3/2	c	m	2	sbk	sh	fr	ssps	-	f	f	f	c	c	s	
A	20-48	10YR3/2	c	m	2	sbk	sh	fr	sp	-	f	f	f	c	c	s	
C	48-52	10YR6/4															
Pedon P_{10} : Typic Ustorthents																	
Ap	0-15	10YR3/6	scl	m	2	sbk	sh	fr	ssps	-	-	f	f	c	c	s	
C	15-27	10YR6/4								-	-	-					

Table 2 . Physical characteristics of the soils (weighted means)

Pedons	Solum depth (cm)	Particle size distribution			Bulk density ($Mg\ m^{-3}$)	Hydraulic conductivity ($cm\ hr^{-1}$)	Water retention		AWC (%)
		Sand (%)	Silt (%)	Clay (%)			33 kPa	1500 kPa	
P_1	108	9.45	28.28	62.27	1.46	0.96	42.52	29.52	13.00
P_2	110	4.36	27.93	67.70	1.50	0.83	41.29	25.52	15.82
P_3	105	13.72	28.63	57.65	1.51	0.93	40.30	24.44	15.91
P_4	22	12.20	31.90	55.90	1.44	1.04	34.50	19.90	14.60
P_5	16	15.60	33.60	50.80	1.47	1.02	33.40	21.80	11.60
P_6	130	3.87	26.62	69.51	1.53	0.54	42.88	24.21	18.66
P_7	76	3.33	30.60	66.07	1.53	0.57	39.75	25.79	13.96
P_8	80	3.51	32.90	63.59	1.43	0.50	41.85	25.27	16.58
P_9	48	4.80	32.23	62.97	1.45	0.58	39.50	22.56	16.94

Table 3. Chemical characteristics of the soils (weighted means)

Pedons	Solum depth (cm)	pH (1:2.5)	ECdsm^{-1}	OC(%)	$CaCO_3$ (%)	Exchangeable bases				Sum bases	CEC	BS, %	ESP
						Ca	Mg	Na	K				
P_1	108	7.63	0.19	0.50	16.20	38.20	13.10	0.20	0.38	51.88	54.07	95.98	0.37
P_2	110	7.90	0.33	0.47	15.64	39.82	15.09	0.24	0.53	55.70	57.35	97.06	0.42
P_3	105	7.63	0.18	0.39	6.40	37.90	12.61	0.28	0.28	51.06	53.37	95.70	0.52
P_4	40	7.48	0.14	0.49	4.50	37.42	11.64	0.24	0.33	49.63	50.32	98.62	0.47
P_5	35	7.53	0.18	0.39	10.75	36.98	10.54	0.24	0.48	48.24	50.16	96.17	0.47
P_6	130	7.71	0.22	0.47	13.87	41.04	13.71	0.15	0.33	53.75	55.91	96.12	0.26
P_7	76	7.66	0.18	0.60	13.83	40.19	11.56	0.48	0.54	53.31	56.40	94.48	0.84
P_8	80	7.63	0.26	0.60	11.54	39.97	16.43	0.34	0.53	56.96	58.54	97.32	0.59
P_9	48	7.47	0.25	0.54	6.22	40.68	15.05	0.12	0.57	56.42	57.61	97.34	0.21
P_{10}	15	7.28	0.34	0.48	5.87	38.46	18.42	0.10	0.66	50.64	51.47	98.38	0.19

Table 4. Soil-site characteristics selected for evaluation

Soil-site characteristics Site characteristics	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	P_{10}
Slope (%)	0-1	0-1	1-3	1-3	1-3	1-3	1-3	1-3	1-3	1-3
Erosion	e_1	e_1	e_2	e_2	e_2	e_2	e_2	e_2	e_2	e_2
Drainage	Well	Mod.	Well	Well	Well	Mod.	Well	Well	Well	Well
Soil characteristics										
Texture	c	c	c	c	c	c	c	c	c	scl
(% clay)	(60.13)	(67.70)	(58.37)	(49.0)	(50.8)	(70.09)	(66.07)	(61.49)	(62.96)	(40.80)
Depth (cm)	108	110	105	22	16	130	76	80	48	15
Calcium carbonate (%)	18.26	16.60	8.19	4.5	13.8	13.87	13.85	11.54	6.22	5.87
Soil fertility										
CEC cmol (p+) kg^{-1}	54.81	58.39	58.10	51.13	50.33	55.91	56.40	58.54	57.61	51.47
Organic carbon (%)	0.63	0.53	0.34	0.32	0.30	0.47	0.60	0.60	0.54	0.48
Base saturation (%)	92.99	96.43	96.43	92.86	94.19	96.12	94.48	97.32	97.94	98.38
EC (dSm^{-1})	0.19	0.33	0.18	0.14	0.18	0.22	0.18	0.26	0.25	0.34
pH (1:2.5)	7.63	7.90	7.63	7.48	7.50	7.71	7.66	7.63	7.47	7.28
ESP	0.35	0.41	0.49	0.53	0.48	0.26	0.84	0.59	0.21	0.19

Table 5. Climatic characteristics of soils and climatic suitability for cotton, sorghum and pigeonpea

S.N.	Climatic characteristics	Cotton	LL	Sorghum	LL	Pigeon	LL
1.	Annual rainfall (mm)(1971-2000)	818.6	1	818.6	0	818.6	1
2.	Rainfall in growing season (mm)	731.2	2	731.2	0	731.2	0
3.	Length of growing period (days)	150	1	150	0	150	2
4.	Mean temp. in growing season (°C)	26.75	0	26.75	1	26.75	0
5.	Mean max. temp. in growing season (°C)	33.9	-	33.9	1	33.9	0
6.	Mean min. temp. in grwoing season (°C)	19.6	-	19.6	1	19.6	-
7.	Mean relative humidity in growing season	64.0	0	64.0	0	64.0	-
	Suitability class		**S_2**		**S_1**		**S_2**

Land capacity classification

Soils were classified as per Soil Taxonomy (Soil Survey Staff, 1994) and in all the cases the mineralogy and temperature regime are montmorillonitic and hyperthermic respectively at the family level.

The land capability classification is a broad grouping of soils based on their limitations and is designed to emphasize the hazards in different kinds of soils. 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. The soils of study area have been classified into capability classes II, III, IV and VI, indicating that most of the soils are suitable for cultivation. The capability classification, however does not suggest the most profitable use of soils.

Soil-site suitability for crops

Land suitability refers to the fitness of a given type of land for a defined use. Every crop has specific requirements of soil for economic production. Therefore land suitability for various crops can be assessed by comparing the crop requirements with the available soil characteristics and the land is classified according for its suitability for different crops.

The climatic and soil-site characteristics were evaluated to determine the suitability of soils for sorghum , cotton and pigeonpea. The data on climatic suitability evaluation (Table 5) indicate that the area is climatically moderately suitable to highly suitable for the crops under study.

Based on major limitations of soils and crop requirement tables, soil-site suitability for some major rainfed crops were worked out according to the scale suggested by FAO (1976). The data (Table 6) indicate that most of the pedons were found to be moderately suitable (S_2) for cotton due to moderate limitation of erosion and calcium carbonate content. Soils of pedon 9 have been classified as marginally suitable (S_3) due to severe depth, topographic limitation and organic carbon content and soils of pedons 4, 5 and 10 have been classified as unsuitable for cotton cultivation due to severe depth limitations.

Suitability evaluation for sorghum (Table 7) indicate that most of the soils were moderately suitable (S_2) for sorghum cultivation while soils of pedons 4, 5 and 10 were categorised as marginally suitable (S_3) due to severe depth and erosion limitations.

The data presented (Table 8) also indicated that soils of pedons 1, 2, 3, 6, 7 and 8 are moderately suitable for pigeonpea as they have moderate limitations of climatic characteristics, physical soil condition and erosion while soils of remaining pedons were not suitable for pigeonpea cultivation. The results obtained in the present investigation not only suggests the capability and the suitability of soils for some important rainfed 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.

Table 6. Degree of limitations in each pedon and overall suitability for Cotton

Soil-site characteristics	Pedon number									
	1	2	3	4	5	6	7	8	9	10
Climatic characteristics										
Total rainfall (mm)	1	1	1	1	1	1	1	1	1	1
Rainfall in growing season (mm)	2	2	2	2	2	2	2	2	2	2
Length of growing season (days)	1	1	1	1	1	1	1	1	1	1
Mean temp. in growing season (^{0}C)	0	0	0	0	0	0	0	0	0	0
Mean max. temp. in growing season (^{0}C)	-	-	-	-	-	-	-	-	-	-
Mean min. temp. in growing season (%)	-	-	-	-	-	-	-	-	-	-
Mean RH in growing season (%)	0	0	0	0	0	0	0	0	0	0
Climatic suitability	S_2	S_2	S_2	S_2	S_2	S_2	S_2	S_2	S_2	S_2
Site characteristics										
Slope (%)	0	0	1	1	1	1	1	1	1	1
Erosion	1	1	2	2	2	1	2	2	2	3
Drainage	0	1	0	0	0	1	0	0	0	0
Soil characteristics										
Texture	0	0	0	0	0	0	0	0	0	2
Depth (cm)	0	0	0	4	4	0	1	1	3	4
Calcium carbonate (%)	2	2	1	1	2	2	2	2	1	0
Soil fertility										
CEC cmol (p+) kg^{-1}	0	0	0	0	0	0	0	0	0	0
Organic carbon (%)	2	2	3	2	3	2	2	2	2	3
Base saturation (%)	0	0	0	0	0	0	0	0	0	0
EC (dSm^{-1})	0	0	0	0	0	0	0	0	0	0
pH (1:2.5)	0	0	0	0	0	1	1	0	0	0
ESP	0	0	0	0	0	0	0	0	0	0
Actual suitability	S_2	S_2	S_2	N_1	N_1	S_2	S_2	S_2	S_3	N_1

Table 7. Degree of limitations in each pedon and overall suitability for Sorghum

Soil-site characteristics	Pedon number									
	1	2	3	4	5	6	7	8	9	10
Climatic characteristics										
Total rainfall (mm)	1	1	1	1	1	0	0	0	0	0
Rainfall in growing season (mm)	2	2	2	2	2	1	1	1	1	1
Length of growing season (days)	1	1	1	1	1	0	0	0	0	0
Mean temp. in growing season (^{0}C)	0	0	0	0	0	0	0	0	0	0
Mean max. temp. in growing season (^{0}C)	-	-	-	-	-	2	2	2	2	2
Mean min. temp. in growing season (%)	-	-	-	-	-	1	1	1	1	1
Mean RH in growing season (%)	0	0	0	0	0	0	0	0	0	0
Climatic suitability	S_2	S_2	S_2	S_2	S_2	S_2	S_2	S_2	S_2	S_2
Site characteristics										
Slope (%)	0	0	1	1	1	1	1	1	1	1
Erosion	1	1	2	2	2	0	2	2	2	3
Drainage	0	1	0	0	0	1	0	0	0	0
Soil characteristics										
Texture	0	0	0	0	0	0	0	0	0	3
Depth (cm)	0	0	0	3	3	0	0	0	2	3
Calcium carbonate (%)	3	3	2	1	2	2	2	2	1	0
Soil fertility										
CEC cmol (p+) kg^{-1}	0	0	0	0	0	0	0	0	0	0
Organic carbon (%)	2	2	3	2	3	1	1	1	1	2
Base saturation (%)	0	0	0	0	0	0	0	0	0	0
EC (dSm^{-1})	0	0	0	0	0	0	0	0	0	0
pH (1:2.5)	0	0	0	0	0	1	1	0	0	0
ESP	0	0	0	0	0	0	0	0	0	0
Actual suitability	S_2	S_2	S_2	S_3	S_3	S_2	S_2	S_2	S_2	S_3

Table 8. Degree of limitations in each pedon and overall suitability for Pigeonpea

Soil-site characteristics	Pedon number									
	1	2	3	4	5	6	7	8	9	10
Climatic characteristics										
Total rainfall (mm)	1	1	1	1	1	1	1	1	1	1
Rainfall in growing season (mm)	2	2	2	2	2	2	2	2	2	2
Length of grwoing season (days)	1	1	1	1	1	2	2	2	2	2
Mean temp. in growing season (°C)	0	0	0	0	0	0	0	0	0	0
Mean max. temp. in growing season (°C)	0	0	0	0	0	0	0	0	0	0
Mean min. temp. in growing season (%)	-	-	-	-	-	-	-	-	-	-
Mean RH in growing season (%)	-	-	-	-	-	-	-	-	-	-
Climatic suitability	S_2	S_2	S_2	S_2	S_2	S_2	S_2	S_2	S_2	S_2
Site characteristics										
Slope (%)	0	0	1	1	1	1	1	1	1	2
Erosion	1	1	2	2	2	1	2	2	2	3
Drainage	0	1	0	0	0	1	0	0	0	0
Soil characteristics										
Texture	1	1	1	1	1	1	1	1	1	2
Depth (cm)	1	1	1	4	4	0	2	2	4	4
Calcium carbonate (%)	-	-	-	-	-	-	-	-	-	-
Soil fertility										
CEC cmol (p+) kg^{-1}	0	0	0	0	0	0	0	0	0	0
Organic carbon (%)	2	2	2	2	2	1	1	1	1	2
Base saturation (%)	0	0	0	0	0	0	0	0	0	0
EC (dSm^{-1})	0	0	0	0	0	0	0	0	0	0
pH (1:2.5)	0	0	0	0	0	1	1	0	0	0
ESP	0	0	0	0	0	0	0	0	0	0
Actual suitability	S_2	S_2	S_2	N_1	N_1	S_2	S_2	S_2	N_1	N_1

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Studies on Growth Performance and Yield of *Lathyrus* as Influenced by Residual Effect of different Bio-inoculants Under Integrated Nutrient Supply System in Rice

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ABSTRACT

In order to evaluate the carry over effect of *kharif* applied bio-inoculants on growth parameters and yield attributing characteristics of *Rabi Lathyrus* under rice-*Lathyrus* relay cropping system on Alfisols, a field study was carried out at Indira Gandhi Agricultural University, Raipur (C.G.). There were eight treatments replicated thrice in randomized block design. The results indicated that carry over effect of 60:40:30 NPK kg ha^{-1}, PSB, VAM, *Azospirillum* along with FYM @ 5t ha^{-1} increased the plant height, dry matter accumulation plant^{-1}, effective nodule plant^{-1} at 50 DAS and pod plant^{-1} at harvest. The yield of succeeding *Lathyrus* was significantly increased due to carry over effect of integrated use of chemical fertilizer and bio-inoculants along with FYM as compared to recommended dose of NPK.

Lathyrus (*Lathyrus sativus* L.) is important pulse crop taken as bonus crop in belts of central and eastern parts of India. The total cultivated area of this crop is more than 0.89 m ha. Out of this, 0.61 mha is situated in Chhattisgarh representing the major *Lathyrus* growing belts in the country under rice based relay cropping system. This is a long standing traditional crop known for its ability to with stand moisture stress and other productivity constraints. The annual production of *Lathyrus* is 224.8 thousand tonnes with a low productivity of 0.38 t ha^{-1}. Low organic matter content and negligible presence of crop beneficial microbes in soils of Chhattisgarh are the basic causes for low productivity (Gupta *et. al.*, 1995 a). In view of the maintenance of soil fertility, productivity and soil health attention should be focussed on the concept of IPNS system. Integrated use of chemical fertilizer, organic manure and biofertilizer give higher use efficiency of inputs (Gaur, 1988). Mishra and Bangar (1986) reported that phosphorus solubilizing microorganisms exert residual effects on succeeding crops. Bhagyaraj (1984), reported that VAM improve nutrient uptake and thereby contribute to improved productivity. Rai (1998) reported that organic matter, soil physical properties, aggregate stability, water retention and microbial activity get improved with integrated use of FYM and mineral fertilizers.

MATERIAL AND METHODS

The field experiment was conducted on Alfisols during *rabi* season of 2000-2001 using *Lathyrus* cultivar Bio L-212 with eight treatments. The integrated nutrient supply system applied to preceeding rice crop were T_1-60:40:30 NPK kg ha^{-1} (control), T_2-T_1 + PSB, T_3-T_1+ *Azospirillum*, T_4-T_1+VAM+PSB, T_5-T_1+VAM + *Azospirillum*, T_6 - T_1+ VAM + PSB + *Azospirillum* + FYM @ 5 t ha^{-1}, T_7-80:50:30 NPK kg ha^{-1} and T_8 - 120:60:40 NPK kg ha^{-1}. Each treatment was replicated thrice in randomized block design. Nitrogen, phosphorus and potassium @ 20, 50 and 30 kg ha^{-1}, respectively were applied as basal dose through Urea, SSP and MOP before sowing of *Lathyrus*. Amount of N added through urea reduced and adjusted by FYM. Standard procedures were adopted for soil analysis. Data on initial soil properties are given in Table 1.

Table 1. Physico-chemical properties of the soil (0 to 20 cm depth)

Particulars	Values
Physical properties	
Mechanical composition	
Sand (%)	25.30
Silt (%)	37.10
Clay (%)	37.60
Chemical properties	
Organic carbon (%)	0.40
Available N (kg ha^{-1})	186.00
Available P (kg ha^{-1})	19.70
Available K (kg ha^{-1})	382.00
pH (1:2.5 soil : water)	7.01
EC (dSm^{-1}) at 25°C	0.24

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RESULTS AND DISCUSSION

The data on effective nodule plant^{-1} (at 50 DAS), plant height (at 50 DAS and harvest), Dry matter accumulation plant^{-1} (At 50 DAS), pod plant^{-1} and yield are presented in Table 2 and 3. Nodulation was enhanced due to residual effect of integrated nutrient supply systems (mineral fertilizers and bio inoculants with and without FYM) and sole chemical fertilizer treatments in succeeding *Lythyrus*. The maximum number of effective nodule plant^{-1} was observed in the treatment of 60:40:30 NPK kg ha^{-1} + PSB + VAM + *Azospirillum* + FYM @ 5 t ha^{-1} followed by 60:40:30 NPK kg ha^{-1} + VAM + *Azospirillum*. Residual effect of integrated use of chemical fertilizers and bio-inoculants along with organic manure significantly accelerate the nodulation process in *Lythyrus*, however such a significant effect was not observed in dry matter accumulation plant^{-1} at flowering stage of succeeding *Lythyrus*.

Table 2. Effect of bio-inoculants on growth characters of *Lathyrus*

Treatments		Plant height (cm)		Dry matter accumulation	Effective nodule plant^{-1} at 50 DAS
		at 50 DAS	at harvest	Plant^{-1} at 50 DAS(g)	(No.)
T_1	60:40:30 kg NPK ha^{-1}(control)	31.38	49.62	5.881	6.10
T_2	T_1 + PSB	32.48	51.57	5.519	6.55
T_3	T_1 + *Azospirillum*	34.09	52.69	7.578	7.33
T_4	T_1 + VAM + PSB	33.82	55.95	7.378	7.88
T_5	T_1 + VAM + *Azospirillum*	33.06	59.72	7.027	9.99
T_6	T_1 + VAM + PSB + *Azospirillum* + FYM @ 5 t ha^{-1}	35.97	62.50	8.503	10.22
T_7	80:50:30 kg NPK ha^{-1}	32.56	50.36	6.969	7.66
T_8	120:60:40 kg NPK ha^{-1}	33.70	54.48	7.132	8.00
	CD at 5%	NS	7.44	NS	2.04

Table 3. Effect of bio-inoculants on yield and yield attributing characters at harvest

Treatments		Yield (q ha^{-1})		Pods plant^{-1}
		Seed	Straw	(No.)
T_1	60:40:30 kg NPK ha^{-1} (Control)	11.03	12.66	21.44
T_2	T_1 + PSB	12.13	13.86	23.77
T_3	T_1 + *Azospirillum*	12.96	14.65	26.33
T_4	T_1 + VAM + PSB	13.80	15.30	25.22
T_5	T_1 + VAM + *Azospirillum*	14.00	16.80	27.44
T_6	T_1 + VAM + PSB + *Azospirillum* + FYM @ 5 t ha^{-1}	15.66	17.98	29.44
T_7	80:50:30 kg NPK ha^{-1}	12.25	14.00	25.44
T_8	120:60:40 kg NPK ha^{-1}	12.86	15.41	26.44
	CD at 5%	1.51	2.56	4.07

All the bio-inoculants combination of PSB, VAM and *Azospirillum* with organic and inorganics was found non significant with respect to plant height at flowering stage. However, plant height of succeeding *Lathyrus* at harvest stage was significantly influenced by the carry effect of different INSS and sole fertilizer treatments. The plant height of succeeding *Lathyrus* ranged from minimum of 49.62 con in control to maximum of 62.50 cm in 60:40:30 NPK kg ha^{-1} + VAM + PSB + *Azospirillum* + FYM @ 5 t ha^{-1} treatment. The treatment producing maximum plant height was significantly superior over 120:60:40 NPK kg ha^{-1} + PSB, 80:50:30 NPK kg ha^{-1} and control.

Podding behaviour of succeeding *Lathyrus* changes significantly due to residual effect of different combination of bio-inoculants and inorganic fertilizer with and without FYM. The maximum number of pod $plant^{-1}$ was recorded in the treatment of 60:40:30 NPK kgh^{-1}+PSB+VAM+*Azospirillum*+FYM @5t ha^{-1} and lowest in the control.

Data presented in Table 2 on seed and straw yield of succeeding *Lathyrus* indicated that residual effect of integrated use of chemical fertilizers and bio-inoculants (viz. PSB, VAM and *Azospirillum*) along with FYM (applied to preceeding crop) enhanced yield of succeeding crop considerably. The seed and straw yield of succeeding *Lathyrus* ranged from 11.03 to 15.66 q ha^{-1} and 12.66 to 17.98 q ha^{-1}, respectively. The treatment 60:40:30 NPK kg ha^{-1} + PSB + VAM + *Azospirillum* + FYM @ 5 t ha^{-1} was significantly superior over other treatments. In case of straw yield, the same treatment was superior over other treatments. Although it was statistically similar to 60:40:30 NPK kg ha^{-1} + PSB + *Azospirillum* treatment.

Shrivastava and Alhawat (1995) observed that residual effect of bio-fertilizer and FYM led to better availability, absorption and utilization of essential nutrients resulting in balanced nutritional environment inside the plant giving better growth. Parasuram *et. al.*, (2000) also reported that seed yield of succeeding horse gram was maximum in the plots receiving RIF + FYM and FYM + biofertilizers, both in sorghum-horse gram and fingermillet - horse gram sequences.

CONCLUSION

To conclude, the present investigation clearly showed that the residual effect of different INSS of bio-inoculants and inorganics with or without organics on the nutrients dynamics in succeeding *Lathyrus* was quite marked. The integrated nourishment of bio-inoculant, chemical fertilizer along with FYM can be considered a boon to farming community to minimize the use of chemical fertilizer apart from maintaining the soil fertility by improving the physical, chemical and biological properties of soil. The concept of balanced fertilizer for sustaining the productivity of soil for increasing the yield of crop is taken care of by this technology since the carry over effect of bio-inoculants and FYM is felt in all major and micronutrients in this investigation.

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Effect of Time and Severity of Pruning on Physico-Chemical Characteristics and Yield in Ber Varieties

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ABSTRACT

An investigation was carried out at Horticulture Department, Dr. PDKV, Akola (M.S.) in the year 1996-1997 to study the effect of severity and time of pruning on physico-chemical characteristics and yield in different varieties of ber. Findings revealed that maximum fruit weight; pulp weight and stone weight were found in Kadaka variety with pruning time of 25th March, however severity of pruning had no effect on these characters. Highest pulp : stone ratio was observed in Sonur-6, whereas it was minimum in Panjab Chhuhara. Maximum ascorbic acid ad TSS were found in Sonur-6 and Punjab Chhuhara, respectively, where as both were minimum in Gola. Ascorbic acid and TSS were more in fruits with medium pruning on 25th March. Yield was found significantly increased in all five varieties when trees were pruned severely on 25th March. Maximum quality yield was observed from Gola and Panjab Chhuhara.

Among the various cultural practices to be adopted for augmenting quality production of ber, regular pruning with proper severity and time has got greater significance for inducing good and healthy growth for getting maximum fruit bearing area on the tree. Pruning of ber trees is highly essential to maintain their vigour and productivity as well as to improve fruit size and quality (Gupta, 1990). Owing to introduction of newer promising varieties of Ber in Vidarbha region, work on standardization of severity and time of pruning in case of these varieties was therefore considered worth necessary to find out the extent of pruning required to be done at proper time for getting quality production in different varieties of ber.

MATERIAL AND METHODS

The investigation was undertaken during the year 196-97 at experimental orchard of Department of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.) on seven-year-old Ber trees of Cv. Gola (V_1), Umran (V_2), Sonur-6 (V_3), Punjab Chhuhara (V_4), and Kadaka (V_5) planted at spacing of 6 x 6 meter. The pruning treatment comprised of two dates of pruning that is 25th March (P_1) and 25th April (P_2) with two pruning severities i.e. S_1 (Removal of all wood expect 1.0 meter shoot length from base "severe pruning") and S_2 (Removal of all wood expect 0.5 meter shoot length from base "medium pruning"). The treatments were replicated twice in factorial randomized block design. The observations were recorded on physico-chemical characters of the fruits and total yield.

RESULTS AND DISCUSSION

Physical parameters : Among varieties, fruit length and fruit diameter that contributes fruit size differed significantly. Kadaka variety produced fruits of more length, diameter, fruit weight, pulp weight and stone weight while pulp:stone ratio was found maximum in Sonur-6 (Table 1). Fruit size was not influenced significantly due to pruning time and severity (Table 2). Similar results were obtained by Gupta and Singh (1977). Maximum fruit weight, pulp weight and seed weight were found to be associated with pruning time of 25th March (Table 2). Singh and Sandhu (1984), observed that fruit and pulp weight were reduced significantly. More fruits weight was associated with Sonur-6 with medium pruning of 25th April, while pulp weight was significantly more in Kadaka variety with severe pruning on 25th March (Table 3). Significanly highest pulp:stone ratio was observed in variety Sonur-6 with severe pruning on 25th March (Table 4).

Chemical parameter : Among the different varieties, fruits of Sonur-6 had maximum ascorbic acid content and minimum being in Gola. Punjab Chhuhara surpassed the other all varieties in respect of TSS content (Table 1). The Variation in different varieties might be due to varietal performance. Fruits of medium pruned trees contained higher amount of ascorbic acid and TSS (Table 2). Fruits of trees pruned on 25th

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Table 1. Physical-chemical characteristics and yield of fruit of different varieties of Ber

Variety (V)	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (gm)	Seed weight (gm)	Pulp weight (gm)	Pulp:Stone ratio	TSS (%)	Ascorbic acid (mg)	Yield tree^{-1} (kg)
Gola	3.86	2.90	16.38	0.91	15.47	16.97	16.13	90.98	111.56
Umran	3.89	2.73	18.50	10.3	17.39	16.82	17.36	108.93	56.73
Sonur-6	4.29	3.32	20.02	10.3	18.97	18.34	17.66	131.92	62.21
Punjab Chhuchara	2.70	2.41	11.18	0.67	10.51	15.82	96.77	96.45	104.07
Kadaka	5.01	3.62	20.23	1.15	19.08	16.59	16.70	96.40	100.63
'F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m)±	0.092	0.061	0.056	0.03	0.069	0.076	0.076	0.16	0.55
CD at 5%	0.27	0.18	0.16	0.091	0.20	0.22	0.22	0.47	1.63

Table 2. Effect of severity and time of pruning on physico chemical characteristics and yield

Variety (V)	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (mg)	Seed weight (mg)	Pulp weight (mg)	Pulp:Stone ratio	TSS (%)	Ascorbic acid(mg)	Yield (kg)
Medium	-	-	-	-	-	-	17.88	110.52	85.95
Severe	-	-	-	-	-	-	17.16	99.31	88.13
'F' test	NS	NS	NS	NS	NS	NS	Sig	Sig	Sig
SE (m)±	-	-	-	-	-	-	0.048	0.10	0.34
CD at 5%	-	-	-	-	-	-	0.14	0.30	1.03
25th March	-	-	17.48	16.47	0.97	-	17.63	111.28	99.42
25th April	-	-	17.05	16.10	0.94	-	17.41	98.55	74.66
'F' test	NS	Ns	Sig	Sig	Sig	NS	Sig	Sig	Sig
SE (m)±	-	-	0.035	0.043	0.0019	-	0.048	0.10	0.34
CD at 5%	-	-	0.10	0.12	0.0057	-	0.14	0.30	1.03

March had more ascorbic acid and TSS content (Table 2). Kandu *et al.*, (1995), reported similar results with different pruning time in Umran variety. It might be due to greater concentration of metabolies which might achieved in presence of sufficient leaf area in relation to number of fruits under medium pruning intensity. Similar results were obtained by Lal and Prasad (1980) in respect of pruning severity. Punjab Chhuhara registered significantly highest TSS with medium pruning on 25th March. Significantly highest ascorbic acid content was found in variety Umran with medium pruning on 25th March (Table 4).

Yield : Among the different varieties, Gola registered maximum yield while, it was minimum in Umran (Table 1). This might be attributed to more flowering and fruit set in Gola variety. Nanthakumar and Shanmugvelu (1990), observed higher yield in Umran and low in *Zizyphus rotundifolia*. Ber trees pruned with severe pruning produced higher yield (Table 2.). This could be due to more number of flowers and fruit set in severely pruned trees. Mukherjee and Soni (1993) reported significant yield differences with various level of pruning. In respect of pruning time, pruning on 25th March gave higher yield and it was reduced when pruning delayed (Table 2).

In present study, varieties Kadaka, Punjab Chhuhara and Gola produced significantly maximum yield with severe pruning on 25th March (Table 5), however quality parameters were not found to be influenced by severity and time of pruning.

Table 3. Effect of interaction between variety x Severity x time of pruning on fruit weight, pulp weight and stone weight

Variety (V)	Fruit weight (g)				Pulp weight (g)				Stone weight (g)			
	Medium pruning (S_1)		Severe pruning (S_2)		Medium pruning (S_1)		Severe pruning (S_2)		Medium pruning (S_1)		Severe pruning (S_2)	
	Time (P_1)		Time (P_2)		Time (P_1)		Time (P_2)		Time (P_1)		Time (P_2)	
	25th March	25th April	25th March	25th April	25th March	25th April	25th March	25th April	25th March	25th April	25th March	25th April
Gola	16.75	16.38	16.00	16.40	15.80	15.48	15.12	15.46	0.94	0.90	0.87	0.92
Umran	18.50	17.50	19.50	18.52	17.14	16.48	18.44	17.52	1.07	1.01	1.05	0.99
Sonur-6	20.50	20.59	20.00	19.00	19.40	19.50	18.99	17.99	1.09	1.04	1.00	1.00
Punjab Chhuhara	10.88	11.35	11.50	11.00	10.29	10.68	10.78	10.30	0.58	0.66	0.71	0.69
Kadaka	20.08	19.75	21.10	20.00	18.86	18.68	19.87	18.89	1.21	1.07	1.23	1.10
'F' test		Sig				Sig				Sig		
SE (m) +		0.11				0.13				0.0061		
CD at 5%		0.33				0.40				0.018		

Table 4. Effect of interaction between variety x severity x time of pruning on pulp : stone ratio, TSS and ascorbic acid

Variety (V)	Pulp : stone (g)				TTS (%)				Ascorbic acid (mg)			
	Medium pruning (S_1)		Severe pruning (S_2)		Medium pruning (S_1)		Severe pruning (S_2)		Medium pruning (S_1)		Severe pruning (S_2)	
	Time (P_1)		Time (P_2)		Time (P_1)		Time (P_2)		Time (P_1)		Time (P_2)	
	25th March	25th April	25th March	25th April	25th March	25th April	25th March	25th April	25th March	25th April	25th March	25th April
Gola	16.75	17.19	17.28	16.68	16.50	16.23	16.00	15.80	118.21	76.07	93.57	76.07
Umran	15.98	16.30	17.47	17.55	18.60	17.06	16.18	17.60	143.21	114.63	94.28	93.21
Sonur-6	17.78	18.75	18.99	17.84	18.20	17.00	17.85	17.61	141.07	138.21	135.35	113.06
Punjab Chhuhara	17.47	16.05	15.01	14.75	20.01	20.97	19.00	19.10	79.78	105.35	110.71	89.99
Kadaka	15.58	17.49	16.15	17.14	17.50	16.80	16.50	16.00	99.28	89.42	107.35	89.53
'F' test		Sig				Sig				Sig		
SE (m)+		0.15				0.15				0.32		
CD at 5%		0.45				0.45				0.95		

Table 5. Effect of interaction between variety x severity x time of pruning on fruit yield per tree (kg)

Variety (V)	Medium pruning (S_1)		Severe pruning (S_2)	
	25th March	25th April	25th March	25th April
Gola	120.74	107.57	125.18	92.73
Umran	57.54	52.05	69.09	48.55
Sonur-6	71.26	47.63	78.34	51.59
Punjab Chhuhara	108.98	98.16	126.64	82.49
Kadaka	107.94	87.94	128.78	77.88
'F' test			Sig	
SE (m)±			1.10	
CD at 5%			3.26	

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Heterosis in Pumpkin (*Cucurbita moschata* Duch) Ex. Poir)

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ABSTRACT

The extent of magnitude of heterosis to provide the promising F_1 hybrids in Pumpkin was studied involving 10 promising F_1 cross combinations of 8 parental lines. Heterosis was calculated as Heterosis, Heterobeltiosis and Standard Heterosis. The minimum and maximum heterosis observed were 17.57 and 57.39 per cent, 0.07 and 30.19 per cent, and 18.65 and 54.36 per cent over better parent, top parent and commercial check (Pusa Vishwas), respectively, for yield plant^{-1}. In order of merit, F_1 hybrid P_6 x P_7 (S-12 x S-20), P_7 x P_8 (S-20 x S-17), P_3 x P_5 (S-124-10 x S-15) and P_1 x P_5 (Pusa Vishwas x S-15) were observed to be best performing and they showed heterosis percentage of 30.2, 17.5, 13.5 and 10.9 respectively, over commercial check (Pusa Vishwas).

Pumpkin occupies a prominent position due to its high productivity, nutritive value, good storeability, long period of availability and better transport qualities. The quantum jamp in its yield can be obtained through exploitation of heterosis, as this being monoecious and cross-pollinated crop provides ample scope for the exploitation of hybrid vigour on commercial scale. Several workers have demonstrated the existence of varying degrees of heterosis for yield and other traits in a number of cucurbits. However, information on the extent of heterosis is Pumpkin in meager except for reports of Breznev (1961), Lozanov (1969) and Doijode (1981).

The study reported here was designed to gather information on the extent of magnitude of heterosis to provide the promising F_1 hybrids in this crop.

MATERIAL AND METHODS

The present study was undertaken on the basis of an experiment conducted in the year 1994 and 1995 by Mr. Y.S. Reddy and Dr. P.S. Sirohi on Heterosis in Pumpkin through 8 x 8 diallel cross, 10 promising F_1 cross combinations involving 8 parental lines, namely, Pusa Vishwas (P_1), S-107B (P_2), S-124-10 or Pusa Vikas (P_3), NDPK-24 (P_4), S-15 (P_5), S-12 (P_6), S-20(P_7), S-17(P_8).

The 10 F_1 hybrids alongwith 8 parents were grown in the summer season of 1996 and 1997 in a randomized block design with two replications. The crop was planted in rows. i.e. 4.5 m. apart and 75 cm plant to plant. The observations were recorded on 10 plants leaving the border plants on 9 important characters, namely, vine length, days to first male flower opening, days to first female flower opening, days to first fruit harvest, fruit weight, fruit size index, fruits plant^{-1}, fruit flesh thickness and total yield plant^{-1}. Periodical harvetings till the end of the experiment were summed up plant-wise to give the data of the total yield plant^{-1}.

Heterosis was calculated as given below.

i) H_1 = Heterosis
ii) H_2 = Heterobeltiosis
iii) H_3 = Standard Heterosis

RESULTS AND DISCUSSION

The analysis of variance showed highly significant differences among the varieties and lines studied. The range of parental and F_1 means average percentage of heterosis estimated as increase ovr the mean of the parents, number of heterotic F_1 hybrid which were better than the better parents, top parent and commercial check, also been indicated in Table 1.

The range of mean of F_1 hybrids was in favourable direction than that of the parents for all the characters except for vine length and fruit flesh thickness. The range of heterosis percentage in F_1 crosses over better parent, top parent and commercial check varied from 3.93 to 6.20, 0.00 to 6.20 and 0.00 to 12.32, respectively, for vine length; -0.22 to -4.55, nil and -0.22 to 3.62 for days to open first male flower, -1.94 to -4.39, nil and -1.32 to -7.43 for days to open first female flower, 0.00 to -0.28, 0.00 to 0.28 and 1.54 to -6.62 for days to first fruit harvest; 4.04 to 69.66, nil and 4.04 to 55.75 for fruit weight, 1.13 to 16.01, 0.00 to 1.24 and 2.40 to 33.29 for fruit size index; 11.36 to 24.88, 0.00 to 24.88 and 2.13 to 100.00 for fruits plant^{-1}; 2.88 to 15.49, 2.93 to 15.49 and 2.93 to 15.49 for fruit flesh thickness and from 17.75 to 57.39, 0.07 to 30.19 and 18.65 to 54.36 for total yield plant^{-1}.

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Table 1. Range and mean values in parents and F_1 hybrids and heterosis

Range of means and heterosis		Vine length (m)	Days to first male flower opening	Days to first female flower opening	Days to first fruit harvest	Fruit weight (kg)
1	2	3	4	5	6	7
Range of means	Parents	4.03 to 5.32	58.31 to 60.37	61.31 to 62.56	93.37 to 96.37	2.11 to 6.53
	F_1	3.38 to 5.02	56.68 to 59.87	57.58 to 63.50	87.18 to 99.00	4.16 to 6.53
Range of heterosis						
% over BP	F_1	3.93 to 6.20	-0.22 to -4.55	-1.94 to -4.39	0.00 to -0.28	4.04 to 69.66
TP	F_1	0.00 to 6.20	-	-	0.00 to -0.28	-
CC	F_1	0.00 to 12.32	-0.22 to -3.62	1.32 to 7.43	-1.54 to -6.62	0.04 to 55.47

Range of mean and heterosis		Fruit size index (cm2)	Fruits plant^{-1}	Fruits flesh thickness, cm	Yield (kg) plant^{-1}
		8	9	10	11
Range of mean	Parents	31.66 to 75.4	2.25 to3.68	2.73 to 4.77	7.47 to 14.11
	F_1	36.68 to 76.34	2.56 to5.62	4.01 to 4.77	14.11 to 18.37
Range of heterosis (%)					
Over BP	F_1	1.13 to 16.01	11.36 to 24.88	2.88 to15.49	17.57 to -57.39
Over TP	F_1	0.00 to 1.24	0.00 to 24.88	2.93 to 15.49	0.07 to 30.19
Over CC	F_1	2.40 to 33.29	2.13 to 100.00	2.93 to 15.49	18.65 to 54.36

Of the 10 F_1 crosses, the heterotic effects over their respective better parents, top parents and commercial check were observed in 2, 1 and 1 crosses, respectively, for vine length, 6, 0 and 1 crosses for days to first male flower opening, 5, 0 and 1 crosses for days to first female flower opening, 1, 1 and 8 crosses for days to first fruit harvest, 8, 0 and 7 crosses for fruit weight, 8, 1 and 6 croses for fruit size index, 3, 1 and 9 crosses for fruit flesh thickness, and all the 10 crosses each for total yield plant^{-1}.

It is observed that total yield of fruits plant^{-1} in Pumpkin is mainly dependent on fruit weight, fruit size and number of fruits plant^{-1}. The number of fruits plant $^{-1}$ is influenced by the size of the fruit (length and diameter) and vegetative vigour (vine length). The fruit weight increases or decreases depending upon the number of fruits, size of fruits and fruit flesh thickness. Early fruiting tends to produce larger nuber of fruits.

Among the 8 parental lines included in the study, P_3 (S-124-10) was observed to be earliest flowering parent and it took minimum days to its fruit harvest. The parent P_5 (S-15) produced the longest vine and the parent P_3 (S-124-10) produced the highest number of fruits of highest weight and larget fruit size and gave highest yield plant^{-1}. In the F1 hybrid of these parental lines, there was appreciable hecterosis in all the characters. The best F_1 hybrid for increased number of fruits plant^{-1} was P_6 x P_7. The earliest maturing hybrid was P_1 x P_3, while the best F_1, showing highest fruit weight, fruit size index and fruit flesh thickness was P_7 x P_8.

Appreciable heterosis was observed in the F_1 hybrids in all the characters except in vine length and fruit flesh thickness. The F_1, P_6 x P_7 exhibited the maximum heterosis for yield plant^{-1} of 60.19 and 54.36 over top parent and commercial check, respectively, Lozanov (1969) and Doijode (1981) also observed heterosis for some characters in this crop including yield. The best heteroric F_1 hybrids were different from the best heterotic F_1 hybrids in majority of the characters. The F_1 P_1 x P_3 was the best hybrid for early maturity over better parent, top parent as well as commercial check. While the F_1 P_7 x P_8 exhibited the highest fruit weight with heterosis percentage of 55.47 over commercial check and highest fruit size index with heterosis percentage of 33.29, 24.6 and 3.09 over better parent, top parent and commercial check, respectively.

In order of merit, P_6 x P_7, P_7 x P_8 and P_3 x P_5 were recorded as 3 best performing ones for total yield plant^{-1} and they showed 60.19, 17.57 and 17.36 per cent heterosis, respectively, over top parent P_8 (S-17) and 54.36, 39.41 and 39.15 per cent heterosis, respectively, over Commerical Check (Pusa Vishwas). The higher yield recorded in these F_1 hybrid has been attributed to early flowering, increased number of fruits plant^{-1}, bigger fruit size and higher fruit weight. The higher fruit weight, fruit size, number of fruits plant^{-1} with medium long vine length were mainly responsible for the higher yield plant^{-1} in the hybrid P_6 x P_7 (18.37 kg plant^{-1}) and P_7 x P_8 (16.59 kg plant^{-1}). It is apparent from the foregoing discussion that almost in all the hybrids which showed best effects, the parental lines involved were at least one of the three most outstanding parental lines, namely, P_6 (S-12), P_8 (S-17) and P_3 (S-124-10) which had high effects for one or more of the characters contributing towards yield. This indicated that there was a strong tendency for higher gain to be transmitted from the parents to the offspring. These results suggest that from the economic point of view, it is necessary to utilize the best performing parental lines for one or more characters associated with yield in order to achieve higher gains in the F_1 hybrid through exploitation of heterosis.

Summary

Ten F_1 hybrid of Pumpkin (*Cucurbita moschata* Duch Ex. Poir) involving eight parents were studied to investigate the extent of heterosis at the Division of Vegetable Crops and Floriculture, Indian Agricultural Research Institute, New Delhi 110012. Nine important characters, namely, vine length, days to first male flower opening days to first female flower opening, days to first fruit harvest, fruit weight, fruit size index, number of fruits plant^{-1}, fruit flesh thickness and yield plant^{-1} were studied.

Appreciable heterosis was recorded for all the characters. The mean of hybrid was higher than those of the parents for all the characters except vine length and fruit flesh thickness. The minimum and maximum heterosis observed were 17.57 and 57.39 per cent, 0.07 and 30.19 per cent, and 18.65 and 54.36 per cent over better parent, top parent and commercial check (Pusa Vishwas), respectively, for yield plant^{-1}. In order of merit, F_1 hybrid P_6 x P_7 (S-12 x S-20), P_7 x P_8 (S-20 x S-17), P_3 x P_5 (S-124-10 x S-15) and P_1 x P_5 (Pusa Vishwas x S-15) were observed to be best performing and they showed heterosis percentage of 30.2, 17.5, 13.7 and 10.9, respectively, over commercial check (Pusa Vishwas). The high yield in these top 4 F_1 hybrids has been attributed to early maturity,

increased number of fruits plant^{-1}, fruit size and fruit weight associated with higher yield in order to achieve higher gains in F_1 hybrids.

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Host Preference of *Helicoverpa armigera* Hb. and its Bioagents in Cotton and Pigeonpea Based Intercropping System

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ABSTRACT

Host Preference of *Helicoverpa armigera* Hb. and its bioagents was studied in cotton and pigeonpea based intercropping systems with cow pea, soybean, greengram and sorghum for 3 years during 1995-96, 96-97 and 97-98 at N.A.R.P., C.V.Z., Yavatmal, M.S. India. Minimum infestation of *H. armigera* was observed in Cotton + Cowpea and increased progressively in cotton + soybean, sole cotton, pigeonea + sorghum, pigeonpea + soybean, pigeonpea + green gram, sole pigeonpea and highest in cotton + pigeonpea. Parasitoid population was maximum in cotton + cowpea and pigeonpea. Bioagent population was maximum in cotton + cowpea and pigeonpea + sorghum intercropping systems. As such, pigenopea was preferred by *H. armigera* than cotton. Considering *H. armigera* infestation and parasitoid activity, cotton + cowpea intercropping system for cotton and pigeonpea + sorghum intercropping system for pigenopea appeard to be better for Central Vidarbha Zone. Cotton + pigeonpea intercropping system should be avoided.

Cotton and pigeonpea based intercropping systems are being followed in Vidarbha region of Central India with sorghum, green gram, soybean cowpea, etc. as intercrops. Larval food affects the growth and reproduction of the pest (Roxanny *et. al.*, 1986 and Katole, 1992). Parasitoids also show preference to different crops. Cowpea, soybean and green gram are suggested as intercrops in cotton to attract parasitoid population (Anonymous, 1994), which can be explored in IPM approach. It was, therefore, thought to generate the information on host preference of *H. armigera* and its parsitoids for cotton and pigeonpea based intercropping systems for *Helicoverpa* management.

MATERIAL AND METHODS

Studies on host preference of *H. armigera* and its biogents were conducted at N.A.R.P., Central Vidarbha zone, Yavatmal, M.S., India, during 1995-1996, 96-97 and 97-98, as non replicated trial with twelve treatments of cropping systems, each in the plot of 9 x 9 m2 size. Details of the treatments are given in Table 1.

Observations on the cotton bolls and pods of other crops damaged by *Helicoverpa armigera* were recorded at harvest. In case of sorghum, observation were recorded on greeen earheads. Population of biogeants were recorded in each plot

Table 1. Details of cropping systems, varieties and spacing

S.N.	Treatments	Ratio of	Variety	Spacing (cms)	
	Main crop + Intercrop	rows		Main crop	Intercrop
1.	Cotton + Soybean	1:1	-	90 x 60	90 x 10
2.	Cotton + Cowpea	1:1	-	90 x 60	90 x 10
3.	Cotton + Pigeonpea	6:2	-	60 x 60	60 x 30
4.	Cotton + Sorghum	3:3	-	45 x 20	45 x 10
5.	Pigeonpea + Soybean	1:2	-	90 x 20	30 x 10
6.	Pigeonpea + Green gram	1:2	-	90 x 20	30 x 10
7.	Cotton sole	-	AHH-468	90 x 60	
8.	Pigeonpea sole	-	C-11	60 x 30	
9.	Sorghum sole	-	CSH-9	45 x 10	
10.	Soybean Sole	-	PKV-1	30 x 10	
11.	Cowpea sole	-	RC-19	30 x 10	
12.	Green gram sole	-	Kopargaon	30 x 10	

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Table 2 : Infestation of *Helicoverpa armigera* Hb, and its natural enemies under different intecropping systems (3 years pooled)

S.N.	Treatments (Cropping system)	Ratio of rows	Pods/bolls/earheads infested *Helicoverpa armigera*			Popularion of bioagents plant^{-1}							
						Main crop				Intercrop			
			Main crop	Inter crop	Total	LBB	Chrysoperla eggs	Camp-oletis	Appentelis	LBB	Chrysoperla eggs	Camp-oletis	Appentelis
1.	Cotton + Soybean	1 : 1	15.46	0.02	15.48	0.90	0.15	-	0.10	0.33	-	-	-
2.	Cotton + Cowpea	1 : 1	12.68	0.01	12.69	1.50	0.25	-	0.10	2.06	0.10	-	-
3.	Cotton + Pigeonpea	6 : 2	13.03	42.28	55.31	1.21	0.15	-	0.10	0.66	-	0.25	-
4.	Pigeonpea + Sorghum	3 : 2	26.86	0.02	26.88	1.00	-	0.15	-	2.66	-	-	0.20
5.	Pigeonpea + Green gram	1 : 2	32.72	0.02	32.74	1.00	-	0.15	-	0.33	-	-	-
6.	Pigeonpea + Green gram	1 : 2	34.72	0.02	34.74	0.66	-	0.20	-	0.33	-	-	-
7.	Cotton sole	-	19.60	-	19.60	1.05	0.15	-	0.15	-	-	-	
8.	Pigeonpea sole	-	39.95	-	39.95	1.16	-	0.22	-	-	-	-	-
9.	Sorghum sole	-	0.02	-	0.02	2.40	-	-	0.30	-	-	-	-
10.	Soybean sole	-	0.33	-	0.33	0.33	-	-	-	-	-	-	-
11.	Cowpea sole	-	0.01	-	0.01	2.40	0.15	-	-	-	-	-	-
12.	Green gram sole	-	0.02	-	0.02	0.73	-	-	-	-	-	-	-

separately for each crop season. Trials were conducted under unprotected condition. Three years data were pooled to find out better cropping system having minimum infestation of *H. armigera.*

RESULTS AND DISCUSSION

Infestation of *Helicoverpa armigera* on main crops

1) On cotton : Minimum infestation was observed in the cotton + cowpea intercropping system (12.68%), which was increased progressively in cotton + pigeonpea (13.03%), cotton + soybean (15.46%) and maximum on sole cotton (19.60%).
2) On pigeonpea : Least infestation was noticed in pigeonpea + sorghum cropping system (26.86%) and progressively increased in pigeonpea + soybean (32.72%), sole pigeonpea (39.95%), and maximum in pigeonpea + cotton (42.28%).

Infestation of *H. armigera* on main crop + intercrop

As regards total infestation of *Helicoverpa* in cotton based intercropping system, it was minimum in cotton + cowpea (12.69%) and increased in cotton + soybean (15.48%), sole cotton (19.60%) and considerably highest in cotton + pigeonpea (55.31%).

Total infestation in pigeonpea based intercropping system, it was minimum in pigeonpea + sorghum (26.88%) with progressive increase in pigeonpea + soybean (32.74%), pigeonpea + green gram (34.74%) and maximum in sole pigeonpea (39.95%).

These observations revealed that the infestation of *Helicoverpa* was maximum on pigeonpea than control and was highest in Cotton + pigeonpea (53.31%) indicating more food preference to pigeonpea, followed by cotton. It is, further, revealed that infestation was reduced when cotton and pigeonpea were grown with other intercrops than sole crops.

Growth index to *Helicoverpa* is reported to be more on pigeonpea than cotton (Bilapate *et al.* 1991 and Kulkarni, 1996) and fecundity was more on coton (Argulwar, 1972 and Katole, 1992). These literature also indicated *Helicoverpa* food preference for pigeonpea than cotton was observed in these studies form larval damage.

Population of bio-agents

Lady bird beetle : Among the bioagents, population of coccinellid lady bird beetle was predominant. On individual crops, it was maximum on cowpea and sorghum (2.40 plant^{-1}), followed by pigeonpea (1.16 plant^{-1}), cotton (1.05 plant^{-1}), green gram (0.73 plant^{-1}) and least on soybean (0.33 plant^{-1}).

Population in the plots including intercrop, was maximum in pigeonpea + sorghum (3.66), followed by cotton + cowpea (3.56), cotton + pigeonpea (1.87), pigeonpea + soybean (1.33), cotton + soybean (1.23) and minimum in pigeonpea + green gram (0.99).

Eggs of *chrysoperla* carnea : *Chrysoperla* eggs were observed only on cotton (0.15 to 0.25 plant^{-1}) and cowpea (0.10 to 0.15 plant^{-1}) in sole or in intercropping.

Campoletis chloridae : Pupal population of *C. chloridae* was observed only on pigeonpea as sole or with intercrop (0.15 to 0.25 plant^{-1}).

Apentelis sp. : Pupal population of *Apentelis sp.* was seen only on sorghum (0.20 to 0.30 paltn^{-1} and 0.10 to 0.15 plant^{-1}).

These observations revealed that three bioagents i.e. LBB, *Chrysoperla* eggs and *Apentelis* have preferred cotton crop and two bioagents i.e. LBB and Campoletis have preferred pigeonpea. However, among the crops used for intercropping cowpea and sorghum attracted more population of bioagents and that of soybean and green gram could not attract except meager population of coccinellid lady bird beetles.

As such, infestation of *Helicoverpa* in cotton and pigeonpea based intercropping systems indicated some relationship with bioagent population. Infestation was minimum in cotton + cowpea and pigeonpea + sorghum where population of bioagents was more. On the other hand, infestation of *H. armigera* on cotton pigeonpea was increased when sown with soybean and green gram where population of bioagents was meager.

It can be concluded that cowpea should be sown as intercrop in between two rows of cotton (1 : 1) and pigeonpea should be sown with sorghum (3 : 3) to have minimum infestation of *Helicoverpa armigera.* However, cotton + pigeonpea cropping system should be avoided, as both the crops were most preferred and having highest infestation of *H. armigera.*

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Effect of Third Day Insecticidal Application on the Emergence of *Trichogramma chilonis* Ishii from Parasitized Host Eggs

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ABSTRACT

Fourteen insecticidal treatments were applied to the *Corcyra* host eggs parasitized by *T. chilonis* three days after the release of parasitoids compared with untreated eggs to assess the safety / toxicity of these insecticides on the adult emergence of *T. chilonis*. These studies were conducted on UV irradiated as well as unirradiated host eggs and each trial was repeated twice. Results revealed that endosulfan 35 EC 0.06 per cent, confidor Ultra 100 SC 0.0.005 per cent, Indoxacarb 14.5 EC 0.01 per cent abamectin 1.8 EC 0.002 per cent were safest, thiamethoxam 25 WG 0.005 per cent, azadirachtin 3000 ppm 1 ml l^{-1}, endosulfan 40 EC 0.05 per cent, acetamiprid 20 SP 0.005 per cent and neem oil 1 per cent were safer, imidacloprid 17.8 SL 0.05 per cent was moderately safer, B-cyfluthrin 2.5 EC 0.0025 per cent, spinosad 48 EC 0.005 per cent and Spark 36 EC 0.02 per cent were relatively toxic and sprayable mineral oil D-C-Tron plus 5 ml l^{-1} was highly toxic for the adult emergence of *T. chilonis* when applied 3rd day after parasitoid release. Unirradiated and untreated host eggs showed 10 to 11 per cent more parasitization and adult emergence than irradiated and treated eggs.

Conservation of natural enemies of crop pests in crop ecosystem is an important concept of IPM. Safer insecticides are to be explored in crop protection to achieve this object (Brar, 1991). As such, newer insecticides are to be recurringly tested for their safety or toxicity to natural enemies. *Trichogramma chilonis* Ishii is a major egg parasitoid being used in biological conrol of lepidopteran pest (Smith, 1996).Therefore, some newer insecticides were tested by applying 3rd after parasitoid release to already parasitized host eggs to assess their effect on the adult emergence of *T. chilonis*.

MATERIAL AND METHODS

Laboratory experiments were planned with insecticidal treatments, including control, replicated thrice in C.R.D. during 2002-2003 at Akola, M.S., India, to assess their effect on the emergence of *T. chilonis*. Factual eggs of *Coryra cephalonica* were used as host eggs for parasitization of *T. chilonis*. Experiments were conducted on U.V. irradiated and unirradiated host eggs glued on Trichocards. Trichocards were placed in inflated polybags in which parasites were released in the host: parasitoid ratio of 30:1 (Singh and Jalali, 1994) for parasitization and mouth of inflated polybags were tied. Application of 14 insecticides (Table 1) was made after 3 days of parasitoid release as per the method suggested by Santharam and Kumarswami (1985) and adopted by Pratiksha Tawar (2001) by dipping trichocards in different insecticidal solutions of desired strength for a moment which were again placed in their respective inflated polybags after shade dried. Before application of insecticidal treatments, pretreatment observations were recorded on the per cent parasitization both in irradiated and unirradiated eggs. Observations on the per cent parasitoid emergence were recorded, after 10 days of parasitoid release, by counting total parasitized eggs and the eggs from which adults were emerged per microscopic field. Each experiement was repeated twice. Data, so obtained, were subjected to statistical analysis after suitable transformations. Data of two trials were pooled and results are presented in Table 1.

RESULTS AND DISCUSSION

Per cent parasitization recorded before insecticidal treatments as pretreatment observations revealed non-significant differences both in irradiated and unirradiated host eggs, which ranged between 65 to 66 per cent in irradiated and 76 to 77 per cent in unirradiated host eggs, causing 11.0per cent more parasitization to unirradiated host eggs.

However, the emergence of adult parasitoid was influenced by the insecticidal treatments applied 3 days after parasite release. Irradiated eggs showed maximum emergence from confidor ultra (89.55%), indoxacarb (83.67%), acetamiprid (78.45%), endocyper (77.98%), thiamethoxam (77.60%), azadirachtin (76.31%) and neem oil (72.27%) also showed parasitoid emergence of *T. chilonis*. Relatively toxic treatments were sprayable mineral oil D-C-Tron plus (61.97%) followed by more toxic treatments of β-cyfluthrin (40.64%), spinosad (36.42%), imidacloprid

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Table 1 : Effect of insecticidal treatments of host eggs after 3rd day of parasitoid release on the adult emergence of Trichogramma chilonis Ishii (Pooled mean data of two trials)

	Treatments	Concentration (%)	Irradiated host eggs		Unirradiated host eggs	
			Pretreatment parasitization (%)	Adult emergence (%)	Pretreatment parasitization (%)	Adult emerence (%)
T_1	Imidacloprid 17.8 SL	0.05	65.51	32.12 (33.58)*	76.98 (8.77)*	82.99 (65.96)*
T_2	B - cyfluthrin 2.5 EC	0.0025	65.68	40.64 (39.23)	76.75 (8.76)	67.32 (55.30)
T_3	Abamectin 1.8 EC	0.002	65.64	84.55 (67.26)	76.96 (8.79)	92.07 (73.93)
T_4	Spinosad 48 EC	0.005	65.86	36.42 (37.11)	76.79 (8.76)	31.47 (34.02)
T_5	Neem oil	1.0	65.66	72.27 (58.77)	76.98 (8.76)	91.80 (73.84)
T_6	D-C-Tron plus	5 ml l^{-1}	65.83	61.97 (52.26)	76.84 (8.76)	13.73 (73.84)
T_7	Spark 36 EC	0.02	65.59	24.27 (28.82)	76.80 (8.76)	78.48 (62.97)
T_8	Endocyper	0.05	65.62	77.98 (63.14)	76.86 (8.76)	94.47 (79.23)
T_9	Indoxacar 145 EC	0.01	65.60	83.67 (66.64)	76.88 (8.76)	94.59 (79.23)
T_{10}	Endosulfan 35 EC	0.06	65.41	88.88 (70.97)	76.82 (8.76)	95.34 (77.83)
T_{11}	Azadirachtin 3000 ppm	1 ml l^{-1}	65.62	76.31 (61.83)	76.88 (8.76)	95.27 (76.08)
T_{12}	Confidor ultra 100 sc	0.005	65.51	89.65 (72.09)	76.87 (8.76)	95.27 (76.08)
T_{13}	Acetamprid 20 sp	0.005	65.46	78.49 (63.35)	76.78 (8.76)	96.36 (76.08)
T_{14}	Thiamethoxam 25 WG	0.005	65.65	77.60 (61.91)	76.79 (8.76)	94.66 (76.93)
T_{15}	Control		64.45	87.28 (69.15)	76.91 (8.77)	97.50 (81.78)
SE m±			0.89	4.73	0.03	3.10
CD at 5%			-	14.06	-	9.20

(32.12%) and spark (24.27%) at par with each other in their order.

Adult emergence from unirradiated host eggs was maximum from untreated eggs (97.50%) at par with endosulfan (95.34%), azadirachtin (95.27%), thiamethoxam (94.66%), indoxacarb (94.59%), endocyper (94.47%), confidor ultra (93.71%), acetamiprid (93.36%), abamectin (92.07%) and neem oil (91.38%). Next group relatively safer insecticides includes imidacloprid (82.99%) and spark (78.48%). β-cyfluthrin was relatively toxic (67.32%). More toxic treatment was spinosad (31.47%) and most toxic treatment for adult emergence of *T. chilonis* was D-C-Tron plus (13.73%) when applied 3 days after parasite release.

From these results, it is concluded that parasitization and adult emergence were more by 10-11per cent in unirradiated untreated eggs than irradiated Corcyra host eggs, may be due to live embryo of host eggs available for their nutrition. As regards insecticidal safety for the adult emergence of *T. chilonis*, endosulfan 0.06 per cent, confidor ultra 0.005 per cent, indoxacarb 0.01per cent, abamectin 0.002 per cent, were safest thiamethoxam 0.005 per

cent azadirachtin (3000 ppm) 1 ml l^{-1}, endocyper 0.05 per cent, acetamiprid 0.005 per cent and neem oil were safer; imidacloprid 0.05 per cent was moderately safer; β-cyfluthrin 0.0025 per cent, spinosad 0.005 per cent and spark 0.02 per cent were relatively toxic and sprayable mineral oil D-C-Tron plus 5ml l^{-1} was highly toxic.

Gupta et al. (1984), Varma and Singh (1987), Rajendran and Gahukar (2000) and Pratiksha Tawar (2001) reported endosulfan to be safer for adult emergence of *T. chilonis*. Klemm and Shmutterer (1993) reported neem oil to be moderately safer, Dhawan (2000) observed indoxacarb to be safer and β-cyfluthrin to be toxic for adult emergence.

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Growth and Development of Spotted Bollworm, *Earias vitella* (Fab.) Reared on Different Hosts Under Laboratory Conditions

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ABSTRACT

Effect on the growth and development of *Earias vitella* (Fabricius) when reared on different hosts was studied in the Insect Biotech Laboratory, Department of Entomology, Dr. PDKV, Akola during 2000-02. The experiment was conducted to study the host preference and its suitability for complete growth and development. The results indicated that okra was the most preferred host for the development of the pest, followed by cotton, artificial diet and mesta. The life cycle was completed within 27-28 days when reared on okra, followed by 30-31, 29-30 and 34-35 days when reared on cotton, artificial diet and mesta, respectively. Average minimum pupal period, highest fecundity, maximum pupal and adult weight was recorded when reared on okra fruits, followed by cotton squares/flowers, artificial diet and mesta leaves.

Earias vitella, known as spotted bollworm of cotton and shoot and fruit borer of okra. It is the most dreaded pest of these two important cash crops of not only Maharashtra, it is distributed all over India. As a bollworm of cotton, it causes 40 per cent losses in seed cotton (Veeresh, 1980) and also being devastating okra, the losses upto 41.6 per cent has been reported in different parts of India (Krishnakumar and Srinivasan, 1987).

The host plants or food substrates on which the insects are reared influence the development of an insect, its metabolism activity and its susceptibility to insecticides (Singh, 1996). Moreover, the preferred hosts have a great influence on oviposition, fecundity, developmental period and adult longevity (Hiremath, 1984 and Ananthkrishnan, 1977). Studies on the biology of *E. vitella* on different hosts provide information on aspects of feeding and development of *Earias spp*. Therefore, the present study will be useful for understanding the pattern and extent of population build up as influenced by host plants. This paper reports comparative results of studies to measure the developmental times of immatures and adult fecundity and longevity of the *Earias* larvae feeding on cotton, okra, mesta and artificial diet under laboratory conditions.

MATERIAL AND METHODS

The spotted bollworm culture was maintained from field-collected larvae in the Insect Biotech laboratory, Department of Entomology, Dr. PDKV, Akola. From the F_1 culture of *Earias*, one hundred eggs were separated and kept for hatching in plastic containers at room temperature with a photoperiod of 14 L: 10 D h. Larvae upon hatching were transferred on different hosts viz., okra fruits, cotton squares/ flowers, mesta leaves and artificial diet (Gupta *et al*., 1998) using a camel hairbrush. Fresh food was provided every alternate day until pupation. Adults emerged on any given day were paired and released in separate cages for mating and oviposition. Fecundity on subsequent days was noted regularly until all females died.

Observations on the larval duration, percent larvae pupated, pupal period, percent adult emergence at each combination of temperature and relative humidity were recorded. The adults emerged on any given day were paired and released in separate cages for mating and oviposition, at the rate of approximately 5 pairs mating^{-1} chamber. Fecundity on subsequent days was recorded regularly and also the egg duration and percent hatching in further generation was noted.

RESULTS AND DISCUSSION

Growth and development of *E. vitella* (Fabricius) on different hosts

The results presented in Table 1 indicated non-significant differences among the treatments in case of survival of eggs of *E.vitella*. However, there were significant difference amongst larva and pupal survival among the treatments with maximum survival of 69.8 and 65.4 per cent of larvae and pupae, respectively when reared on okra, which was

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significantly superior over rest of the treatments. This was followed by cotton, artificial diet and mesta with 63.0 and 56.4, 58.0 and 53.84 and 55.0 and 51.8 percent larval and pupal survival, respectively, all being at par with each other except cotton which was significantly superior over mesta in case of larval survival. The results of the present investigation go to corroborate the result of Mehta (1971). As per the report laboratory and field studies on okra was found to be the most preferred host for *Earias,* followed by cotton and *Urena lobata.* Senapati *et al.,* (1978) reported that *Earias* attained the best growth and had the shortest duration of development period when okra fruits were used as the larval food.

Results on duration of eggs and pupa revealed non-significant differences among the treatments. However, shortest duration of eggs of *Earias* was noticed when reared on cotton, which was 3.0 days, followed by okra, artificial diet and mesta, all being at par with each other. Similarly, the pupal period was completed in 11.4 days on okra followed by 11.6, 12.0 and 13.4 days on cotton, artificial diet and mesta, respectively. *Earias* larvae reared on okra completed its duration in 13.2 days which was significantly superior to rest of the treatments. It was followed by 14.2 days when reared on artificial diet and they were at par with each other, whereas significantly prolonged larval duration (17.4 days) was recorded when reared on mesta leaves. Significantly highest fecundity of *E. vitella* (288.6 eggs female^{-1}) was noticed when reared on okra, which was significantly superior to rest of the hosts and was followed by cotton, artificial diet and mesta with fecundity of 244.6, 238.7 and 205.3 eggs female^{-1} (Fig. 3). As it was previously reported by Hiremath (1984) who found that the maximum damage was caused in okra, followed by cotton among the six different hosts of *E. vitella* tested showing the preference of hosts as okra, cotton, pundi, hollyhock, *Hibiscus* and *Abutilon indicum* in that order. Likewise Suryavanshi *et al.,* (2001) reported that the okra seeds and fruits were most suitable for *E. vitella* than cotton showing highest reproductive potential as well as comparatively shorter generation time.

Food consumption was measured as weight gained by the larva, which varied significantly among hosts. Observations on pupal and adult weight indicated that the larvae fed on okra were having more pupae and adult weight which was significantly superior to rest of the treatments. The mean pupal weight was highest (49.01 mg) on okra which was followed by cotton and artificial diet, both being at par with each other, while significantly lowest pupal weight was recorded on mesta (24.04 mg). The results on adult weight indicated that larvae fed on okra were significantly heavier adults, followed by the larvae reared on cotton, mesta and artificial diet which were at pat with each other. The adult weight on okra, cotton, mesta and artificial diet was 29.2, 23.24, 20.8 and 21.6 mg, respectively (Fig. 2).

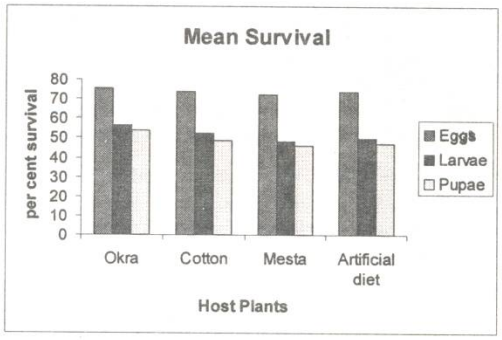

Fig. 1: Influence of hosts on mean per cent survival of different life stages of *E. vitella*

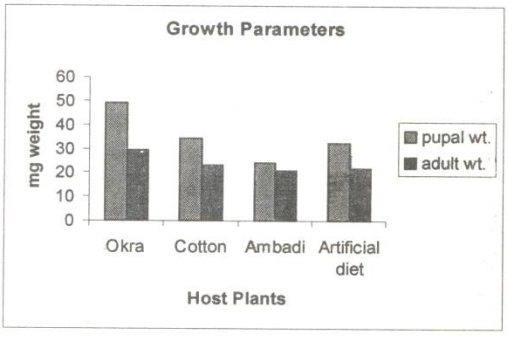

Fig. 2: Influence of host plants on different growth parameters

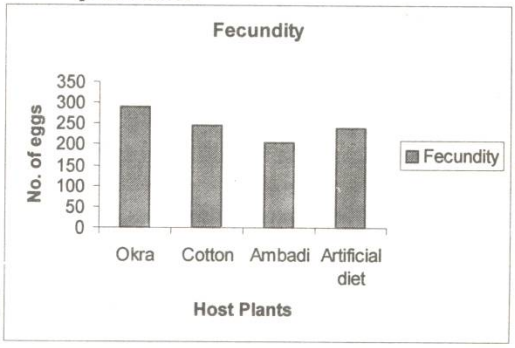

Fig. 3: Influence of host plants on fecundity of *Earias*

Table 1: Growth and development of *E. vitella* on different hosts

Hosts	No. of eggs	% mean survival			Mean duration (days)			Mean fecundity (eggs female^{-1})	Mean Pupal weight (mg)	Mean Adult weight (mg)
		Eggs	Larvae	Pupae	Eggs	Larvae	Pupae			
Okra fruits	100	93.4 (75.11)	69.8 (56.66)	65.4 (53.97)	3.2	13.2	11.4	288.6	49.01	29.20
Cotton squares/ flowers	100	92.2 (73.78)	63.0 (52.53)	56.4 (48.68)	3.0	16.0	11.6	244.6	34.20	23.24
Mesta	100	90.4 (71.95)	55.0 (47.87)	51.8 (46.03)	3.6	17.4	13.4	205.3	24.04	20.80
Artificial diet	100	92.2 (73.78)	58.0 (49.60)	53.84 (47.18)	3.4	14.2	12.0	238.7	32.40	21.60
SE(m)±	—	3.04	1.33	1.37	0.19	0.88	0.78	6.65	1.42	1.19
CD (5%)	—	NS	3.97	4.08	NS	2.63	NS	19.77	4.24	3.54

Figures in parentheses are arc sine transformations

The other two natural hosts of *Earias* viz., cotton and mesta also showed good effect on the biology of *Earias* but were found to be second choice after okra in the present studies. However, in Pakistan, Hafeez and Ali (1983) found cotton to be the first choice of *E. vitella,* followed by okra fruits and Siddiqui *et al.*,(1987) found cotton to be comparatively more infested than okra, which is in contrary to the present findings. But, Sumathi and Balasubramanian (2002) in their laboratory studies observed that okra was better suitable host than cotton with high reproductive potential and also that the mean generation time and doubling time of the population was shorter on okra. Overall results on effect of host plants on survival and duration of *E. vitella* life stages revealed that okra was the most preferred host, followed by cotton and mesta, being the least preferred host.

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Studies of Management of Collar Rot Disease (*Sclerotium rolfsii*) of Chickpea by Use of Fungicides

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ABSTRACT

Chickpea is important crop in India. In the Chhattisgarh region, where rice based cropping system is predominant, chickpea is becoming an important crop of this region. It is grown on an area of 0.204 million hectares with production of 0.107 million tonnes having an average productivity of 525 kg ha^{-1} (Anonymous, 1997).

It is mostly cultivated under rainfed condition in a veriety of soil varying in residual moisture. Wilt causing fungi in chickpea under above condition creates severe problems and mortality due to this fungi may vary from 10-100 per cent.

More than 50 pathogens have been reported so far to infect chickpea (*Cicer arietinum* L.) in different parts of world (Nene *et. al.*, 1989).

Wilt of chickpea has drawn attention of researchers. In the present study, invitro experiments were set to study the efficacy of different fungicides to prevent the attack of *S. rolfsii* causing collar rot infection in the seedlings of Gram plants.

MATERIAL AND METHODS

Six fungicides viz. Bavistin, Thiram, Benomyl, Captan, Prochloraz & Mancozeb were selected for studing the effect on growth of *S. rolfsii* by adopting food technique (Nene and Thapliyal, 1971). The colony diameter and per cent inhibition of growth over control in each treatment was recorded by formula.

$$\text{Per cent inhibition of growth} = \frac{\text{Radial growth in control - Radial growth in treatment}}{\text{Radial growth in control}} \times 100$$

In pot culture studies surface sterilized grown seeds were soaked in spore suspension of *S. rolfsii*. The spore treated seeds were air dried and later treated with different fungicides. Treated seeds sown in pots with sterized soil. Four treated seeds were sown in each pot and 5 replications were maintained for each treatment. Surface sterilized and uninoculated seeds served as control. Observation were made on Germination, Collar rot infection, Shoot length, Root length, Fresh weight, Dry weight and Nodulation at 30 DAS. Collar rot infection was calculated as :

$$\text{Collar rot infection (\%)} = \frac{\text{No. of seedlings with collar rot}}{\text{Total No. of seedlings emerged}} \times 100$$

RESULTS AND DISCUSSION

The results indicate that among the fungicides, Bavistin, followed by Benomyl and Captan were significantly superior to rest of the fungicides by reducing growth of *S. rolfsii* to 1.09 from 8.60 in control when the concentration of fungicide was increased for 0.1 per cent, to 0.3 per cent a gradual decrease was seen in the growth of *S. rolfsii*.

Studies on pot culture revealed that Bavistin and Benomyl treatment resulted in minimum collar rot infection of 11 per cent and 22 per cent, respectively compared to control and other treatments. Captan followed by Benomyl and Procloraz treated seeds recorded maximum dry matter content.

Mancozeb was found to be good in increasing nodule number recording 14.33 nodules $seedling^{-1}$, followed by Bavistin treatment with 10.66 nodules $seedling^{-1}$ as against 3.3 nodules $seedlings^{-1}$ in control. A significant increase in shoot length of 25.0 cm was observed with Bavistin treated seeds.

A similar result was noted in fresh weight with Bavistin treated seeds showed12.2g fresh weight $seedling^{-1}$ compared to 5.26 g fresh weight in control. It can be concluded that Bavistin, Benomyl and Captan were most effective fungicides as seed treatment in checking the collar rot infection and favouring growth of chickpea.

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Table 1. Effect of fungicides on the growth of *S. rolfsii*

Treatments	Colony diameter (cm)* conc. of fungicides			Mean	% inhibition of growth
	0.1%	0.2%	0.3%		
Captan	2.80	2.80	2.73	2.77	67.79
Benomyl	2.30	2.23	1.90	2.14	75.11
Prochloraz	5.46	4.93	3.96	4.78	44.41
Mancozeb	7.23	6.93	5.80	6.65	22.67
Bavistin	1.16	1.13	1.00	1.09	87.32
Thiram	6.56	6.00	5.40	5.98	37.20
Control	8.60	8.60	8.60	8.60	
CD (5%)	0.65	0.35	0.29		

* Mean of three replications

Table 2. Effect of seed treatment of fungicide on growth of chickpea under artificial inoculation

Treatments	Germination (%)	Collar of infection, %	Shoot length (cm)	Root length (cm)	Fresh wt.* (g)	Dry wt. * (g)	Nodule No. *
Captan (0.2%)	75.0	27.6	16.0	17.0	8.70	3.26	8.33
Benomyl (0.2%)	83.3	22.0	19.6	18.8	10.3	3.03	8.33
Prochloraz (0.2%)	66.6	44.3	18.8	15.5	8.10	2.76	6.33
Mancozeb (0.2%)	58.3	50.0	15.6	13.2	6.50	2.23	14.33
Bavistin (0.2%)	91.6	11.0	25.0	18.3	12.2	2.70	10.66
Thiram (0.2%)	58.3	55.3	14.6	14.5	7.23	1.76	6.33
Control	33.3	77.6	13.2	11.8	5.26	1.03	3.33
CD (5%)	NS	29.19	1.54	1.76	0.49	0.30	2.13

* Mean of 3 replications

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Diversification in Agriculture – Markov Chain Approach

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ABSTRACT

With the passage of time farmers are increasingly commercialised and have transformed their farming activity into agri-business enterprenuership. In order to develop competitiveness in the global market, the farmers have become conscious in allocation of area under crops / enterprises. This has necessiated research workers to undertake indepth studies related to the extent of diversification and identifying the crops responsible for diversification.

In the present study attempt was made to examine the diversification in Agriculture of Vidarbha . Markov Chain Approach was used to study the crops causing diversification while Herfindahl and Entropy index for the extent of crop-diversification.

The results of the study are summarized below :

- The results of Herfindahl and Entropy index confirm the existence of diversification in Agriculture of Vidarbha.
- The transition probability matrix was estimated using "Markov Chain Analysis" which indicated that there is a shift in area under different crops over the previous year.

The study concludes that results of Herfindahl and Entropy index confirm the diversification. On the basis of transitional probability matrix obtained under Markov Chain Approach *Kharif* jowar, paddy and cotton were identified as the most stable crops of Vidarbha.

Advancement of technology in different fields and increasing exploitation of irrigation sources, development of varieties of seeds, changing markets and other infrastructure has led to continuous reallocation of land resources towards different crops. Sometimes a new cropping pattern is practised in view increasing net farm incomes. The process of diversification is other way of avoiding risk and uncertainty involved due to vagaries of nature and market. In the early years of development farmers used to grow subsistence crops mainly for own requirement. With the passage of time farmers became increasingly commercialised and started farming for maximising their farm output. Now a days farmers have realised the need for emphasizing more on the long term net return. Due to economic importance the analysis of crop diversification has been a considerable interest to the agro-economists.

Diversification is an integral part of the process of structural transformation of an economy within agriculture. Diversification is taking place at micro and macro level and as such this necessiated to undertake study related to the extent of diversification and identifying the crops responsible for diversification.

MATERIAL AND METHODS

The study was based on secondary data on area under different crops in Vidarbha collected from the Government publications.To measure the diversification, Herfindahl and Entropy indices were used .

Markov probability model :

A stochastic process is one which can analyse a set of trials or experiments probabilistically. For stochastic process if N assumed that the movements (transitions) of objects from one state (possible outcome) to another are governed by a probability mechanism or system. A finite Markov process is a stochastic process whereby the outcome of a given trial t (t = 1, 2, ... T) depends only on the outcome of the preceeding trial (t-1) and this dependence is the same at all stage in the sequence of trials. Consistence with this definition, let

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S; represent the r states or possible outcomes; i 1, 2 ..... r.

Wit represent the probability that state Si occurs on trial t or the proportion observed in trial t in alternative outcome state i.e. of a multinomial population based on a sample of size n, i.e. Pr (Sit).

Pit represent the the transitional probability that which denotes the probability that if for any time t the process is in state Si it moves on the next trial to state S_j i.e. Pro $(S_{jt} + 1/S_{jt}) = P_{ij}$.

$P = (P_{ij})$ represent the transitional probability matrix which denotes the transitional probability for every pair of states (i, j = 1,2 .... r) and has the following properties.

$$0 \leq P_{ij} \leq 1 \quad \text{..... (1)}$$

and $$\sum_j P_{ij} = 1, \quad \text{for } i = 1, 2 \text{ ..... r ..... (2)}$$

Given this set of notations and definitions for a first order Markov chain the probability of a particular sequence Si on trial t and St on trial t+1 may be represented by Pr $(S_{it}$ t $S_{jt} + 1) = P_r$

(S_{it}) Pr $(S_t$ t +1 / Sit) = Wit P_{jt} ..... (3)

and the probability of being in state j at trial t+1 may be represented by

$$\Pr(Sj. \; . \; t+1) = \sum_i W\,it\; Pit \text{ or}$$

$$W_t \qquad t+1 = \sum_i W_{it}\; P_{tj} \quad \text{..... (4)}$$

The data for the study are the proportion of area under eight crops i.e. Rice, Kh. Jowar, Tur, Bajara, Cotton, Sunflower, Groundnut, Soybean. These proportions change from year to year as result of the factors like weather, technology, price and other institutional change. It is reasonable to assume that the combined influence of these individually systematic forces approximate to a stochastic procedss and the propensity of farmers to move from one crop state to another differs according to the crop state involved. If these assumptions are acceptable, then the process of cropping pattern change may be described in the form of a matrix p of first order transitional probabilities. The element of P_{ij} of the matrix indicates the probability of a farmer in crop state i in one period will more to crop state j during the following period. The diagenal element P_{ij} measures the probability that the proportion share of j^{th} category of crop will be maintained.

Estimation of transition probability matrix :

Equation (4) can be as a basis for specifying the statistical model for estimating the transition probabilities. If errors are incorporated in equation (4) to account for the difference between the actual and estimated occurance of $(W_j$ t+1), the sample observations may be assumed to be generated by the following Linear Statistical Model.

$$W_j t = \sum_j Wt\; t-1\; P_{ij} + U_j t \quad \text{..... (5)}$$

Or in Matrix form it can be written as

$$Y_j = X_j P_j + U_j \quad \text{..... (6)}$$

Where -

Yj is a (T x 1) vectors of observations reflecting the proportion in cropping pattern j in time t, x_j is a (T x R) matrix of realised values of the proportion in cropping pattern i in time t-1, P_j is a (rx1) vector of unknown transition parameters to be estimated and Uj is a vector of random disturbances.

The relability of this approach was examined using X^2 tests

RESULTS AND DISCUSSION

Crop diversification :

An attempt was made to examine the level of crop diversification in different districts of Vidarbha at different points of time. The approach adopted in this study was to utilise two indicators of crop diversification i.e. Herfindahl index and Entropy index. The results of this analysis are presented in Table-1.

It could be observed from table-5 that the values of Herfindahl and Entropy index are in the range of 0.17 to 0.53 and 0.46 to 0.89 respectively in different districts of Vidarbha. A gradual decrease of Herfindali index and increase of Entropy index over the years in Vidarbha and also in districts confirms the increase in diversification.

Markov chain analysis :

Markov chain analysis is an application of dynamic programming to the solution of Stochastic

decision process that can be described by a finite number of states. In the present study, an attempt has been made to apply Markov chain analysis to study the structural change in the cropping pattern in Vidarbha and there by gain an understanding about the dynamics of the changes using data of crop proportion from 1998-99.

The transition probability matrix estimated is presented in Table 2.

Table 2 shows the direction of changes in crop shares and stability of crops by a transition probability matrix which comprised elements that are conditional probabilities of the share a crop P in time t, given its share in time t-1. The values of the diagonel elements indicate the extent of the stability of crops. As P_{ij} for i = j approached 0, less stability is exhibited by crops and as it approaches 1, crops tends to exhibit more stability. Off-diagonal elements, Pit for ij, are the probability of switching crops. For example P2t is the probability of switching from crop 2 in t-1 to crop 1 in t. Thus, the diagonal elements indicate the probability of retention and the off-diagonal elements indicate the crop to which another crop is likely to lose or from which crop another crop is most likely to gain.

Farmers of Vidarbha retained 64 per cent of the previous years share of *kharif* jowar to cotton and 10 per cent to paddy. However, *kharif* jowar could get all the cropped area where sunflower was cultivated in previous year and 11 per cent of land from cotton and soybean, 38 per cent from groundnut and 29 per cent from paddy.

Tur crop retained 43 per cent of the previous year's share. They diverted 32 per cent and 25 per cent of previous year's share to bajra and cotton respectively. However, tur gained 61 per cent, 35 per cent, 3 per cent and 3 per cent of previous year's share from sunflower, bajra, cotton and paddy respectively during the year under reference. Bajra retained 54 per cent of previous year's share about 35 per cent of share was switched to tur and 11 per cent sunflower.

Cotton is the cash crop in Vidarbha region and retained 56 per cent of previous year's share. They diverted 11 per cent, 3 per cent, 5 per cent and 2 per cent of land to *kharif* jowar, tur, bajra and groundnut respectively. However, cotton gained 52 per cent, 26 per cent and 25 per cent of previous year's share of paddy, *kharif* jowar and tur during the year under reference.

Farmers of Vidarbha retained 39 per cent of the previous year's share of sunflower during the current year. They shifted 61 per cent of the previous year's share of sunflower to tur. However, sunflower gained 1 per cent of previous year's share of bajra. Another important oilseed of this region is groundnut and retained 62 per cent of the previous year's share. They diverted 38 per cent to *kharif* jowar. However, groundnut gained 2 per cent of area from cotton.

Farmers could retain 26 per cent of the previous year's share during the current year of soybean and

Table-1. Crop diversification indices

S.N.	Districts	Herfindahl index			Entropy index		
		1980-90	1990-99	Overall	1980-90	1990-99	Overall
1.	Buldhana	0.98	0.18	0.20	0.76	0.87	0.84
2.	Akola	0.99	0.22	0.24	0.64	0.78	0.76
3.	Amravati	0.29	0.24	0.24	0.69	0.79	0.78
4.	Yavatmal	0.33	0.28	0.30	0.62	2.15	0.68
5.	Wardha	0.28	0.21	0.22	0.67	0.78	0.77
6.	Nagpur	0.16	0.16	0.16	0.87	0.89	0.89
7.	Bhandara	0.52	0.62	0.55	0.47	0.40	0.46
8.	Chandrapur	0.21	0.17	0.17	0.79	0.86	0.85
9.	Gadchiroli	0.50	0.57	0.53	0.45	0.41	0.44
	Vidarbha	0.19	0.15	0.17	0.86	0.93	0.91

Table 2. Transition probability matrix for crops in Vidarbha (1990-1999)

Crops	*Kharif* Jowar	Tur	Bajara	Cotton	Sunflower	Groundnut	Soybean	Paddy
Kharif Jowar	0.64	0	0	0.26	0	0	0	0.10
Tur	0	0.43	0.32	0.25	0	0	0	0
Bajra	0	0.35	0.54	0	0.11	0	0	0
Cotton	0.11	0.03	0.05	0.56	0	0.02	0	0.23
Sunflower	0	0.61	0	0	0.39	0	0	0
Groundnut	0.38	0	0	0	0	0.62	0	0
Soybean	0.11	0.03	0.06	0	0	0.09	0.26	0.45
Paddy	0.03	0.05	0	0.04	0.02	0	0.02	0.84

diverted 45 per cent and 11 per cent of the land towards paddy and *kharif* jowar.

Paddy retained 84 per cent of the previous year's share during the current year. They shifted 4 per cent of land to cotton, 3 percent of *kharif* jowar and 5 per cent to tur. While Rice gained 23 per cent and 10 per cent of land from cotton and *kharif* jowar.

The results of study showed a shift in area. Price incentive played an important role for diversion of land towards pulses and oilseeds. Further the reliability was tested using chi-square test and it was observed that the Markov Chain Approach for studying the changes in cropping pattern was reliable.

CONCLUSION

It is concluded from the analysis that the results of Herfindahl and Entropy index confirms the diversification in area. On the basis of transition probability matrix obtained under Markov Chain Approach, *kharif* jowar, paddy and cotton were the most stable crops of Vidarbha.

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Growth and Diversification in Agriculture - A Spatio Temporal Analysis

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ABSTRACT

With the development of agriculture, cropping pattern has been changed to cope with the changing scenario and to meet the ever changing demands of growing population. Limited supply of land alongwith increasing population and declining yield, compelled the farmers to search for alternative ways of raising farm income and for the sustainability of growth. With the passage of time farmers became increasingly commercialised and started farming for maximising their farm output. Now, farmers have realised the need for emphasizing more on the long term net return. Due to economic importance, diversification studies have gained considerable interest.

In the present study an attempt was made to examine the diversification in Agriculture of Vidarbha. The performance of different crops was studied through. Kendall's Rank Correlation was used to study the dynamics of cropping pattern. A sample of 800 farmers were selected from Agril. Prices Scheme of the Department to examine the changes in cropping pattern at different points of time viz. 1980-81, 1990-91, 2000-2001 on farmers field.

The results of the study are summarized below :

- Analysis of overall agreement in cropping pattern was examined by coefficient of Concordance. The concordance coefficient (0.92) and Kendall's rank correlation coefficients were found to be significant indicating that there was no shift in the cropping pattern over a peiod of 19 years.
- Analysis of cropping pattern at different points of time on farmer's field shows the crop diversification.
- Soybean, Horticultural crops and forest crops were found responsible in causing diversification in most of the districts of Vidarbha.
- Agri-Horti system was found to be more profitable among the existing system.

Advancement of technology in different fields and increasing exploitation of irrigation sources, development of varieties of seeds, changing markets and other infrastructure has led to continuous reallocation of land resources towards different crops. Sometimes new cropping pattern is adopted to increase net incomes. The problem facing the farmers therefore, lies in the design - making about the profitable levels of diversification of crop enterprise or crop selection by the farmers that can give optimal level of profit. In the early years of development, farmers used to grow subsistence crops mainly for own requirement. With the passage of time, farmers became increasingly commercialized and started farming for maximizing their farm output. Due to economic importance the analysis of crop diversification has gained considerable importance.

The present study aims

1) To study spatio-temporal changes in cropping pattern, and
2) To study the economics of diversification at farmers level.

Methodology

The study was based on primary as well as secondary data. The data on area under different crops for all districts of Vidarbha were collected from Government publications.

The primary data on cropping pattern at different points of time from 800 farmers were collected from Agricultural Price Scheme of Department of Agricultural Economics and Statistics, Dr. P.D.K.V. Akola.

The study period was split in two sub-periods, namely, 1980-81 to 1989-90 and 1990-91 to 1998-99.

Analytical tools

Temporal changes in cropping pattern

Cropping pattern refers to distribution of crop acreages expressed as a percentage of the gross cropped area under different crops.

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The changes in the cropping pattern in different districts of Vidarbha was studied using Kendall's Rank Correlation Coefficient.

Kendall's rank correlation coefficient

The analysis is based on the ranking of different crops between the year and to estimate shift or deviation in the cropping pattern. Ramsubban (1963).

Shift or deviation in cropping pattern

When two or more cropping patterns are compared on arranging the acreage under same crops of the patterns on an increasing or decreasing order and if they do not exhibit similarity between them it is termed as shift. On the other hand, when differences occur on account of changes within the cropping pattern due to difference in the allocation of land between the same set of crop, they are termed as deviation.

The concept of shift as defined above rests on the notion of relative order of placement of the constitutents making up a cropping pattern and for this purpose, the acreage under each crop in cropping pattern was ranked according to their magnitude and changes in a cropping pattern was measured with the help of Kendall's rank correlation coefficient (ý).

$$y = \frac{4S}{n(n-1)} - 1$$

Where - n = number of crops
S = total score

Subscore S in Y is formed by considering each number in sequence and counting the total number which lie to the right of and whose magnitudes are larger than the number under consideration. Adding the sub scores, we arrive the total score S.

In case of complete or perfect agreement between A & B, Y coefficient attains the value of + 1 and it is -1, vice-versa.

Test of significance of Kendall's rank Correlation coefficient

Testing of significance of coefficient was based on the standard error of coefficient which is as given under :

$$\sigma\gamma = \left[\frac{2(2n+5)}{9n(n-1)}\right]^{1/2}$$

To test the hypothesis of nullity i.e. there is no correlation between cropping pattern for all the years are same or different and to test the significance that there is no agreement between these patterns and that the rankings are arbitary, arising by chance alone, the concordance coefficient (W) was worked out using the formula

$$W = \frac{12 \sum_{i=1}^{N} Di^2}{[m^2 (n^3 - n) + 2]}$$

Where -

$12 \sum Di^2$ = Square differences between observed and expected rank total.

m = number of cropping pattern years.

n = number of crops.

A complete randomness in the ranking leads to W = 0 and on the other hand a perfect agreement between the patterns resulted W = 1. It does not take netagive value.

Test of significance of 'W'

To determine whether the null hypothesis of randomness originally set up is true or not, Sndecor's 'F' test was carried out using formula -

$$F = \frac{(m-1)\,W}{1-W}$$

with V_1 = (n-1) - 2/m.d.f.

V_2 = (m-1) V1 d.f. for the greater and lesser estimates, respectively.

Temporal changes in cropping pattern

Among the different techniques for examination of changes in cropping pattern, in the present study techniques like Kendall's rank correlation were used to study dynamics of cropping pattern.

1. Kendall's rank correlation technique

Overall agreement in cropping pattern

The rank assigned to the crops on the basis of percentage to the gross corpped area are presented in Table 1 alongwith the "Kendall's Co-efficient of Concordance."

Table 1. Ranks assigned to crops on the Basis of coverage in Vidarbha in different Periods.

S.N.	Crops	1980-81	1990-91	1997-98
1.	Rice	3	3	3
2.	Wheat	5	6	9
3.	*Kharif* Jowar	2	2	2
4.	Bajra	11	12	14
5.	Other Cereals	12	15	13
6.	Tur	7	5	6
7.	Gram	9	8	7
8.	Other Pulses	4	4	4
9.	Groundnut	8	10	11
10.	Safflower	10	11	10
11.	Sunflower	15	13	12
12.	Soybean	14	9	5
13.	Sugarcane	13	14	15
14.	Cotton	1	1	1
15.	*Rabi* Jowar	6	7	8

Coefficient of Concordance 'C' = 0.92***

*** Significant at 1 per cent level.

It could be seen from table-1 that the coefficient of concordance for assessing the overall agreement among cropping pattern was found to be 0.92 and significant at one per cent. This indicates that the area allocation in Vidarbha is almost fixed over the period of 19 years since 1980-81. Hence, it could be concluded that there was no change in the cropping pattern over a period of 19 years of study with minor changes for some crops.

Agreement of cropping patterns between the years

Rank correlations between cropping pattern at different points of time was worked out and presented in table-2.

Table-2 indicate that all the correlation coefficients were found to be significant at one per cent level in all districts of Vidarbha which indicate that there was no change in the cropping pattern. However, the cropping pattern of Akola and Buldhana district showed some changes in the cropping patterns of short term nature during 1998-99.

Economics of diversification

One of the objective of the present investigation is to study the economics of crop / enterprise diversification. Results in this behalf are presented in Table 3.

I. Crop activity

This activity includes crops like cotton, Kharif Jowar, Tur and Soybean. The per hectare Cost-'A' was Rs.3197.60, Rs.6636.20 and Rs.6892.67, respectively. At the present market price, the total value of produce was Rs.8874.08. The net income at Cost-'A' and Cost-'C' was Rs.5676.48 and Rs.1981.41, respectively. This indicates that the cultivation of crop activity is a profitable proposition. The profitability is further evident by the return per rupee which was 2.77 and 1.28 at Cost-'A' and Cost -'C' respectively.

II. Agri-Hort activities

This activity includes crops + Vegetables like Brinjal, Leafy vegetables, Cauliflower and Cabbage. The per hectare Cost-'A', Cost-'B', Cost-'C' required to produce was Rs.4664.53, Rs.11328.64 and Rs.11590.62, respectively. The total value of produce from this activity was Rs.18268.50. The net income at Cost-'A' was positive being Rs.13603.97 and at Cost-'C' Rs.6677.88. The return per rupee at Cost-'A' and Cost-'C' was 3.92 and 1.58, respectively.

III. Agri-Silvi activities

This activity includes crops + forest crops like Teak, Eucalyptus and Bamboo. The per hectare Cost-'A', Cost-'B' and Cost-'C' was Rs.3741.70, Rs.9548.14 and Rs.9747.66, respectively. The total value of produce from this activity was Rs.13971.

The net income at Cost-'A' and Cost-'C' was Rs.10229.3 and Rs.4223.34, respectively. This indicates that the cultivation of forest crops alongwith agricultural crops is a profitable proposition. The profitability is further evident by the return per rupee which was 3.73 and 1.43 at Cost-'A' and Cost-'C', respectively. (The itemwise per hectare cost of cultivation of different activities are given in Appendix-III.)

Comparative economics of diversification

The gross return ranged from Rs.8874.08 in crop activity to Rs.18268.50 in Agri-Horti activity. The Cost-'A' and Cost-'C' was highest in Agri-Hort system and lowest for crop activity.

The profit at Cost-'A' which is more relevant from the farmer's point of view was highest in Agri-Hort system (Rs.13603.97) followed by Agri-Silvi

Table-2 : Kendall's Rank co-rrelation co-efficients between cropping pattern in different districts of Vidarbha.

Years	Akola	Buldana	Amravati	Yavatmal	Wardha	Nagpur	Bhandara	Chandrapur	Gadchiroli	Vidarbha
1980-81	0.96	0.68	0.95	0.90	0.86	0.91	0.97	0.84	0.86	0.96
1985-86	0.96	0.95	0.91	0.78	0.88	0.93	0.97	0.92	0.90	0.93
1990-91	0.81	0.91	0.90	0.98	0.96	0.95	0.94	0.96	0.91	0.94
1998-99	0.68	0.71	0.91	0.91	0.88	0.95	0.82	0.86	0.88	0.91
Test of Con-cordance	0.89	0.89	0.91	0.94	0.74	0.79	0.89	0.84	0.85	0.92

All correlation coefficient were found to be statistically significant at 1 per cent level

Table 3. Economics of diversification.

(Costs ha.$^{-1}$)

Particulars	Activities		
	Crop	Agri. hort	Agri. silvi
I. Costs			
Cost- 'A'	3197.60	4664.53	3741.70
Cost- 'B'	6636.20	11328.64	9548.14
Cost- 'C'	6892.67	11590.62	9747.66
II. Total gross return	8874.08	18268.50	13971.0
III. Net return at			
Cost- 'A'	5676.48	13603.97	10229.3
Cost- 'B'	2237.88	6939.86	4422.86
Cost- 'C'	1981.41	6677.88	2223.34
IV. Return per rupee at			
Cost- 'A'	2.77	3.92	3.73
Cost- 'B'	1.33	1.61	1.46
Cost- 'C'	1.28	1.58	1.43

system (Rs.10229.97) and Rs.5676.48 from crop activity.

The per hectare profit at Cost-'C' was highest for Agri-Hort (Rs.6677.88) followed by Rs.4223.34 from Agri-Silvi system.

A comparative profitability of different cropping systems can be judged from return per rupee. The return rupee^{-1} at Cost-'A' was highest in Agri-Hort. System (3.92) followed by Agri-Silvi system (3.73). The lowest ratio was observed in crop activity. The same trend was observed at Cost-'C' also.

The foregoing discussion thus reveals that all the systems studied were profitable at direct and total cost. However, Agri-Horti. System was observed to be more profitables among the other existing system or activities.

Conclusion

It is concluded from the analysis that there was no change in the cropping pattern over a period of 19 years of study with minor changes for some crops. Kendall's Rank Co-rrelation Co-efficients all the correlation co-efficients were found to be significant at one per cent level in all districts of Vidarbha which indicate that there was no change in the cropping pattern. However, the cropping pattern of Akola and Buldhana district showed some changes in the cropping patterns of short term nature during 1998-99.The agri-horti system of crop diversification was found to be more remunerative among the existing systems under study.

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Knowledge and Adoption of Integrated Weed Management Practices by the Farmers

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ABSTRACT

Weeds have been a problem for man ever since he took domestication of plants. Weeds cause enormous losses and suffering to human beings by way of reduction in crop yield, quality and increase expenditure on weed control.

In India, 33 per cent of the agriculture production per year is reduced due to weeds. The reduction in yield of crops like sorghum, cotton and wheat is accounted for 6 to 40 per cent, 15 to 25 per cent and 26 to 28 per cent respectively (Bhan and Mishra, 1998). Though the weed control through herbicide is cheaper than manual weeding, the wide spread of herbicide use has resulted in various harmful impacts such as toxicity to animals and appearance of resistance in weed species. To overcome these problems Integrated Weed Management is used to control weeds.

Integrated Weed Management (IWM) refers to utilisation of weed science knowledge to manage weeds so that they neither cause economic loss nor adversely affect the environment (Hosamani, 1995). Integrated Weed Management include various methods of weed control such as preventive measures, cultural methods, biological control and chemical control. The efforts were made to know the perception of farmers about attributes of IWM practices, their knowledge and adoption of recommended practices of IWM.

MATERIAL AND METHODS

The present study was undertaken in Nandura Panchayat Samiti of Buldana district. A sample of 225 respondents who were mainly engaged in cotton based cropping system was selected from 15 villages by proportionate random sampling method. The data were collected by interviewing the respondents with the help of interview schedule.

For the measurement of knowledge and adoption, a list of IWM practices recommended for cotton was prepared and responses of the respondents were collected on it. Knowledge was ascertained on the basis of correctness or incorrectness of replies whereas adoption was measured on three-point continuum i.e. complete, partial and non adoption.

RESULTS AND DISCUSSION

Perception of Attributes of Integrated Weed Management

Table 1. Distribution of respondents according to perception about attributes of IWM.

Perception about IWM	Respondents	
	Frequency	Percentage
Profitability		
Low	4	1.78
Medium	97	43.11
High	124	55.11
Congruity		
Low	0	0
Medium	194	86.22
High	31	13.78
Complexity		
Low	8	3.56
Medium	142	85.33
High	25	11.11

More than half of the respondents (55.11%) perceived that IWM as highly profitable, followed by 43.11 per cent in medium level of perception about profitability. Only 1.78 per cent of the respondents had low level of perception about profitability of IWM (Table 1).

Regarding perception of congruity, most of the respondents (86.22%) perceived the congruity at medium level and relatively less percentage of the respondents (13.78%) perceived high congruity in IWM. Majority of respondents (85.33%) perceived medium level of complexity in IWM practices. Relatively less proportion of the respondents i.e. 11.11 per cent and 3.56 per cent perceived high and low complexity in IWM practices, respectively.

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Table 3. Distribution of the respondents according to praticewise knowledge and adoption

S.N.	IWM practices	Knowledge		Adoption					
				Complete		Partial		No.	
		Number	Per cent	Number	Per cent	Number	Per cent	Number	Per cent
1.	Crop rotation	221	98.22	192	85.32	0	0	33	14.68
2.	Intercropping	221	98.22	177	78.64	0	0	48	11.36
3.	Use of recommended weedicide	68	30.22	24	10.66	0	0	201	89.33
4.	Recommended dose of weedicide	27	12.00	8	3.55	16	7.11	201	89.33
5.	Time of weedicine application	33	14.67	24	10.66	0	0	201	89.33
6.	Method of weedicide application	34	15.11	18	7.99	6	2.66	201	89.33
7.	Number of harrowing	218	96.87	179	79.55	44	1.55	2	0.88
8.	Time of harrowing	204	90.66	174	77.33	49	21.17	2	0.88
9.	Number of weeding	209	92.88	145	64.44	78	34.66	2	0.88
10.	Time of weeding	192	85.33	120	53.33	103	45.77	2	0.88

Knowledge and adoption of IWM practices

Table 2. Knowledge and adoption level of respondents about IWM practices

S.N.	Knowledge level	Respondents	
		Number	Per cent
1.	Low	28	12.45
2.	Medium	149	66.22
3.	High	48	21.33
	Total	225	100.00
	Mean = 23.75	S.D. = 2.42	

S.N.	Adoption levels	Respondents	
		Number	Per cent
1.	Low	13	3.78
2.	Medium	193	85.78
3.	High	19	8.44
	Total	225	100.00

As regards knowledge about IWM it is revealed that most of the respondents had moderate knowledge level whereas comparatively less 21.33 per cent and 12.45 per cent respondents had high and low level of knowledge about IWM practices (Table 2). It was also found that mean knowledge value was 23.75 which was quite low against the maximum score of 100. Similar findings were reported by Katole *et. al.*, (1996) and Nimje *et. al.*, (1990).

As regards adoption level it is seen that most of the respondents (85.78%) had moderate level of adoption about IWM practices. A negligible percentage of the respondents i.e. 8.44 per cent and 3.78 per cent had high and low adoption level, respectively. These findings are in concurrence with the findings of Kude *et. al.*, (1996).

Practice wise knowledge and adoption

Practice wise analysis revealed that more than 85.00 per cent of the respondent had complete knowledge about cultural practices such as crop rotation, intercropping, number of harrowing, time of harrowing, number of weeding and time of weeding. Relatively less proportion of the respondents (30.22%) knew the name of recommended weedicide and more than 80.00 per cent of respondent did not possess any knowledge about recommended dose of weedicide, time of weedicide application and method of weedicine application.

Regarding adoption of IWM practices recommended for cotton, most of the respondents adopted cultural practices completely such as crop rotation (85.32%), intercropping (78.64%), number of harrowing (79.55%), time of harrowing (77.33%), number of weeding (64.44%) and time of weeding (53.33%). In case of chemical weed control, 10.66 per cent of the respondents adopted recommended weedicide and time of weedicide application, followed by the respondents (7.99%) who adopted the method of weedicide application as per recommendation. Whereas 7.11 per cent of the respondents adopted the dose of weedicide partially.

It is further observed that more than 85.00 per cent of the respondents did not adopt chemical weed control for cotton. The plausible reasons behind non-adoption of chemical weed control was mainly the lack of knowledge, high cost of weedicide and non-availability of required weedicides in market.

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Socio Economic Status and Resource Mapping of Village Deulgaon Banda

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ABSTRACT

Detail study of the village is necessary for proposing any development plan for it. Participatory Rural Appraisal in addition to the classical methods of social research provides an opportunity to study village resources and their developmental disabilities. In view of the socio economic backwardness of village Deulgaon Banda Dist. Washim over last several decades, prompted to appraise its resources and prepare plan for development. Whole population of this village has been studied and problem identified. It was observed that priority problem was soil and water conservation. The overall socio economic status and resource base was found to be low in Deulgaon Banda.

India is a constitution of thousands of villages. However the exorbitant and irrational use of the available resources resulted in tremendous loss and caused the irreparable damages to the socio economic fabric of the rural system of the country.

The people's participation in village development has gone down. Deulgaon Banda is one of the such villages which remained backward for similar reasons. Once upon a time it was progressive and self sustained economy based village, but extant resources are found to be totally depleted and hence it was felt necessary to conduct socio economic survey map of the resources of the village to develop action plan to deal some priority of problems. Involvement of farmers, farm women and other people was saught through Participatory Rural Appraisal (PRA), (Angadi and Ram 1999).

PRA is an improved technique over the traditional social science research as it ensures effective people's participation in resource mapping (Samanta, 1992)

Objectives

1. To undertake the socio economic survey of Deulgaon Banda village
2. To undertake resource mapping of Deulgaon Banda village
3. To prepare action plan for solving the selected priority problems

Methodology

The present study was conducted in Deulgaon Banda village Dist. Washim of Maharashtra state.

The data were collected using PRA methods and personal interview of households on various aspects related to the objectives of the study. In all, 235 families which included 1367 person were studied. Social, technological and demographic resources were studied. Problems were identified and developmental plan had been prepared for one priority problem i.e. soil and water conservation.

Findings

Relatively larger portion of the respondents (35.91%) were upto 34 years of age. According to the standard of education 22.27 per cent and 21.24 per cent were educated up to middle and secondary school level. Overall literacy percentage was found to be 76.4 percent. Majority of the households were small and marginal farmers. Majority of the households had low level of information. It was observed that majority of the households had no social participation.

Nearly one fourth of households had annual income up to Rs. 25000/-. Although majority of the population belonged to dominant caste category, 38.73 per cent households depended exclusively on agriculture + labour. It is seen that more than half of the households did not possess any source of irrigation.

In the study of knowledge and adoption of improved farm technologies it was observed that moderate knowledge and 46.67 per cent had high adoption level about various crop cultivation practices. Overall socio economic status was found to be low in study village.

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Social status of village Deulgaon-Banda

The social map of the village Deulgaon Banda has been propared with the help of farmers with PRA techniques (Fig.1).

Deulgaon Banda is situated 15 km towards South – North in Risod taluka of Washim district. The study village comprised of 265 families. Total population of the village was 1367 wit 679 males and 688 females. The village has mixed type of population with 141 households of Maratha caste, followed by 50 households of Koli(Fisherman), Dhangar (23), Gosawi (12) and 9 households of Buddha (SC) community. The location of the houses of different castes is clearly distinguished in the social map of the village.

At the entry of the village Dalits houses were found to be situated and in the middle Maratha houses surrounded by Dhangar, Koli and Gosawi community houses. There were three Hindu temples. The village was fully electrified. There were four community handpumps in the village out of which three pumps were in working condition. Besides this, there were three community wells used for water supply. There was one co-operative society, youth club, bhajan and mahila mandal. National, social, religious and cultural festivals were found to be common feature wherein all the households participated.

The primary school is situated near group gram panchayat of study village. The medium to rich farmers maintained bullocks and cows. Whereas landless labourers were found keeping goats for income generation.

Water resource status of Deulgaon Banda village

Water resource map of Deulgaon Banda village has been shown in Fig.2. In the study village it is observed that in all, 24 wells of different sizes exist out of which 14 wells were found to be equipped with electric pumps providing protective irrigation to the field crops. obviously the water level was found to be very low.

The water level in the well depended mostly on amount of precipitation received and its distribution. As most of the wells were having low water level, the seasonal irrigation was found to be meagre. Handpumps and community well were found to be for drinking water.

Painganga river flows by the side of the study village Deulgaon Banda. Fifteen electric pumps were found to be installed on this river for lift irrigation and for protective irrigation of field crop was possible for 54 households and that 48 households possessed well for providing irrigation to their field crops.

Technology status of Deulgaon Banda village

In Deulgaon Banda some of the farmers were found to use mechanization for field operations. The technologies used have been mapped along with their relevance to the study area. It was observed that there were 3 tractors, 87 seed drills, 67 harrows, 57 plough, 6 threshers in the village.

Only two households adopted sprinkler irrigation system for the field crops. The adoption of improved crop varieties like soybean (JS-335), pigeonpea (BDN-1) and green gram (Kopergaon-1) had been observed on relatively large area.

In addition, wheat MACS 2496 and Phule G-5 gram varities were adopted by the respondents on large scale.

Action plan for solving the selected priority problems

The main purpose of the research was to discover facts that bear upon problem and to find answers to one or more aspects of the problem in the light of the facts discovered. Research falls on a continuum of human thinking involving the process of problem solving.

On similar lines efforts were made in the present study to identify the problems of village Deulgaon Banda, to prioritize them, find solution and to propose plan of action for soil and water conservation problem.

The action plan was prepared for 2003 – 2004 so as to overcome the major problems of the village and to satisfy the most urgent need of the villages. The action plan is collaborative and involves co-operative efforts, with participation of the villagers.

Problem I

Action plan to overcome problem of soil erosion and water runoff.

It is observed from the survey that serious problems of soil erosion and water runoff exists in village of Deulgaon Banda. The causal factors for the same were found to be as follows.

Causal factors

1. Low adoption of soil and water conservation practices. Even low and no cost practices were

Action Plan

Plan of action for the soil and water conservation (2003-2004)

S.N.	Activity to be undertaken	Starting time	Finish time	Agencies to be involved	Farmers role/ involvement	Predicted changes	Number of farmers to be benefited	Area covered	Technical guidance	Material required
1.	Nala bunding	March 2004	April 2004	Gram panchayat village youth and farmers	Own labour providing empty cement bags and bulldozers	Harvesting of water	25	50 ha	Civil engg. irrigation deptt.	Empty cement bags, bulldozers
2.	Deepening of well	March 2004	April 2004	Gram pahchayat village youth & farmers	Own involvement labour involvement	Depth of well increase, water storing capacity increase	30	60 ha	village develop-ment officer, Gramsevek	Buckets, ropes, spade
3.	Form pond	March 2004	April 2004	Individual farmer youth, NOGS labours soil conservation department	Own labour for digging pond	Availability of wate at time of critical stage when to irrigation is needed to crop	205	645 ha	Agril. devp. officer, Gramsevek	Pickaxe, spade, roller
4.	Sowing across the slope	June 2004	July 2004	Farmers, Ext. agencies	Own labour for sowing operation	Absorbing excess water by root zone harvesting of water	87	160 ha	Gram panchayat farmers	Bullock pairs, seedrill, seed
5.	Deepening of river beds	March 2004	April. 2004	Distict collector soil conservation department youth Gram panchayat farmers	Own involvement, labour involvement	Harvesting of water	235	645 ha	Technical advisor of irrigation department	Bulldozers provide dbh govt.
6.	Khas bunding	July, 2004	Sept. 2004	Farmers SAU panchayat samati	Own labour and hired labour	Harvesting of water	15	45 ha	Soil water conservation deptt.	Khas from P.S. or SAU
7.	Vegetative barriers	July 2004	Aug. 2004	Farmers seed supplier ext. agency	Own labour for planting	Reduce the velocity of wind that reduces loss of water & soil erosion	25	59 ha	Agriculture develop. officer village develop officer	Seedling of bamoboo, subabhul
8.	Crop rotation	July 2004		Farmers, ext. agency	Own involvement	Reducing run off minimising soil losses	205	645 ha	Gram panchayat farmers	

9.	Intercropping	July 2004		Farmers labour ext. agencies in PS	Own labour for sowing	Legumes crops like gr. Nut, soybean were erosion resistant crops that not allow runoff water to carry much soil with eit.	205	645 ha	Dr.PDKV, Akola	Seeds of leguminous crops
10.	Mulching	Aug. 2004		Farmers labour ext. agencies	Own involvement of labour	Reducing water run off, increase water in take by pudding and surface sealing	105	210 ha	Dr. PDKV, Akola	Stabble, straw or plas papers
11.	Contour bunding	March, 2004	April. 2004	Gram panchayat farmer, youth labour, Ext. agencies	Labour involvement for preparing	Harvesting of water by chicking the run off water at any particular level	35	70 ha	Soil and water conservation deptt.	Spades

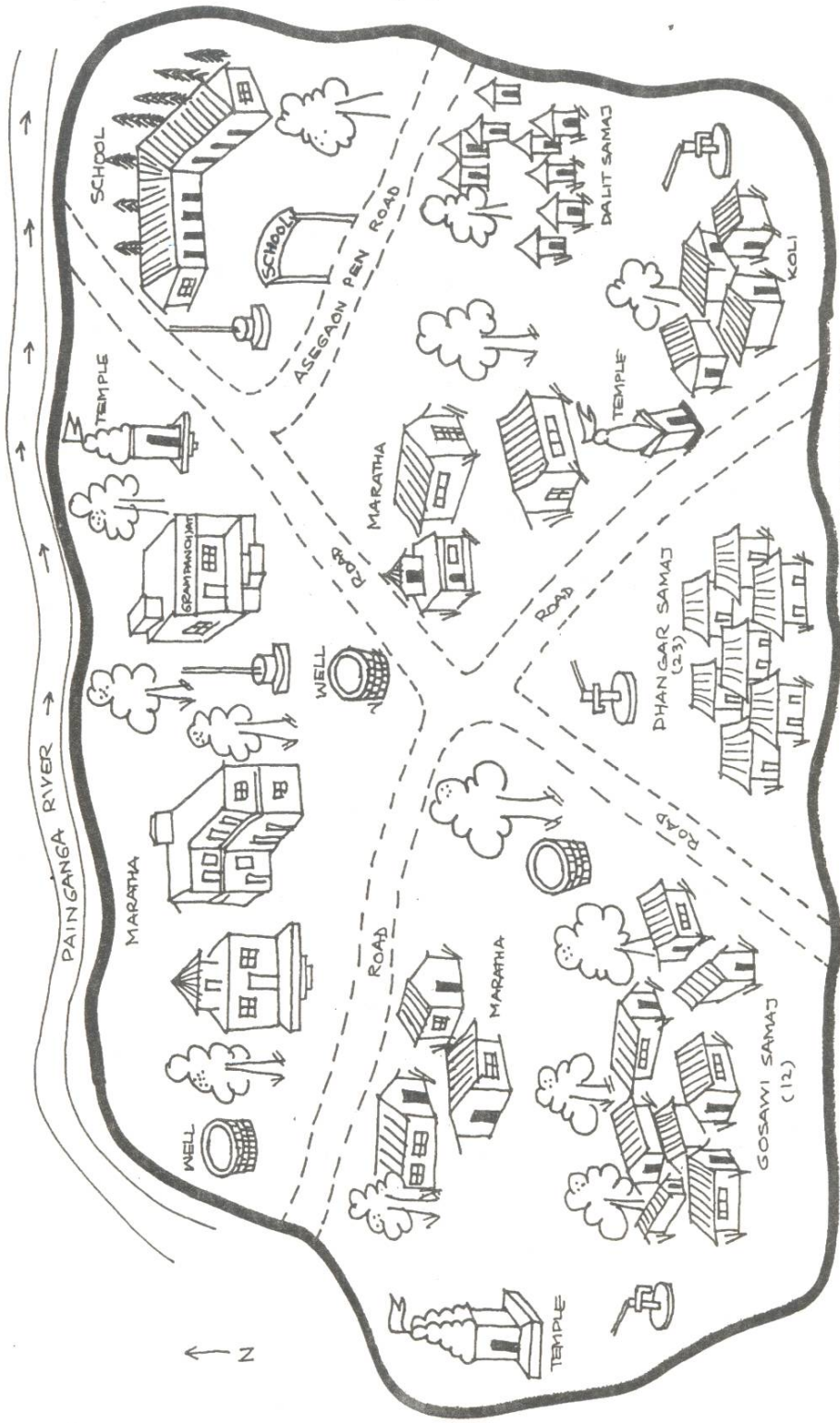

Fig. 1. SOCIAL MAP OF VILLAGE DEULGAON BANDA

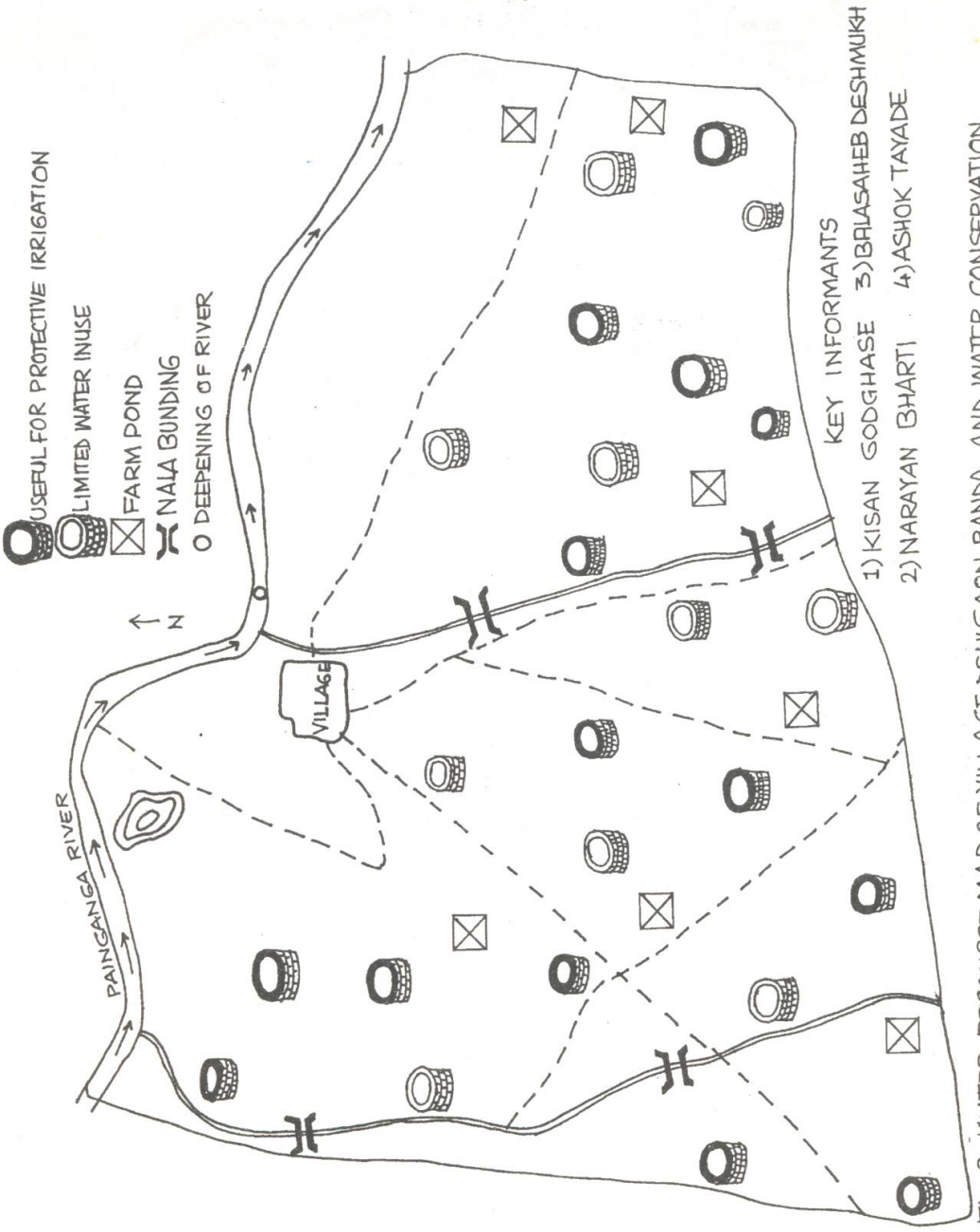

Fig. 2. WATER RESOURCE MAP OF VILLAGE DEULGAON BANDA AND WATER CONSERVATION INTERVENTIONS SUGGESTED

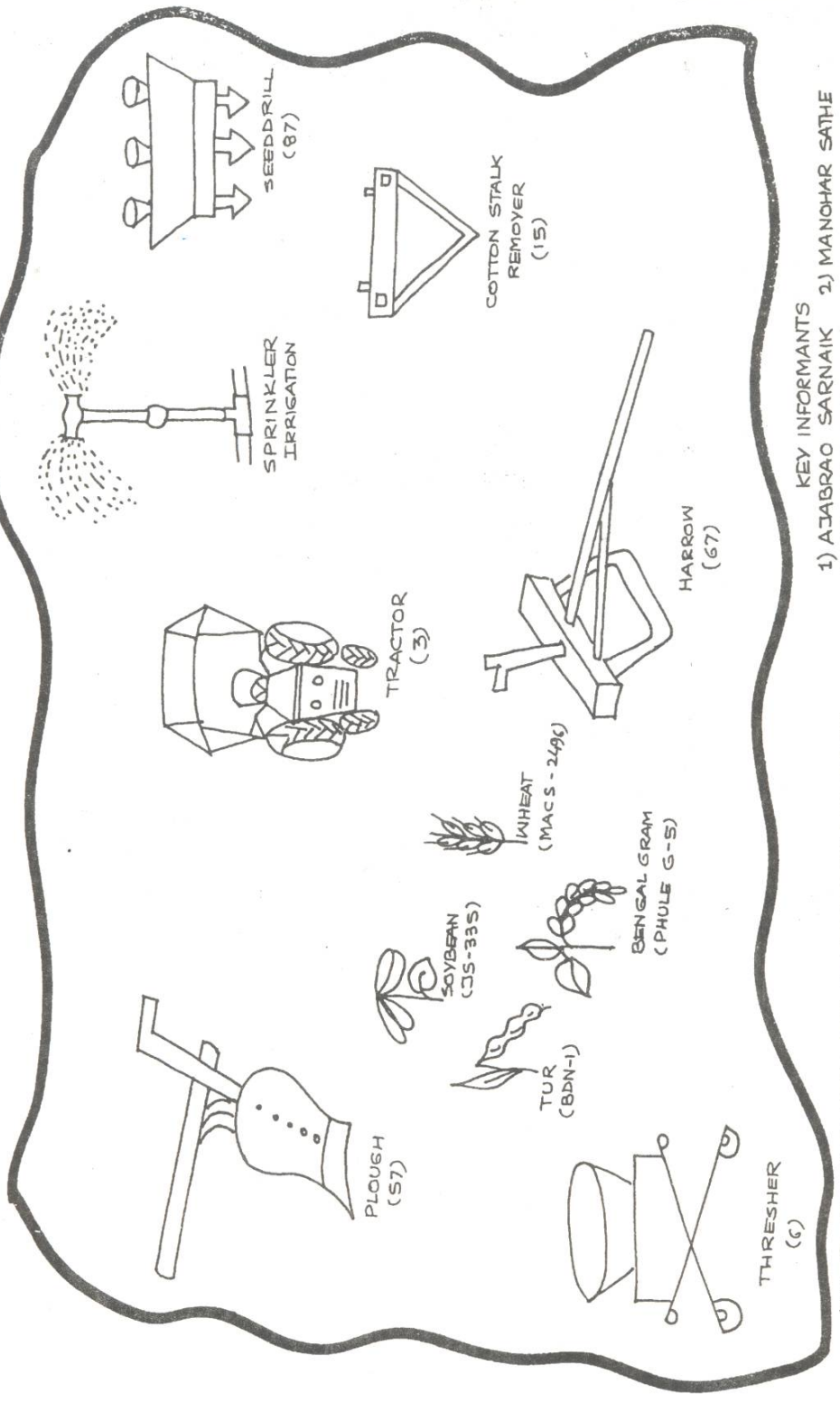

FIG. 3. TECHNOLOGY MAP OF DEULGAON VILLAGE

not adopted by majority of farmers in village area.

2. There was lack of government programmes related to nala bunding, farm ponds, recharging of wells. No soil and water conservation programmers of Government had been executed in the village. Farmers also not adopted soil and water conservation practices on their own.
3. Low water table in wells. Ten wells were completely dry and 14 wells dried after Oct. to Nov. every year. However, deepening of wells had not been done although it was very necessary.
4. Improper management and insufficient utilization of water resources available to the villagers.
5. In village contour sowing and contour bunding had not been adopted for a long time.

Objectives:

1. To promote use of low and no cost SWC practices
2. To promote recharging of wells
3. To promote storage of water in river, nalas and wells
4. To reduce soil erosion and conserve water

Solutions:

1. Sowing across the slope practices helpful in checking soil and water runoff. Therefore, it is needed to be popularized among farmers for intensive adoption.
2. Soil erosion and water runoff is harmful from agricultural point of view. For decreasing the soil erosion and water runoff contour bunding is necessary in the study village.
3. Stilting affect the water storage capacity of wells and river. For increasing the storage capacity of wells a drive for deepening of wells and river is necessary.
4. Construction of nala bunding water storage tank.
5. Plantation of forest species on a waste land is necessary.

CONCLUSION

It is concluded from the findings that more than 50 percent of households did not have social participation. For most of the households used little sources of information. It implies that the farmers should be motivated to form self groups so that they can organize social activities as well as they can manage costly sources of information. Majorities of the households were found not possessing any source of irrigation. Village faces the problem of water for nearly six months in a year. So, there is a need to impart the knowledge about soil and water conservation practices as well as to explain them the necessity of rain harvesting. The training in this regard should be carried out and it is necessary to increase adoption of soil and water conservation practices. In the village, PHC, community hall, Veterinary dispensary were not available. The provision of PHC, community hall and Veterinary dispensary need to be made available.

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Computer Graphics of Rotary Tiller Blade Surface

Varinder Singh[1] and D.S. Wadhwa[2]

ABSTRACT

Mathematical expressions of three dimensional computer graphics have been applied to describe a rotary tiller blade surface. The graphics descriptions of tool geometry determine how the design and operating parameters influence the energy requirement and quality of operation. This description has the potential of achieving a quantitative analysis of the tillage process. The C-type blade was selected for blade surface generation. Bezier surface generation approach was adopted and multiple Bezier surface patches were joined to develop complete blade surface. The dimensional error between actual and generated blade surface was below 1.2, 5 and 8 per cent for x, y and z coordinates, respectively. An interactive computer program was developed to visualize the three dimensional shape of rotary blade. The program allows the user to change the control surface of the rotary tiller blade. The three dimensional geometric modelling system for tillage blades may be adapted for computer aided design.

Agricultural implement design is hindered by lack of adequate analytical methods, thus many implements are designed empirically. True engineering design cannot be achieved until analytical relationships, based on scientific principles, are available. The goal of tool design is to optimize the function, efficiency and economy of the tillage process. In the past, much attention has been directed to tillage tool shape as related to energy requirements and final soil conditions These investigations were concerned not only with macroshape but also with the boundary or cutting edge of the tool. Since the area of the cutting edges of a tool is much smaller than the area of the surface, emphasis was also placed on the surface over which the soil moves (Ros *et. al.* 1995).

Graphical representation is an effective communication device between design engineer and computer. Computer graphics techniques have been applied to some soil working tools such as mould board plough (Richey *et. al.* 1989) and rotary tiller blades (Kinzel *et. al.* 1981, Singh, 1999). Thomas Jefferson (1799) developed a method to accurately describe the surface of a mouldboard plough. It was a physical method that can be used in constructing a plough. He used two straight lines as fixed directives while a third line moved and rotated in a fixed plane. Jefferson's method was practical, however, it was purely based on intuition. White (1918) analysed a number of ploughs using Jefferson's method. He established equations to derive the surface in the Cartesian coordinate system. He demonstrated that an existing plough shape could be mathematically represented.

Graphical description of plough shapes have been developed by various researchers including White (1918) and Ash by (1931) as described by Gill and Vandenberg (1967). They used graphical methods to define shape and to establish design equations. One graphical method to establish the shape of an existing plough was to use a pair of parallel vertical surface with coinciding grid holes. The surfaces established the y-z plane while the horizontal plane was the x-y plane. The plough whose shape was to be determined was placed in front of the vertical gridded surfaces. A measuring rod was inserted through the grid holes until it touched the plough surface. This established the x measurement while the location of grid hole determined the y and the z dimensions. Using this data, a two dimensional representative of the surface was plotted in the x-y plane by plotting the constant z value grid lines. Soehne (1959) used an optical means to expedite this method. He projected a light through a slit, either horizontal or vertical, on to the painted plough surface. A camera was used to record the reflected light. A series of photographs was taken by moving the plough to different positions.

Ros, *et. al.* (1995) identified and defined

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the geometrical parameters of tillage tools, from a simple blade to mouldboard surfaces, and developed a mathematical representation for a tool surface. He also developed a general approach to tillage tools system design in relation to energy and soil properties. Cracium and Leon (1998) presented a complete methodology for analytically solving the entire problem related to mouldboards with cylindroidal geometry. He gave mathematical equation of the mouldboard and the working surface of the plough bottom in Cartesian coordinate system.

The premises of this paper centers around generation of three dimensional rear surface of C-shape blade using multiple patch technique, such that the error between the computer generated surface and the real surface is minimised.

Computer graphics

There are many ways to define a bicubic parametric surface. The Bezier-Bernestein form is of special interest. Bezier surface can also be generated in patches (Asthana and Sinha, 1996). A Bezier surface patch and its control points are created using isoparametric lines. Continuity between two patches can be achieved by taking the corner points common between two consecutive patches. In this way, the error in modelling of Bezier surface can be minimized to a large extent. The following is the brief discussion of the Bezier Curve and subsequently developing Bezier surface. The reader is referred to Hill (1990), Plastock and Kalley (1986) and Asthana and Sinha (1996) for a complete discussion.

The Bezier curve

The Bezier curve, p(t), based on the (L + 1) control points, Fig 1 (a), $p_0, p_1, p_2 \ldots\ldots, p_L$ is given by

$$p(t) = \sum_{i=0}^{L} p_i B_i^L (t) \qquad \ldots\ldots 1$$

Where the function $B_i^L(t)$ are known as Bernstein polynomials. The i^{th} Bernstein polynomial is defined as :

$$B_i^L(t) = {}^LC_i\ (1-t)^{L-I}\ t^i \qquad \ldots\ldots 2$$

Where ${}^LC_i$ is the bionomial coefficient function, the number of ways of choosing 'i' items from a collection of 'L' items. It is given by

$${}^LC_i = \frac{L!}{i!\ (L-I)!} \quad \text{for } L>1 \qquad \ldots\ldots 3$$

and 0 otherwise.

One can write a single equation for each variable x, y and z to represent 3D curve as follows :

$$x(t) = \sum_{i=0}^{L} x_i B_i^L (t) \qquad \ldots\ldots 4$$

$$y(t) = \sum_{i=0}^{L} y_i B_i^L (t) \qquad \ldots\ldots 5$$

$$z(t) = \sum_{i=0}^{L} Z_i B_i^L (t) \qquad \ldots\ldots 6$$

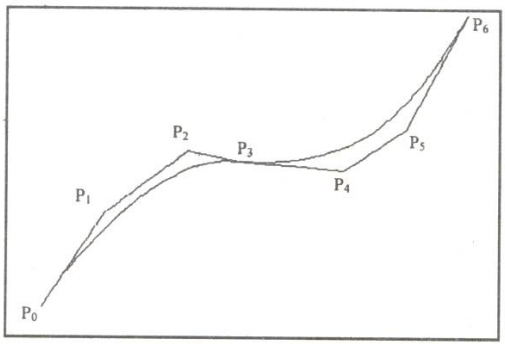

Fig. 1. A Bezier curve based on seven (6+1) control point

The behaviour of the Bezier curve is governed by the interpolating functions $B_i^L(t)$, (Plastock and Kalley, 1986). Bezier curves are quite suitable for interactive graphics and are used in the automobile and aviation for modelling of surfaces.

The Bezier surface

The methods stated above can be generalized to describe curved surfaces. To describe a surface a grid of control points (xij, yij, zij) is needed. Stepping through 'i' moves one direction of the grid while changing 'j' moves in the other direction. Such a grid can be used to define patches which will fit together to form a smooth surface.

The formulation of the Bezier curve extends easily to describe three-dimensional

surfaces by generating the Casteljau product of two curves. Two similar blending functions are used, one for each parameter.

$$p(s,t) \quad \sum_{i=0}^{L} \sum_{j=0}^{M} p_{ij} B_i^L(s) B_j^M(t) \quad .....7$$

Bezier surface with (L + 1) x (M + 1) control points can be shown as Fig. 1(b), arranged in a mesh. Adjacent control points are connected with lines in order to show the mesh. The surface itself is shown by drawing two sets of curves. One set holds the 's' parameter constant and allows 't' to range from 0 to 1, the other set holds 't' and varies 's'. These curves of constant 's' and 't' are in fact Bezier curves. The coordinates values for points on the surface of a patch are given by :

$$x(s,t) \quad \sum_{i=0}^{L} \sum_{j=0}^{M} x_{ij} B_i^L(s) B_j^M(t) \quad .....8$$

$$y(s,t) \quad \sum p_{ij} \quad \sum_{i=0}^{L} \sum_{j=0}^{M} y_{ij} B_i^L(s) B_j^M(t) \quad .....9$$

$$z(s,t) \quad \sum_{i=0}^{L} \sum_{j=0}^{M} z_{ij} B_i^L(s) B_j^M(t) \quad ....10$$

There are two parameters which specify the position on the surface patch, s and t. Just as for curves each varies from 0 to 1.

Generating blade surface

Earlier sixteen control points were measured (Singh, 1999) on a pre-selected portion of the blade surface, Fig. 2, such that there were four points on each x-y plane. In this method referred to as GS method (Singh, 1999) four x-y planes separated by known Z-distance (alone z-axes) were selected. The cutting edge was developed from the (V_i, 4) points lying on the vertical plane V_i. Point '4' lies on the cutting edge while point '1' was the extreme trailing point. Points '2' and '3' were in between '1' and '4' but on Vi plane. In GS method it is apparent that to cover a surface as large as a rotavator blade and especially the one whose surface in three-dimensional space keeps on articulating, would yield Bezier developed surface with very large percentage of error.

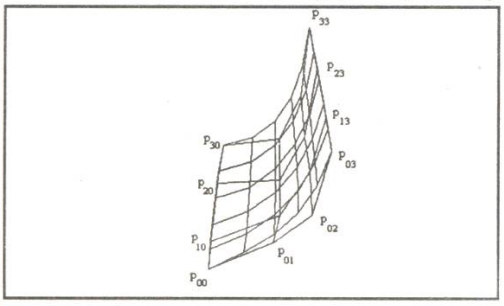

Fig. 1(b). A Bezier surface patch based on 4 x 4 (3 + 1) x (3 +1) control point

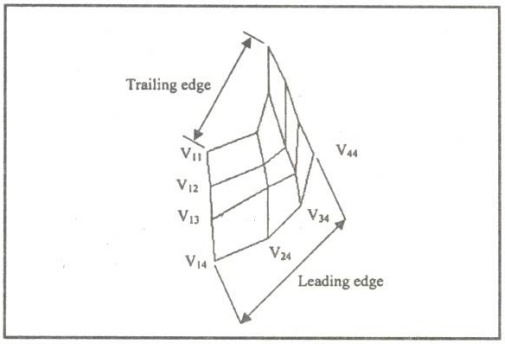

Fig. 2. Control points of developed blade surface at 0 degree orientation in single patch (GS method)

In order to develop Bezier surface of complete blade such that it comes very close to the real blade surface, one has to cover the entire blade surface in patches-each patch having sixteen control points. The method to measure control points in each patch need not have the constraint of four x-y planes of GS method. However, in this method four control points were taken on the leading edge and four on the trailing edge and the rest were selected in between the leading and trailing edge in each patch. Two flat boards 28x23x1 cm and 23x17x1 cm thick had mesh of holes of 2-mm diameter. The mesh size was 5x5 mm. They were fitted perpendicular of each other and were aligned with each other's meshing, Fig 3. One of the flat-board 23x23x1 cm referred to a base plate had mesh in x and y-axis and the other flat-board 23x17x1 cm referred to as vertical plate had mesh in y and z-axis. A hole of 12.7mm (1/2") was drilled for mounting the blade on the base plate. The center of the hole but lying on the rear surface of the blade was considered the origin of blade

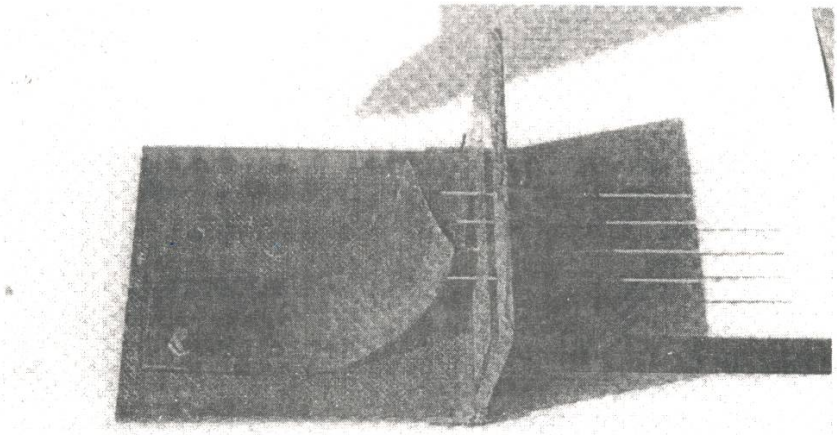

Fig. 3. Schemetic setup for measurement of blade coordinates

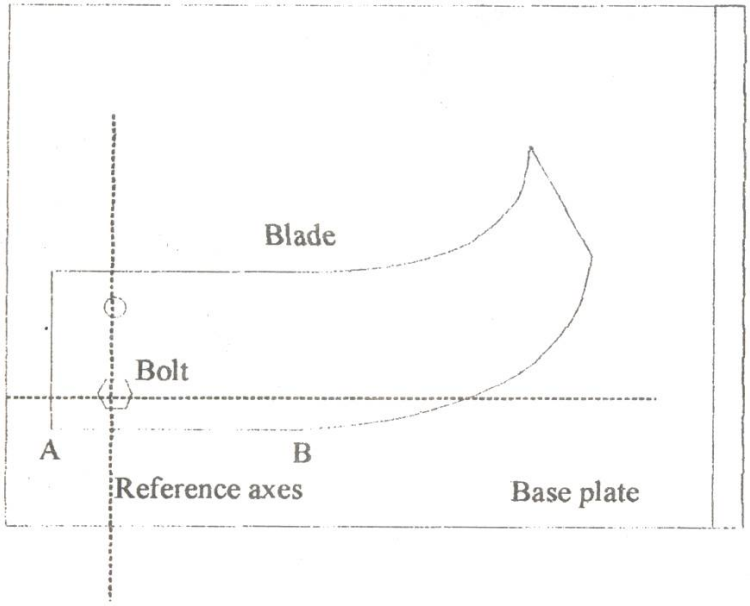

Fig. 4. Fixing of blade on the base plate of the setup

coordinate system. The blade was bolted (in lower hole of blade) on the base plate, Fig 4. The orientation of the blade was taken as angle, which the line passing through origin and parallel to the lower edge, AB in Fig 4 in the flat length of blade made with x-axis of base plate, Fig 5. Four identical needles, Fig 3, of 2 mm in diameter and 20 cm in height were taken. The control points all over the blade surface were selected and needles were inserted in the holes at desired location. The position of hole, in the base plate gave x and y coordinates and length of needle protruding out of the base plate was subtracted from 20 cm to get z coordinate, similarly in the vertical plate, the hole, wherein the needle was inserted gave y and z coordinate and the length

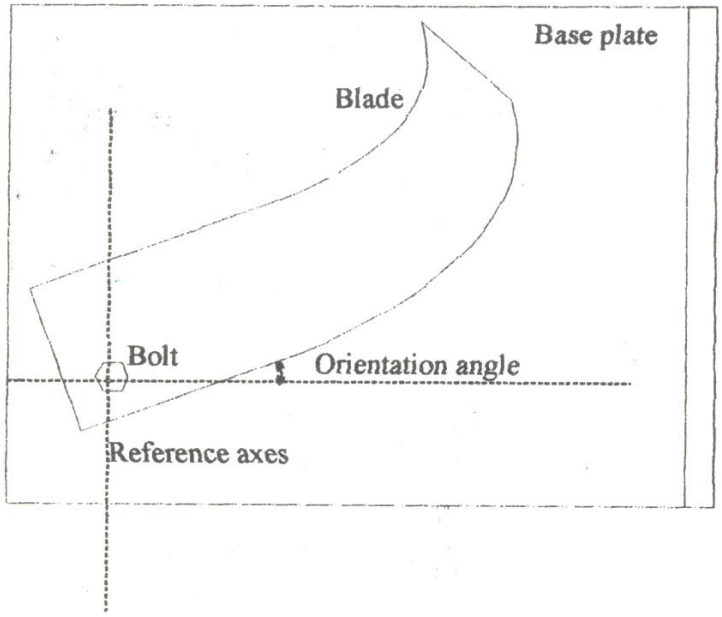

Fig. 5. Measurement of orientation angle of blade

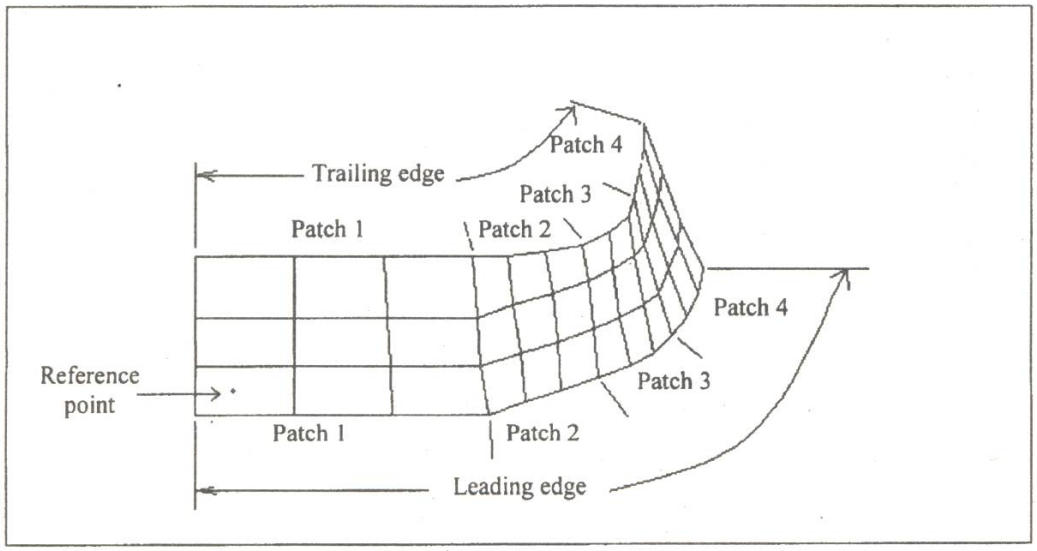

Fig. 6. The complete blade surface generated by joining four patches of control points

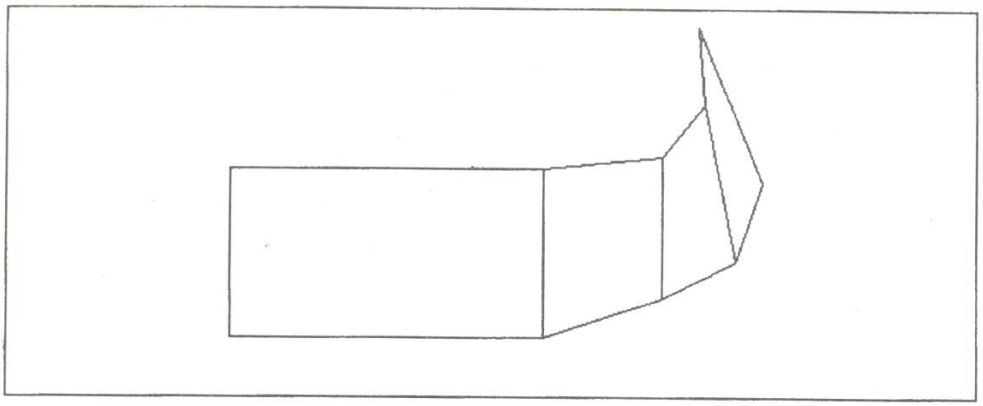

Fig. 7 (a) . Developed Bezier surface with minimum number of Bezier points i.e. 10

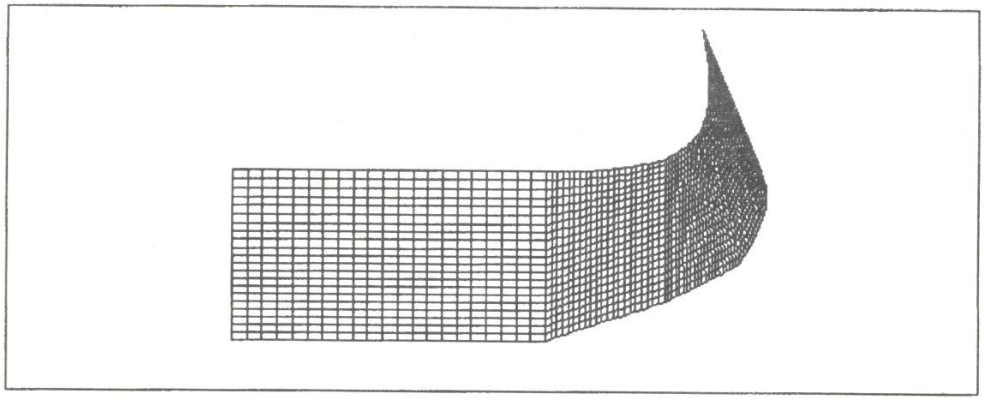

Fig. 7 (b) . Developed Bezier surface with minimum number of Bezier points i.e. 1870

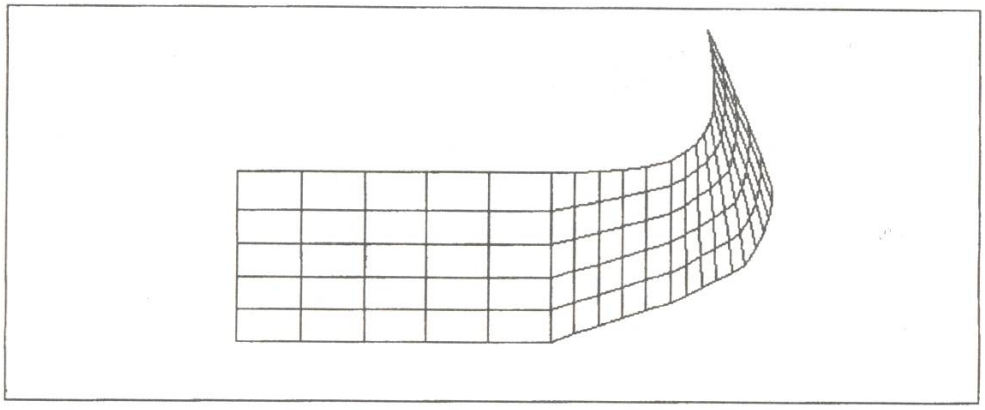

Fig. 7 (c) . Developed Bezier surface with 126 Bezier points

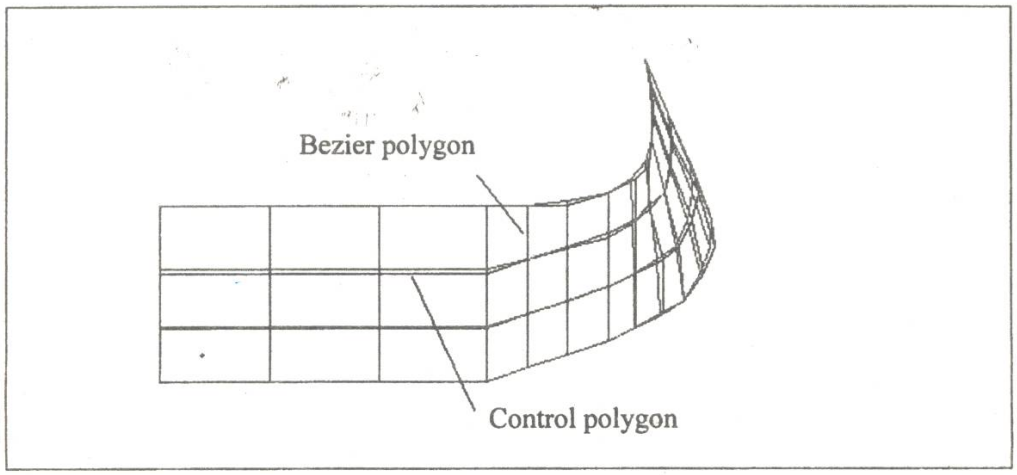

Fig. 8 (a) . Equal mesh size for control and Bezier polygon

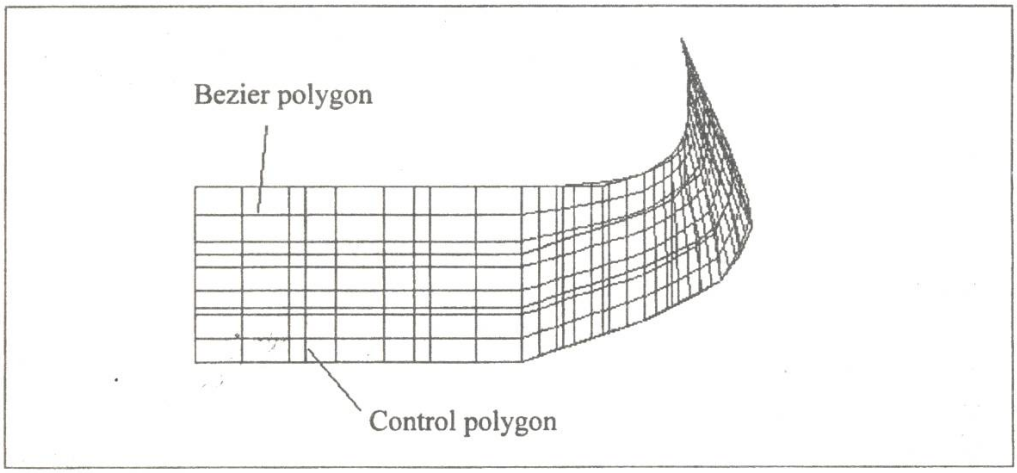

Fig. 8 (b) . Different mesh size for control and Bezier polygon

of needle protruding out of the vertical plate was subtracted from 20 cm to get x coordinate. The vertical plate was needed to measure the desired control points on that portion of the rear surface of the blade which was nearly vertical and/or control points the were difficult to measure from base plate.

This method referred to as VS method (Singh, 2001) had the advantage that the entire blade surface was covered in four patches, Fig. 6, besides it consumed less time in measurement of control points. The control points were specified as CPa [i][j], where CP along the row is labeled as x, y and z. The 'a' denotes the patch number and it varies from 1 to 4, i and j denote the position of control point in individual patch and their values vary from 0 to 3. The lower left corner in each patch is specified by CPa [0][0], the other corner points are specified as CPa [0][3], CPa[3][0] and CP[3][3]. The point on leading (cutting) edge and trailing edge are CPa [i][0] and CPa [i][3] respectively. The points specified by CPa [0][j] and CPa[3][j] are common to the joined patches where patches were formed. End to end points, where patches were joined, were common to both the patches.

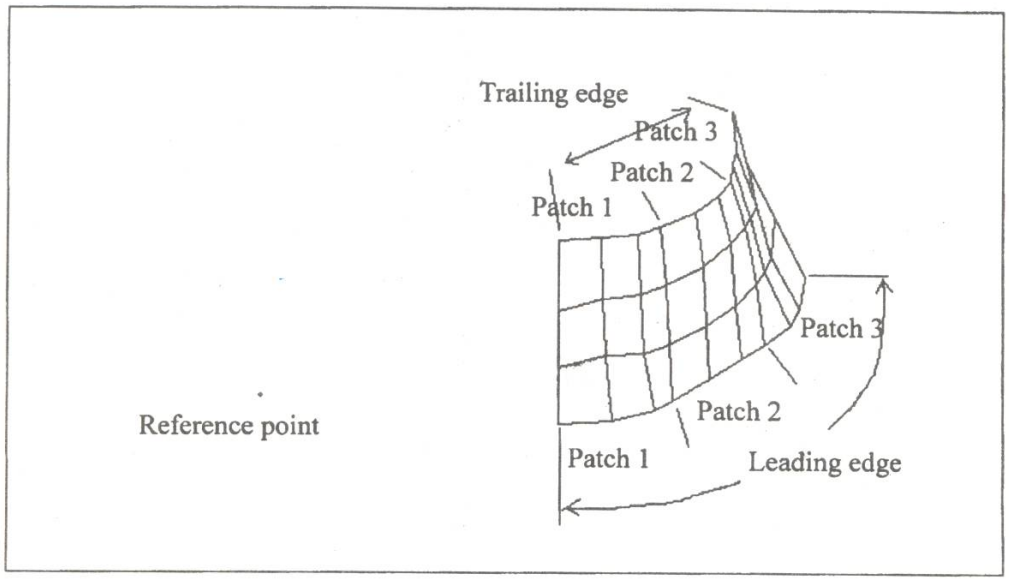

Fig. 9 (a) Working surface of the C-type blade developed using GS method

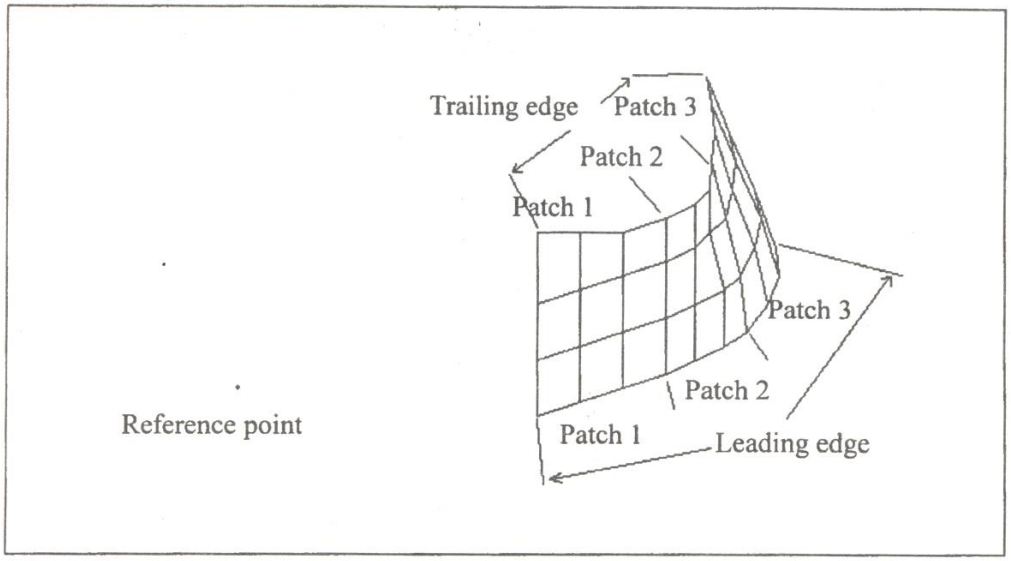

Fig. 9 (b) Working surface of the C-type blade developed using VS method

Thus there were fifty-two control points for each blade. The three dimensional blade surface developed can have mesh size ranging from 2 x 2 to 22 x 22 points in single patch, with nodes representing approximated points generated by Bezier surface. Thus one can have from a single patch of 16 control points 4 to 484 points and 8 to 1870 points (complete surface) from 52 control points constituting four patches. Fig. 7(a) and 7(b) show the developed blade surface with minimum and maximum possible mesh size while Fig. 7(c) shows mesh size of 6 x 6 selected for final development of blade surface.

Error in generated surface

The error in developing the blade surface occurs because the approximately Bezier points do not match with control points on actual blade surface except at four corner points in a patch. The surfaces generated using the Bezier method do not oscillate away from the control points as it always remains within the convex hull of the control points.

The error in developed blade surface was found at each node of control polygon with corresponding node in approximated Bezier surface. While computing error the number of nodes in approximated Bezier surface were maintained same as that in control polygon i.e. 4 x 4 mesh size. The reason for having equal mesh size was to have one to one correspondence between control polygon and Bezier polygon, Fig. 8(a), otherwise it is difficult to make a comparison, Fig 8(b). The error at four corners in each patch was zero because the nodes at these corners remain invariant for both the control polygon and Bezier approximated surface.

Comparing the errors using GS and VS method for C shaped blade

In both GS as well as VS method error was calculated by dividing the difference of corresponding Bezier and control points by the control point and it was expressed in per cent. The error in developing the C shaped blade surface for 0 degree orientation using GS and VS method with reference point stated earlier was found. The location of control points at rear surface of the blade was different in both methods. In GS method only a portion of the working surface of blade was covered in a single patch, whereas in VS method the entire blade surface was covered using four patches of control points for developing surface. Thus the error could not be compared point by point however overall error was compared.

In GS method the error in x-coordinate of the developed blade surface for all the vertical planes was reported below 5.0 per cent. It was reported below 6.0 per cent for the z-coordinate and zero for the plane 1. However, for point (1,4) the error in y-coordinate was reported to be 48.2 per cent.

The maximum percentage error in developing the blade surface using VS method at 0 degree orientation was 1.19, -4.94 and -8/02 per cent for x, y and z coordinate, respectively.

In GS method, the control points, for developing blade surface, were measured at 10 and -10 degree orientation and maximum error in developing blade surface were found to be 144.4 and 227.2 per cent, respectively. However there was no need to measure control points at different orientations. Coordinate transformation (rotation about reference point) could be applied to control points at 0-degree orientation.

Variation in error using GS and VS techniques by generating the same surface using three patches

The working surface of the C-type blade at 0^0 orientation was divided into three patches. Control points were measured for each patch using GS and VS method. The reference point, for measuring coordinates, in both cases was same viz. center of one of the holes for mounting the blade. It was difficult to keep same size of each patch in GS and VS techniques, as in Fig. 9(a) and Fig. 9(b), for the reason that control points in GS method had a constraint that they should lie on x-y plant for Z=constant.

Irrespective of the methods, the error in general remained high where blade curvature was least e.g. in patch one. This occurred because of very small magnitudes of control points. The maximum per cent error in patch one alone x, y and z coordinate was 2.03, 9.97, -7.41 using GS technique and 0.78, -4.94, -9.43 using VS technique. It stood at 1.17, 6.17, 2.4 (using GS method) and 1.16, 3.97, 2.64 (using VS method) in patch two and 0.98, -5.21, -2.96 (using GS method) and 048, -1.98, 1.48 (using VS method) in patch three. Since reference point was not same in GS and VS method, it is worthwhile to look for absolute errors. The magnitude of absolute errors was quite small e.g. in patch two alone x, y, z coordinate it was 0.18, 0.17, 0.14 cm in GS method and 0.14, 0.15 and 0.21 cm in VS method.

Conclusions

Using computer graphics Bezier surfaces of rear surface of C-shape blade was generated. The VS method was suitable for

generation of blade surface than GS method in respect of error. The error in generating surface was considerably reduced by joining multiple Bezier surface patches. The treatment can be extended, with ease, to any shape of a rotary tiller blade. Also, method can be generalized for designing, analyzing and developing any part of agricultural implement.

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Performance of Solar Photovoltaic Powered System for Boom Sprayer

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ABSTRACT

Solar photovoltaic powered boom sprayer was developed considering the matching of components for more capacity, pressure and energy conservation. The tri-cycle was fabricated for proper spraying on cotton crop having arrangement for row-to-row spacing and adjustment for boom height. The total cost of the boom sprayer without the SPV panels comes to Rs. 17,000/- (estimated in the year 2002).

The study was conducted to understand charging and discharging of the lead acid battery. It is observed that the charging time required to charge the battery with solar panel and regular power supply is 16 hours and 10 hours, respectively. Ampere-hour efficiency, Watt-hour and voltage-hour efficiency was found to be 67.96 per cent, 66.88 per cent and 98 per cent respectively.

The SPV sprayer was tested in the laboratory for different tests and it was found that discharge was directly proportional to the pressure of the pump and cone angle of nozzle vary slightly as the pressure of the pump. The developed SPV powered boom sprayer was found satisfactory for different laboratory tests and calibration showed that the sprayer is a medium volume sprayer with theoretical field capacity of 0.33 ha hr^{-1}. The performance of the sprayer is equally good for charging the battery with SPV panel and regular power supply.

India is indeed fortunate to receive abundance sunshine with about 1648-2108 kWh/m^2 per year with nearly 250 to 300 days of useful sunshine in a year. The duly solar energy incidence is between 5-7 kWh/m^2 at different parts of country. This is an enormous resource which needs to be converted into other forms of energy through thermal or photovoltaic conversion routes (Ghosh, 1982).

The most useful way of harnessing solar energy is by directly converting it into electricity by means of solar photovoltaic cells (Rai, 1989).

There is a need to introduce solar energy systems for wide application in agricultural sector. A ULV sprayer powered by photovoltaic system available in department of Un-conventional Energy Sources and Electrical Engineering, Dr.PDKV, Akola was modified as boom sprayer for more capacity.

MATERIAL AND METHODS

Solar photovoltaic powered boom sprayer

It is the modification of SPV powered ultra low volume sprayer by increasing capacity of tank and by using 12V, 40 Ah lead acid battery, motor, pump and trolley system. The details of major parts of boom sprayer are given below.

a) Solar PV module

It is a combination of silicon cell connected in series and converts the solar radiation into useful DC electric power.

Specifications

No. of modules	:	2
Module type	:	L 123 T
Dimensions	:	1015 x 408 x 40 mm
Weight	:	5 kg
No. of solar cells	:	36
Short circuit current	:	2.4A
Open circuit voltage	:	21V
Maximum power	:	35W

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The panel is made of two modules connected in parallel with two diodes for preventing reversal of current through module. Fig. 1 and 2 show the front and side view of the SPV powered boom sprayer, respectively.

b) Control unit

The control unit prevents the reverse flow of current from battery to panel and prevents battery from overcharging and over discharging.

c) Battery

It consists of lead acid battery of 12V, 40 Ah capacity. It can give eight hours of spraying .

d) Pump

The sprayer is equipped with a Hi-tech imported diaphragm pump. It provides pressure up to 55 psi for spraying and the discharge is 3.52 lit min^{-1}.

Fig.3 shows the different components of SPV powered boom spryer.

Selection of components

1) SPV module and battery

Charging time required to charge the lead acid battery was 32 hrs. Two modules were used for charging so as to reduce charging time. (Bhondve & Jondhale, 2000)

2) Pump and nozzle

Hallow cone nozzle work well for SPV power boom sprayer (Sawargaonkar & Khan, 2000).

3) Tank and Piping system

A cylindrical plastic tank of capacity 60 lits, height 60 cm and diameter 30cm was used.

4) Trolley

The trolley was fabricated considering the requirement of cotton crop and spraying technique.

5) Frame

It consists of a metal chassis made up of rectangular G.I. pipes. This chassis is supported on three wheels with pneumatic tyres. The horizontal base line was made by angles of size 40mm x 40mm and length 80cm. A square pipe of size 35mm x 35mm was inserted inside the base pipe to adjust the spacing between two wheels. The distance between two wheels can be varied from 90cm to 150cm. A horizontal standing support of 'T' type chassis was made up of 40cm x 20cm rectangular G.I. pipe.

6) Boom and its height adjustment

A boom was made up of square G.I. pipe of size 1.75cm x 1.75cm. The total length of boom was 150cm. Four nozzles were attached to the boom with the help of iron clamps. The optimum nozzle spacing for getting a uniform spray distribution from a boom was 50 cm. One lever like arrangement was provided to adjust the height of the boom according to crop height. The minimum height of boom over the crop was kept as 50cm.

7) Tracking and support system for SPV panel

To support the SPV panel, arrangement was provided with a vertical stand of diameter 40mm. It was connected to chassis at the center of the frame. A horizontal clamp like arrangement was provided to the vertical bar on which nut and bolts can be fixed. A ball and socket arrangement was provided at the top of the stand so that the panel can be tracked manually. A frame of two half circular bars was used for panel mounting.

8) Wheels and motion guiding system

At the front there were two wheels fastened with support similar to bicycle and there was one wheel located at rear to which handle for guiding motion was provided.

RESULTS AND DISCUSSION

A) Cost estimation of SPV powered boom sprayer

The cost of three wheel trolley with tank, nozzles and plastic pipe is nearly Rs.3,500/- and motor, pump and battery (with charger) is Rs.13,500/- . The total cost of the sprayer is Rs. 17,000/- (Cost of panels is not included in given cost).

B) Field capacity

From calibration of the sprayer it was observed that the capacity of SPV powered boom sprayer was 198 lit. ha^{-1} or 60 lit $hr.^{-1}$ with theoretical field capacity of 0.33 ha hr^{-1} (medium volume sprayer).

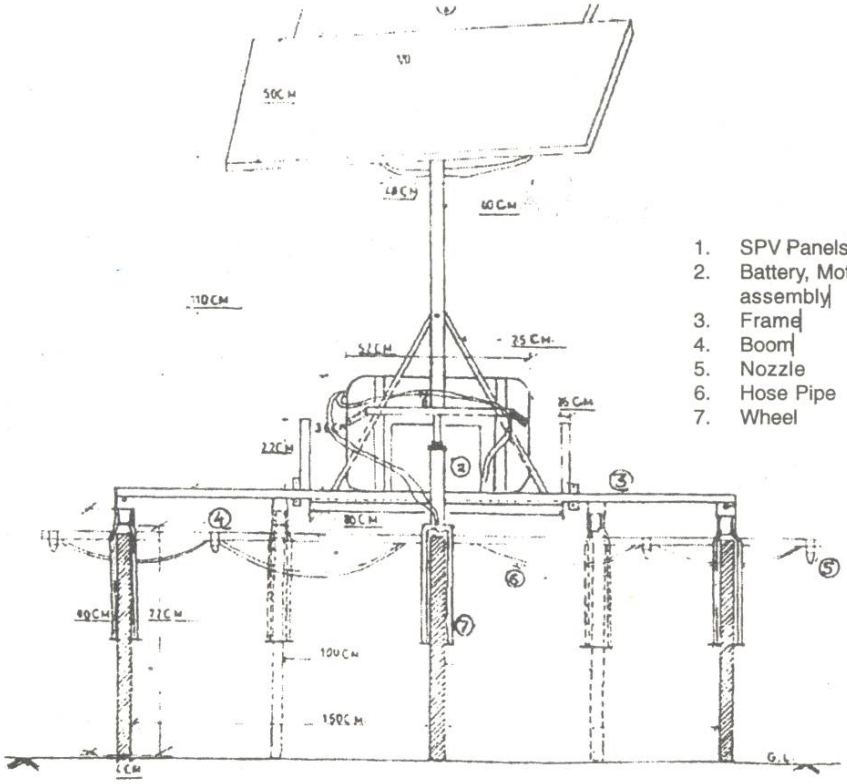

Fig. 1. Front view of SPV powered boom sprayer

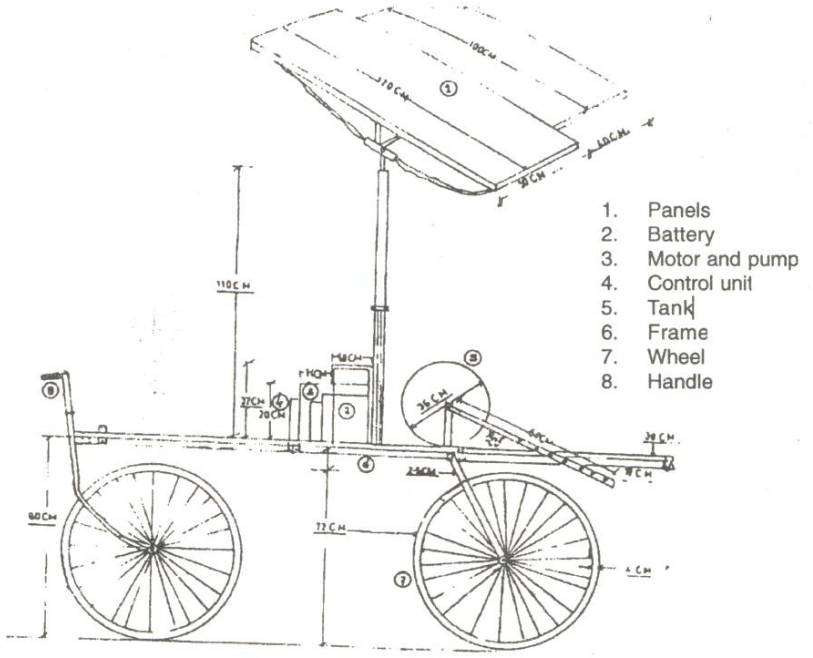

Fig. 2. Side view of SPV powered boom sprayer

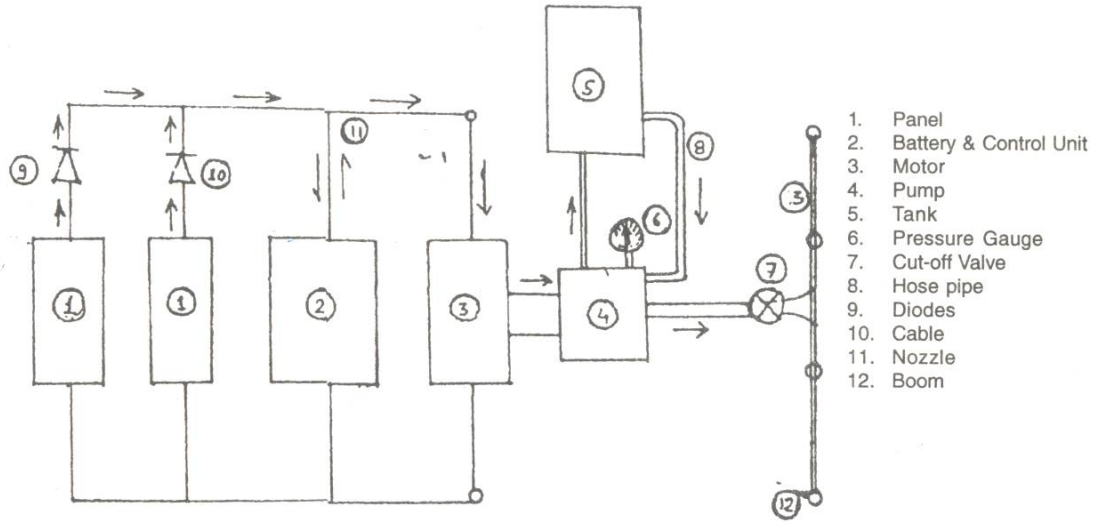

Fig. 3. Different Components of SPV Powered Boom Sprayer

Table 1: Nozzle discharge at different pressure

Sr.No.	Working pressure (kg cm^2)$^{-1}$	Nozzle discharge (cc min^{-1})			Average discharge (cc min^{-1})
		1	2	3	
1	2	210	200	190	200
2	3	250	260	250	254
3	4	320	320	310	317

Table 2: Boom discharge at different pressure

Sr.No.	Working pressure (kg cm^2)$^{-1}$	Nozzle discharge (cc min^{-1})				Average discharge
		L_1	L_2	R_1	R_2	(cc min^{-1})
1	2	200	210	210	190	810
2	3	250	260	250	240	1000
3	4	310	320	310	310	1250

Table 3: Cone angle at different pressure

Sr.No.	Working pressure (kg cm^2)$^{-1}$	Cone angle (°)			Average cone angle (°)
		1	2	3	
1	2	57	56	57	57
2	3	59	60	60	60
3	4	61	62	62	62

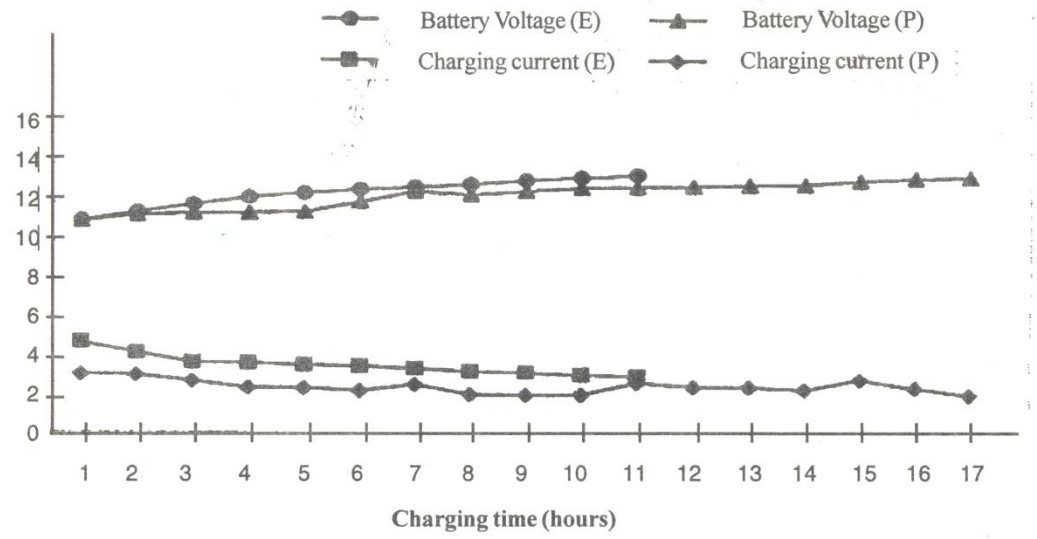

Fig. 4. Camparison of charging of lead acid battery with electric charger and SPV panel

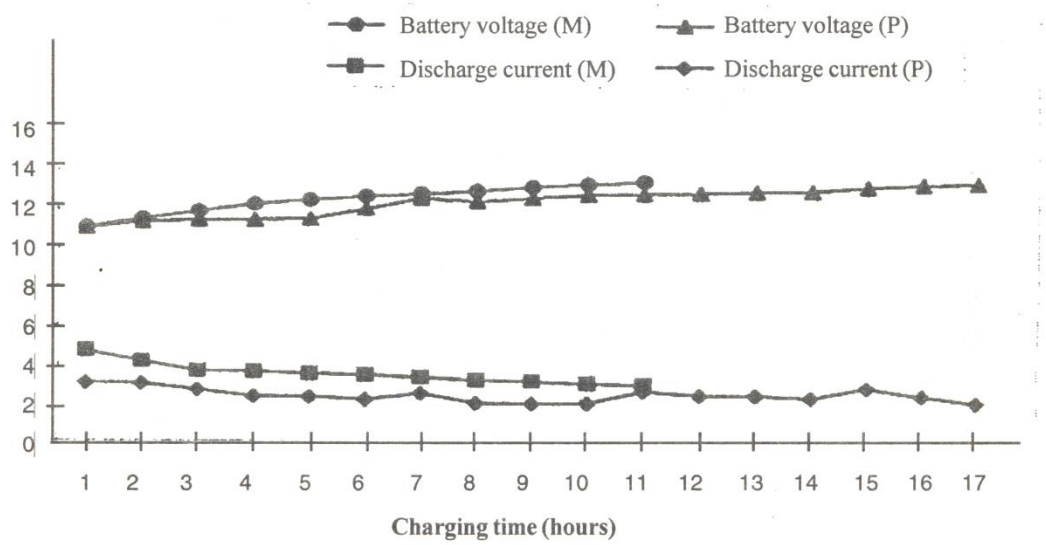

Fig. 5. Camparison of discharging of lead acid battery with motor load and motor load + panel

A) Laboratory trials of boom sprayer

1) Nozzle discharge

Discharge of hallow cone nozzle 60°, 250 at varying pressure at 2 kg/cm² 3 kg/cm² and 4 kg/cm²- were noted for a period of 1 min.(Table 1) From the table it is clear that discharge is directly proportional to the pressure of the pump.

2) Boom discharge

Discharge of boom having four nozzles at varying pressure at 2 kg/cm², 3kg/cm² and 4 kg/cm² were noted for a period of 1 min.(Table 2)

3) Cone angle

Cone angle of NMD/s (60°, 250) nozzle at varying pressure were noted (Table 3). Cone angle

of nozzle slightly increases as the pressure of pump increases.

4) Charging of lead acid battery

The charging tests of lead acid battery were conducted with thehelp of electric charger and SPV panel. The battery was charged from 11V to 13.5V. To charge the battery by electric charger, time required was 10 hrs. Whereas with 70W SPV panel was 16 hrs. Fig 4 shows the comparison of charging of battery with SPV panel and regular power supply.

5) Discharging of battery

Fig.5 Shows the behavior of discharging of battery with motor pump. To discharge the battery with motor pump load, the time required is 5 hrs and with motor pump load and SPV panel is 7 hrs.

The electolyte gravity can be used to know the battery state i.e. charged or discharged. When the ampere hour, voltage hour and Watt hour efficiencies were computed by studying the charging & discharging characteristics of the battery, it is observed that ampere hour, voltage hour and Watt hour efficiencies for SPV charging were 67.96 per cent, 98 per cent and 66.88 per cent respectively and for regular power supply (230V, AC) were 67.21 per cent, 97.76 per cent and 65.70 per cent respectively.

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Performance Evaluation of Paddy Disc Plough

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ABSTRACT

The main function of notched disc plough is to open the hard land. The field trials were conducted as per RNAM test code (1995) to test and evaluate the performance of paddy disc plough. The comparative study of conventional and notched disc plough was also studied. The field trials of the ploughs were carried out at Dr. PDKV. Research station NARP, Sindewahi, Dist. Chandrapur. Notched type disc plough was found to be most suitable for land preparation in paddy. The actual field capacity of notched disc plough was found to be 0.1161 ha h^{-1}, where as of conventional disc plough was found to be 0.0947 ha h^{-1}. The mean weight diameter of the soil prepared by notched disc plough was found to be 35.22 mm and by conventional disc plough was found to be 51.85 mm. The field efficiencies of notched and conventional disc plough were found to be 60.65 per cent and 54.48 per cent respectively.

The problem of land preparation after harvest of paddy has been raised often by the farmers of rice growing area. Due to non availability of proper implement, land can not be prepared well in time for the next crop. After harvesting the paddy crop soil crust becomes harder and harder progressively due to loss of moisture and it becomes very difficult to break soil crust with the conventional bullock drawn implements, like desi plough, harrow etc. Hence, this problem is attempted to solve using notch type disc plough. The main objective of this investigation was comparative study of performance of conventional disc plough and notched type disc plough for land preparation after harvest of paddy crop.

The important research work related to land preparation in paddy is reported here. Abdul Razzaq (1991) reported that, cultivator and other conventional implements become too difficult to operate in heavy soil. Bokade (2003) reported that using notched disc plough once followed by disc harrow found best suitable for land preparation in paddy.

MATERIAL AND METHODS

Two bottom disc plough was modified for land preparation in paddy. The discs of 660 mm. diameter and 80 mm concavity were used for land preparation as shown in Fig.1.

Testing procedure :

The tests were carried out according to RNAM test code 1995 as type of field, length and width of cut, area of field, soil moisture content, soil inversion, soil pulverision, condition of soil, bulk density etc. and two rectangular test plots were selected (Plot 1, Plot 2) in field for testing plough for its operational feasibility. The following observations are noted during field trials.

Soil inversion

Number of stubble in 1 m^2 area were counted before operation and no. of stubbles left in that 1 m^2 area were counted after operation.

$$F = \frac{(Wp - We)}{Wp} \times 100$$

Where, F = Indicates soil inversion
Wp = No of crop stubbles before operation per unit area
We = No. of crop stubbles after operation.

Mean weight diameter of soil aggregates (Soil pulverization)

Soil pulverization is evaluated by using a set of sieves using 100, 80, 64, 40, 20, 10, 4.75, 1 mm. size of mesh using the formula.

$$MWD = \sum_{i=1}^{n} \frac{Wi\ di}{W}$$

Where, MWD = Mean Weight Diameter of soil aggregates, mm.

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Wi = Weight of soil sample retained over the i^{th} sieve, kg.
di = Class of mean size for i^{th} sieve, mm and
W = Total weight of soil samples, kg.

Travelling speed

The speed was calculated from the time required for the plough to travel the distance (20 m) between the two poles on opposite side. The average of such 10 readings were taken to calculate the travelling speed of tractor with implement in km/h.

Actual field capacity

Actual field capacity was calculated as.

$$S = \frac{A}{T_P + T_I}$$

Where, S = Actual field capacity, ha h^{-1}.
A = Area covered, ha.
T_p = Productive time, h.
T_I = Non productive time,h (Time lost for turning and adjustment)

Theoretical field capacity

It is calculated by following formula.

$$\text{Theoretical field capacity ha } h^{-1}. = \frac{S\ W}{10}$$

Where, S = Speed, km h^{-1}
W = Theoretical width, cm.

Field efficiency

Field efficiency is the ratio of Actual field capacity to Theoretical field capacity, expressed in percentage.

Fuel consumption

The tank is filled to full capacity before and after the test, amount of refueling after the test is the fuel consumption for the test.

Bulk density of soil

It is the mass after oven drying of soil of a unit volume.

$$\text{Bulk density of soil} = \frac{M}{V} = \frac{4M}{3.14\ D^2L}$$

Where, M = Mass contained in core sample of oven dry soil
V = Volume of cylindrical core sample
D = Diameter of cylindrical core sample
L = Length of cylindrical core sample

RESULTS AND DISCUSSION

The field conditions during field trails are presented in table No. 1. The field trails were conducted as per RNAM test code 1995. The results as well as comparative performance of notched disc plough and conventional disc plough have been furnished in Table 2.

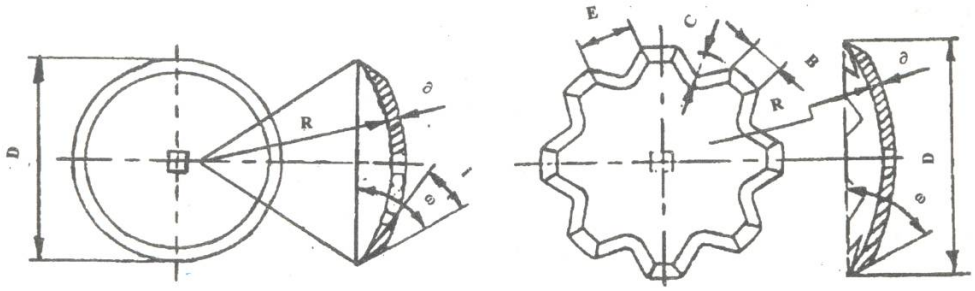
The results obtained in field trials are presented as discussed below.

Mean weight diameter of soil aggregates

Notched disc plough gave the highest reduction in the value of MWD 35.22 mm. because of notches on the disc plough produce grip on the soil, thus it reduce slippage and decrease contact area and break the furrow slice in to the pieces (Table 3).

Table 1 Field conditions of test field

Sr. No.	Particular	
1	Location of the field	NARP Sindewahi, Dist. Chandrapur,
2	Type of soil	Sandy clay loam.
3	Average soil moisture content	11.8 %
4	Crop before land preparation	Paddy
5	Stubbles height	12 cm
6	Name of the implement used in the trials	i) Conventional disc plough ii) Notched disc plough
7.	Bulk density of soil	1.44 gm cc^{-1}



Conventional disc Notched disc

Fig. 1. Geometric parameters of the discs

D = Diameter of disc = 66 cm.
B = Length of cutting edge = 6.91 cm.
E = Length of notch (blade edge) 10.36 cm.
C = Height of notch = 5.5 cm.
ω = Cutting angle of disc cutting edge = 42-45^{0}---
i = Angle of taper of disc cutting edge = 15-25^{0}
∂ = Thickness of disc = 0.628 cm
R = Radius of curvature.

Table 2 : Field observations of the implements used in trials

S. N.	Particulars	Notched disc plough	Conventional disc plough
1	Total area covered (ha)	0.06	0.06
2	Average tilling depth obtained (cm.)	12.1	8.3
3	Average width of operation (cm.)	58	57
4	Gear selected	2nd low	2nd low
5	Speed of operation (km h^{-1})	3.30	3.05
6	Duration of test (min.)	31	38
7	Effective field capacity (ha h^{-1})	0.1161	0.0947
8	Theoretical field capacity (ha h^{-1})	0.1914	0.1738
9	Field efficiency (%)	60.65	54.48
10	Soil inversion (%)	91.104	84.996
11	Fuel consumption (lit h^{-1})	2.794	3.048
12	Wheel slip, %	8.8	15.4
13	MWD (mm) after operation	35.22	51.85

In case of conventional disc plough, it gave higher value of MWD 51.85 mm. because the conventional disc plough cuts and turns the complete furrow slice without breaking it into the pieces (Table 3).

Working depth

It was observed that, using notched disc plough the average working depth was found to be 12.1 cm. which was satisfactory working depth in paddy growing area. Using conventional disc plough the average working depth was observed to 8.3 cm.

Speed of operation

The notched disc has given best performance in 2nd low gear with speed of 3.30 km h^{-1} and the speed of operation of conventional disc plough given 3.05 km h^{-1}.

Fuel consumption

The fuel consumption in case of notched type disc plough was found to be 2.794 l h^{-1} where as in case of conventional disc plough it was 3.048 l h^{-1}. The lower fuel consumption was noticed for notched disc plough because due to lower slippage and less time required to cover the area.

Table 3 : Sieve analysis of test field after operation

Size of aperture	Dia of soil passed the left sieve and retain on the next sieve	Representative dia.of soil in the left column	Weight of soil (Notched disc)	Weight of soil (Plane disc)
Mm	Mm	mm	Kg.	Kg.
1	<1	0.5	0.94	0.65
4.75	1-4.75	2.875	0.56	0.30
10	4.75-10	7.375	0.88	0.44
20	10-20	15	1.68	1.37
63	20-63	41.5	0.83	0.95
80	63-80	71.5	0.92	0.28
100	80-100	90	1.29	3.21
			35.23	51.85

$$MWD = \sum_{i=1}^{n} \frac{Widi}{W}$$

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Analysis of Effect of Use of Fertilizer, Irrigation and Farm Power in Increasing Food Grains Productivity in Maharashtra

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ABSTRACT

An analysis has been made, based on time series secondary data, to study the trends in use of major inputs viz. fertilizer, area under irrigation, and farm power and their influence in increasing the yield of food grains for the state of Maharashtra. Mathematical models were developed linking growth in yield and use of inputs. The yield elasticity was estimated through the interaction of different inputs by linear multiple regression function. The analysis revealed that growth in yield was linearly correlated with increased use of fertilizer and power, but it was exponential in the case of irrigation. The standardized regression coefficient values revealed that growth in irrigation has been more effective input than fertilizer and power in increasing the yield. With the present growth rate in use of inputs, it would be possible to achieve yields of about 1150 kg ha^{-1} by the year 2005-06 and 1320 kg ha^{-1} by 2010-11 in the state compared to 974 kg ha^{-1} of 1998-99.

Maharashtra is the third largest state of India with 30.77 million hectare (Mha) land of which about 60 per cent area is under cultivation. The food grains production has increased to 12.75 million tonnes (MT) in 1998-99, but it has been highly fluctuating due to erratic rains and limited irrigation facilities. The yield levels for most of the crops are very low compared to All India average yield. Major agricultural inputs, which affect yield, are quality seeds, soil nutrients and use of fertilizer, water including natural precipitation and integrated pest management measures. Farm power facilitates use of these inputs effectively in the field through improved machinery. At micro level the farmers need these information for proper management of inputs. However, for the analysis in this paper fertilizer, irrigation and unit farm power has been considered as the major inputs that are important to influence food grains yield.

MATERIAL AND METHODS

District wise time series secondary data from 1960-61 to 1998-99 relating to cropped area, food grains production, productivity, fertilizer consumption, area irrigated under food grains, farm power and other relevant agricultural statistics were collected from the Agricultural Statistical Information of Maharashtra, Agricultural Statistics at a Glance, Fertilizer Statistics, and Livestock Census Reports of Ministry of Agriculture, Government of India, New Delhi. Various mathematical functions were fitted as yield, Y = f (inputs), and the best model was selected in each case based on the highest value of the coefficient of determination (R^2) (Singh and Chandra, 2000). Linear multiple regression function was used to examine the combined effect of inputs on yield (Draper and Smith, 1981):

$$Y = a + b_1 X_f + b_2 X_i + b_3 X_p$$

Where, X_f = fertilizer consumption, kg ha^{-1}; X_i = food grains area under irrigation, %; X_p = farm power availability, kW ha^{-1}; and a, b_1, b_2 and b_3 are the regression coefficients. Standardized regression coefficients were also calculated to study the relative effect of different inputs.

RESULTS AND DISCUSSION

Trends in use of inputs

The average use of fertilizer consumption in the State of Maharashtra has increased from 2.14 kg ha^{-1} in 1960-61 to 77.89 kg ha^{-1} in 1998-99, recording an annual compound growth rate of 9.92 per cent. The net irrigated area by all sources in the state has increased from 1.23 M ha to only 2.57 M ha during 1960-61 to 1995-96, with compound growth rate of 2.56 per cent per annum (Table 1). The irrigation through canal grew from 0.24 M ha to 0.538 M ha at the rate of 2.33 per cent per annum, and through wells and tube wells it has increased from 0.508 M ha to 1.57 M ha, indicating an overall annual growth rate of 2.75 per cent. Canal irrigation covers about 21 percent of total irrigated area and tube well 61per cent. The population of diesel engine and electric operated irrigation pumps has increased from 0.317 million to 1.037 million with a growth rate of 4.32 per cent per annum only (Table 2). The food

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Annexure 1. Estimate of regression coefficients for the model with fertilizer, irrigation and power on yield Maharashtra

Variables	Regression coefficients	Standard error	Standardized coefficient	Calculated t-value
Constant	141.77	242	-	0.58
Fertilizer	1.8	3.6	0.25	0.50
Irrigation	35.5	23.7	0.32	1.6***
Power	482.25	750.5	0.31	0.64
R^2= 0.69*				

*Significant at 1 % level, * ** Significant at 10 % level

Table 1: Area irrigated by source ('000 ha)

Sources	1971-72	1981-82	1991-92	1995-96	Growth, %
Canal	312	417	495	538	2.33
	(21.86)	(21.64)	(22.87)	(20.95)	
Wells & tube well	821	1097	1177	1571	2.85
	(57.53)	(56.73)	(54.36)	(61.20)	
Other sources	294	413	493	458	1.97
	(20.61)	(21.43)	(22.77)	(17.85)	
Net irrigated area	1427	1927	2165	2567	2.56
	(100)	(100)	(100)	(100)	

Source: Directorate of Agriculture, Maharashtra.
The values in brackets indicates percentage of the total irrigated area.

Table 2: Growth of irrigation pumps in Maharashtra ('000)

Sources of power	1971-72	1981-82	1991-92	1998-99	Growth, %
Diesel pumps	147	166	144	104	-1.23
Electric pumps	170	410	703	933	6.27
Total pumps	317	576	847	1037	4.32

*Total area under irrigation

Table 3: Growth of farm power in agriculture in Maharashtra

Sources, in thousands	1971-72	1981-82	1991-92	1998-99
Agricultural workers	11930	14963	18445	21352
Draught animals pairs	6371	6605	6847	7022
Tractors	6,000	22,000	66,000	1,41,000

grain area under irrigation has increased from 5.92 per cent in 1960-61 to 13.30 percent in 1998-99, recording a growth rate of 2.15 per cent annually.

Major sources of farm power available in the state are given in Table 3. The average use of human energy per hectare has increased from 400 human hours in 1971-72 to 1299 human hours in 1996-97 which is much higher compared to All India average (Singh, 1997). The population of draught animals in the State has increased from 6.371 million bovine in 1971-72 to 7.022 million in 1998-99 (Table 3). The average use of draught animals hectare^{-1} has declined to 64 pairs-hour ha^{-1} in 1996-97 as against 133 pairs-hour ha^{-1} in 1971-72 (Singh, 1997), possibly due to use of tractors, engines and motors for many farm operations. The population of tractor

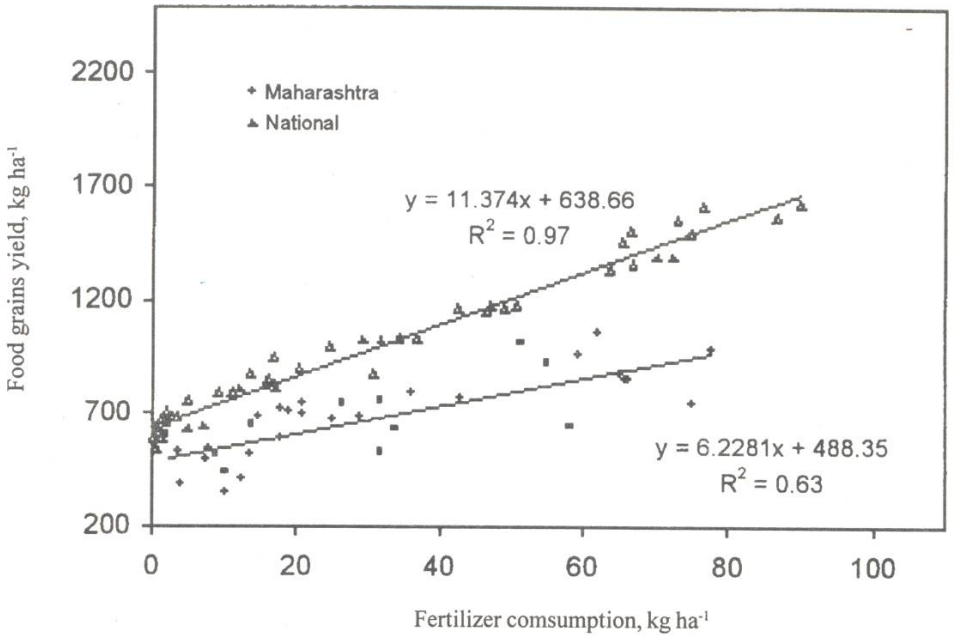

Fig. 1. Trends in fertilizer consumption and food grains yield in Maharashtra and India

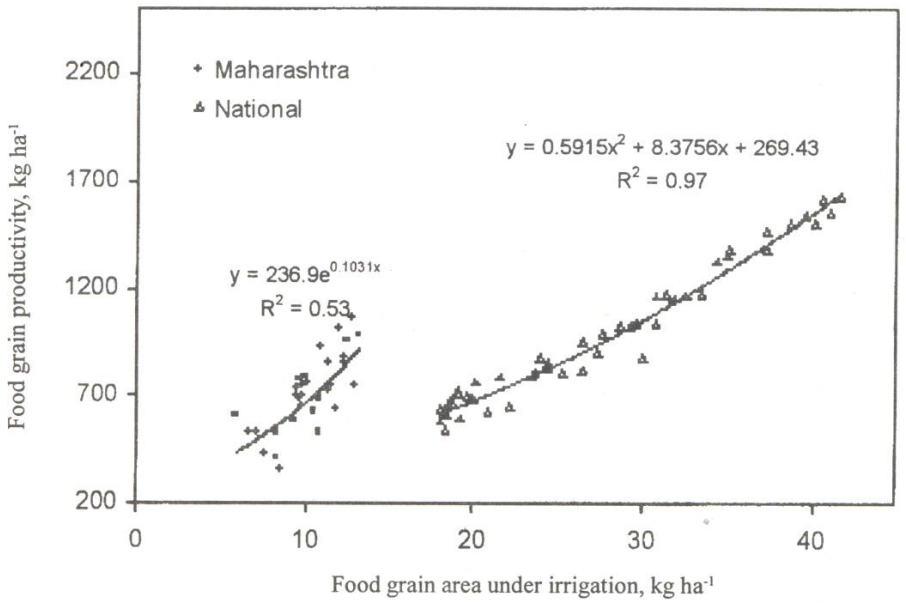

Fig. 2. Trends in irrigation and food grains yield in Maharashtra and all India

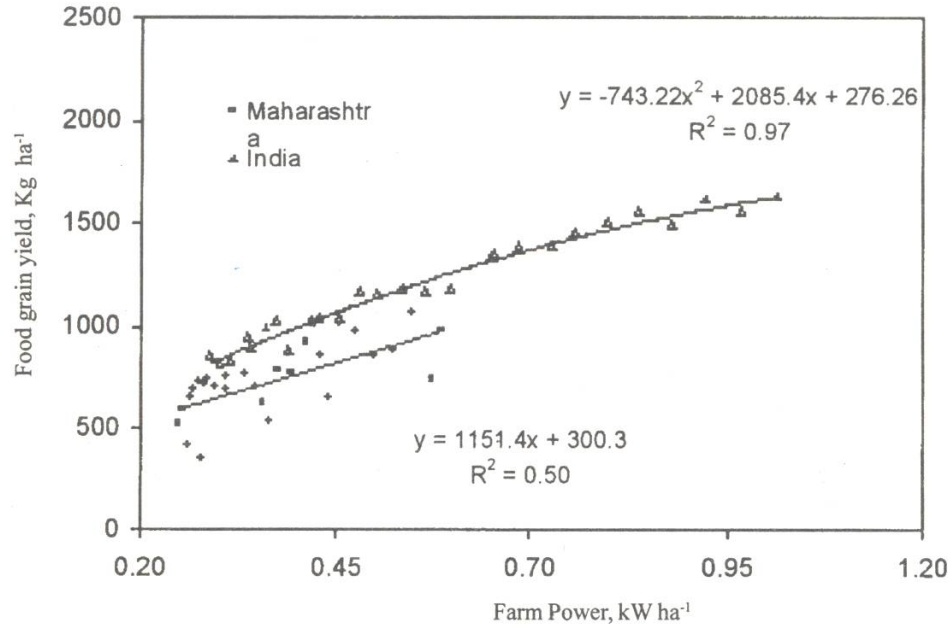

Fig. 3. Trend in unit farm power and food grains yield in Maharashtra and India

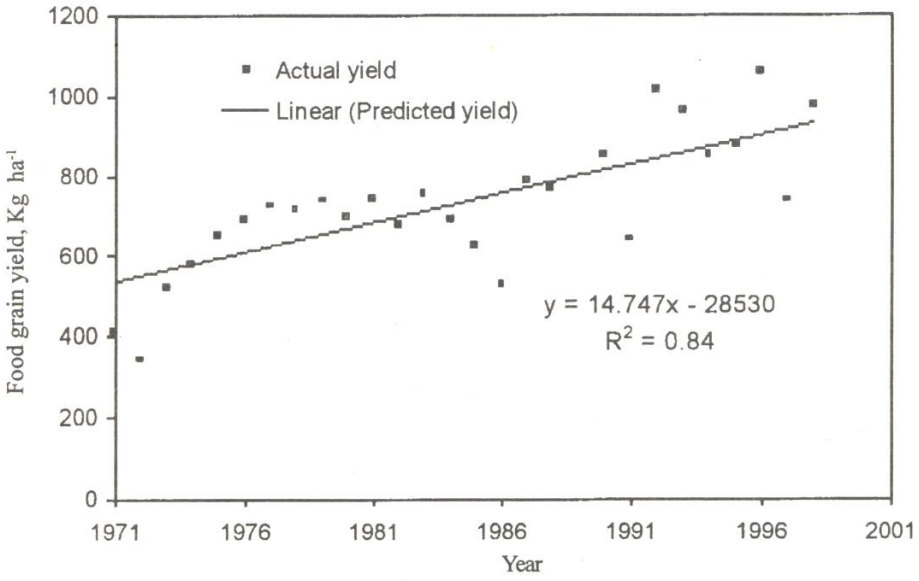

Fig. 4. Trends in predicted yield and actual yield in Maharashtra

in the state is estimated as 1,41,000 in 1998-99. It has shown an increased growth of 11.96 per cent per annum since 1971-72. The average availability of tractor in the state has improved to 128 ha tractor^{-1} as compared to 2750 ha tractor^{-1} in 1971 -72. This is still low compared to All India average of 63 ha tractor^{-1} (De *et. al.* 2000; and Alam and Singh, 2003). The total animate and mechanical farm power input per unit cultivated land in the state has increased from 0.169 kW ha^{-1} to 0.587 kW ha^{-1} (net sown area basis) between 1960-61 to 1998-99 indicating an annual growth rate of 3.33 per cent only. The availability from animate sources has been limited to 0.17 kW ha^{-1} and the additional increase has been mainly from mechanical sources. Animate power contributed 54.57 per cent of total power in 1971-72, which has reduced to 28.72 per cent in 1998-99 but use of mechanical power increased to 71.28 per cent from 45.45 per cent (Table 4).

Table 4. Share of farm power sources in Maharashtra

Power source, million kW	1971-72	1998-99
Human power	0.60	1.06
	(13.70)	(10.05)
Animal power	1.79	1.97
	(40.82)	(18.67)
Mechanical and electrical power	1.99	7.52
	(45.45)	(71.28)
Total farm power	4.38	10.55

Note: The values in brackets indicate percentage of the total power.

Effect of growth of inputs in influencing yield

The best mathematical relationship in growth of food grains yield, use of fertilizer, irrigated area, and potential availability of unit farm power, could be expressed by (Figs. 1 to 3):

$$Y = 488.35 + 6.23\ X_f \quad (R^2=0.63) \quad ...(1)$$

$$Y = 236.9\ e^{0.103\ Xi} \quad (R^2=0.53) \quad ...(2)$$

$$Y = 300.3 + 1151.4 X_p \quad (R^2=0.50) \quad ...(3)$$

Where, y = state average food grains yield, kg ha^{-1}; X_f = state average fertilizer consumption, kg ha^{-1}; X_i = average food grain area under irrigation, % and X_p = state average availability of power, kW ha^{-1}. It is observed from the Figs. 1 to 3 that for the same level of adoption of inputs, yield in Maharashtra was lower compared to all India average yield; possibly due to other factors like lower area under irrigation, low and erratic distribution of rainfall, including predominance of cultivation of low yielding coarse cereals and pulses.

Interaction of inputs affecting food grains yield

Combined effect of all the above inputs has been analyzed by using linear multiple regression function. This could be expressed as:

$$Y = 141.7 + 1.8\ X_f + 35.5\ X_i + 482.25\ X_p,\ (R^2 = 0.69) \quad ...(4)$$

The value of coefficient of determination (R^2=0.69) is statistically significant. Productivity elasticity values for fertilizer, irrigation and farm power are 1.8, 35.5 and 482.25, respectively (Annexure-1). The standardized regression coefficient values i.e. relative effects of the inputs reveal that irrigation is more effective input than fertilizer and power in increasing the yield (Annexure 1: Fertilizer, 0.25; irrigation, 0.32; and power, 0.31). The projected yield from the Eqn. 4, compares well with the yield estimated from state average time series data (Fig. 5). With the present rate of growth of use of inputs, it would be possible to achieve an yield of about 1150 kg ha^{-1} by the year 2005-06, and 1320 kg ha^{-1} by 2010-11 in the state of Maharashtra.

However, it is clarified that the agricultural production in the state of Maharashtra is highly monsoon dependent which is highly erratic. Although, food grains yield could be projected using the expression, but erratic and low rain fall precipitation and natural calamities may alter the agricultural productivity, and area under cultivation, and consequently, total production of food grains. These factors have not been incorporated in the model.

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Research Notes

Analysis of Stability Parameters for Yield in Sunflower

Relatively ranking of genotypes in different seasons for a given attributes is rarely the same. This results in difficulty in detecting superior genotypes. The most suitable procedure for plant breeder, Therefore, is to select genotypes showing a high degree of stability of performance over a wide range of environments. The stability parameters of five elite sunflower hybrids synthesised at RARS, Nandyal were analysed before being popularised.

Five pre released hybrids with two checks, i.e. APSH 11 and KBSH 1 were grown during summer 1995, *Rabi* 1996 and *Kharif* 1997 seasons at Regional Agricultural Research Station, Nandyal. The experiment in each season was laid out in RBD with three replications adopting a plot size of 3.0 m. x 3.0 m. A fertilizer dose of 60 kg N, 90 kg P_2O_5 and 60 kg K_2O ha^{-1} was applied. Nitrogen was applied in three split doses. Half of it as basal, the remaining half in two splits, one at 30 DAS and the other at 50 DAS. Grain yield was recorded on plot basis and subjected to phenotypic stability analysis as per the model suggested by Eberhart and Russel, 1966.

Table 1. Pooled analysis of variance

Sources of variation	DF	Seed yield MSS
Geno	6	19.8507*
E + (G x F)	14	15.2539*
E (Linear)	1	103.6195*
G x F (Linear)	6	13.4652*
Pooled deviation	7	4.1635
Pooled error	42	0.1153

* Significant p = 0.05 against pooled deviation

Data presented in Table 1 exhibited significant genotypic differences in their response to environments as genotype mean squares when tested against pooled deviation and pooled error found significant. It indicates genetic control of response to environments and independent nature of genetic systems in controlling stability parameters. Significant environment (linear) when tested against pooled deviation and pooled error proved the importance of additive environmental variance confirming that the environments were quite varied in their effect on the performance of genotypes. This was further supported by widely ranging environmental indices obtained for seed yeield. Summer season was more favourable unlike *kharif* season for genotypic expression. Prediction of performance of the genotypes was possible as the magnitude of linear component of GE interaction was observed to be higher than non-linear component. Similar observations were made by Laishram and Singh (1997). Significant GE interaction for the genotypes established the fact that they interacted significantly under all the environment under study.

The genotypes are said to be suitable to varied environments when they exhibit high mean performance, more stability over environements and non responsiveness to change in environments as reflected by non significant S^2 di and bi values. None of the genotypes exhibited ideal stability values (Table 2). Similar results were reported by Fick and Zimmer (1976) for single cross hybrids in sunflower. However, KBSH 1 was found to be suitable to poor environments because of high mean performance, low bi and non-significant S^2di values. NDSH 15 was

Table 2. Mean performance and stability parameters of elite sunflower hybrids

S.N.	Genotypes	Seed yield kg ha^{-1}			Stability parameters		
		1995 summer	1996 *Rabi*	1997 *Kharif*	Mean	bi	S^2di
1.	NDSH 3	9.80	15.01	10.07	11.63	-0.2690	15.9976*
2.	NDSH 5	17.90	9.42	11.02	12.78	1.4569	9.0898*
3.	NDSH 15	21.33	15.31	11.89	16.81	1.7545+	-0.0059
4.	NDSH 16	22.92	12.84	10.59	15.45	2.3881+	1.6806*
5.	NDSH 18	18.00	15.03	12.17	15.07	1.0513	0.5212*
6.	KBSH 1	13.00	11.11	9.64	11.25	0.6136+	-0.0137
7.	APSH 11	9.50	8.34	9.79	9.21	0.0047+	1.0676*
	Mean	16.06	12.44	10.74	13.08		
	EI	2.9846	-1.6435	-2.3411			

* Significant P = 0.05 + Significantly deviated from unity at 5% level.

suitable to more favourable environments due to high mean performance, high bi and non-significant S^2di values. NDSH 18 with non-significant regression coefficient was observed to be non-responsible to environmental flucuations and was relatively stable due to its low deviation from regression.

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Production Trends in Food Grains as Influenced by Growth in Area Under Cultivation and Yield in Maharashtra

The food grains production in any region is influenced by the growth in area under cultivation and yield. Technological advancement, quality agricultural inputs, and better management of natural resources (land, water and solar energy) influence the yield; where as area under cultivation is altered with crop diversification and reclamation of land. Maharashtra is one of the largest states in the country with 30.77 million hectares (Mha) geographical area of which about 60 per cent is under cultivation. The area under food grains crop was recorded 13.32 million hectares in 2000-01, which is 72 per cent of the total area under cultivation. With a total production of 10.88 million tones, the state contributes only 5 per cent to the total food grains production to the country while it occupies about 11 per cent of total area under food grains crops. Due to low irrigated area under food grains crops (14.3%), coarse cereal crops occupy more than 56.3 per cent of the total area and pulses 26.7 per cent. The area under paddy (11.4%) and wheat (5.6%) has been recorded low. Coarse cereals and pulses in general are not remunerative crops and as a result farmers are diversifying to other crops (Singh and Chandra, 2003). This is affecting the total food grains production in the state. Time series secondary data for the period 1950-51 to 1998-99 has been analysed to study the growth trends in area, yield and total production of food grains during different phases of green revolution, and contribution of area and yield in affecting total production.

The time series data were collected from the Agricultural Statistical Information, Government of Maharashtra, Agricultural Statistics at a Glance, Government of India, and Fertilizer Statistics, Fertilizer Association of India. The time period has been divided into three different periods of agriculture development; (i) pre-green revolution (1950-51 to 1965-66); (ii) green revolution (1966-67 to 1975-76); and (iii) post-green revolution (1976-77 to 1998-99). The growth trends were expressed by linear, quadratic, exponential, power, compound growth, and logarithmic function and the best curves as per highest values of coefficient of determination were adopted (Singh and Chandra, 2001). Compound growth rates were calculated as $y = ab^x$, where b, is regression coefficient of y on x and expressed as percentage $r = (b - 1) \times 100$. Significance of growth rates were tested by using 't' test as,

$t = r/SE(r)$, and,

$$SE(r) = \frac{b \sqrt{\{[(\Sigma \log y^2) - (\Sigma \log y)^2/n] - (\log b)^2 (\Sigma x^2)\}}}{0.43429 (n-2) (\Sigma x^2)} \times 100 \quad ...(1)$$

Where, n is number of years considered under the study. Significance of difference between growth rates of any two periods of agriculture were tested by test statistics given by Subramanyan and Vasanthi (1988) as,

$$t = \frac{b_i - b_j}{\sqrt{[\{SE(b_i)\}^2 + \{(SE(b_j)\}^2]}}, \ (i, j = 1,2,3) \quad ...(2)$$

Where, b_1, b_2 and b_3 are regression coefficients in pre-green revolution, green revolution, and post-green revolution periods, respectively. The effect of area, yield and their interaction in increasing the food grains production between any time periods was computed as (Sharma, 1977):

$$\nabla p = y_0 \nabla A + A_0 \nabla y + \Delta A \nabla y \quad ... (3)$$

Where, $\nabla A = A_n - A_0$; $\nabla y = y_n - y_0$; $\nabla p = p_n - p_0$; A_0, y_0, p_0 are area, yield, production in the base year, A_n, y_n, p_n are area, yield and production in current year, and ΔA, Δy, Δp are the changes in area, yield and production.

The mathematical expressions for the growth of different production factors in the state are shown in Fig 1. The growth in area under cultivation of food grains is decelerating, as coefficient in quadratic function is negative (-0.002). The growth in the total food grains production however, is linear as expression for the growth of yield has positive coefficients. The annual compound growth rates for these production factors for the different pre and post-green revolution periods are given in Table 1. It is seen that highest growth rate in total food grains production (3.17% per annum) is recorded for the green revolution period (1966-67 to 1975-76). During this period growth rates in area was recorded 1.61per cent and in the yield 1.52 per cent per annum. During the post green revolution period growth rate in yield is recorded 1.5 per cent annum^{-1} but in area it is negative (-0.29% per annum). Share of contribution of increased area and yield in increasing the total production is given in the Table 2. It seen that increased area contributed 53 per cent compared to

Table 1. Compound growth rate of area, production and yield during different phases of agriculture development in Maharashtra, (%)

	Era	Area	Production	Yield
1.	Pre-green revolution (1950-51 to 1965-66)	0.21	1.13	1.08
2.	Green revolution (1966-67 to 1975-76)	1.61	3.17	1.52
3.	Post green revolution (1976-77 to 1998-99)	-0.29*	1.21**	1.50*
	1950-51 to 1998-99	0.33*	2.26*	1.93*

*significant at 1 per cent level, **significant at 5 per cent level.

Table 2. Effect of change in area, yield and their interaction in production of food grains in Maharashtra

Periods	Differential production, ∇p	Area effect $\nabla A y_o$	Yield effect $\nabla y A_o$	Interaction effect, $\nabla A \nabla y$
1. 1950-51 to 1959-60	3181	1008	1752.6	421
	(100)	(31.67)	(55.10)	(13.23)
2. 1960-61 to 1969-70	1978	1062	806	110
	(100)	(53.69)	(40.75)	(5.56)
3. 1970-71 to 1979-80	4765	500	3915	350
	(100)	(10.50)	(82.16)	(7.34)
4. 1980-81 to 1989-90	3514	267	3161	86.0
	(100)	(7.60)	(89.95)	(2.45)
5. 1990-91 to1998-99	3060	1113	1785	162
	(100)	(36.0)	(58.0)	(6.0)

The values in the brackets are percentage contribution

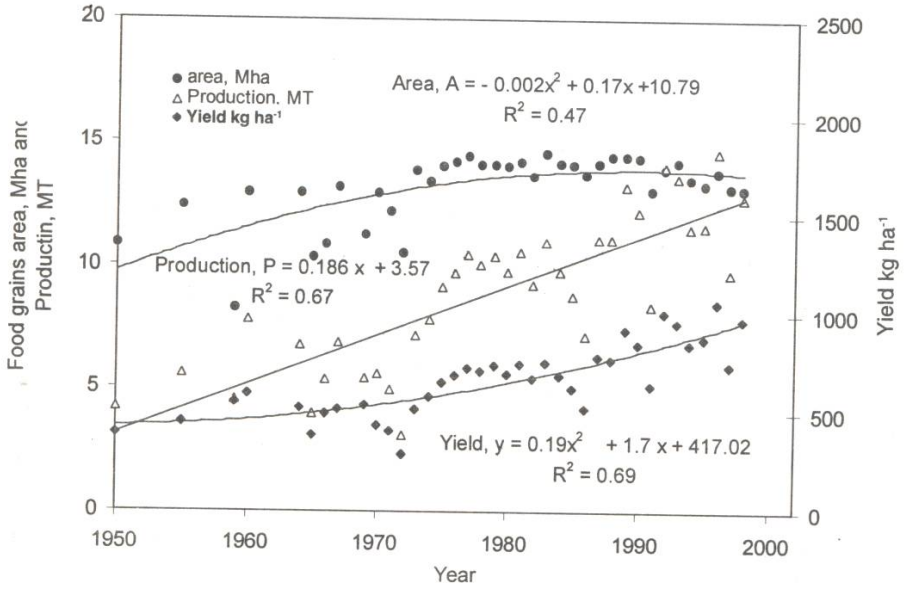

Fig. 1. Growth trends in area, yield and production of food grains in Maharashtra

40.75per cent of the yield and 5.56per cent interaction of yield and area during the period 1960-61 to 1969-70. Since 1990-91 to 1998-99, the contribution due to increased yield was recorded 58per cent, area 36 per cent and interaction due to area and yield was only 6 per cent. Thus, yield will have the major role in future in increasing the total production of food grains in the State.

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PKV Res. J. Vol. 26 (1& 2) : 2002

Outbreak of *Helicoverpa armigera* (Hubner) on Cotton Around Nagpur

American bollworm *Helicoverpa armigera* is widely distributed throughout the world and known to be a major pest of cotton inflicting yield losses to the tune of 40-66 per cent in different cotton growing states of the country (Dhaliwal and Arora, 1996). Lal (1996) reported the yield losses in chickpea upto 75-90 per cent due to this pest. Besides these two crops it has been also reported to cause damage to a wide range of crops viz. maize, sorghum, sunflower, tobacco, tomato, chickpea and pigeonpea. The outbreak of this pest was reported earlier on pigeonpea (Kotikal, 1994 and Singh *et. al.*, 1998), sorghum (Pawar, *et. al.*, 1989), tobacco (Sreedhar, *et. al.*, 1995), and on cotton (Thakare *et. al.*, 1984). Agroclimatic conditions of an area play an important role in determining the pest incidence and population built up in a particular area. These conditions operating for long period of time can also influence the biology and behaviour of the pest, which may differ for the same pest occuring in other agroclimatic zone It is well known that this phenomenon of population fluctuation due to cropping pattern and agroclimatic conditions lead to the formation of biotypes, subspecies and ultimately different species.

Unusual heavy outbreak of *Helicoverpa armigera* was recorded on cotton crop in the *Kharif* season of 1997 at and around Nagpur, inflicting boll damage to the extent of 30-35 per cent. The data collected on the average per cent boll damage, irrespective of varieties, during frequent surveys undertaken in the area and the meteorological conditions prevalent in the five preceeding years and the outbreak year are presented in Table 1. On perusal (Table 1) of the weather patterns during the outbreak year, it was found that the total rainfall was not so excess as compared to the preceeding years but was delayed and unseasonal, whereas during the preceeding years the region received more or less similar rainfall, but was of regular nature and well distributed.

Due to the premonsoon rains in the month of April and May 1997, the temperature remained around 40.1 - 43.1°C., i.e. about 2-4°C less than the average temperature prevailing in the area. The low temperature associated with humidity might be the probable reason for carry over of the aestivated pest. Though the incidence was initiated at low level during early August and September 1997, the intermittent rains followed by dry spell during earlier part of September and beginning of October appeared to be conducive for the development of the pest. Heavy oviposition by the pest in the month of September was synchronised with the first flush of cotton in October causing considerable damage to the crop. November and December months appeared to be normal with warmer days and comparatively unusual high humidity because of post monsoon rains, which might have aggrevated the pest problem.

Further it was noticed that during the year of outbreak there was almost negligible populations of *Earias* spp. and *Pectinophora gossypiella*, as compared to the population of *Helicoverpa armigera*, which otherwise have competed for food with the population of *H. armigera* and might resulted in the supression of *H. armigera* population. Hence the negligible population of other bollworms and fluctuations in the abiotic factors (Lal, 1996) might be attributed to the outbreak of *Helicoverpa armigera* on cotton crop during 1997 at and around Nagpur.

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Table 1. The meteorological data in relation to the average per cent boll demage in cotton by *H. armigera*

Year	March						April						May						June						July					
	A	B	C	D	E	F	A	B	C	D	E	F	A	B	C	D	E	F	A	B	C	D	E	F	A	B	C	D	E	F
1992	-	-	41.10	13.20	37.37	-	-	-	42.00	21.40	45.80	-	4.00	2	44.30	24.10	51.50	-	92.80	7	44.00	25.40	57.40	-	205.00	13	38.60	23.76	74.20	-
1993	58.50	6	35.45	15.00	59.00	-	-	-	47.56	20.70	49.60	-	10.00	3	45.00	26.20	56.00	-	173.60	13	44.00	23.40	68.20	-	233.60	16	33.10	22.70	84.00	-
1994	-	-	39.90	14.20	58.00	-	5.40	3	41.20	20.10	55.00	-	-	-	45.20	24.70	52.40	-	196.00	17	42.10	23.60	79.20	-	684.00	22	30.70	23.00	91.40	-
1995	62.20	8	37.50	17.00	64.50	-	6.50	2	42.30	18.90	47.60	-	1.60	1	45.40	22.10	47.50	-	137.00	8	46.90	20.10	54.50	-	200.70	19	34.70	21.70	82.20	-
1996	10.30	3	40.90	17.20	50.50	-	38.80	4	40.90	20.10	40.10	-	-	-	44.60	26.80	25.50	-	37.60	4	42.70	23.60	58.20	-	279.90	15	34.70	19.20	82.80	-
1997	-	-	37.30	13.30	42.50	-	48.60	7	40.10	20.80	48.60	-	10.60	6	43.10	19.20	37.20	-	8.00	8	40.70	34.00	63.80	-	188.50	15	34.00	24.20	80.40	-
1998	34.20	4	32.95	16.72	58.50	-	16.80	3	39.26	22.12	47.00	-	24.00	2	42.90	26.60	41.75	-	111.80	8	40.50	27.80	45.30	-	85.90	11	33.50	24.48	80.20	-

Year	August						September						October						November						December					
	A	B	C	D	E	F	A	B	C	D	E	F	A	B	C	D	E	F	A	B	C	D	E	F	A	B	C	D	E	F
1992	306.00	20	32.50	21.90	89.75	2-3	90.40	4	34.10	22.60	77.60	4-5	8.20	3	30.30	17.80	68.25	7-10	4.40	2	32.10	9.90	65.00	12-15	-	-	28.66	9.32	65.30	15-17
1993	299.40	17	33.30	22.50	88.00	2-3	320.90	18	31.40	22.20	86.20	2-3	115.20	8	32.20	20.70	83.25	4-7	0.60	1	30.90	11.00	72.50	10-15	2.00	1	27.00	9.74	70.20	15-17
1994	409.60	22	30.30	22.00	87.25	1-2	226.00	6	33.30	22.00	83.20	2-3	132.00	2	32.10	17.50	79.50	5-7	13.00	1	30.50	13.20	74.00	12-15	-	-	28.48	10.60	74.40	15-19
1995	394.10	20	31.80	21.60	83.75	2-3	98.10	7	33.00	21.60	81.80	2-3	32.60	4	34.40	15.00	71.50	7-10	-	-	31.30	14.00	60.50	12-15	-	-	29.10	13.44	76.20	15-20
1996	301.90	23	30.90	20.70	85.50	2-3	128.80	12	33.80	21.30	81.80	2-3	99.30	7	32.20	17.80	72.70	4-7	16.80	1	31.40	11.80	66.20	10-12	-	-	28.30	10.07	58.00	13-17
1997	271.00	14	33.80	23.20	77.70	2-4	291.70	14	33.20	22.20	82.00	4-5	96.70	8	33.80	18.10	75.00	10-17	100.05	4	31.40	18.10	77.00	20-32	123.70	13	24.80	16.30	88.40	30-35
1998	229-70	17	32.07	23.32	87.25	1-2	383.90	19	31.64	22.34	86.00	2-3	25.80	4	32.62	22.45	75.50	4-7	73.60	6	29.10	15.57	77.75	8-10	-	-	27.92	9.48	65.50	12-17

A = Total rainfall in (mm), **B** = No. of rainy days, **C** = Av. max. temperature ^{0}C, **D** = Av. min. temp.^{0}C, **E** = Av. morning RH%, **F** = Av. Per cent boll damage

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Nutrient Utilization in Goats Fed on Anjan (*Hardwickia binata roxb.*) Tree leaves

Anjan is a deciduous tree grows up to 120 feet in height, thrives well in a dry climate, rooted on dry shallow soil and rocky ground. The tree leaves are palatable to goats and commonly used as a cheap conventional fodder source for livestock. The present investigation was undertaken to study the nutritive value of Anjan tree leaves in Osmanabadi goats.

Six Osmanabadi bucks (19.33 ± 0.61 kg.) were solely stall fed on Anjan tree leaves for 100 days. The digestibility trial was conducted following 7 days collection period after 49 days of experiment. The record of daily feed consumed and weekly body weight gain was maintained throughout the experiment. The samples of feed and faeces were analyzed for proximate chemical composition as per AOAC (1990). The data collected during the experiment for weekly dry matter intake, crude protein intake and body weight gain were analyzed statistically as per Snedecor and Cochran (1967).

Chemical composition, digestibility and growth performance in goats fed on Anjan tree leaves are presented in Table 1. The proximate chemical composition of Anjan tree leaves was DM 36.68, CP 12.76, EE 2.80, CF 29.45, NFE 48.24, Ash 6.75, Ca 2.20, P 0.10 per cent. The results obtained in the present study for chemical composition of Anjan tree leaves are similar to that reported by Mehta and Bhaid (1984). The values for Ca and P content are in agreement with that reported by Singh *et al.*, (1994) as 2.26 and 0.12 per cent, respectively.

The digestibility coefficients of different nutrient of Anjan tree leaves were dry matter 54.39 ± 0.61, crude protein 42.37 ± 0.19, ether extract 45.33 ± 0.79, crude fiber 47.02 ± 1.07 per cent and nitrogen free extract 63.08 ± 0.13 per cent for goats. The results on dry matter digestibility are in agreeement with the value of 52.41per cet reported by Singh *et al.*, (1994) in goats fed *Hardwickia binata Roxb* tree leaves. However, Mehta and Bhaid (1984) have reported lower values for dry matter digestibility of 47.3 5 per cent in goats than the present findings. Singh *et al.*, (1994) reported slightly higher value (44.53%) for crude protein and (48.96%) ether extract digestibility of *Hardwickia binata Roxb* in goats than the present study whereas, Mehta and Bhaid (1984) reported much lower values (37.82%) for crude protein and (23.37%) for ether extract digestibility. The observation on digestibility of cude fibre was lower than reported by Singh *et al.*, (1994) as (50.21%). The digestibility of NFE coroborates with Singh *et al.*, (1994).

The mean DCP and TDN was found to be 5.40 ± 0.02 and 52.51 ± 0.32 per cent, respectively. Prasad *et al.*, (1974) and Singh *et al.*, (1994) reported lower values of DCP in Anjan leaves for goats as 4.26 and 3.99 per cent respectively. The daily voluntary intake varied significantly ($P<0.01$) and it was 1981.69 ± 49.35 g/d which was much higher than 1142.50 ± 21.0 g per day, reported by Singh *et al.*, (1994). The DMI per 100 kg body weight through Anjan leaves was 3.87 ± 0.14 kg corroborates with Mehta and Bhaid (1984). The average daily gain was 45.00 ± 0.04 g, indicates that the Anjan leaves as a sole feed serves the purpose of maintenance and growth.

Table 1. Chemical composition, digestibility and performance in goats of Anjan tree leaves

Chemicals composition	
DM (%)	36.68 ± 1.04
CP (%)	12.76 ± 0.24
EE (%)	2.80 ± 0.09
CF (%)	29.45 ± 1.77
NFE (%)	48.28 ± 2.06
Ash (%)	6.75 ± 0.96
Ca (%)	2.20 ± 0.12
Digestibility (%)	
DM	56.36 ± 1.40
CP	42.37 ± 0.19
EE	45.33 ± 0.79
CF	47.02 ± 1.07
NFE	63.03 ± 0.13
Nutritive value	
DCP (%)	5.40 ± 0.02
TDN (%)	52.51 ± 0.32
Performance of goats	
Daily voluntary intake (g)	1981.59 ± 49.35
DMI 100^{-1} kg body weight (kg)	3.87 ± 0.14
Average daily gain (g)	45.00 ± 0.04

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Structural Changes in the Demand for Food in Maharashtra

Household income and food prices strongly influence the pattern of food consumption. However, rapid structural transformation may have an important influence on food demand in the long run. Most previous demand studies have ignored the possible influence of structural shifts on food demand.

Per capita cereals consumption decline over the past three decades while the consumption of fruits, vegetable, meat, fish, eggs and dairy product increased. More specifically, the objectives of the study are : 1) To study the consumption expenditure pattern in Maharashtra state 2) To analyze the shift in consumption pattern overtime for major food and non-food.

The study was based on the secondary data collected by the National Sample Survey Organization (NSSO) reports, Government of India. The NSSO conducts annual as well as quinquennial survey are broad based (large sample) and thus are more reliable. The present study pertained to 1988 to 1999 for Maharashtra state The shift in consumption pattern was studied using Kendall's Rank Correlation coefficient.

Consumption expenditure

In order to study the change in consumption expenditure in rural and urban households the data on consumption expenditure at different point of time. Table 1 revealed that the total per month per capita expenditure incurred by the family on various items was Rs. 170.99 in 1998-89 and which increased to Rs. 505.92 in 1999-2000 in rural households. As regards urban household, it was Rs. 311.76 in 1998-99 and increased to Rs. 1025.44 in 1999-2000. The share of food items in total expenditure in rural households was 61.14 per cent in 1988-89 reduced to Rs. 53.79 per cent in 1999-2000, while the share of food items in total expenditure in urban household was 54.99 per cent which reduced to 43 per cent in 1999-2000. The expenditure share on cereals decreased from 21 to 17 per cent over a period. This might be due to increasing urbanization and economic growth. So also due to change in taste and preference on account of availability of varied variety of food items. Among different non-food items, the expenditure on fuel, light, clothing, housing, education and medical treatment increased over a period of time in rural and urban sector. In general, results of the study indicated that the share of expenditure on food items decreased while that of non-food items increased over a period in rural and urban area.

Shift or deviation in consumption pattern

The present investigation was to examine the shift or deviation in the consumption pattern in rural and urban households over a period of time. Food and non-food items of consumption were ranked on the basis of proportion of expenditure incurred to total expenditure. The rank of each items of consumption is presented in Table 2. The coefficient of concordance for assessing the overall agreement among consumption expenditure pattern at five stage worked out to be 0.87 and 0.88 and significant at one per cent in rural and urban households respectively. This indicates that allocation of consumption expenditurence is almost fixed over the period of

Table 1. Kendall's rank correlation coefficient between consumption expenditure pattern at different stages in M.S.

Consumption pattern during	Correlation with consumption pattern of the stage				
	1987	1988	1992	1996	1999
Rural area :					
1987	1	0.97	0.84	0.73	0.66
1988		1	0.91	0.80	0.74
1992			1	0.74	0.70
1996				1	90
1999					1
Urban area					
1987	1	0.92	0.96	0.69	0.64
1988		1	0.92	0.86	0.82
1992			1	0.73	0.74
1996				1	0.92
1999					1

Table 1. Average per capita expenditure shares (per cent) in rural and urban household

S.N.	Items	1988-99	1992-93	1996-97	1999-2000	1988-89	1992-93	1996-97	1999-2000
		Rural households				Urban households			
1.	Cereal	20.73	22.23	19.39	17.38	12.04	12.67	11.63	9.78
2.	Gram	0.12	0.08	0.05	0.08	0.17	0.17	0.10	0.07
3.	Cereals ubtitute	0.50	0.44	0.37	0.40	0.27	0.26	0.23	0.15
4.	pulses	5.47	6.23	6.67	4.74	3.66	3.22	3.35	2.66
5.	Milk and Milk product	6.31	6.23	6.67	5.92	9.62	9.99	8.89	708
6.	Edible oil	5.53	6.50	5.99	4.29	5.19	6.05	5.05	3.30
7.	Meat,eggs and fish	3.45	3.03	3.21	2.88	3.75	3.89	3.64	2.79
8.	vegetable	4.41	4.43	4.83	5.12	4.56	4.54	5.21	4.57
9.	Fruits and nuts	2.69	2.87	2.51	2.73	3.28	3.20	2.95	2.77
10.	Sugar	4.02	3.63	3.95	2.95	2.42	2.06	2.18	1.49
11.	Salt	0.13	0.16	0.18	0.22	0.11	0.13	0.13	0.14
12.	spices	3.35	3.23	2.56	2.74	1.86	1.93	1.46	1.55
13.	Beverage	4.44	5.03	4.25	4.34	8.06	7.33	6.84	6.65
	Total food items	61.14	62.93	8.55	53.79	54.99	55.44	51.66	43.00
14.	Pan,tobacco and intoxicant	3.10	2.24	2.54	2.25	2.60	1.83	1.75	1.50
15.	Fuel and light	7.57	7.46	7.05	7.21	6.39	6.27	6.37	6.33
16.	Clothing	7.95	6.62	8.34	7.41	6.38	5.30	6.06	5.68
17.	Food wear	0.56	0.60	0.74	1.06	0.82	0.74	0.95	1.08
18.	Miscellaneous goods	14.84	17.36	11.17	14.84	23.10	22.76	15.88	23.44
19.	Housing rent	0.64	0.72	1.11	1.69	3.06	2.28	4.59	5.08
20.	Educaion	0.42	0.08	1.67	1.67	0.51	0.63	5.41	3.86
21.	Medical treatment	-	-	5.95	7.44	-	-	3.67	5.36
22.	Durable goods	3.78	1.99	2.88	2.64	2.05	4.65	3.66	4.67
	Total non-food items	38.86	37.07	41.45	46.21	45.01	44.56	48.34	57.00
	Total	100	100	100	100	100	100	100	100
	Total consumption expenditure	170.99	250.60	350.73	505.32	311.76	462.50	660.82	1025.44

Table 2. Rank assigned to the different ites and consumption on the basis of per cent coverage in total consumption expenditure in rural and urban area

S.N. Commodity	1987		1988		1992		1996		1999		rank total		Expected rank total	
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
1. Cereal	1	2	1	2	1	2	1	2	1	2	5	10	57.50	57.50
2. Gram	21	20	21	20	20	20	22	22	22	22	106	104	57.50	57.50
3. Cereals ubtitute	18	19	18	19	18	19	20	20	20	94	94	97	57.50	57.50
4. pulses	8	10	7	10	7	11	9	14	8	15	39	61	57.50	57.50
5. Milk and Milk product	6	3	5	3	6	3	5	3	6	3	28	15	57.50	57.50
6. Edible oil	7	6	6	7	5	6	6	9	10	12	34	40	57.50	57.50
7. Meat,eggs and fish	12	12	12	9	12	10	12	13	12	13	60	57	57.50	57.50
8. vegetable	10	8	9	8	9	9	8	8	7	10	43	43	57.50	57.50
9. Fruits and nuts	15	11	15	11	13	12	16	15	14	14	73	62	57.50	57.50
10. Sugar	11	14	10	14	10	14	11	16	11	18	53	76	57.50	57.50
11. Salt	20	21	20	21	19	21	21	21	21	21	102	105	57.50	57.50
12. spices	13	16	13	16	11	15	14	18	13	16	64	81	57.50	57.50
13. Beverage	9	4	8	4	8	4	10	4	9	4	44	20	57.50	57.50
14. Pan,tobacco and intoxicant	14	15	14	13	14	16	15	17	16	17	73	78	57.50	57.50
15. Fuel and light	4	5	4	5	3	5	4	5	5	5	20	25	57.50	57.50
16. Clothing	5	7	3	6	4	7	3	6	4	6	19	32	57.50	57.50
17. Food wear	16	17	17	17	17	17	19	19	19	19	88	89	57.50	57.50
18. Miscellaneous goods	2	1	2	1	2	1	2	1	2	1	10	5	57.50	57.50
19. Housing rent	17	13	16	12	16	13	18	10	17	8	84	56	57.50	57.50
20. Educaion	19	18	19	18	21	18	17	7	18	11	94	72	57.50	57.50
21. Medical treatment	22	22	22	22	22	22	7	11	3	7	76	84	57.50	57.50
22. Durable goods	3	9	11	15	15	8	13	12	15	9	57	53	57.50	57.50

Rural Area - Coefficient of concordance 'C' = 0.87*
Urban area - Coefficient of concordance 'C' =0.88**
** Significant at 1 per cent level.

13 years study. Hence, it could be concluded that there was no change in the consumption pattern over a period of study with minor change for some items.

Agreement of consumption expenditure pattern between the year :

Rank correlation between consumption expenditure pattern at different point of time was worked out in Table 3. The different stages of correlation coefficient were estimated from the ranking. This indicates there is high degree of correlation of the consumption expenditure pattern of every stage with consumption expenditure pattern of all the subsequent stages. This indicates that there was no shift in the consumption expenditure pattern in M.S. However, the correlation with consumption expenditure pattern of the stage of 1996 and 1999 showed relatively lower correlation thereby indicating short term changes.

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Income, Saving and Consumption Pattern of Households

Food is basic human necessity and sensitive to income and price changes. Thus, parameters describing consumer behaviour help consumer to take rational decision in allocation of households' budget to food and non-food commodity. There is no doubt the household's income and food prices strongly influence food consumption pattern. Determination of income and consumption pattern is the need of the day, therefore, the study on income, saving and consumption pattern of households was undertaken with specific objectives : 1) To study the consumption expenditure pattern of selected households 2) To study the income and saving pattern of selected households 3) To examine the relationship between income and consumption.

The study was based on primary data, collected from Akola district of Western Vidarbha. The urban households were selected from Akola city while rural households from four villages of Akola Tehsil namely Kanheri, Alanda, Gorvha and Dhotardi. A sample of 100 urban households and equal number of rural households were selected. After selecting sample the rural and urban households were stratified in to four groups on the basis of level of income i.e. below Rs. 15500 (Group I), Rs. 15500-25000 (Group II), Rs. 25000 to 50000 (Group III) and Above Rs 50000 (Group IV). Simple tabular analysis was used for accomplishing the first two objectives and Keynes's consumption function was used to determine income and consumption relationship.

$$C = a + bI$$

Where, C = Consumption expenditure per household.
I = Disposable Income.
a = Intercept term i.e. the amount of consumption expenditure at zero level of income
b = Regression coeficient of C on I.

Family budget

Information on per family expenditure incurred on various items of consumption is presented in Table1. The share of food items worked out to 60.75 per cent of the total expenditure in rural area and 48.64 per cent in urban area, respectively. Proportion of expenditure on clothing, housing, fuel and light and education were 8.87, 3.83, 3.70 and 5.46 per cent, respectively on various items of consumption mentioned above in urban area. A comparison of budget shares of non-food items was 39.25 per cent in rural area and 51.36 per cent in urban area. Amongst the different income group of households, per family total expenditure on food items decreased with the increase in income of the families. This was noticed in rural as well as urban area. On the other hand expenditure on non-food items increased with the increase in income. Results of the study conforms the Engles law of consumption.

Income and saving pattern of selected households

Table 2 revealed that, the per family average annual grossincome from different sources worked out to Rs. 44187.30 in rural area and Rs. 51897.12 in urban area. Proportion of expenditure on consumption and saving worked out to 58.12 and 41.88 per cent in rural households while that of 58.25 and 41.75 per cent in urban households.

Intergroup comparison indicates that relatively more consumption expenditure was incurred by Group-I (91.82% and 92.69%), followed by Group-II (85.54% and 83.14%), then Group-III (82.16% and 79.14%), and Group-IV (40.47% and 44.42%) in rural and urban households. The study observed that as the income increased, expenditured on consumption decreased in both the households. Maximum saving was observed in Group-IV (59.33 % in rural household and 55.58 % inurban household) because of the larger income households substantial amount of their saving for purchanse of capital good like farm machinery for irrigation structure, equipment, building and luxurious article, etc.

Income-consumption relationship

On critical examination of Table 3, it was observed that at overall level, the independent variable explained 36 per cent of total variation in rural area and 85 per cent in urban area. Intergroup total variation ranged between 32 to 83 per cent in rural area and 51 to 72 per cent in urban area. The coefficient of determination (R^2) was observed more in Group-1 i.e. 83 and 71 per cent in rural and urban area, respectively. The regression coefficient of consumption expenditure was found to be highly significant at one per cent level in all groups. In rural households of Group-IV, value of regression coefficient was negative and significant. This indicates that with the increase in income of a family the consumption expenditure would decrease. In general, the consumption expenditure of selected households was significantly influenced by the annual gross family income.

Table 1. Per family expenditure on different items of consumption

(Rs. Month^{-1})

Item	Income group									
	I		II		III		IV		Over all	
	Expenditure	per cent	Expenditure	per cent	Expenditure	per cent	Expenditure	per cent	Expenditure	per cent
Rural household										
Food	718.71	74.97	1057.31	71.54	1554.13	61.17	1870.81	52.21	1300.14	60.75
Clothing	58.33	6.08	128.33	8.68	185.00	7.28	473.33	13.21	211.25	9.87
Cosmatic	3.87	0.40	9.33	0.63	46.50	1.83	66.00	1.84	31.43	1.47
Housing rent	20.67	2.16	27.17	1.84	60.67	2.39	220.67	6.16	82.29	3.85
Fuel and light	19.25	2.01	52.00	3.52	102.67	4.04	142.67	3.98	79.15	3.70
Religious function	4.83	0.50	10.42	0.71	33.17	1.31	54.67	1.53	25.77	1.20
Education	28.17	2.94	42.67	2.89	173.33	6.82	223.33	6.24	116.88	5.46
Entertainment	6.53	0.68	7.83	0.53	21.47	0.84	31.67	0.88	16.88	0.79
Medical Treatment	18.77	1.96	27.33	1.85	55.67	2.19	73.33	2.05	43.78	2.05
Journey tours	10.83	1.14	13.42	0.91	63.15	2.49	62.33	1.74	37.44	1.75
Others	68.67	7.16	102.14	6.91	244.88	9.64	364.12	10.16	195.02	9.11
Non-food	239.92	25.03	420.64	28.46	986.51	38.83	1712.12	47.79	839.89	39.25
Total expenditure	958.62	100	1477.95	100	2540.64	100	3582.93	100	2140.03	100
Urban household										
Food	755.28	71.21	986.21	64.37	1376.99	51.26	1780.72	37.14	1225.20	48.64
Clothing	62.00	5.85	138.33	9.03	196.67	7.32	331.00	6.91	182.00	7.23
Cosmetic	7.25	0.68	14.53	0.95	62.17	2.32	87.67	1.82	42.90	1.70
Housing rent	28.33	2.68	39.17	2.55	173.00	6.44	781.67	16.29	255.54	10.14
Fuel and light	39.00	3.68	83.00	5.42	150.17	5.59	465.48	9.71	184.41	7.32
Religious function	4.17	0.39	10.75	0.70	42.50	1.58	154.00	3.21	52.85	2.10
Education	35.67	3.36	94.00	6.14	198.67	7.40	326.33	6.81	163.67	6.50
Entertaiment	6.42	0.61	7.92	0.51	23.33	0.87	75.63	1.58	28.33	1.12
Medical treatment	24.73	2.33	29.17	1.90	103.67	3.86	170.83	3.56	82.10	3.26
Journey tours	11.17	1.05	15.60	1.02	68.82	2.56	149.33	3.11	61.23	2.43
Others	86.57	8.16	113.47	7.40	290.06	10.80	473.08	9.87	240.79	9.56
Non-food	305.31	28.79	545.94	35.63	1309.06	48.74	3015.08	62.87	1293.83	51.36
Total expenditure	1060.59	100	1532.15	100	2686.05	100	4795.74	100	2519.03	100

Table 2. Per family income, consumption expenditure and saving of selected house hold (Rs. year^{-1})

Income groups	Income	Consumption expenditure	Saving
Rural households:			
I	12666.00	11503.44	1162.56
		(90.82)	(9.18)
II	20733.20	17735.28	2997.89
		(85.54)	(14.46)
III	106242.00	42995.116	63246.84
		(40.47)	(59.53)
IV	44187.30	25680.36	18506.94
		(58.12)	(41.88)
Urban households:			
I	13732.00	12729.00	1003.00
		(92.69)	(7.31)
II	22115.60	18385.85	3729.78
		(83.14)	(16.86)
III	42186.00	32232.85	9951.26
		(76.41)	(23.59)
IV	129554.88	57548.88	72006.00
		(44.42)	(55.58)
Overall	51897.12	30228.36	21668.76
		(58.25)	(41.75)

Figures in parenthesis are percentage to total income.

Table 3. Estimated consumption expenditure function for selected households

S.N.	Income groups	a	b	R^2
1	**Rural households**			
	Group I	-4760.75	1.2840	0.8327
	Group II	2910.47	0.7150	0.5014
	Group III	6468.93	0.6472	0.6088
	Group IV	4748.70	-0.0420	0.2334
	Overall	18889.16	0.1550	0.3660
2	**Urban household**			
	Group I	-327.40	0.9479	0.7120
	Group II	-11968.18	1.3700	0.5204
	Group III	-6785.76	0.9171	0.5152
	Group IV	29686.96	0.2140	0.7005
	Overall	13583.45	0.3190	0.8570

All regression coefficient and coefficient of determination were found to be statistically significant at 1 per cent level.

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Unusual Phytophagous Behaviour of Lady Bird Beetle, *Cheilomenes sexmaculatus* F.

Grubs and adults of coccinellid lady bird beetles are known for feeding on soft bodied insects, preferably aphids on field, vegetable and fruit crops (Katole and Sarode, 1995 and Mathur and Singh, 1997). As such, these are being explored in the post management as bio-control agents (Taley *et al.,* 1988 and Singh, 1997). However, unusual phytophagous behaviour of these coccinellid adults of *Chielomenes sexamaculatus* L. was observed on pigeonpea leaves in absence of aphids or other host insects.

Since, the adults of lady bird beetles were observed feeding on pigeonpea leaves during dry spell of October 1996 and 1997, their leaf feeding was critically and constantly watched by the authors in person for ours together during 3rd week of October in 1996 and 1997 at Yavatmal and by third author during 1997 at Akola locations, in Maharashtra. Other crops surrounding pigeonpea were also observed for LBB adults and their phytophagous or predacious feeding, if any. Whether data during dry spell and that of preceeding and succeeding meteorological weeks were also noted (Table 1). Beetles were identified from ICRISAT pigeonpea and chickpea identification book (Reed *et al.,* 1989).

Adults of lady bird beetle, identified as *Chielomenes sexmaculatus* L. were present on pigeonpea crops without thier grubs. Adults were observed feeding on the leaves. Beetles preferred succulent and young leaves. Feeding was evident by their mandibles forming round, irregularly round or oblong 1 to 2 holes leaf^{-1} measuring about 2-3 mm. It was noted that inner margin of the hole started browing and turned completely brown after feeding was over. About 7-10 minutes were required to feed out a hole. This feeding behaviour was observed throughout 3rd week of October in both the years at Yavatmal and in 1997 at Akola.

Grubs of LBB and their host insects were not observed on pigeonpea. LBB adults or grubs and their host insects were also not observed on the surrounding crops like cotton, maize, sorghum, soybean etc. It was noted that during this dry spell only pigeonpea had young and succulent leaves than surrounding crops. There was 2 to 6^{0}C increased temperature and 24 to 29 per cent low humidity during dry spell (Table 1).

These observations indicated that adults of *Cheilomenes sexmaculatus* F. under dry spell and in absence of its host insects, might have changed themselves to phytophagous behaviour temporarily. Such phytophagous behaviour could not come across in the literature, hence carries significant importance. As such, this may be the first record of its type.

Table 1 : Weather conditions at Yavatmal during October 1996 and 97.

Month year	M.W.	period	Rainfall	Rainy	Temp. (^{0}C)		Humidity (%)	
			(mm)	days	Max.	Min.	Mor.	Eve.
Oct. 1996	40	1-7	46.1	4	28.6	25.2	77	77
	41	8-14	0.0	0	30.9	21.0	60	52
	42	15-21	0.0	0	30.2	19.4	61	48
	43	22-28	42.7	3	29.5	21.6	84	69
		Variations			(+)2.3	(+)5.8	(-)24	(-)29
Sept./Oct. 97	39	24-30	16.6	2	31.1	22.7	81	69
	40	1-7	0.0	0	31.0	23.1	63	52
	41	8-14	0.0	0	32.5	25.4	54	47
	42	15-21	2.7	1	32.2	21.3	60	57
	43	22-28	14.0	2	28.7	20.5	78	72
		Variation			(+)3.8	(+)4.9	(-)27	(-)25

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Perception of Farmers Regarding Utility and Coverage of Agricultural Telecast

Television plays an important role in the field of agriculture by informing the farmers about the new techniques. It helps to narrow the gap between research results and their application by the farmers. The informative agricultural programme under 'Bhuiya Ke Goth' is telecast from Raipur Doordarshan Kendra in Chhattisgarh State.

The study was carried out in purposively selected Raipur district of Chhattisgarh state. Twenty one villages from three blocks of Raipur district were selected randomly. A list of TV viewing farmers was prepared with the help of 'Sarpanch' of particular village through personal contact. From each selected village eight TV viewing farmers were selected. Thus a sample of 168 farmers were selected randomly. The extent of utility perception and coverage of agricultural programme under 'Bhuiya ke Goth' were ascertained in terms of coverage and utility perception indx. The utility perception was assessed in term of the usefulness, applicability, timeliness, completeness and innovativeness of agricultural programme telecast.

The perception about utility of agricultual programme (Table 1) brings into focus that 61.90 per cent of the respondents reported medium level utility of agricultural programmes. High level utility of agricultural programmes was found only to 20.84 per cent of the respondents. The observations of Bhople and Dhapke (1992) and Laharia and Joshi (1992) end support to the findings of the study.

Regarding coverage of agricultural programme telecast (Table 1), 64.28 per cent of the respondents reported average level coverage of subject matter. Good level coverage of agricultural programmes was reported by only 20.24 per cent of the respondents.

The variables like education, social participation, mass media exposure, frequency of viewing, economic motivation and attitude were observed to be significant in relationship with utility of agricultural programme telecast (Table 2). However,

Table 1. Distribution of respondents according to utility perception and coverage of agricultural programme telecast

Category		
Utility perception	Frequency	Per cent
Low	29	17.26
Medium	104	61.90
High	35	20.84
Coverage		
Poor coverage	26	15.48
Average coverage	108	64.28
Good coverage	34	20.24

Table 2. Relationship of selected characteristics of respondents with the utility perception and coverage of agricultural programme telecast

Characteristics	Correlation coefficient values	
	Utility perception	Coverage
Age	0.188*	0.112NS
Education	0.197*	0.171*
Caste	0.115NS	0.053NS
Family type	0.028NS	0.092
Land holding	0.122NSS	0.112NS
Annual income	0.137NS	0.088NS
Social participation	0.235**	0.181*
Extension contact	0.167*	0.178*
Mass media exposure	0.203**	0.219**
Cosmopoliteness	0.103NS	0.158*
Frequency of viewing	0.242**	0.269**
Scientific orientation	0.184*	0.165*
Economic motivation	0.239**	0.208**
Attitude	0.201**	0.179*

** Significant at 0.01% level of probability, * Significant at 0.05 % level of probability,
NS - Non significant

caste, family type, land holding, annual income, cosmopoliteness were positive but non-significantly related with utility of agricultural programme telecast. The findings show that higher education, social participation, mass media exposure, frequency of viewing, economic motivation and attitude broaden the horizon of the individuals and perceived more usefulness of telecast programmes.

Mass media exposure, frequency of viewing and economic motivation had established positive and significant relationship with coverage of agricultural programme telecast (Table 2). While age, cast, family type, land holding and annual income were positive but non significant in relationship with coverage of agricultural programme telecast. Those who had higher mass media exposure, frequency of viewing and economic motivation felt that the coverage of the agricultural programme telecast from farmer's point of view was good and vice-versa.

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Performance Evaluation of Solar Photovoltaic Tracking System using Stepper Motor

The most useful way of harnessing solar energy is by directly converting it into electricity by means of solar photovoltaic cells. A PV system may involve the cells, energy storage component, power conditioning unit and control equipment (Green, 1982). It has been found that after comparing the experiment results of power output of a sun tracking solar cell with that of a stationary solar cell, the tracking was found to produce 30 per cent more electrical energy in the course of a relatively clear day than with the stationary cell (Mosher *et al.*, 1977). Kharche(1997) developed a PV tracking system, which consumed a power of 12 W using operational amplified, comparator and d.c. motor components. The present study was undertaken with an objective to test the performance of solar PV tracking system using a stepper motor with a load sprayer. The solar PV system consists of following components.

I) Solar PV module

The specifications of the module used for tracking were as follows.

Solar PV Module (BHEL)	: L-1235
Weight	: 5 kg
Open circuit voltage	: 21 V
Short circuit current	: 2.4 A
Dimensions	: 1015 x 408 x 40 mm.

II) Supporting unit for the PV module consists of

a) Stand b) Half circular pipe c) Clamp d) Shaft e)Bearing

III) Mechanical power transforming unit

a) Half circular gear

b) Shaft with gear, with one side having spined gear

The Mechanical power transforming unit consisted of a gear train (worm and worm wheel and full and half circular gears) having a reduction ratio of 1:1.50. The motor used in the tracking system was 4 pole stepper motor. The shaft of the motor used in the present study moved in steps of 2°.

IV) Electronic and electrical unit

a) Printed circuit boards with integrated circuit chips

b) Stepper motor

c) Capacitor

The electrical unit consisted of power supply regulator, stepper motor comparator and driving unit etc. The function of the power supply regulator was to bring down the voltage of 21 V, which was generated by the PV module, two voltages of 12 V and 5V. Two window comparators, consisting of light dependent resistor(LDR) placed at the lower closed bottom ends of the two PVC pipes, were placed apart on the edge of the panel. In the transistor driver circuit a total of 8 transistors were used to give the drive to the steppe motor. Transistor, four of 2N 2222A and the other four of the KSP 2222A specifications were used in the driving unit.

The performance of the tracked PV system using the stepper motor with a load sprayer was done and it was found that a specific setting of the window comparator was necessary. With the help of the CRO, the frequency of current passing through the motor was found to be approximately 250 cycles sec^{-1}. Using the digital photo-type tachometer the rotational speed of the motor shaft was found to be 95 rpm. The reading of voltage, current and solar lux were noted using multimeter and luxmeter from 8.00 AM till 4.00 PM at one hour intervals. The angle through which the module traveled per hour was also noted down. The open circuit voltage (V_{oc}) varied from 10.5V to 18.6V with a maximum of 18.6V at 12.00 AM at 61300 lux and the short circuit current (I_{sc}) varied from 1.1A to 1.8A with a maximum of 1.8A at 12.00 AM (Table 1)

The voltage (12V) and current (2.8A) supplied to the motor of the sprayer was constant, the batteries generate it. It was seen that solar energy was harnessed for operating sprayer and it was more advantageous to use a stepper motor to tract a PV module. Tracking system was more sensitive to the variation of solar radiation through the day. Also

Table 1. Observations taken for PV module during tracking when load used was sprayer

S.N.	Times	Lux	Angle	V_{oc} (V)	I_{sc} (A)	Voltage to motor(V)	Current supplied to motor (A)
1	08.00 am	14000	32°	10.5	1.1	12	2.8
2	09.00 am	24200	43°	13.3	1.2	12	2.8
3	10.00 am	51500	60°	14.1	1.3	12	2.8
4	11.00 am	56500	75°	15.2	1.4	12	2.8
5	12.00 am	61300	90°	18.6	1.8	12	2.8
6	01.00pm	53500	105°	17.5	1.5	12	2.8
7	02.00pm	50100	116°	16.4	1.3	12	2.8
8	03.00pm	33000	130°	15.3	1.1	12	2.8
9	04.00pm	32500	145°	14.5	1.1	12	2.8

the system consumed a very low power of about 6W only. It was also found that the panel tilted through an angle of 15° for every hour, using the tracking system. The tracking system ensured a constant supply of voltages to keep the sprayer in a working condition throughout the day. The sprayer also gave the maximum discharge during the noon and a few hours afternoon. (Tayade, N.H. and Regi Kuttappan , 1999)

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Threshability of a Plot Thresher For Pigeonpea

The pigeonpea (Variety C - 11) samples were threshed on plot thresher at 14 per cent moisture content (db) through the thresher operated at 11.5 m s^{-1} cylinder speed (650 rpm) and at 25, 30 and 35 mm concave clearances. The resulting observations of the tests and their analysis have discussed (Katkhede *et al.*, 2003)

Percentage un-threshed grain

The percentage of unthreshed seed was found to be 3.96, 3.46 and 7.56 at concave clearances of 25, 30 and 35 m respectively (Table 1). As the clearance was increased from 25 to 30 mm the percentage of un-threshed seed decreased. Further increasing clearance increases the percentage of un-threshed grain. This may due to the fact that maximum clearance make the layer of crop dense which reduces the amount of separation of grains.

Percentage of broken grain

The percentages of un-threshed seed varied from 0.246 to 2.63 (Table 1). Thus at minimum clearance of 25 mm, the average percentage of broken seed was maximum i.e. 2.63 per cent and at maximum clearance of 35 mm, the average percentage of broken seed was minimum i.e. 0.246 per cent.

As the clearance was increased, the percentage of broken seed decreased. This may due to the reason that minimum clearance, the crop layer is thinner and hence contact between cylinder and crop is more. This lead to more impact of pegs on seed and hence more breakage of seed.

Threshing efficiency

At minimum clearance threshing efficiency initially increased, further increase in clearance decreased threshing efficiency (Table 1). This may due to fact that at maximum clearance (35 mm) there were more un-threshed seeds than at minimum clearance (25 mm). While at 30 mm concave clearance, un-threshed seed were very less than at other two clearances used and hence threshing efficiency was found maximum at 30 mm clearance.

The average manual threshing efficiency was found to be 94.53 per cent and the average threshing efficiency by thresher was obtained 92.96 per cent. Though threshing efficiency of plot thresher was observed to be low over manual threshing, however, it reduces labour requirement, saves time and drudgery involved in manual threshing operation.

The study concluded that the maximum threshing efficiency for pigeonpea seed at 14 per cent moisture content (db) was obtained at maximum concave clearance used i.e. 35 mm and at 11.5 m s^{-1} cylinder speed with minimum percentae of broken seed.

Table 1. Threshing performance of plot thresher at 14 per cent moisture content (db) of pigeonpea

S.N.	Concave clearance (mm)	Speed (rpm)	Replication	Un-threshed seed (%)	Broken seed (%)	Threshing efficiency (%)
1.	25	650	1st	4.1	2.5	95.9
			2nd	4.0	2.6	96.0
			3rd	3.8	2.8	96.2
2.	30	650	1st	3.7	1.46	96.3
			2nd	3.3	1.20	96.7
			3rd	3.4	1.20	96.6
3.	35	650	1st	7.3	0.29	92.7
			2nd	7.4	0.27	92.6
			3rd	8.0	0.20	92.0
			Avg.	7.56	0.246	92.43

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Effect of Plant Population on Growth and Yield of Hirsutum Cotton Variety PKV Rajat Under Drip Irrigation System

Being a cash crop, Vidarbha region is on top in area under cotton as compared to other cotton growing regions of Maharashtra State which account to 65 per cent area. In India very little area (5 to 6 %) of the cotton crop is irrigated. In the North the land is first irrigated before planting. Early sowing of cotton in second fortnight of May or first week of June as pre-monsoon crop with minimum quantity of water (1.0 litday^{-1} hill^{-1}) resulted in substantial increase in productivity. Maintaining available soil moisture at higher range throughout the growing season and imposing calculated stress conditions for beneficial results in terms of economic yield can very well be achieved with drip irrigation system on any soil type. Application of water at the rate of one litre per day with drip emitters was observed to result in higher yield than spot application even on very shallow soils.

A field experiment with 5 spacing treatments i.e. 96 x 10, 96 x 20, 96 x 30, 96 x 40 and 96 x 50 cm was tested in RBD with six replications. Experiment was conducted at Babulgaon Block, Central Research Station, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola in Israel Project of drip irrigation system, during 1998 – 99 to 2000 – 01. The soil was medium deep clayey in texture having 213.36 kg ha^{-1} available nitrogen, 18.1 kg ha^{-1} available phosphorus and 569.5 kg ha^{-1} available potash with 0.463 per cent organic carbon. Sowing of cotton variety PKV Rajat was done on 3rd June, 31st May and 3rd June during respective season. Sowing was done with the help of Jondear tractor drawn sowing instrument at 2 cm depth as per treatments. Drip irrigation was given at the rate of 2.3 lit hr^{-1} by altaf made dripper, each dripper was fixed on lateral at even distance of 50 cm. Fertilization (100 : 50 : 50 N : P : K kg ha^{-1}) was given to the experiment with the help of fertilizer injection pump. Pre-soaking irrigation was given to the experimental plot for 24, 24 and 0 hrs (No pre-soaking irrigation) and post sowing irrigation was given for 81, 92.30 and 145 hrs. during respective seasons.

In all the three years of experimentation and in pooled data seed cotton yield of PKV Rajat was significantly affected with the change in plant to plant spacing in a uniform row spacing of 96 cm under drip irrigation with mechanical cultivation.

On the basis of pooled results seed cotton differences were significant. Sowing of PKV Rajat at 96 x 30 cm produced more seed cotton yield as compared to rest of spacing levels, however, the seed cotton yield differences with 96 x 40 cm did not reach to a level of significance. Seed cotton yield obtained under these two spacing were significantly superior over closer and wider spacing of 96 x 10 and 96 x 50 cm. Too close (96 x 10 cm.) or too wide (96 x 50 cm) seeding distance in PKV Rajat resulted in reduction of seed cotton yield significantly udner drip irrigation with mechanical cultivation (Table -1). According to Gomase and Patil (1985) and Solanke *et al.* (2001) closer spacing recorded significantly higher seed cotton yield than wider spacing in hirsutum cotton.

Cost benefit ratio was maximum with 96 x 30 cm (1: 1.65), followed by 96 x 40 cm (1:1.61) and minimum in 96 x 10 cm (1:1.36). While, water use efficiency (kg ha^{-1}-mm) was higher in 96 x 40 cm (0.97), followed by 96 x 50 cm (0.96) and lower in closer spacing 96 x 10 cm (0.33).

Table 1. Seed cotton yield as influenced by various treatments.

Treatments	Seed cotton yield (q ha^{-1})			Pooled mean
Spacing (cm)	1998-99	1999-2000	2000-01	
S_1 – 96 x 10	10.99	14.09	13.79	12.96
S_2 – 96 x 20	13.02	15.89	14.74	14.55
S_3 – 96 x 30	13.19	17.15	15.96	15.44
S_4 – 96 x 40	12.58	16.99	15.14	14.90
S_5 – 96 x 50	11.23	15.87	12.82	13.31
S.E.m±	0.55	0.58	0.46	0.31
C.D. at 5%	1.58	1.71	1.28	0.87

Table 2 : Ancillary information (Av. of three years)

Treatments Spacing (cm)	Bolls harvested m^{-1}	Seed cotton yield m^{-1}	Plant height (cm)	Monopodia $Plant^{-1}$	Sympodia $plant^{-1}$	No. of nodes $plant^{-1}$	Dry matter $plant^{-1}$ (g)	C:B ratio	WUE kg ha^{-1} mm^{-1}	Plant stand at harvest ('000' ha^{-1})
S_1 – 96 x 10	55.3	141.9	111.4	0.55	20.7	27.0	135.8	1:1.36	0.33	94.54
S_2 – 96 x 20	59.0	158.4	109.4	0.83	21.9	28.2	171.9	1:1.55	0.62	47.37
S_3 – 96 x 30	61.5	170.0	107.1	1.12	22.1	28.6	199.5	1:1.65	0.86	32.33
S_4 – 96 x 40	56.9	157.8	105.4	1.42	23.5	30.2	222.6	1:1.61	0.97	24.38
S_5 – 96 x 50	52.5	144.1	102.5	1.53	23.4	30.2	245.1	1:1.46	0.96	20.05

On an average of three years it could be seen that bolls harvested and seed cotton yield per ha were more with 96 x 30 cm spacing (Table - 2). A closer spacing of 96 x 10 cm recorded maximum plant height and it was decreased with increase in plant spacing in a row spacing of 96 cm. However, the values of other growth attributes i.e. monopodia, sympodia, dry matter and node number were maximum in 96 x 50 cm and minimum in 96 x 10 cm spacing. Similar, result was reported by Solanke *et al.* (2001).

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Effect of Concentration and Time of Application of Growth Regulators on Yield and Growth of Cotton Under Drip Irrigation

Cotton is one of the major fibre crops grown throughout the world and contributing nearly 80 per cent of World's total fibre production and an important cash crop of Haryana, Punjab, Andhra Pradesh, Gujrat, Karnataka, Maharashtra, Madhya Pradesh, Tamilnadu and parts of Rajasthan.

Cotton productivity in India suffers from excessive vegetative growth, shedding of fruiting bodies, poor boll opening and attack of numerous insect pest and diseases. Of all these, excessive vegetative growth and shedding of fruiting bodies are parctical agronomic and physiological problems that need immediate attention. Poor seed cotton yield is due to less number of picked bolls per unit area. On the other hand excessive vegetative growth and dense canopy interfere with intercultural and plant protection measure in addition to poor source sink relationship. Various workers in India and abroad have reported modification of crop growth and development through exogenous application of growth retardant. Keeping these points in view the present study was conducted with an objective to find out the effect of plant growth regulators with different concentration and time to application on growth and yield of cotton under drip irrigation.

The field experiment was conducted on a medium deep black soil, testing moderate in organic carbon (0.464%), medium in available nitrogen low in phosphorus and rich in potassium (viz. 213.3, 18.2 and 569.43 kg ha^{-1}). The experiment was laid out in split plot design keeping two growth regulators (Pix and cycocil) and four concentrations (0,25,50 and 75 ppm) in main plots and two time of application of growth regulators at first bloom stage (60-65 DAS) and at peak bloom stage (85-90 DAS) in sub – plots during 1998-99 to 2000-01. Seed was sown with the help of Jondear tractor drawn sowing instrument at 2 cm deep and plant population after emergence was maintained at 96 x 50 cm. Cotton hybrid PKV Hy-4 was used for experimental purpose. Fertigation was given to the experiment with the help of fertilizer injection pump through drip at the rate of 100 : 50 : 50 N, P_2O_5 and K_2O kg ha^{-1} applied through urea, phosphoric acid and muriate of potash, respectively. Drip irrigation was given at the rate

Table 1 Seed cotton yield as influenced by various treatments

Treatments	Seed cotton yield (q ha^{-1})			Pooled urea
	1998-99	1999-00	2000-01	
I. Main treatments				
a. Growth regulators				
Pix	14.96	11.81	12.59	13.12
Cycocel	15.14	11.70	12.53	13.12
S.E.m±	0.28	0.30	0.41	0.19
C.D. at 5%	NS	NS	NS	NS
B. Concentration (ppm)				
Control	15.08	12.04	13.05	13.39
25	15.93	13.57	14.71	14.07
50	14.85	11.61	12.91	13.13
75	14.35	9.79	11.56	11.90
S.E.m±	0.40	0.42	0.58	0.28
C.D.at 5%	NS	1.27	NS	0.81
II. Sub treatments				
Time of application				
At first bloom stage	14.32	11.21	12.34	12.62
At peak bloom stage	15.79	12.30	12.77	13.62
S.E.m±	0.31	0.21	0.29	0.16
C.D. at 5%	0.94	0.63	NS	0.45

Table 2 : Ancillary information (Av. of three years)

Treatments Spacing (cm)	Bolls harvested m^{-1}	Seed cotton yield m^{-1}	Plant height (cm)	Monopodia $Plant^{-1}$	Sympodia $plant^{-1}$	No. of nodes $plant^{-1}$	Dry matter $plant^{-1}$ (g)	C:B ratio	WUE kg ha^{-1}-mm	Plant stand at harvest ('000' ha^{-1})
I. Main treatments										
a. Growth regulators										
Pix	41.7	143.7	103.9	2.7	25.7	32.4	236.3	1:1.45	0.91	21.62
Cycocel	41.5	142.6	102.2	2.7	25.5	32.2	241.8	1:1.45	0.91	21.08
B. Concentration (ppm)										
Control	43.6	145.5	118.3	2.5	25.2	32.9	253.7	1:1.50	0.93	21.06
25	44.1	153.3	105.5	3.0	25.5	32.3	246.2	1:1.54	0.97	20.98
50	41.4	142.4	94.5	3.1	25.9	32.3	236.2	1:1.44	0.91	21.04
75	37.4	130.4	93.9	2.5	26.0	32.7	220.1	1:1.32	0.82	20.98
II. Sub treatments										
Time of application										
At first bloom stage	39.3	137.4	100.7	2.8	25.3	31.9	231.7	1:1.40	0.87	20.97
At peak bloom stage	43.3	148.4	103.7	2.6	26.3	32.3	246.4	1:1.50	0.94	21.06

of 2-3 lit hr^{-1} by altaf made dripper presoaking irrigation were given in all the respective season for 24, 24 and 0 hrs (No presoaking irrigation). Post sowing irrigation during respective season were given for 81.00, 92.30 and 157.00 hrs.

A. Growth regulators In all the three years of experimentation and in pooled data seed cotton yield of PKV Hy-4 did not differ significantly with the use of pix and cycocel growth regulators. But Brar *et al.* (2001) reported that application of different growth regulators viz. Mepiquat chloride, TIBA and Maleic hydrazide and cycocel significantly affected seed cotton yield over control.

B. Concentration of growth regulators

During 1998-99 and 2000-01 seed cotton yield was not significantly influenced due to the foliar spraying of growth regulators with the different concentration. During 1999 – 2000 seed cotton yield was significantly affected with different concentration of growth regulators and 25 ppm spray showed 12.7 per cent increase in seed cotton yield over control. This treatment was also significantly superior to 50 and 75 ppm spraying treatments. Spraying of growth regulators with higher concentration 75 ppm significantly reduced seed cotton yield by 13.9 per cent as compared to control.

Pooled data showed (Table 1) that the seed cotton yield differences were significant due to spraying of growth regulators at different concentration. Spraying of growth regulator at 25 ppm concentration and control were similar in seed cotton yield. Spraying of growth regulators 75 ppm concentration significantly reduced that seed cotton yield 11.1 per cent as compared to control. Yield reduction was also seen with 50 ppm treatment but the differences with control was not significant. Similar result was recorded by Fletcher and Kirkwood (1982).

C:B ratio and WUE were similar due to different growth regulators. Concentration of growth regulators at the rate of 25 ppm showed the higher C : B ratio (1: 1.54) and WUE (0.97 kg $ha^{-1} mm^{-1}$).

C. Time of application

The seed cotton yield differences due to time of application of growth regulators were significant during 1998-99, 1999-2000 and in pooled data.

Pooled results indicated that spraying of growth regulators at peak bloom stage produced 7.9 per cent increased seed cotton yield over spraying of growth regulators at first bloom stage. Application time at peak bloom stage recorded maximum C : B ratio (1: 1.50) and WUE (0.94 kg $ha^{-1}mm^{-1}$). Interaction effects were found to be non- significant.

D. Growth and yield parameters

From the average of three years it is seen that all the growth and yield parameters were more or less similar due to growth regulator treatment. Bolls and yield per meter were more in treatment having 25 ppm growth regulator spray, followed by control and minimum in 75 ppm spray level. Plant height was reduced by 10.8, 20.1 and 20.6 per cent with application of growth regulator at 25, 50 and 75 ppm, respectively. On an average all the yield and growth attributes were higher in the treatments having spraying of growth regulators at peak bloom stage. Growth retardants cycocel and mepiquat chloride reduced plant height by 18.5 and 9.5 per sent as compared to control (Brar *et al.* 2001).

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Efficacy of Homeopathic Drugs Against Citrus Greening by Trunk Injection

Studies were conducted on the evaluation of two Homeopathic drugs of Botanical origin viz., Cedron Thuza each at 1000 and 2000 ppm concentration for the management of citrus greening in Kinnow. These drugs were applied as a Trunk Injection @ 1 to 1.5 litre trees^{-1} of 14 years of age in mid May and June end from 1999 to 2001. All the trees injected with either of the drugs showed recovery from the disease. However, cedron @ 1 per cent gave better results whereas highest reduction in chlorosis was obtained (74.32%). The increase in growth parameters like height, canopy volume and yield per plant also showed a positive trend in trees injected with lower concentration of each drug. It was 6.2, 52.7, 6.2, 35.1 per cent, respectively in case of cedron 1000 ppm concentration The increase in amount of total chlorophyll (highest in case cedron 17.2%) also showed the effectiveness of these drugs in the greening infected Kinnow trees. It seems that these drugs inhibit the growth and multiplication of greening pathogen. Since greening disease could be checked for (8-12 months) when trees were trunk injected with drugs does not pose any potential risk of residue problems and environmental pollution and thus fit well in the strategies for disease management of citrus greening.

Citrus greening spreading through citrus psylla an efficient insect vector is one of the most common Bacterial (*Liberobactor-asiaticum*) diseases affecting citriculture in Northern India. This disease is major cause of citrus decline in India. More than 64.7 per cent of the trees in existing citrus plantations have been reported to be greening positive. The effectiveness of Tetracycline injections against greening has been indicated by a number of workers. The present study was to evaluate the efficacy of two Homeopathic formulations for the management of citrus greening in Kinnow plantations.

Greening infected Kinnow plants were trunk injected with Thuja and Cedron each @ 1000 ppm and @ 2000 ppm concentration. 1 to 1.5 litres of each drug trunk was injected during last week of May and again after 20 days with three replications in a randomized block design during 2000-2002. To get treatment material into the tree injection holes upto half depth of the trunk diameter were drilled. The injection screws were inserted as shallow into drilled holes and supply house was coupled to the Screws and the whole was sealed with wax. The observations on the growth parameters and amount of chlorophylls were recorded before and after four months of injections.

Table1. Effectg of Homeopathic drugs on chlorosis before and after 4 months treatment (Mean of two years)

Treatments	Concentration (%)	Chlorosis, %		Percentage reduction in A.T. over B.T.
		Before treatment (B.T.)	After treatments (A.T.)	
Cedron	1	50.0	15.1	74.32
Cedron	2	40.0	12.1	72.25
Thuja	1	48.0	18.5	67.29
Thuja	2	42.0	17.5	63.57
Control		48.20	62.0	(-)24.5

Table 2. Effect of Homeopathic trunk injected into greening positive Kinnow plants on various growth parameters, fruit yield and chlorophyll increase in

Treatments	Concentration (%)	Height (cm)	Canopy volume (cm)	Fruit yield tree^{-1} (kg)	Deviation in chlorophylls (%)		
					Chl Total	Chl(a)	Chl(b)
Cedron	1	6.2	52.7	35.1	24.0	23.1	17.2
Cedron	2	3.9	20.1	20.5	14.2	20.2	6.4
Thuja	1	6.1	38.4	30.2	15.0	20.4	7.6
Thuja	2	6.2	35.9	12.2	8.2	17.4	9.4
	CE (p = 05)	26	10.0	3.2	4.2	NS	8.8

All the tree trunks injected with either of the drugs showed recovery from the disease. Among the two drugs tested cedron @ 1 per cent gave better results. Thirty per cent of the Kinow trees treated with Cedron recovered from severe symptoms. A significant decline in amount of chlorosis was also recorded in both the treatments and it was 74.32 and 72.25 in case of cedron and 67.29 and 63.57 in Thuja at 1 and 2 per cent concentration, respectively (Table 1). The deviations in growth parameters like height canopy volume and yield per plant showed a positive trend injected with lower concentration proved superior in suppressing the greening symptoms besides increasing tree height, canopy volume and yield tree^{-1} which was 6.2, 54.7 and 35.1 per cent, respectively (Table 2). The increase in amount of total chlorophyll, chlorophyll (a) and chlorophyll (b) was 24.0, 23.1 and 17.2, respectively.

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