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RESEARCH NOTES

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Effect of Synchronizing NK Supply to Demand of Bt Cotton on Yield and Nutrient Use Efficiency on Different Rainfed Vertisols

Jagvir Singh[1], M. V. Venugopalan[2], D. N. Gokhale[3], Y. R. Aladakatti[4], S. Jaffar Basha[5] and R. I. Sisodia[6]

ABSTRACT

A multi-location trial was conducted on Bt cotton (*G. hirsutum*) at Nagpur, Parbhani, Dharwad, Khandwa and Nandyal for two *Kharif* season, to study the effect of synchronizing N and K supply on yield and nutrient use efficiency on different rainfed Vertisols. The pooled analysis of two years data revealed that four splits of N (10,30,45, 60 DAS) and three splits of N (10, 45, 60 DAS) in Bt cotton at Parbhani, Nandyal and Dharwad were at par and produced significantly higher seed cotton yield as compared to rest of the splits at different timings. Whereas three splits of N had significant increase in seed cotton at Nagpur and Khandwa over two splits of N. The synchronising effect of K alongwith N application had no statistical difference on seed cotton yield. Maximum seed cotton yield with four equal splits of N was registered at Parbhani (2700 Kg ha^{-1}), Nandyal (2563 Kg ha^{-1}), Dharwad (3090 Kg ha^{-1}) and three splits of N at Nagpur (2344 Kg ha^{-1}) and Khandwa (1785 Kg ha^{-1}). Similar trend was found on total number of opened bolls per plant and fertilizer N and K use efficiency (FUE_N and FUE_k) at the different locations.

Bt cotton area in semi arid regions of central part of India is rapidly increased from 1.2 m ha (2002) to 6.3 m ha in 2007-08 (Anonymous 2007). Imbalanced fertilization of cotton affects the growth, development of reproductive parts and final productivity. Since hybrid cotton is long duration and nutrient exhaustive crop, balanced fertilizer with suitable time of application is one of the key point for enhancing the cotton yield (Nehra *et al.*, 2004). Productivity of rainfed Bt cotton and its response to supply of nutrients in Vertisols depends upon amount and distribution of rainfall and soil moisture storage capacity. Erratic distribution of rainfall is the primary constraint for the nutrient management in rainfed cotton. In rain dependent areas, imbalanced fertilization of nutrients in cotton due to major factors of soil available moisture and nutrients supply, affects the vegetative and reproduction growth (Blaise, 2006). The hybrid cotton has a remarkable ability to produce repeated flushes fruiting parts to compensate for early season damages due to biotic or abiotic stress.

These physiological complexities make scheduling of nutrients for cotton more difficult than other field crops.

In view of importance of nutrient management in Bt cotton, field studies were carried out at different locations to find out appropriate time and splits of nutrient N and K for improving the yield and fertilizer nutrient use efficiency on different rainfed Vertisols.

MATERIAL AND METHODS

The multi-location field studies were undertaken for two years during 2007-08 to 2008-09 at Central Institute for Cotton Research, Nagpur, Marathwada Agricultural University, Parbhani and University of Agricultural Sciences, Dharwad and same experiment was conducted in 2008-09 to 2009-10 at Cotton Research Station, Khandwa, and Regional Agricultural Research Station, Nandyal. The soils of the experimental sites are reported Vertisols, clayey in texture (clay 47-57%), slightly alkaline in reaction (pH 7.8 to 8.6), low in available nitrogen and phosphorus at Nagpur (112 kg N ha^{-1}, 7.9 kg P ha^{-1}), Parbhani (130 kg N ha^{-1}, 13.5 kg P ha^{-1}), Khandwa (170 kg N ha^{-1}, 19.2 kg P ha^{-1}), medium at Nandyal (214 kg N ha^{-1}, 37.5 kg P ha^{-1}), Dharwad (305 kg N ha^{-1}, 23 kg P ha^{-1}) and rich in available potash (range 285 to 695 kg K ha^{-1}) for all locations. Treatments consisted of eight different timings and splits of nutrients, S1: 10, 45 DAS; S2: 10, 30, 45 DAS; S3: 10, 30, 60 DAS; S4: 10, 45, 60 DAS; S5: 10, 45, 75 DAS; S6: 10, 30, 75 DAS; S7: 10, 30, 45, 60 DAS and S8:10, 30, 45, 75 DAS combined with two factors viz., F1: N only (P and K as basal), F2: N K (P as basal).

1. Central Institute of Cotton Research, Nagpur, 2. Marathwada Agricultural University, Parbhani, 3. University of Agricultural Sciences, Dharwad, 4. Regional Agricultural Research Station, Nandyal and 5. Cotton Research Station, Khandwa.

Table 1. Experimental details for different locations

Particulars	Nagpur	Parbhani	Khandwa	Nandyal	Dharwad
Bt hybrids	Bunny Bt (NCS 145)	Rudra Bt	NCPL 999Bt	Bunny Bt (NCS 145)	Bunny Bt (NCS 145)
Sowing dates	20-6-2007	28-6-2007	26-6-2008,	25-7-2008	19-7-2007
	23-6-2008	27-6-2008	29-6-2009	11-8-2009	23-7-2008
Plot size (m)	5.4 x 4.8	5.4 x 4.8	5.4 x 3.6	5.4x 4.8	5.4x 4.8
Spacing (m)	0.9 x 0.6	0.9 x 0.6	0.9 x 0.6	0.9 x 0.6	0.9 x 0.6
RDF ($N:P_2O_5:K_2O$ kg/ha)	90:45:45	80:40:40	120:60:40	150:75:75	80:40:40
*ASER	10.2	6.2	5.2	7.1	6.4
Total Rainfall (mm)	974 in 2007	680 in 2007	615 in 2008	996 in 2008	675 in 2007
	569 in 2008	610 in 2008	690 in 2009	603 in 2009	719 in 2008

* ASER: Agro eco sub-region

The design of experiment used was factorial randomized block design (FRBD) with three replications. Recommended dose of fertilizer N and K in splits was applied as per treatment, whereas complete dose of recommended P_2O_5 was applied as basal. The experimental details are given in Table 1. All other recommended intercultural practices and plant protection measures as per location were adopted. Rainfall distribution pattern during crop season was recorded for each location.

RESULTS AND DISCUSSION

A. Yield and yield attributes

Time of application of nutrients

The mean data of two years on seed cotton yield of nutrients N and NK applied in different splits and times are presented in Table 3. The pooled analysis of data on yield revealed that timing of application of nutrients had pronounced effect on seed cotton yield at all the locations. Four splits of N at 10, 30, 45 and 60 DAS and three splits of nutrient at Parbhani, Nandyal and Dharwad were at par and produced significantly higher seed cotton yield as compared to rest of the splits at different timings. While three splits of N had significant increase in seed cotton at Nagpur and Khandwa over two splits of N application. The synchronising effect of potassium alongwith nitrogen had no statistical difference on seed cotton yield of Bt cotton. Four equal splits of N at 10, 30, 45 and 60 DAS at Parbhani (2700 Kg ha^{-1}), Nandyal (2563 Kg ha^{-1}), Dharwad (3090 Kg ha^{-1}) and three splits of N at 10, 45 and 60 DAS at Parbhani (2593 Kg ha^{-1}), Nandyal (2304), Dharwad (3005 Kg ha^{-1}), Nagpur (2344 Kg ha^{-1}) and Khandwa (1785 Kg ha^{-1}) recorded significantly higher seed cotton yield as compared to two equal splits of N in all the locations. This may be indicated that in the Vertisols of scare rainfall zones such as Dharwad and Nandyal rainfall received during boll formation to development stage in September to November (Fig. 1.) was found most useful that is why N application in four splits respond to Bt hybrid cotton in achieving higher yield of seed cotton. Whereas, three splits of N at 10,45 and 60 DAS produced maximum yield of seed cotton at Nagpur (2244 kg ha^{-1}) and Khandwa (1785 kg ha^{-1}). The results are confirmed with the findings of Srinivasan (2003), Read (2006) and Narayana *et al*., (2009). Potassium applied as basal or in splits along with N did not significantly influence the yield and yield attributing parameters.

The data on total opened bolls per plant as influenced by splits application of N with different timing schedules revealed that the total opened bolls $plant^{-1}$ were significantly increased with the three splits of N applied at 10, 45 and 60 DAS in Nagpur and Khandwa location whereas four splits of N (10, 30, 45 and 60 DAS) increased the number of bolls $plant^{-1}$ significantly at Parbhani, Nandyal and Dharwad (Table 2). Similarly, K applied as basal or in splits along with N did not influence the yield attributing parameters. Least number of bolls $plant^{-1}$ was recorded with two splits of nutrient N and N x K applied at 10, 45 DAS.

Nutrient splitting

Application of splits of N only at different timings recorded significantly higher seed cotton yield across the locations except Nagpur as compared to split

Table 2: Opened bolls per plant as influenced by different splits and timings of nutrients (mean of 2 years)

Nutrient splits	Nagpur		Parbhani		Khandwa		Nandyal		Dharwad	
(DAS)	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
S_1 (10,45)	30.0	30.5	31.1	31.5	14.0	14.5	22.1	20.1	19.6	20.4
S_2 (10,30,45)	38.3	37.8	36.4	33.6	16.3	15.7	24.4	24.0	23.8	22.7
S_3 (10,30,60)	38.7	38.6	37.4	34.6	15.7	15.0	26.7	26.1	24.9	23.9
S_4 (10,45,60)	41.1	38.9	40.6	36.7	17.9	15.8	30.7	24.1	28.6	26.3
S_5 (10,45,75)	40.8	38.8	36.6	34.5	16.9	15.6	25.8	24.0	24.5	24.0
S_6 (10,30,75)	38.6	38.9	37.6	37.3	15.9	14.7	25.5	24.2	23.1	23.1
S_7 (10,30,45,60)	37.0	38.8	40.9	34.5	16.1	14.5	32.6	25.7	29.6	24.9
S_8 (10,30,45,75)	37.6	37.0	37.3	37.4	15.0	14.6	27.0	24.3	25.4	24.2
Mean	37.8	37.4	37.9	35.0	15.9	15.1	26.8	24.1	24.9	23.7
CD at 5 % S	2.8		2.1		1.79		4.2		2.8	
F	NS		NS		NS		NS		NS	
SxF	**NS**		**NS**		**NS**		**NS**		**NS**	

application of both the nutrients N K. Pooled data on total opened bolls plant^{-1} as influenced by splits application of N with different timings showed similar trend as in case of seed cotton yield across the locations. Data clearly showed that splits application of N showed main effect on yield where K can be applied as basal to these types of soils where Bt cotton is being grown in large. This might be because of the fact that potash get fixed immediately after its application and becomes slow release process in Vertisols.

B. Nutrient utilization efficiency

$$\text{Nutrient utilization efficiency is derived as} = \frac{\text{seed cotton yield in kg ha}^{-1}}{\text{amount of nutrient applied in kg ha}^{-1}}$$

The fertilizer N (FUE_N) and K (FUE_k) was determined from mean of two years seed cotton yield is presented in Table 4. Pooled results revealed that highest nutrient N and K use efficiency was recorded at Dharwad followed by Parbhani and Nagpur location when it compared to Khandwa and Nandyal location. This may be because of higher dose of NK fertilizer used for Bt cotton at Nandyal that may require less amount of nutrients. Higher fertilizer N use efficiency (FUE_N) and K use efficiency (FUE_k) was determined around 30 and 60 respectively with four splits of nutrients (at 10, 30, 45 and 60 DAS) at Dharwad and Parbhani, whereas three splits of nutrient (10, 45 and 60 DAS) had higher nutrient use efficiency at other locations. Results clearly indicate that the nutrients applied in splits at higher dose did not produce highest yield at Nandyal, because of nutrient utilization efficiency was recorded less than other locations. The amount of nutrient applied to soil may not be utilized completely due to insufficient moisture, resulted in lowest nutrient use efficiency. Similar trend was also recorded at Khandwa. Secondly, total rainfall and its distribution during crop season may also play role in nutrient mineralization or utilization by Bt cotton.

CONCLUSIONS

On Vertisols for rainfed Bt cotton hybrids, splitting of N and K has no additional benefit over splitting of N alone. To synchronize the supply of N and K in relation to the element N can be applied in four equal splits at 10, 30, 45 and 60 day after sowing for achieving higher seed cotton yield at Dharwad, Nandyal and, Parbhani whereas application of N in 3 equal splits at 10, 30 and 60 DAS was found to be most beneficial at Nagpur and Khandwa. The maximum N utilization efficiency was achieved with recommended dose of fertilizers at Dharwad as compared to other locations. The entire recommended dose of K can be applied as basal. Split application of nitrogen is more useful for cotton in Vertisols and found beneficial for improving nutrient use efficiency as well as crop yield. However, potassium splits were not found beneficial in Vertisols.

Table 3: Seed cotton yield (kg/ha) of Bt cotton as influenced by different splits and timings of N and NK nutrients at different locations (mean of 2 years)

Nutrient schedule &		Nagpur		Parbhani		Khandwa		Nandyal		Dharwad	
	(DAS)	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
S1	(10,45)	1996	2020	1505	1645	1303	1423	1746	1586	2400	2458
S2	(10,30,45)	2192	2106	2385	2352	1702	1622	2055	1909	2680	2498
S3	(10,30,60)	2204	2201	2505	2145	1698	1564	2077	2010	2855	2745
S4	(10,45,60)	2344	2245	2593	1821	1785	1535	2304	1946	3005	2877
S5	(10,45,75)	2194	2175	1806	1798	1679	1587	2193	1921	2703	2627
S6	(10,30,75)	2170	2210	2005	2035	1625	1381	2133	1905	2650	2658
S7	(10,30,45,60)	2149	2170	2700	2488	1680	1442	2563	2135	3090	2898
S8	(10,30,45,75)	2135	2096	2090	2134	1500	1456	2242	2018	2906	2684
	mean	2173	2153	2199	2052	1621	1501	2164	1916	2786	2681
CD at 5%	S	118.3		135.2		63.2		417.0		178.0	
	F	NS		NS		NS		NS		NS	
	SxF	NS		NS		NS		NS		NS	

F1 : Nonly, F2 : NKonly

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Influence of Different Stand Establishment Methods on Grain Yield and Economics of Puddled Rice (*Oryza sativa L.*)

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ABSTRACT

A field experiment was conducted during *Rabi* 2011 and 2012 to study the effect of different stand establishment methods on rice grain yield and economics in puddled soils of Nagarjuna Sagar left canal command of Andhra Pradesh. Of the different establishment methods tested, machine transplanted rice produced maximum number of tillers, panicle length, filled grains and ultimately higher grain yield. Net returns as well as returns per rupee invested were also highest with machine transplanted rice and lowest in drum seeded rice.

In India, rice is the principle food crop grown in area of 42.2 m.ha with production 95.9 m.t and productivity of 2.24 t ha^{-1}. In Andhra Pradesh, it is grown in an area of 4.56 m.ha with a production of 7.51 m.t and productivity 3.02 t ha^{-1} (Ministry of Agriculture, 2010-2011). Cultivation of rice by transplanting in puddled condition is popular in Andhra Pradesh but it is highly labour intensive and involves huge cost. Transplanting alone accounts for about 15 per cent of total rice production cost and at times delayed due to shortage of labour, which causes substantial loss in yield (Mahajan *et. al.,* 2006). To overcome the crisis of labour and increasing cost of cultivation, farmers have to adopt a labour and time saving stand establishment to cover larger area over short period of time. This is more true under canal irrigation as most of the transplanting are to be completed over a short period of time to be in line with the neighbouring farmers.

Direct seeding of rice eliminates the need of nursery raising and subsequent labour intensive transplanting thus reducing cost of cultivation and is now fast replacing traditionally transplanted rice (Balasubramanian and Hill, 2000). Stand establishment with paddy transplanters is also now gaining attention of farmers, especially under canal command areas. Many multinational companies like Tegra of syngenta on cost basis are transplanting the rice fields by using machines without any risk to the farmers. They are attending the field operations right from sowing of seed, transportation of nursery trays, transplanting with machines and weedicide application by charging Rs. 13750-15000 Rs. $ha^{-1.}$

Keeping this in mind, the present investigation was carried out (i) to evaluate the different stand establishment methods on grain yield and economics of puddled rice. (ii) to work out the yield and cost benefits for different stand establishment methods in puddled fields.

MATERIALS AND METHODS

A field experiment was conducted during summer season of 2011 and 2012 at the Agricultural Research Station, Kampasagar, Nalgonda of A.P. which falls under Nagarjuna Sagar left canal command. Soil of the experimental site was sandy loam in texture with average organic carbon content of 0.32 per cent , pH 7.7 available nitrogen 145 kg ha^{1}. Phosphorus 18.7 kg ha^{1} and Potassium 243 kg ha^{-1}.

The experiment was laid out in Randomized block design with five replications. Treatments comprised of four systems of rice cultivation – conventional transplanting, machine transplanting, broadcasting and drum seeding. Short duration (120-125 days) rice variety, MTU 1010 (cotton dora sannalu) was used as test variety in the present study. The seeding was done on 21-1-2012 and 8-1-2013 during the two years.

The 24 hours soaked and 24 hours incubated sprouted seed was either broadcasted or drum seeded on the same day as nursery sown for transplanting. The seed rate adopted was 50, 30, 30 and 25 kg ha^{-1} for conventional transplanting, machine transplanting, broadcasting and drum seeding respectively. For machine transplanting, mat nursery was raised in plastic trays. Seedlings of 17 and 30 days old were used in machine and conventional transplanting during both the years of study. The row spacing was 15, 20, and 30 cm and plant spacing was 15, 5-8 cm and 12-15 cm in conventional, drum and machine transplanting respectively. Uniform dose of 120:60:40 kg

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N, P_2O_5 and K_2O kg ha^{-1} was applied to the crop. Nitrogen was applied in 3 equal splits as basal, tillering and panicle initiation, where as entire phosphorus and half the dose of potassium was applied basally and remaining half the dose of potassium was scheduled with last dose of nitrogen at panicle initiation. At harvest, the yield and yield attributes were recorded and analyzed as per the procedure outlined by Gomez and Gomez (1984). The cost economics were worked out based on actual expenditure incurred and on the prevailing market prices. The size of the each experimental treatment was 42 m^2.

RESULTS AND DISCUSSIONS

Tillers and panicles

There was no significant difference in tiller and panicle number with different stand establishment techniques in the first year, whereas in second year conventional transplanted rice significantly recorded higher tiller (368 m^{-2}) and panicle (331 m^{-2}) over other methods of rice cultivation. These results are in line with the findings of Akbar and Ehsanullah (2004) and Singh *et.al* (2010).

Panicle length (cm)

Machine transplanted rice significantly recorded higher panicle length (21.90 and 22.50 cm) in both the years over other stand establishment methods. The wider row spacing (30 cm) practiced in this method was the reason for better panicle length. Lowest panicle length (20.40 and 21.70 cm) was observed in Broadcasted rice may be due to overcrowding and competition between the plants for resources (Singh *et.al.*, 2010).

Number of grains per panicle

The different planting methods had significant effect on filled grains $Panicle^{-1}$ in first year, where as chaffy grains $panicle^{-1}$ were significantly influenced in both the years. Machine transplanted rice significantly recorded higher filled grains (92 $panicle^{-1}$) in first year and numerically higher number (108 per panicle) of grains in second year. The greater number of grains $panicle^{-1}$ in machine transplanted rice might be attributed to be the better development of panicles as a result of well established plants and better resources utilization as compared to other methods. Chaffy grains were maximum under broadcasting and drum seeding indicating competition for resources. These results are in accordance Singh *et.al.* (1981) and Kin *et.al.* (1991) who recoded lower number of spikelets $panicle^{-1}$ in direct sown rice.

1000 grain weight

The grain weight was significantly not influenced in first year and where as in second year it was maximum (23.38 g) under machine transplanting closely followed by conventional transplanting (23.20 g) and significantly superior over broadcasting (22.30 g) and drum seeding (22.0 g). Akbar and Ehsanullah (2004) evaluated six planting methods in direct sown rice and concluded that 1000 grain weight was not influenced by different planting methods.

Grain yield

Perusal of the data revealed that there was a significant effect of different stand establishment methods on grain yield. Machine transplanting produced significantly higher grain yield (7967 kg ha^{-1}) over other methods in second year and it was at par with conventional transplanting in first year. From pooled data, machine transplanting recorded significantly higher grain yield than the other methods.

Higher paddy yield obtained in machine transplanted rice was attributed to more number of filled spikelets per panicle, better panicle length and higher 1000 grain weight which might be due to transplanting young seedlings at shallow depth and better utilization of resources ultimately resulting in higher grain yield. No published literature is available on the performance of machine transplanted rice vis-à-vis other methods.

However, Jana *et.al.*, (1984), Akbar and Ehsanullah (2004) reported that paddy yield was highest in transplanted rice, where as Visalakshi and Sireesha (2013) from farmers field experiments concluded that direct sowing of paddy using drum seeding is better over conventional transplanting.

Economic analysis

Broadcasted rice gave maximum net return of Rs.27563 ha^{-1} in first year with Rs 0.89 returns $rupee^{-1}$ invested. In second year machine transplanted rice gave maximum net return of Rs. 69038 ha^{-1} against the minimum of Rs.51000 ha^{-1} in broad casted rice.

Higher net benefits realized in machine transplanted rice were attributed to higher grain yield which was followed by conventional transplanting.

From results of the experiment it is inferred that machine transplanting is preferable method to get maximum yield and net benefits under Nagarjuna Sagar left canal command of Andhra Pradesh.

Table 1: Yield attributes as influenced by different stand establishment techniques in puddled rice

Treatments	Tillers m^{-2}		panicles m^{-2}		Panicle length (cm)		Filled grains $panicle^{-1}$		Chaffy grains $Panicle^{-1}$		1000 grain weight (g)	
	I	II	I	II	I	II	I	II	I	II	I	II
Conventional transplanting	479	368	460	331	19.40	20.20	63	99	7.4	6.0	20.92	23.20
Machine transplanting	492	301	473	293	21.90	22.50	92	108	7.0	7.0	20.60	23.38
Broad casting	458	304	445	287	20.40	21.70	80	104	9.4	11.0	19.90	22.30
Drum seeding	472	304	439	285	21.10	21.70	74	101	8.8	15.0	20.20	22.00
SE (m) ±	10	13	11	11	0.23	0.20	2.3	2.5	0.2	1.0	0.29	0.20
C.D. (p=0.05)	NS	41	NS	35	0.73	0.63	7.0	NS	0.7	3.0	NS	0.62

Table 2: Grain yield and economics as influenced by different stand establishment techniques in puddled rice

Treatments	Grain yield (kg $ha^{-1)}$			Cost of cultivation (Rs $ha^{-1)}$		Net Returns (Rs ha^{-1})		Return $rupee^{-1}$ invested	
	I	II	Pooled	I	II	I	II	I	II
Conventional transplanting	5135	6957	6046	37200	41664	26988	55734	0.73	1.33
Machine transplanting	4965	7967	6466	41750	42500	20312	69038	0.49	1.65
Broad casting	4687	6125	5406	31025	34750	27563	51000	0.89	1.47
Drum seeding	4627	6237	5432	31775	35600	26063	51718	0.82	1.45
SE (m) ±	78	81	80						
C.D (p=0.05)	245	254	250						

Paddy sale price (Rs kg^{1}): 12.50 (2011), 14.00(2012)

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PKV KISAN: A High Yielding Rice Variety for Eastern Vidarbha

D. S. Phad[1], P. V. Shende[2], B. N. Chaudhari[3] and U. R. Dongarwar[4]

ABSTRACT

As a part of continuous efforts to evolve high yielding good quality rice variety, the cross was made between SKL-6-1-23 × SYE-3-17 resulted in the development of new culture SKL22-39-31-25-31-34 (PKV KISAN). It has been tested extensively in University, State and All India level breeding trials. In the three years testing of the Maharashtra state level trials , PKV KISAN recorded 25.7 Per cent and 24.8 Per cent higher grain yield than PLG 1 (Ch) in Western Maharashtra and Vidarbha region respectively and showed 10.2 Per cent yield advantage on overall mean of three years against PLG 1 check. PKV KISAN has acceptable medium slender grain with good cooking quality. This culture showed resistance to Leaf blast, Bacterial leaf blight and moderate resistance to Neck blast.

It has recorded 6.07 per cent higher grain yield over widely adopted variety Jaya and 9.57 per cent higher grain yield over regional check Triguna during 2008-09 at 27 locations in AICRIP trials. It has found promising over Triguna in region 4 (24.81%) and in region 5 (24.26 %) in India. It has exhibited resistance to Gall Midge biotype 4 at Directorate of Rice Research, Hyderabad (India). Similarly, it has also exhibited moderately resistant reaction to major pest and diseases *viz;* Gall midge, Leaf blast, Bacterial leaf blight of Eastern Vidarbha region.

Rice is the staple food of 2/3rd of the population of the world. In India, it ranks first, contributing to 43 per cent of the total food grain production and 55 per cent of cereal production followed by wheat (41%). Rice production of the country crossing 100 M T mark (103.41 M T during 2011-12) has made this food grain production possible. This was despite of 1.47 m hectare decline in rice area indicating a substantial improvement in its productivity (Anonymous, 2012 a). The total area under rice in the Maharashtra state is 15.18 lakh ha with an annual rice production of 26. 96 lakh tonnes and the average productivity is 1776 kg ha^{-1} (Anonymous, 2012 b). Over the years, efforts were made to increase the rice production transformed the state from food deficit to net surplus. Intensive cultivation of rice has resulted in the frequent outbreaks of pests and diseases. In Vidarbha region of Maharashtra during 1989, Gall midge damaged 85 per cent of paddy crop (Mathur and Krishnaiah, 2004). Many of the gall midge resistant varieties have an increased incidence of silver shoots up to 36 per cent (Prakash Rao and Kittur, 1989 and Krishnaiah *et. al*. 1994). Blast and Bacterial leaf blight are major disease of rice in this region.

For achieving and maintaining self sufficiency in rice, in view of ever increasing population, continuous enhancement of rice production is the need of hours as suited to irrigated ecological condition. The mid late duration varieties are very popular in Eastern Vidarbha region of Maharashtra. Hence, the mid late varieties like Jaya, Suraksha, RP-4-14, and PKV HMT are widely adapted varieties in this region. The efforts were made to evolve high yielding rice variety with good cooking quality and moderately resistant / tolerant to biotic stresses especially Gall midge and BLB.

MATERIAL AND METHODS

As a part of continuous efforts to evolve high yielding rice variety with good quality, the cross was made between SKL-6-1-23 × SYE-3-17 at Agriculture Research station, Sakoli resulted in the development of new culture SKL-22-39-31-25-31-34 (IET 20880) by pedigree method. This culture has been tested extensively in University, State and All India level breeding trials during the year 2004 to 2009 in the Randomised Block Design (RBD) along with PKV HMT as a common check in all the breeding trials in the Eastern Vidarbha region. In addition to this PLG 1 and Jaya were the state and national level check respectively. In addition to important morphological character, quality parameters like kernel length (mm), kernel breadth (mm), L/B ratio, grain type, grain chalkiness, volume expansion ratio, water uptake (ml), kernel length after cooking, elongation ratio, alkali spreading value, amylose content, gel consistency, gelatinization temperature and aroma were studied.

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Similarly, reaction to most of the biotic stresses was studied in green house and field conditions.

RESULTS AND DISCUSSION

In the three year testing of the Maharashtra state level trials, SKL 22-39-31-25-31-34 gave 11.74 per cent, 19.21 per cent and 0.55 per cent higher grain yield over check PLG 1 (Table 1). On pooled basis, it has recorded 25.7 per cent and 24.8 per cent higher grain yield over check PLG 1 in Western Maharashtra and Vidarbha region, respectively and showed 10.2 per cent yield advantage on overall mean of three years against check PLG 1. SKL 22-39-31-25-31-34 (PKV KISAN) with medium slender grains recorded acceptable kernel length after cooking (10.10 mm), intermediate alkali spreading value (5.5) and intermediate amylose content (20.35%) with soft gel consistency (90 mm) which are acceptable parameters (Table 2).

Table 1: Overall yield performance of the PKV KISAN (SKL- 22-39-31-25-31-34) in State level trial during the year 2006 to 2008.

Year	Region	Grain yield kg ha^{-1}		
		PKV- Kisan	PKV HMT (LC)	PLG -1(SC)
2006	**Konkan region**	3031	3332	3327
	% Increase over check		-4.43	-8.90
	Western Maharashtra	4328	3493	3137
	% Increase over check		23.91	38.00
	Vidarbha	4150	3583	3592
	% Increase over check		15.82	15.60
	Mean over all locations (9 locations)	3712	3442	3322
	% increase over check (9 locations)		7.84	11.74
2007	**Konkan region**	3559	3065	3534
	% Increase over check		16.12	0.71
	Western Maharashtra	4557	3984	3494
	% Increase over check		14.44	30.42
	Vidarbha	3956	3139	2915
	% Increase over check		26.03	35.71
	Mean over all locations (10 locations)	3977	3363	3336
	% increase over check (10 locations)		18.26	19.21
2008	**Konkan region**	3221	2640	3892
	% Increase over check		22.00	-17.24
	Western Maharashtra	3711	3549	3386
	% Increase over check		4.56	9.60
	Vidarbha	4573	3626	3641
	% Increase over check		26.17	25.60
	Mean over all locations (10 locations)	3685	3162	3665
	% increase over check (10 locations)		16.54	0.55
Average	**Konkan region**	3270	3012	3584
	% Increase over check		8.5	-8.80
	Western Maharashtra	4199	3675	3399
	% Increase over check		14.25	25.70
	Vidarbha	4188	3449	3356
	% Increase over check		21.42	24.80

Source : Progress Report of MSCRIP *Kharif* 2008 p. 37 (+ Progress Report of MSCRIP *Kharif* 2006 p. 64-65 + Progress Report of MSCRIP *Kharif* 2007 p. 82 + Progress Report of MSCRIP *Kharif* 2008 p. 81)

Table 2. Quality parameters of the culture PKV KISAN (SKL-22-39-31-25-31-34) at State level in Advance Varietal Trial

S.N.	Designation	KL (mm)	KB (mm)	L/B ratio	Grain type	Grain chalk	VER	WU (ml)	KLAC (mm)	ER (mm)	ASV	AC (%)	GC (mm)	GT	Aroma
1	SKL22-39-31-25-31-34	5.65	1.92	2.94	MS	A	2.25	225	10.10	1.87	5.5	20.35	90	Intermediate (70-74^{0}c)	NS
2	PKV HMT	5.32	1.76	3.02	SS	A	2.75	210	9.10	1.71	4.0	18.75	86	High more than 74^{0}c	NS
3	PLG-1	5.75	1.91	3.01	MS	A	2.25	275	9.0	1.66	4.5	19.93	84	High - Intermediate	NS

Table 3. Comparative performance of PKV KISAN (IET-20880) in Initial Varietal Trial –Irrigated Medium (IVT-IM) of AICRIP

Year/ Location	Grain yield kg ha^{-1}					CD	CV %
2008-09	SKL-22-39 -31-25-31-34 (IET-20880)	Jaya (National check)	Regional check (NDR-359 / Triguna)	Local check grain yield	Local check name		
PNT- Pantnagar	3085	2832	2832	2819	Panta Dhan-4	667	13.2
LDH- Ludhiana	3544	4302	4393	5387	PAU-201	1310	15.4
KUL- Kaul	-	2900	3000	3050	HKR-126	563	8.9
BBN- Bhubaneshwar	2106	2083	2592	3240	Surendra	652	13.3
CRR- CRRI, Cuttack	4500	4900	3724	4775	Tapswini	686	7.4
CHP- Chiplima	4000	3888	4222	-	-	807	9.4
JYP- Jeypore	3453	2824	3851	2611	Suphala	534	7.7
SBR-Sabour	3500	4083	4583	3666	Rajendra Sweta	1056	13.2
CHN- Chinsurah	4608	3472	3977	1199	Triguna	1051	13.4
MSD- Masodha	5452	5452	5651	5452	Sarjoo-52	555	5.0
VRN-Varanasi	5000	5125	5625	6750	HUR-105	529	5.2
WRS-Waraseoni	3381	4111	3812	3614	JR-503	656	8.4
RPR-Raipur	4389	3645	3571	3794	Mahamaya	1067	15.2
JDP- Jagdalpur	6010	5488	5196	5548	Mahamaya	705	6.6
LPP-Lamphalpat	4825	6240	5750	6530	Maniphou-7	1136	10.1
KJT- Karjat	3645	4270	4010	4531	Karjat-7	949	11.4
SKL- Sakoli	3256	3431	3221	2906	PKV HMT	146	1.9
SND- Sindewahi	5149	4651	3622	5575	SYE-2001	1061	11.3
NWG- Nawagam	4450	3882	2367	3882	GR-11	446	5.7
MTU- Maruteru	5000	3950	5250	4865	MTU-1001	1248	13.2
RNR- Rajendranagar	2646	2204	844	2639	Early Samba	1149	18.7
WGL- Warangal	6397	4477	5833	5283	WGL-32100	1214	11.2
BPT- Bapatla	4296	3784	3857	4514	BPT-5204	777	8.8
CBT- Coimbatore	6095	5450	5226	5557	CO-43	674	7.4
TRR- Tirur	3903	2973	2893	3270	ADT-39	56	1.2
PTB- Pattambi	3461	2948	2564	3653	Aathira	1226	21.5
MND-Mandya	6919	7335	4695	8373	BR-2655	1003	7.5
REGIONAL MEANS							
R2	3314	3344	3408	3752	R2 : Pantnagar,Ludhiana,Kaul		
R3	4269	4276	4379	4289	R3 : Bhubaneswar, CRRI, Chiplima, Jeypore, Sabour, Chinsurah, Masuda, Varanasi, Waraseoni, Raipur, Jagdalpur, Lakhoati		
R4	4125	4059	3305	4223	R4 : Karjat, Sakoli, Sindewahi, Nawagam % increase in R4		
	1.62	24.81					
R5	4840	4140	3895	4769	R5 : Maruteru,Rajendranagar, Warangal,Coimbatore, Bapatla, Tirur, Pattambi, Mandya		
% increase in R5 region		16.91	24.26	1.49			
Over all Mean	4349	4100	3969	4365			
Over all % increase		6.07	9.57				

(Source.: - DRR, AICRIP Progress Report-2008 Vol. 1 p.p. - 1.240 to 1.247 and 1.252 to 1.253)

Table 4a. Reaction of the culture SKL22-39-31-25-31-34 (PKV KISAN) to pest and diseases in State level trials.

Designation	Year	Karjat			Lonavala					Sindewahi						Sakoli	
		W.E.	BLB	LB	LB		NB	LB	BLB	BPH	WBPH	GLH	SB	GM	GM	BLB	LB
					GH	Field				70 DAT	70 DAT	70 DAT	70 DAT	50 DAT	50 DAT	50 DAT	
SKL22-39-31-25	2006	-	4	-	5	5	5	0	5	-	-	-	-	-	-	-	-
-31-34	2007	1	1	-	5	3	5	5	5	0.8	1.0	0.4	0.0	0.0	7.0	0.0	-
(PKV KISAN)	2008	9	7	6	2	3	5	0	3	-	-	-	-	-	9	0	0
	Mean	5.0	4.0	6.	4.0	3.6	5.0	1.6	4.3	0.8	1.0	0.4	0.0	0.0	8.0	0.0	0.0
PKV HMT (Ch)	2006	-	8	-	5	7	5	0	5	-	-	-	-	-	-	-	-
	2007	3	5	-	2	1	1	0	5	1.6	1.6	0.2	5	0	9	3	-
	2008	9	7	9	4	5	5	1	3	-	-	-	-	-	9	3	1
	Mean	6	6.6	9	4	4.3	3.6	0.3	4.3	1.6	1.6	0.2	5	0	9	3	1
PLG-1 (Ch)	2006	-	-	-	6	7	7	-	-	-	-	-	-	-	-	-	-
	2007	5	3	-	3	3	3	3	5	1.2	0.8	1.2	0	0	NR	NR	-
	2008	9	8	9	4	4	7	0	1	-	-	-	-	-	9	1	0
	Mean	7	5.5	9	4.3	4.6	5.6	1.5	3	1.2	0.8	1.2	0	0	9	1	0
Ajaya (Res.Ch.)	2006	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2007	7	2	-	3	5	3	1	5	1.6	1.8	0.2	0	0	9	0	-
	2008	7	4	9	2	3	3	0	0	-	-	-	-	-	9	0	0
	Mean	7	3	9	2.5	4	3	05	2.5	1.6	1.8	0.2	0	0	9	0	0
TN-1(Sus.Ch.)	2006	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2007	9	6	-	8	7	9	5	5	1.8	1.6	0.4	0	0	9	5	1
	2008	9	9	9	5	6	5	1	3	-	-	-	-	-	9	3	-
	Mean	9	7.5	9	6.5	6.5	7	3	4	1.8	1.6	0.4	0	0	9	4	1
EK 70(Sus.Ch.)	2006	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2007	9	5	-	9	9	9	3	5	1.4	1.0	0.4	0	0	7	3	-
	2008	9	9	9	9	9	7	1	3	-	-	-	-	-	9	3	1
	Mean	9	7	9	9	9	8	2	4	1.4	1.0	0.4	0	0	8	3	1

Source: 1. Progress Report of MSCRIP *Kharif* 2007 p. 151 & 2. Progress Report of MSCRIP *Kharif* 2008 p. 151,152, 153

Note : - WE- White ears, BLB-Bacterial leaf blight, LB- Leaf blast, GH-Green house, NB- Neck blast, BPH-Brown planthopper, WBPH-Whitebacked planthopper, GLH-Green leaf hopper,SB-Stem borer,GM- Gall midge, DAT- Days after transplanting.

Table 4b. Performance of SKL 22-39-31-25-31-34 / PKV KISAN against paddy pests at National level during *Kharif* 2008 in NSN-2.

S N	IET No.	BPH	WBPH	PH		GMB_4		GMB_5	Stem borer							Leaf folder			RT	EHB
									% Dead hearts Field reaction			White ears Field reaction								
		DRR*	DRR*	PNR	DRR	WGL	PTB	MNC	PTB	MNC	SBP	GGT	LDN	SBP	KJT	NVS	PUS	LDN	PTB	NVS
		DS	DS	No./10h	%DP	DS	% SS	% SS				DS	%WE	%WE	%WE	DS	DS	%DL	%DL	DS
1	20880 (PKV KISAN)	6.7	4.3	7	0	7.0	13	5	11	1	2	5.0	1	5	7	1.0	1.0	55	3	1.0
2	Jaya	6.3	8.9	4	100	7.0	28	25	6	2	7	5.0	9	3	18	1.0	3.0	89	5	3.0
3	Triguna	7.7	8.0	7	88	7.0	11	8	20	2	1	1.0	8	2	8	1.0	NT	66	5	3.0
4	IR 64	3.7	3.4	15	70	7.0	20	5	16	1	3	3.0	7	18	11	3.0	3.0	16	5	3.0
5	MTU 1010	3.8	7.2	10	80	7.0	13	1	12	0	3	3.0	0	1	8	3.0	1.0	25	1	1.0
6	TN-1 (Sus.Ch.)	9.0	5.1	12	100	9	30	19	19	9	3	5.0	4	2	7	1.0	5.0	61	7	3.0
7	Ajaya (Res.Ch.)	9.0	9.0	17	NT	NT	22	3	9	4	4	3.0	3	3	10	1.0	5.0	47	7	3.0

***** Green house reaction:

Note:- BPH-Brown planthopper, WBPH-Whitebacked planthopper, PH- Planthoppers, **GMB_4**- Gall midge biotype 4, **GMB_5** - Gall midge biotype 5,RT- Rice thrips, EHB-Earhead bug, DS- Damaged shoot, DP- Damaged plant, SS:- Silver shoot,WE: White ears , DRR- Director of Rice Research, PNR- Pantnagar, WGL- Warangal, PTB-Pattambi, MNC- Moncompu, SBP- Sambalpur, GGT- Ghaghraghat, LDN- Ludhiana, KJT- Karjat, NVS- Navsari, PUS- Pusa,

Source: DRR Screening Nurseries 2008 page no.74 – 91.

It has recorded 6.07 per cent higher grain yield over widely adapted variety Jaya and 9.57 per cent higher yield over regional check during 2008-09 at 27 locations in AICRIP trials. It was found promising over Triguna in region 4 (24.81%) and in region 5 (24.26 %) in India (Table 3). As at the Directorate of Rice Research (DRR), Hyderabad (India) , the Gall midge biotypes GMB 1, GMB 3, GMB 4 and GMB 4M are being reared under controlled green house conditions (Vijaya Lakshmi *et al*., 2006), the same genotype was also screened at DRR during *Kharif* 2008 for Gall Midge biotype 4 reaction and it has recorded 0 per cent plant damage. Similarly, it has also exhibited moderately resistant reaction to major pest and diseases *viz;* Gall midge, Leaf blast, Bacterial leaf blight of this region. (Table 4a and 4b).

Therefore, the culture SKL-22-39-31-25-31-34 (PKV KISAN) was recommended to release for Eastern Vidarbha Zone of Maharashtra State in the 46th Rice workshop of Maharashtra State Coordinated Rice Improvement Programme and subsequently in Research Review Committee Meeting and Research Finding and Recommendation committee held during April, 2012 at Dr PDKV, Akola and Joint Agresco-2012 of Maharashtra Agricultural Universities held at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during May, 2012.

Salient features of PKV KISAN

1. Dwarf stature and non lodging.
2. Duration: 130-135 days seed to seed maturity.
3. Medium slender grain with test wt.16.1g.
4. Higher grain yield over check variety PKV HMT and PLG 1.
5. Good cooking quality.
6. Resistant to Gall Midge biotype 4, Leaf blast, Bacterial Leaf blight, and moderate resistance to Neck blast.

Looking to above mentioned salient features, PKV Kisan variety will be one of the best alternatives to the existing cultivated rice varieties of Eastern Vidarbha region of Maharashtra like PKV HMT in the medium slender and medium duration group with added advantage of resistance to major pest and diseases.

Source : Progress Report of MSCRIP *Kharif* 2008 p. 88

Note : - KL-Kernel length, KB- Kernel breadth, L/B ratio- Length and breadth ratio, VER- Volume expansion ratio, WU- Water uptake, KLAC –Kernel length after cooking, ER- Elongation ratio, ASV- Alkali spreading value, AC- Amylose content, GC-Gel consistency, GT-Gelatinization temperature, MS- Medium slender, SS- short slender, A- Absent, NS- Non scented

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Genetic Variability and Morphological Characterization Studies in CMS Lines of Pigeonpea Derived from *Cajanus scarabaeoides*

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ABSTRACT

The present investigation on pigeonpea crop conducted to identify best CMS lines with morphological markers for further maintenance of genetic purity of CMS lines derived from *Cajanus scarabaeoides* cytoplasm. The plant material was comprised of eleven CMS, their corresponding maintainer lines and three checks. The observations were recorded for yield and yield contributing characters in addition to morphological traits like plant, stem, leaf, flower, pods, seeds etc. as per national guidelines of DUS testing. The CMS maintainer AKSMR-736B produced highest seed yield per plant followed by their CMS line AKSMR-736A in addition to highest pod setting percentage. Longest flowering span was noticed for CMS line AK-120-1A. On the basis of morphological characterization study, some of the CMS lines in present investigation differ significantly from other CMS i.e. AKSMR-736A and AKSMR-736B based on anthocyanin colouration of epicotyle and stem colour; further, AKWR-627A and AKWR-627B could be identified on the basis of prominent and special type of pod constrictions. The genotype GT-288A and GT-288B were characterized with typical erect growth habit. The genotype AKWR-627A and AKWR-627B need further purification as it showed variation for flower colour and seed colour to some extent. All the CMS lines and their respective maintainer lines were identical with each other except for fertility and sterility.

Pigeonpea (*Cajanus cajan* L.) is one of the important grain legume (pulse) crop of India. Despite the importance of pigeonpea as an important legume crop in the semi arid tropics, its production has remained static over last several years. Therefore, in order to break the yield platue of this crop, many crop improvement programmes have been initiated to enhance yield potential of pigeonpea including development of hybrids by taking the advantage of pollination behavior and potential of heterosis breeding (Reddy *et. al.*, 1978).

Flowering duration of CMS line is one of the important character in view of matching ability with different restorers for seed production as it facilitates fertility restoration for maximum pods setting percentage. Pigeonpea produces greater number of flowers of which only 1 to 5 pods per recemes may mature (Ariyanayagam *et al*., 1975), so the selection of parental lines based on pod setting percentage develops superior hybrids.

For development of CMS based hybrids, male sterile (A), maintainer (B) lines and restorer (R) are required. Unambiguous characterization of parental lines not only reduces the cost, labour and time but also leads to the hybrid development in the proper perspective. Considering the above said facts, the present study was undertaken with the objectives to select the most useful CMS line on the basis of *per se* performance and other traits related with more hybrid seed production and to identify the morphological markers for maintenance of genetic purity.

MATERIAL AND METHODS

Plant material

Eleven CMS lines with their maintainer and three pigeonpea varieties *viz*., GT-288A, GT-288B, GT-33A, GT-33B (developed at S.D.A.U., S.K. Nagar, Gujarat, India), AK-120-1A, AK-120-1B, AK-120-2A, AK-120-2B, AKWR-627A, AKWR-627B, AKV-2A, AKV-2B, AKV-4A, AKV-4B, AKV-8A, AKV-8B, AKV-9A, AKV-9B, AKSMR-736-A, AKSMR-736-B, AKSMR-854A, AKSMR-854-B, AKT-8811 (check) (developed at Pulses Research Unit, Dr.P.D.K.V., Akola, India), ICPL-87119 (check) and ICP-8863 (check) (developed at ICRISAT, Hyderabad, India) used for present investigation were obtained from Pulses Research Unit, Dr. P.D.K.V., Akola (Table 1).

Field experiment

The experiment was conducted at Pulses Research Unit, Dr. PDKV, Akola, during *Kharif* 2008-09

1. M.Sc. Student and 2. Associate Professor, Department of Botany, Dr. PDKV, Akola

Table 1. Source and derivation of CMS lines, their maintainer and checks.

S.N.	Genotypes	Source	Derivation
1	GT-288A	SDAU, SK Nagar, Gujrat	*C. scarabaeoides* x GT-288 (*C.cajan*)
2	GT-288B	SDAU, SK Nagar, Gujrat	GT-288
3	AK-120-1A	Dr.PDKV, Akola	GT-288A (*C. scarabaeoides*) x UPAS-120 (*C. cajan*)
4	AK-120-1B	Dr.PDKV, Akola	UPAS-120
5	GT-33A	SDAU, SK Nagar, Gujrat	*C. scarabaeoides* x GT-33 (*C. cajan*)
6	GT-33B	SDAU, SK Nagar, Gujrat	GT-33
7	AK-120-2A	Dr.PDKV, Akola	GT-288A (*C. scarabaeoides*) x UPAS-120 (*C. cajan*)
8	AK-120-2B	Dr.PDKV, Akola	UPAS-120
9	AKWR-627A	Dr.PDKV, Akola	AK-120-2A (*C. scarabaeoides*) x AK-627(*C. cajan*)
10	AKWR-627B	Dr.PDKV, Akola	AK-627
11	AKV-2A	Dr.PDKV, Akola	GT-288A (*C. scarabaeoides*) x AKV-2 [(*C. volubilis*) x *C. cajan*]
12	AKV-2B	Dr.PDKV, Akola	AKV-2
13	AKV-4A	Dr.PDKV, Akola	GT-288A (*C. scarabaeoides*) x AKV-4 [(*C. volubilis*) x *C. cajan*]
14	AKV-4B	Dr.PDKV, Akola	AKV-4
15	AKV-8A	Dr.PDKV, Akola	GT-288A (*C. scarabaeoides*) x AKV-8 [(*C. volubilis*) x *C. cajan*]
16	AKV-8B	Dr.PDKV, Akola	AKV-8
17	AKV-9A	Dr.PDKV, Akola	GT-288A (*C. scarabaeoides*) x AKV-9 [(*C. volubilis*) x *C. cajan*]
18	AKV-9B	Dr.PDKV, Akola	AKV-9
19	AKSMR-736A	Dr.PDKV, Akola	AK-120-2A (*C. scarabaeoides*) x BSMR-736 (*C. cajan*)
20	AKSMR-736B	Dr.PDKV, Akola	BSMR-736
21	AKSMR-854A	Dr.PDKV, Akola	AK-120-2A (*C. scarabaeoides*) x BSMR-854 (*C. cajan*)
22	AKSMR -854B	Dr.PDKV, Akola	BSMR-854
23	AKT-8811	Dr.PDKV, Akola	(*C.cajan*)
24	ICPL-87119	ICRISAT, Hyderabad	(*C.cajan*)
25	ICP-8863	ICRISAT, Hyderabad	(*C.cajan*)

() species which has contributed cytoplasm for respective genotype

in Randomized Block Design (RBD) with three replications. Each entry was planted in single row of 4 m length with inter and intra row spacing of 120 cm and 60 cm, respectively. The recommended agronomic practices and plant protection measures were followed for healthy crop growth. The protective irrigation was given to crop whenever necessary.

Observations recorded

The characterization of CMS lines was done by following the National guidelines for DUS testing (Anonymous, 2007). The observations on morphological traits like plant, stem, leaf, flower, pods, seeds etc. along with yield and yield contributing traits (Table 3 and 4) were recorded on five randomly selected plants from each entry and replications except for days to 50 per cent flowering, for which all the plants in a row were considered. The trait days to first picking of pod was recorded by calculating the days between 50 per cent flowering and early mature pods where chances for pod development is more, whereas, days to last picking of pods were calculated by days required from 50 per cent flowering to days for last matured pods where again no chance for pod development was observed. For studying the pod setting percentage under open pollination, weekly 100 buds likely to open on next day were tagged in each replication on selected plants by using coloured threads. This operation was continuously done at weekly interval

Table 2. : Analysis of variance for CMS lines, their maintainers and checks

Source of variation	d.f.	Mean Sum of Square										
		50% flowering	Plant height	100 Seed weight	Pods plant^{-1}	Pods cluster^{-1}	Seeds pod^{-1}	Flowering span	Pod setting %	Days to first picking of pods	Days to last picking of pods	Seed yield plant^{-1}
Replication	2	1.973	951.37	0.77	1113.77	2.72	0.25	7.37	8.58	4.01	2.70	102.55
Treatment	24	1102.8**	721.9*	3.4**	4867.3**	1.1*	0.4**	428.8**	87.5**	10.9**	524.8**	227.1*
Error	48	0.64	333.79	0.47	550.06	0.577	0.09	4.51	1.84	8.99	1.46	105.40
SE m ±	-	0.46	10.54	0.38	13.54	0.43	0.17	1.22	0.78	1.73	0.69	5.92
C.D.	-	1.31	30.02	1.12	38.54	1.24	0.50	3.49	2.23	4.92	1.98	16.87

*, ** Significant at 5% and 1% level of significance

Table 4. Morphological characterization of pigeonpea genotypes under study

S.N.	Descriptor	Status	Genotypes
1	Plant:Anthocyanin	Absent	AKSMR-736A, AKSMR-736B.
	colouration of epicotyl	Present	GT-288A, GT-288B, AK-120-1A, AK-120-1B, GT-33A, GT-33B, AK-120-2A, AK-120-2B, AKWR-627A, AKWR-627B,AKV-2A, AKV-2B,AKV-4A,AKV-4B, AKV-8A,AKV-8B,AKV-9A, AKV-9B, AKSMR-854A, AKSMR-854B, AKT-8811, ICPL-87119, ICP-8863.
2	Plant: Branching pattern	Erect ($<30^0$)	GT-288A, GT-288B, GT-33A, GT-33B.
		Semi-spreading (30^0-60^0)	AK-120-1A, AK-120-1B, AKWR-627A, AKWR-627B, AK-120-2A, AK-120-2B, AKSMR-736A AKSMR-736B, AKSMR-854A, AKSMR-854B, ICPL-87119,AKV-2A, AKV-2B, AKV-4A, AKV-4B, AKV-8A, AKV-8B, AKV-9A, AKV-9B.
		Spreading ($>60^0$)	AKT-8811, ICP-8863.
3	Time of flowering	Very early (<60days)	GT-288A.
	(50% of the plants with	Early (61-90 days)	GT-288B, AK-120-1A, AK-120-1B, GT-33A, GT-33B,
	at least one open flower)		AK-120-2A, AK-120-2B.
		Medium (91-130 days)	AKWR-627A, AKWR-627B, AKV-2A, AKV-2B, AKV-4A, AKV-4B, AKV-8A, AKV-8B, AKV-9A, AKV-9B, AKSMR-736A, AKSMR-736B, AKSMR-854A, AKSMR-854B, AKT-8811, ACPL-87119, ICP-8863.
		Late(131-160 days)	-
		Very late (>160days)	-
4	Plant Growth habit	Determinate	AKV-2A, AKV-2B, AKV-4A, AKV-4B, AKV-8A, AKV-8B, AKV-9A, AKV-9B.
		Indeterminate	GT-288A, GT-288B, AK-120-1A, AK-120-1B, GT-33A, GT-33B, AK-120-2A, AK-120-2B, AKWR-627A, AKWR-627B, AKSMR-736A, AKSMR-736B, AKSMR-854A, AKSMR-854B, AKT-8811, ICPL-87119, ICP-8863.
5	Stem: Colour	Green	AKSMR-736A, AKSMR-736B.
		Purple	GT-288A, GT-288B, AK-120-1A, AK-120-1B, GT-33A, GT-33B, AK-120-2A, AK-120-2B, AKWR-627A, AKWR-627B, AKV-2A, AKV-2B, AKV-4A, AKV-4B, AKV-8A, AKV-8B, AKV-9A,AKV-9B, AKSMR-854A, AKSMR-854B, AKT-8811, ICPL-87119, ICP-8863.
6	Leaf: Shape	Oblong	All
		Obvate	-
		Narrowly oblong	-

S.N.	Descriptor	Status	Genotypes
7	Leaf:Pubescence on l	Absent	-
	ower surface of the leaf	Present	All
8	Flower: Colour of base	Light yellow	-
	of petal (standard)	Yellow	All
		Orange yellow	-
		Purple	-
		Red	-
9	Flower :pattern of	Absent	GT-288A, GT-288B, GT-33A, GT-33B, AKSMR-736A,
	streaks on petal		AKSMR-736 B, AKSMR-854A, AKSMR-854B,
	(standard)		AKT-8811, ICPL-87119, ICP-8863.
		Sparse	AK-120-1A, AK-120-1B, AK-120-2A, AK-120-2B, AKV-2A, AKV-2B, AKV-4A, AKV-4B, AKV-8A, AKV-8B, AKV-9A, AKV-9B.
		Medium	AKWR-627A, AKWR-627B.
		Dense	-
		Mosaic	-
10	Pod: colour	Green	GT-288A, GT-288B, AKSMR-736A, AKSMR-736B
		Green with	AK-120-1A, AK-120-1B, GT-33A,GT-33B, AK-120-
		brown streaks	2A, AK-120-2B, AKWR-627A, AKWR-627B, AKV-2A, AKV-2B, AKV-4A, AKV-4B, AKV-8A, AKV-8B, AKV-9A, AKV-9B, AKSMR-854A, AKSMR-854B, AKT-8811, ICPL-87119, ICP-8863.
		Green with purple streaks	-
		Purple	-
		Dark purple	-
11	Pod: Pubescence	Absent	-
		Present	All
12	Pod: waxiness	Absent	All
		Present	-
13	Pod: surface stickiness	Absent	GT-288A, GT-288B, GT-33A,GT-33B, AKV-2A, AKV-2B, AKV-4A, AKV-4B, AKV-8A, AKV-8B, AKV-9A, AKV-9B, AKSMR-854A, AKSMR-854B, AKT-8811
		Present	AK-120-1A, AK-120-1B, AK-120-2A, AK-120-2B, AKWR-627A, AKWR-627B, AKSMR-736A, AKSMR-736B, ICPL-87119, ICP-8863.

S.N.	Descriptor	Status	Genotypes
14	Pod: Constriction	Slight	GT-288A, GT-288B, AK-120-1A, AK-120-1B, GT-33A, GT-33B, AKSMR-736A, AKSMR-736B, ICP-8863.
		Prominent	AK-120-2A, AK-120-2B, AKV-2A, AKV-2B, AKV-4A, AKV-4B, AKV-8A, AKV-8B, AKV-9A, AKV-9B, AKSMR-854A, AKSMR-854B, AKT-8811, ICPL-87119,AKWR-627A, AKWR-627B.
15	Pod: size (cm)	<4 cm	-
		4-5 cm	AK-120-1A, AK-120-1B, GT-33A, GT-33B, AK-120-2A, AK-120-2B, AKV-2A, AKV-2B, AKV-4A, AKV-4B, AKV-8A, AKV-8 B, AKV-9A, AKV-9B, AKSMR-854A, AKSMR-854B, AKT-8811, ICPL-87119, ICP-8863.
		>5cm	GT-288A, GT-288B, AKWR-627A, AKWR-627B, AKSMR-736A , AKSMR-736B.
16	Pod: No. of seed	2	GT-288A, GT-288B, GT-33A, AK-120-2A, AK-120-2B, AKWR-627A, AKWR-627B, AKV-2B, AKV-4A, AKV-4B,AKV-8A,AKV-8B,AKV-9A,AKV-9B, AKSMR-854A.
		3	AK-120-1A, AK-120-1B, GT-33B, AKV-2A, AKSMR-736A, AKSMR-736B, AKSMR-854B, AKT-8811, ICPL-87119,ICP-8863.
		4	-
17	Plant: Height	Short (<100cm)	-
		Medium (101-150 cm)	All
		Tall (>150cm)	-
18	Seed: colour	Cream	GT-288A, GT-288B, AKV-2A, AKV-2B, AKV-4A, AKV-4B, AKV-8A, AKV-8 B, AKV-9A, AKV-9B, AKWR-627A, AKWR-627B.
		Brown	AK-120-1A, AK-120-1B, GT-33A, GT-33B, AK-120-2A, AK-120-2B, AKSMR-736A, AKSMR-736B, AKSMR-854A, AKSMR-854B, AKT-8811, ICPL-87119,ICP-8863.
		Dark brown	-
		Grey	-
		Purple	-
19	Seed: colour pattern	Uniform	GT-288A, GT-288B, AKV-2A, AKV-2B, AKV-4A, AKV-4B, AKV-8A, AKV-8 B, AKV-9A, AKV-9B,AK-120-1A, AK-120-1B, GT-33A,GT-33B, AK-120-2A, AK-120-2B, AKSMR-736A , AKSMR-736B, AKSMR-854A, AKSMR-854B, AKT-8811, ICPL-87119,ICP-8863.

S.N.	Descriptor	Status	Genotypes
		Mottled	AKWR-627A, AKWR-627B.
		Spotted-brown, black	-
20	Seed: shape	Oval	GT-288A, GT-288B, AKV-2A, AKV-2B, AKV-4A, AKV-4B, AKV-8A, AKV-8B, AKV-9A, AKV-9B.
		Globular	-
		Elongate	AK-120-1A, AK-120-1B, GT-33A, GT-33B, AK-120-2A, AK-120-2B, AKWR-627A, AKWR-627B, AKSMR-736A, AKSMR-736B, AKSMR-854A, AKSMR-854B, AKT-8811, ICPL-87119, ICP-8863.
21	Seed: size	Small (<7g)	-
	(100 seed weight)	Medium (7-9g)	AK-120-1A, AK-120-1B, AK-120-2A, AK-120-2B, AKWR-627B, AKV-2B, AKV-4A, AKV-4B, AKV-8A, AKV-8B, AKV-9A, AKV-9B.
		Large (9-11g)	GT-288A, GT-288B, GT-33A,GT-33B,AKWR-627B, AKV-2A,AKSMR-736B, AKSMR-854A, AKSMR-854B, AKT-8811, ICPL-87119, ICP-8863.
		Very large (>11g)	AKSMR-736A.
i.	Fertility status *	Fertile	GT-288B, AK-120-1B, GT-33B, AK-120-2B, AKWR-627B, AKV-2B, AKV-4B, AKV-8 B, AKV-9B, AKSMR-736B, AKSMR-854B, AKT-8811, ICPL-87119,ICP-8863.
		Sterile	GT-288A, AK-120-1A, GT-33A, AK-120-2A, AKWR-627A, AKV-2A, AKV-4A, AKV-8A, AKV-9A, AKSMR-736A, AKSMR-854A.
ii.	Flowering period*	60-90 days	GT-288A, GT-288B, AK-120-1A, AK-120-1B, GT-33A, GT-33B, AKWR-627A, AKWR-627B, AK-120-2A, AK-120-2B, AKV-2A, AKV-2B, AKV-4A, AKV-4B, AKV-8A, AKV-8B, AKV-9A, AKV-9B.
		91-130 days	AKSMR-736 A, AKSMR-736B, AKSMR-854A, AKSMR-854B, AKT-8811, ICPL-87119, ICP-8863.
iii.	Colour of ripe pod*	Brown	AK-120-1A, AK-120-1B, AKWR-627A, AKWR-627B, AK-120-2A, AK-120-2B, AKSMR-736A, AKSMR-736B, AKSMR-854A, AKSMR-854B, AKT-8811, ICPL-87119, ICP-8863.
		Straw	GT-288A, GT-288B, GT-33A,GT-33B,AKV-2A,AKV-2B, AKV-4A,AKV-4B,AKV-8A,AKV-8B,AKV-9A,AKV-9B.

* Extra characters recorded in addition to the descriptor (SG/07/2006,20/2/2007)

till the end of flowering and pod setting percentage was worked out based on number of pods set from the buds tagged.

Data Analysis

The averages of five selected plants for the observations recorded for quantitative traits were worked out and subjected to statistical analysis i.e. analysis of variance as per the procedure described by Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

Genetic variability

The genetic variability study was conducted to select superior CMS lines, which may be used for the development of superior hybrids. Accordingly, eleven yield and yield contributing traits were recorded and subjected for analysis of variance which exhibited significant differences for all the traits among the twenty five genotypes selected for present investigation (Table-2). The mean values of eleven yield and yield contributing characters for eleven CMS lines with their maintainer and three check varieties were calculated and presented in Table 2.

Minimum days to 50 per cent flowering was recorded by GT-288A (59.67 days) and maximum by AKV-9B (115.67 days) followed by AKV-8B (114.67 days) with an average of 98.23 days for all the lines. Flowering span was recorded with minimum 57 days (AK-120-2B) to maximum 106.67 days (AK-120-1A) with average of 76.31 days. The mean performance for plant height ranged from 105 cm (AKV-8B) to 151.67 cm (GT-288B) with average height of 125.89 cm, whereas, days to first picking of pods ranged from 41.67 (GT-288A) to 76.67 (ICPL-87119) days with average of 49.21 days. The data for days to last picking of pods revealed that, the mean performance of genotypes was ranged from 52.67 (AKSMR-736B) to 76.67 (ICPL-87119) days with average of 64.95 days. The mean performance for pods per plant ranged from 93.67 to 261.33 with the average of 134.51 pods per plant. Highest number of pods per plant recorded by AKSMR-736B (261.33 pods) followed by AKSMR-736 A (196.33 pods) while, lowest number of pods per plant was recorded by genotype AKV-8A (93.67 pods). Further, highest number of pods per cluster was recorded by check AKT-8811 (3.73 pods) followed by AKCMS-854B (3.48 pods) and lowest pods per cluster recorded by AK-120-2A (1.35 pods). The check AKT-8811 (3.37 seeds) recorded highest number of seeds per pod followed by genotype AKSMR-736A (3.36 seeds) and lowest number of seeds per pod recorded by genotype AKV-4A (2.09 seeds). The average performance of all 25 lines for the seed per pod was 2.52. The highest pod setting percentage observed by AKSMR-736B (30.83 %) followed by AKSMR-736A (26.55 %) and the lowest in AKV-8A (7.96 %). Weight of 100 seeds of various lines ranged from 8.24 g to 11.95 g with an average of 9.83 g. AKV-4B (8.24 g) recorded lowest 100 seed weight while, AKSMR-736A (11.95 g) recorded highest 100 seed weight followed by GT-33A (11.16 g). The seed yield per plant for various genotypes ranged from 13.61g to 45.99 g with average of 23.81 g. Highest seed yield per plant recorded by check ICP-8863 (45.99 g) followed by AKSMR-736B (39.38 g) and the lowest by AKV-2A (13.61 g). None of the CMS lines or its maintainer lines could surpass the check for the characters *viz.*, days to first picking of pod, days to last picking of pod, pods per cluster, seeds per pod and seed yield per plant.

Kalaimangal *et al.* (2008), developed two pigeonpea CMS lines, *viz.* CORG 990052A and CORG 990047A by interspecific hybridization of *Cajanus cajan* with *C. scarabaeoides a*nd studied days to first flowering, plant height, primary branches per plant, pods per plant, pod length, seeds per pod, 100-seed weight, plant type, growth habit, stem colour, flower colour, standard petal, anther, seed colour and days to maturity. While studying periodical pod setting percentage for GMS lines of pigeonpea, Chavhan (2001) reported 25 to 29 per cent pods setting in open pollination. Patel (2000) studied different male sterile lines and recorded that pod setting percentage differs due to genotypic differences, incidence of pest (*Maruca vitrata*), frequency of pesticides application, seasonal variation, pollen avaibility and existing environment affect most. Reddy (1990) reported a strong and positive association of seed yield with pods per plant, plant height, and number of pods per cluster and concluded that, environment has relatively less influence on above association and also reported negative correlation of 100 seed weight, days to flowering and maturity with yield per plant.

Characterization and identification of morphological markers

Plant characteristics

Out of twenty five genotypes of pigeonpea under study, only two genotypes AKSMR-736A and AKSMR-

Table 3. Mean performance of twenty five pigeonpea genotypes for yield and yield contributing traits.

Genotypes	Days to 50% flowering	Flowering span (days)	Plant height(cm)	Days to first picking	Days to last picking	Pods plant^{-1}	Pods cluster^{-1}	Seeds spod^{-1}	Pod setting %	100 seed wt (g)	Seed yield plant^{-1}(g)
GT-288 A	59.67	84.33	146.00	41.67	67.00	111.00	1.83	2.24	11.10	11.00	19.13
GT-288 B	61.33	75.33	151.67	45.33	60.33	118.33	2.36	2.48	14.31	10.55	20.68
AK-120-1 A	62.67	106.67	138.00	43.00	68.00	125.33	2.01	2.59	17.92	9.05	23.13
AK-120-1 B	64.67	102.00	126.33	44.33	61.33	120.33	1.84	2.60	19.26	8.75	20.33
GT-33 A	83.00	76.67	124.33	48.00	67.33	118.00	2.70	2.29	13.97	11.16	22.91
GT-33 B	83.67	67.33	115.67	45.33	62.67	129.67	2.23	2.56	11.23	10.40	22.04
AK-120-2 A	90.33	64.67	112.33	45.33	63.67	110.67	1.35	2.22	13.48	8.69	17.72
AK- 120 -2B	88.33	57.00	111.67	43.33	56.67	112.67	2.26	2.28	12.53	8.74	18.03
AKWR-627A	92.33	71.67	125.67	45.67	62.67	132.33	2.73	2.15	14.41	10.94	22.20
AKWR-627B	93.67	66.33	128.00	48.33	61.67	125.33	2.95	2.21	16.68	9.33	21.71
AKV-2A	111.00	72.67	109.00	47.67	64.00	101.00	1.71	2.69	8.23	10.04	13.61
AKV-2B	112.67	70.33	121.67	44.00	56.33	115.33	2.20	2.42	10.14	8.96	18.94
AKV-4A	113.67	74.33	107.67	46.00	62.33	113.00	2.23	2.09	11.29	9.20	16.14
AKV-4B	114.33	69.00	110.33	44.00	70.67	102.00	2.04	2.19	9.53	8.24	13.73
AKV-8A	114.00	74.33	108.00	48.67	68.33	93.67	2.22	2.17	7.96	8.29	14.21
AKV-8B	114.67	71.00	105.00	49.00	64.67	108.67	2.99	2.38	8.67	9.32	23.49
AKV-9A	114.33	74.33	106.33	46.33	72.67	108.00	2.18	2.18	10.72	8.66	23.92
AKV-9B	115.67	70.00	114.00	45.67	65.33	121.00	2.33	2.39	16.22	8.69	24.60
AKSMR-736A	110.67	78.67	138.67	44.33	64.33	196.33	3.02	3.36	26.55	11.95	32.82
AKSMR-736B	112.67	66.33	145.67	48.67	52.67	261.33	3.12	2.95	30.83	10.52	39.38
AKCMS-854A	107.33	76.67	131.67	46.67	65.33	124.33	2.77	2.39	14.32	10.79	22.22
AKCMS -854B	109.33	63.67	130.00	45.67	62.33	139.67	3.48	2.92	16.65	10.85	20.27
AKT-8811 (Ch)	101.67	91.00	148.33	74.00	74.00	206.00	3.73	3.37	12.81	10.63	41.73
ICPL-87119(Ch)	109.67	95.67	148.33	76.67	76.67	178.67	3.55	3.00	17.39	10.87	36.40
ICP-8863 (Ch)	114.33	87.67	143.00	72.67	72.67	190.00	2.92	2.94	19.24	10.12	45.99
Mean	98.23	76.31	125.89	49.21	64.95	134.51	2.51	2.52	14.62	9.83	23.81
SE(m)	0.475	1.22	10.185	1.73	0.71	13.028	0.457	0.171	0.830	0.382	5.92
CD at 5%	1.351	3.49	28.915	4.92	2.03	36.997	1.298	0.488	2.359	1.087	16.87

736B (green epicotyle) were observed without anthocyanin pigmentation and all other genotypes showed presence of anthocyanin pigmentation (purple colour) on epicotyl (Table-3). This trait can be exploited for purification of these two genotypes at seedling stage whenever necessary. The branching pattern of twenty five genotypes were observed and characterized under three groups as erect (4), semi-spreading (19) and spreading (2), however, a typical erect growth habit was noticed in GT-288A, GT-288B, GT 33A and GT 33B which was not found in any other genotypes. Plant growth habit of eight genotypes was observed as determinate and other seventeen genotypes were observed with indeterminate growth habit. The plant height of all twenty five genotypes was ranged between 101 to 150 cm hence, all the genotypes were characterized as medium.

Stem characteristics

For the trait stem colour, only two genotypes AKSMR-736A and AKSMR-736B were observed with green stem colour while all remaining twenty three genotypes were observed with purple stem colour. These findings are in accordance with Narkhede *et al.* (1980) and Singh *et al.* (1993) that Indian pigeonpea germplasm has green stem colour, while, African has purple and in some instances unstable purple colour has also been observed.

Leaf characteristics

According to pigeonpea descriptor for DUS testing, twenty five genotypes under study were observed for leaf shape and presence or absence of pubescence on lower surface of leaf. Oblong leaf shape with presence of pubescence on lower side of leaf was observed in all twenty five genotypes under study. Hence the genotypes under study can not be distinguished on the basis of leaf characteristics.

Flower characteristics

For time of flowering, only one genotype *viz.*, GT-288A was found to be very early however, seven genotypes were grouped as early and seventeen as medium. The colour of base of petal (standard) in all the twenty five genotypes was yellow. The pattern of streaks on petal (standard) recorded as absent for eleven genotypes whereas, sparsely present for twelve genotypes and medium for AKWR-627A and AKWR-627B in which some variation from absent to dense was also noticed. It shows some impurity in these genotypes which needs further purification. Shaw *et al.* (1933) also observed a large variation in flower colour of pigeonpea, i.e. the flower colour differs on dorsal and ventral side which may be yellow with few or no red marks at the base with the red vein being distinct. In between these three grades intermediate forms are also met with the ventral side of the standard may be pale yellow, deep yellow and orange in colour and observed these range of variation in respect of standard colour. On the basis of fertility status, fourteen genotypes were grouped as fertile and eleven as sterile. The flowering period of eighteen genotypes ranged between 60-90 days and seven genotypes with 91-130 days.

Pod characteristics

GT-288A, GT-288B, AKSMR-736A and AKSMR-736B showed green coloured pods, while, rest of the twenty one genotypes showed green with brown streaks pods. The traits pubescence on pod and pod waxiness recorded in all the twenty five genotypes. Stickiness on pod surface was observed in ten genotypes and absent in fifteen. For pod shape constrictions, nine genotypes were observed as slight and sixteen as prominent, however, AKWR-627A and AKWR-627B were observed with very prominent (uncommon) pod shape constrictions. Regarding size of the pod, nineteen genotypes were having pod size of 4-5 cm and six genotypes with more than 5 cm pod length. For number of seeds per pod, fifteen genotypes grouped with two seeds per pod and ten with three seeds per pod. Further, the colour of ripe pod was brown in case of thirteen and straw in case of twelve genotypes.

Seed characteristics

For seed colour, none of the genotypes was observed with dark brown, gray or purple seed; however, twelve genotypes were grouped as creamy seed colour and thirteen genotypes as brown seed colour. The pattern of seed colour was uniform in twenty three genotypes and mottled in AKWR-627A and AKWR-627B. Oval seed shape was noticed in ten genotypes and elongate type of seed shape observed in rest of the fifteen genotypes. Further, the seed size was medium for twelve genotypes, large for other twelve genotypes and very large for AKSMR-736A. The results obtained for seed characteristics in the present study was supported by Ramanadan *et al.* (1988) and Upadhyaya *et al.* (2007).

The CMS line AKSMR-736A and AKSMR-736B were found to be most promising in respect of pod

setting percentage, yield and other yield contributing characters which can be effectively utilized for development of good pigeonpea hybrids. Stable morphological markers like absence of pigmentation on epicotyle and green stem colour in case of AKSMR-736A and AKSMR-736B; typical erect growth habit of GT-288A and GT-288B; typical pod shape and very prominent pod constrictions in case of AKWR-627A and AKWR-627B and semi spreading compact (DT) branching habit were identified for AKV-2A, AKV-2B, AKV-4A, AKV-4B, AKV-8A, AKV-8B, AKV-9A and AKV-9B. The stable morphological markers identified could be exploited for further maintenance of genetic purity of these genotypes which, in turn, would be an alternative to grow out test of these lines, when they will be used commercially.

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Genetic Divergence Studies in Forage Sorghum Genotypes

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ABSTRACT

Genetic divergence studies were undertaken on 32 genotypes of forage sorghum for fodder yield and its contributing characters. All the genotypes were grouped into seven clusters. Maximum inter cluster distance was observed between cluster IV and VI (59.66) Thus, the parents involved in cluster IV (AKFG-09-4,AKFG-09-3, AKFG09-5 and Improved Ramkel) and cluster VI (IS47802) can be utilized for improvement of green fodder yield and its contributing characters. Relative contribution of characters towards total divergence realized the importance of green fodder yield followed by stem girth and leaf length.

Sorghum (*Sorghum bicolor* (L.) Moench) is an important crop of dryland agriculture. In Northern part of India, the sorghum is grown mainly for fodder production, whereas in the central and Southern parts of India , it is grown as a source of food and fodder. Forage sorghum is one of the most widely adapted forage crops in drought prone areas because of its higher productivity, better palatability and digestibility. The improvement of forage sorghum is much emphasized owing to its importance as a fodder crop to feed the increasing livestock population in India.

To meet out the increasing demand, it is necessary to maximize the production by developing sorghum varieties / hybrids with high fodder yield.

Success of any crop improvement programme mainly depends upon the presence of variability and thereafter the selection of parental lines for breeding programme. The more diverse the parents within overall limits of fitness, the greater are the chances of heterotic F_1's and broad spectrum of variability in segregating generation (Arunachalam, 1981 and Falconer, 1989). Therefore, the first step to initiate a hybridization programme is to assess genetic diversity and thereby identify genetically diverse parents. For identifying genetically diverse parents for hybridization, Mahalanobis D^2 statistics is commonly used in plant breeding (Rao, 1952).

MATERIAL AND METHODS

The experimental material comprised of 32 genotypes of forage sorghum (*Sorghum bicolor* L.) obtained from Sorghum Research Unit , Dr.PDKV., Akola. Thirty two genotypes were grown in randomized block design with three replications on the field of Sorghum Research Unit, Dr. PDKV, Akola. Each plot of genotypes in replication consisted of 4 rows of 4 meter length with the row spacing of 30 cm. Observations were recorded on plot basis for days to 50 per cent flowering, green fodder yield (t ha^{-1}), dry fodder yield (t ha^{-1}) and on five randomly selected plants from each plot of the genotypes for the characters viz., plant height (cm), number of tillers per plant, leaf stem ratio, number of leaves per plant, leaf length (cm), leaf breadth (cm), stem girth (cm), TSS (%), protein content (%) . The data were subjected to statistical analysis as per procedure given by Panse and Sukhatme (1967). D^2 analysis was carried out as per the Mahalanobis (1928) . The grouping of genotypes was made by Tocher's method as described by Rao (1952). The main objective of the present study was to identify the parents for their further utilization in hybridization programme.

RESULTS AND DISCUSSION

D^2 analysis revealed the presence of wide genetic diversity among 32 genotypes for all the characters except number of tillers per plant and TSS percent indicating further scope for improvement of green fodder yield and its contributing characters. Substantial genetic diversity in sorghum for studied characters were also reported by Sisodia *et al*. (1983) and Joshi and Vashi (1992).

All the thirty two genotypes studied were grouped into 7 clusters (Table 1). Cluster II and III comprised of eight genotypes. However, cluster I, IV and V consisted of six, five and three genotypes respectively. Cluster VI and VII included only one genotype each. In the present investigation, the clustering pattern revealed that genotypes coming from different geographic area were included in the same cluster, while genotypes having

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Table 1. Distribution of sorghum genotypes into different clusters

Clusters	Total No. of genotypes	Genotypes
I	6	AKFSV-6, AKFR-97, SSG-59, IS-47807, IS-47817-7, AKFSV-2
II	8	EC-2934, IS-23960, AKFR-89, M-48212, M-48212-1, SGL-87, AKFSV-7, AKFG-09-6
III	8	GD-68722, EC-3077, SSG-59-3, AKFSV-3,M-48273, IS-88032-1, IS-47838, IS-47821
IV	5	AKFSV-4, AKFG-09-4, AKFG-09-3, AKFG-09-5, Improved ramkel
V	3	AKFR-4, IS-3203, AKFSV-5
VI	1	IS-47802
VII	1	IS-18581

Table 2. Average intra (bold) and inter cluster distance (D=30.67)

Clusters	I	II	III	IV	V	VI	VII
I	**9.85**	24.68	6.27	47.27	35.04	15.75	23.95
II		**14.67**	25.54	29.19	20.23	35.14	20.85
III			**12.75**	49.60	30.74	20.78	33.92
IV				**11.73**	29.21	59.66	30.68
V					**16.63**	42.79	28.21
VI						**0**	34.77
VII							**0**

common sources were placed into different clusters indicating no relationship between genetic diversity and geographic diversity.

Average intra and inter cluster distance (D^2 values) are presented in Table 2. The intra cluster variation ranged from zero to 16.63. Cluster V showed the highest intra cluster distance (D=16.63) and comprised of 3 genotypes. Cluster VI and VII showed smallest intra cluster distance (D=0.00) comprised of only one genotype each. The average inter-cluster distance was maximum between the clusters IV and VI (D=59.66) having 5 and 1 genotypes respectively, followed by between cluster III and IV (D=49.60) having 8 and 5 genotypes respectively. Thus, the parents involved in cluster IV (AKFG-09-4,AKFG-09-3, AKFG09-5 and Improved Ramkel) and cluster VI (IS47802) can be utilized for further improvement of green fodder yield and its contributing characters through diallel mating system. The results are in agreement with findings of Joshi and Vashi (1992). The minimum inter-cluster distance was found between cluster I and cluster III (D=6.27).

The cluster means for each character are presented in Table 3. The data revealed considerable differences among the clusters for most of the characters studied. The average cluster means for different characters showed that the cluster IV recorded highest cluster mean values for maximum number of characters viz., green fodder yield (25.90 t ha^{-1}), dry fodder yield (6.32 t ha^{-1}), number of leaves $plant^{-1}$ (9.47) and leaf length (72.27 cm) .Whereas, cluster VII had maximum value for leaf breadth (6.33 cm) and stem girth (4.33 cm). Cluster III showed maximum cluster mean value for plant height (233.33 cm). Thus, the genotypes included in the cluster IV (AKFG-09-4,AKFG-09-3, AkFG09-5 and Improved Ramkel) had high mean performance for important traits which may probably due to desirable genes and hence likely to yield desirable sergeants in successive breeding programme. The importance of selection of genotypes from diverse clusters with desirable cluster means and *per se* performance of genotypes for isolating superior recombinants during hybridization programme also reported by Sisodia *et al*. (1983) and Thody (1960).

Table 3. Cluster means for different characters in forage sorghum genotypes.

Clusters	Days to 50% flowering	Green fodder yield(t/ha)	Dry fodder yield (t/ha)	Plant height (cm)	Leaf stem ratio	No. of leaves per plant	Leaf length (cm)	Leaf breadth (cm)	Stem girth (cm)	Protein content %
I	59.00	21.38	5.95	221.44	0.33	7.94	54.83	4.39	3.33	7.45
II	61.71	23.69	6.13	224.50	0.37	8.54	66.42	5.25	3.54	7.96
III	54.67	21.77	5.68	233.33	0.29	8.25	63.00	5.00	3.58	7.14
IV	68.47	25.90	6.32	210.93	0.34	9.47	72.27	5.53	3.80	5.47
V	59.67	20.93	4.52	216.22	0.31	8.44	69.33	5.44	3.56	6.36
VI	54.33	21.52	4.89	220.33	0.25	7.00	51.33	4.67	3.33	7.40
VII	63.67	19.03	4.76	200.33	0.29	8.00	54.00	6.33	4.33	6.46
Variance	24.91	4.78	0.53	109.95	0.0015	0.55	67.98	0.40	0.11	0.71

Table 4. Contribution of various fodder yield and its contributing characters towards genetic divergence in forage sorghum.

S. N.	Characters	Contribution percentage
1	Days to 50 % Flowering (days)	0.40
2	Green fodder yield (t/ha)	31.25
3	Dry fodder yield (t/ha)	2.82
4	Plant height (cm)	1.41
5	Leaf stem ratio	0.00
6	No. of leaves per plant	0.60
7	Leaf length (cm)	21.17
8	Leaf breadth (cm)	12.90
9	Stem girth (cm)	23.59
10	Protein content %	5.82

The contribution of various characters towards genetic divergence among genotypes under study has been presented in Table 4. The most important traits contributing towards genetic divergence were green fodder yield (31.25%), stem girth (23.59%), leaf length (21.17%), leaf breadth (12.90%). However, protein content (5.82%), dry fodder yield (2.82%), plant height (1.41%), number of leaves (0.60%) and days to 50 per cent flowering (0.40) had very less contribution towards total genetic divergence. The characters contributing most towards genetic divergence may be responsible for the variability in the material studied. The characters with less contribution towards genetic divergence are not necessarily being less variable characters. As the material studied involved very small population of 32 genotypes, these characters may show high variability and heritability in other studies. Similar results are also reported by Kukadia *et al*. (1980).

The main objective of the present study was to identify the diverse parents and their utilization in hybridization programme. The parents such as AKFG-09-4, AKFG-09-3, AKFG 09-5 and Improved Ramkel from cluster IV depicted maximum distance with IS47802 from cluster VI and therefore can be used in hybridization programme . These genotypes of the cluster IV i.e.AKFG-09-4, AKFG-09-3, AKFG09-5 and Improved Ramkel also exhibited high mean performance for green fodder yield, dry fodder yield, number of leaves per plant and leaf length which in turn may possess desirable genes to yield desirable sergeants in successive breeding programme. In addition to this the most important traits contributing towards genetic divergence in present study were green fodder yield (31.25%), stem girth (23.59%), leaf length (21.17%)and leaf breadth (12.90%). Thus the genotypes AKFG-09-4,AKFG-09-3, AKFG 09-5 , Improved Ramkel and IS -47802 can be involved in diallel mating system for further improvement in green fodder yield, stem girth, leaf length and leaf breadth to yield desirable sergeants in successive breeding programme.

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Yield Stability over Sowing Windows in Wheat

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ABSTRACT

Experiment was conducted with seven varieties of wheat for sixteen quantitative traits in three sowing windows with 15 days interval Viz., 22nd Nov. (Early sown as E_1), 2nd Dec. (Mid late sown as E_2) , 21st Dec. (Late sown as E_3) during Rabi-2011-12 season. Highly significant variations due to genotypes against pooled deviation revealed the presence of genetic variability for all the traits under study. The component G x E interaction being highly significant indicated that genotypes interacted considerably to environmental conditions in different environments. The predominance of linear component would help in predicting the performance of genotypes across environment. Bread wheat genotypes Viz., AKAW-3997, AKAW-4210-6, AKW-1071 etc. has high mean values and non-significant regression coefficient (β_i) approaching to unity with non-significant deviation from regression ($\delta^2 d_i$) were more stable across three environments. Thus the present study brought out the fact that bread wheat genotypes AKAW-3997 and AKAW-4210-6 were most stable genotypes for yield and its attributing traits and the first sowing window November 22nd, early sown was the most optimum time of sowing of wheat crop. Parameters in respect to grain yield attributing traits revealed that the variety AKAW-3997 was stable for grain yield kgm^{-2}, grain yield qha^{-1} and biological yield g $day^{-1}plant^{-1}$. While variety AKAW-4210-6 was stable for spike characteristics Viz. spike length, spike weight, spike density, spikelet's $spike^{-1}$ and grains $spike^{-1}$. Same variety had average stability for days to heading, days to 50 per cent flowering, days to maturity, grain yield $kgm^{-2}$and grain yield qha^{-1}.

Wheat is an important cereal grain for export and domestic consumption in many countries throughout the world. Thus, continuous supply of wheat to exponentially increasing population is a major concern. The maintenance of wheat genetics had led to ever increasing gains in yield and grain quality, while decreasing the ability of wheat to survive in the wild or in varying climate especially with adverse conditions. The ultimate aim of any breeding program is to develop cultivars with high potential and consistence performance over the diverse environments. Stability of genotypes depends upon the ability to retain certain morphological characters steadily and allowing others to vary resulting in predictable G x E Interaction for quantitative traits. Information about phenotypic stability is useful for selection of crop varieties as well as for breeding programs. An understanding of environmental and genotypic causes leading to G x E interaction are important at all stages of plant breeding including ideotype design, parental selection, establishing breeding objectives, identifying ideal test conditions. Therefore, in the present study seven genotypes were grown over three sowing windows and genotypes possessing stability were identified using the Eberhart and Russell, 1966 model.

MATERIALS AND METHODS

A field study was conducted in randomized block design with three replications for three sowing windows with 15 days interval *Viz.*, 22nd Nov. (Early sown as E_1), 2nd Dec. (Mid late sown as E_2), 21st Dec. (Late sown as E_3) during Rabi-2011-12 season at the farm of Wheat Research Unit, Dr. P.D.K.V., Akola (M.S.). Seven varieties of wheat *Viz.* AKAW4627, AKDW4021, AKAW3722, AKW1071, NIDW295, AKAW3997 and AKAW4210-6 had been taken for the study in 16.56 m^2 plot size drilled in 10 rows of 6 m row length with 23 cm row spacing. Recommended agronomic cultural practices were followed for raising healthy crop. The study was based on seventeen quantitative characters *Viz.*, days to heading, days to 50 per cent flowering, days to physiological maturity, days to maturity, plant height (cm), spike length (cm), spike density, spike weight (g), spikelet's $spike^{-1}$, grains $spike^{-1}$, 1000 grain weight (g), root length 30 DAS(cm), root length 45 DAS(cm), grain yield (kgm^{-1}), grain yield ($q\ ha^{-1}$), grain yield day^{-1} $plant^{-1}$(g) and biomass day^{-1} $plant^{-1}$(g).

Data from the three environments and pooled data are subjected to Analysis of Variance (Panse and

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able 1: Analysis of variance for stability analysis

Sources	df	Germination %	Days to heading	Days to 50% flowering	Days to physiol maturity	Days to maturity	1000 grain wt(g)	Root length 30DAS (cm)	Root length 45DAS (cm)	Plant height (cm)
		1	1	2	3	4	5	6	7	8
Total	20	2.037	26.879	49.344	10.443	67.877	2.651	0.197	0.232	15.601
Genotypes	6	3.085	23.907**	32.691*	6.058*	5.033**	5.035*	0.251	0.201	3.141
Env. +(G×E)	14	1.587	28.153**	56.481**	12.323**	94.810**	1.630	0.175	0.245	20.941
Environments	2	2.394	170.109**	348.047**	78.193**	659.166**	2.688	0.050	1.204**	100.030**
G×E	12	1.453	4.494	7.887*	1.344	0.750	1.453	0.195	0.086	7.760
Env (linear)	1	4.787*	340.218**	696.094**	156.386**	1318.332**	5.375	0.100	2.407**	200.061**
G×E (linear)	6	2.125	7.097*	13.215*	2.103*	1.016	1.362	0.165	0.073	8.386
Pooled dev	7	0.669	1.621**	2.194*	0.502*	0.415**	1.324**	0.193**	0.085**	6.114
Pooled error	42	0.354	0.434	0.804	0.143	0.116	0.286	0.019	0.020	3.771

Sources	df	Spike length (cm)	Spike density	Spike weight (g)	Spikelet's spike^{-1}	Grains spike^{-1}	Grain yield kgm^{-2}	Grain yield qha^{-1}	Grain Yield g day^{-1} pl^{-1}	Biomass g day^{-1} pl^{-1}
		9	10	11	12	13	14	15	16	17
Total	20	1.710	0.189	0.112	0.942	6.881	0.003	3105.327	0.00020	0.0098
Genotypes	6	3.794**	0.499**	0.253**	0.385	4.792	0.012**	1632.322	0.00017	0.0688
Env. +(G×E)	14	0.816	0.056	0.052	1.180**	7.777*	0.004*	3736.615*	0.00022**	0.0110
Environments	2	1.604	0.128	0.186*	6.452**	24.688*	0.018**	1791.317	0.00028**	0.0169
G×E	12	0.685	0.044	0.030	0.301	4.958	0.001	1373.856	0.00021**	0.0100
Env (linear)	1	3.209*	0.255*	0.373**	12.905**	49.375**	0.036**	3582.634	0.00055**	0.0338
G×E (linear)	6	0.720	0.048	0.042	0.450	7.974*	0.002	1828.636	0.00042**	0.0124**
Pooled dev	7	0.557**	0.035	0.015	0.131**	1.664	0.001**	787.607**	0.0001	0.0066
Pooled error	42	0.146	0.037	0.012	0.039	2.275	0.00	173.078	0.00019	0.0109

**Significant at 1% probability level,* Significant at 5% probability level

Sukhatme, 1967). The traits which showed the significant G x E interactions were subjected to stability analysis using the Eberhart and Russell (1966) model. As per the model, three parameters *Viz.*, overall mean performance of each genotype across the environments, the regression of each genotype on the environmental index (β_i) and squared deviation from the regression ($\delta^2 d_i$) were estimated. The significance of stability parameters and deviations from unity were tested by students 't' test.

RESULTS AND DISCUSSION

Mean performance

The three environments (3 dates of sowing i.e. 22nd November, 2nd December and 21st December) showed significant differences for most of the characters except plant height, spike length, spike density, spike weight, grain yield kg m^{-2} and qha^{-1} and biomass yield $gday^{-1}$ $plant^{-1}$. The early, medium and late groups differed significantly for most of the characters. This implies that there is a scope or possibility of selection of better genotypes in each group for most of the characters. Normal environment (E_1) (22nd November) and late environment (E_2) (2nd December) produced significantly higher grain yield than very late environment (E_3) (22nd December). (Shirpurkar *et al*.2006).

Stability analysis

The analysis of variance for stability analysis revealed that the differences among the genotypes were significant for viz. days to heading, days to 50 per cent flowering, physiological maturity and maturity, 1000grain weight, spike length, spike density, spike weight and Grain yield kg m^{-2} indicating sufficient variability among the genotypes for these characters. Difference among the environments were found highly significant for all the characters except 1000 grain weight, root length 30 DAS, spike length, spike density, grain yield qha^{-1} and biomass $gday^{-1}$ $plant^{-1}$ indicating variation in environment for those characters. Significant Environment + (G x E) interaction variances are observed for characters viz. days to heading, days to 50 per cent flowering, physiological maturity and maturity, spikelet's $spike^{-1}$, grains $spike^{-1}$, grain yield kg m^{-2} and qha^{-1} and grain yield$gday^{-1}plant^{-1}$. Significant variance due to environment (linear) for all the characters except 1000-grain weight, root length at 30 DAS and grain yield q ha^{-1}, while G x E linear component found significant for days to heading, days to 50 per cent flowering, days to physiological maturity, grains $spike^{-1}$ and grain yield $gday^{-1}plant^{-1}$ suggesting that prediction of performance of these characters in different environments

Table 2: Estimates of mean, range and environmental index (EI) for eighteen quantitative traits in wheat

SN	Characters	E1- First sowing window			E2- Second sowing window			E3-Third sowing window		
		Mean	Range	EI	Mean	Range	EI	Mean	Range	EI
1	Days to heading	54.19	48.66-59.33	3.95	51.80	49.00-55.66	1.57	44.71	43.33-47.00	-5.52
2	Days to 50 % fl	69.76	62.33-75.66	5.09	67.61	63.66-71.66	2.95	56.61	53.66-59.00	-8.04
3	Days to physiol maturity	95.47	94.66-97.00	2.84	93.47	92.00-95.00	0.841	88.95	86.00-92.00	-3.68
4	Days to maturity	115.76	113.6-118.6	6.46	114.00	112.3-116.6	4.69	98.14	97.0-99.0	-11.15
5	1000 gain wt (g)	40.00	38.00-41.33	0.60	39.42	36.33-41.00	0.032	38.76	36.33-41.33	-0.63
6	Root length (cm)30DAS	7.30	6.72-8.43	0.017	7.36	6.63-7.73	0.075	7.20	6.76-7.42	-0.092
7	Root length (cm)45DAS	8.42	8.12-8.94	-0.429	9.25	8.54-9.98	0.399	8.88	8.56-9.28	0.030
8	Plant height (cm)	83.92	78.11-86.76	0.529	86.88	84.02-88.59	3.48	79.38	76.56-84.40	-4.017
9	Spike length (cm)	8.35	6.50-10.46	0.521	7.73	5.92-10.12	-0.099	7.41	6.54-8.52	-0.421
10	Spike density	2.25	1.71-2.83	-0.119	2.52	1.86-3.21	0.147	2.35	1.90-2.80	-0.028
11	Spike wt (g)	3.5	3.13-3.73	0.183	3.26	2.76-3.90	-0.051	3.18	2.93-3.70	-0.132
12	Spikelet's $spike^{-1}$	18.60	18.26-19.33	0.521	18.66	18.26-19.20	0.587	16.97	15.86-18.13	-1.108
13	Grains $spike^{-1}$	52.63	48.86-57.06	2.156	49.60	47.00-53.46	-0.873	49.2	48.00-51.06	-1.283
14	Grain yield (kgm^{-1})	0.3913	0.344-0.436	0.037	0.385	0.333-0.415	0.021	0.306	0.248-0.354	-0.058
15	Grain yield (qha^{-1})	40.13	34.41-43.65	3.67	38.54	33.37-41.58	2.09	30.68	24.85-35.39	-5.76
16	Yield $gday^{-1}$ $plant^{-1}$	0.040	0.035-0.042	-0.004	0.0375	0.030-0.042	-0.003	0.0316	0.021-0.039	0.007
17	Biomass $gday^{-1}$ $plant^{-1}$	0.15	0.131-0.166	-0.044	0.172	0.125-0.390	-0.009	0.130	0.094-0.145	0.053

Table 3:Stability parameters for various 18 yields and yield contributing characters

S.N.	Genotypes	Germination (%)			Days to heading			Days 50% fl			Days to physiol maturity		
		1			2			3			4		
		M	β_i	$\delta^2 d_i$	M	β_i	$\delta^2 d_i$	M	β_i	$\delta^2 d_i$	M	β_i	$\delta^2 d_i$
1	AKAW4627	79.00	1.320	0.452	47.00	0.584	4.531**	60.33	0.744	7.088**	92.55	0.639	0.145
2	AKDW4021	81.00	0.532	-0.326	53.88	1.272	0.067	68.77	1.230	0.149	94.55	0.736	0.266
3	AKAW3722	81.00	3.290	1.788*	47.00	0.617	1.291	61.55	0.468	0.112	92.22	1.074	1.063**
4	AKW1071	82.33	1.065	-0.242	50.44	0.969	1.087	65.22	1.048	2.194	91.77	1.188	-0.063
5	NIDW295	81.11	2.711	0.021	53.22	1.548*	-0.431	68.00	1.139	1.028	94.66	0.749	-0.003
6	AKAW3997	81.44	0.138	0.595	51.55	1.305	2.198*	66.44	1.576	-0.245	91.33	1.116	0.692*
7	AKAW4210-6	81.44	-2.064	-0.087	48.55	0.704*	-0.433	62.33	0.794	-0.599	91.33	1.498	0.413
8	Pop. mean	81.04			50.23			64.66			92.23		

S.N.	Genotypes	Days to maturity			1000 grain wt (g)			Root length 30 DAS(cm)			Root length 45 DAS(cm)		
		5			6			7			8		
		M	β_i	$\delta^2 d_i$	M	β_i	$\delta^2 d_i$	M	β_i	$\delta^2 d_i$	M	β_i	$\delta^2 d_i$
1	AKAW4627	108.55	0.943	0.094	38.88	3.541	0.379	7.21	0.553	0.159**	8.48	0.374	0.013
2	AKDW4021	110.88	1.071	0.497*	37.00	1.571	0.486	6.89	-3.779*	-0.017	9.00	1.235	0.039
3	AKAW3722	108.55	0.909	1.666**	39.11	-0.441	3.416**	7.35	5.894	0.023	8.82	1.348	0.085*
4	AKW1071	108.22	1.012	0.621*	39.44	1.295	0.722	7.17	-1.131	0.270**	8.59	0.918	-0.020
5	NIDW295	111.44	1.115*	-0.128	39.77	0.303	0.162	7.08	-1.414	0.064*	8.80	1.059	0.095*
6	AKAW3997	108.66	0.954	-0.065	40.88	0.813	0.274	7.69	3.675	0.675**	9.17	0.447	-0.008
7	AKAW4210-6	108.66	0.997	-0.097	40.66	-0.083	2.375**	7.62	3.201	0.044	9.10	1.620	0.248**
8	Pop. mean	109.23			39.39			7.29			8.85		

S.N.	Genotypes	P lant height (cm)			Spike length (cm) S			pike density			Spike wt (g)		
		9			10			11			12		
		M	β_i	$\delta^2 d_i$	M	β_i	$\delta^2 d_i$	M	β_i	$\delta^2 d_i$	M	β_i	$\delta^2 d_i$
1	AKAW4627	82.37	-0.090	23.269*	8.13	0.323	-0.110	2.29	-0.229	-0.036	3.12	1.892	0.013
2	AKDW4021	83.43	0.856	-2.813	6.56	-0.422	0.574*	2.95	1.553	-0.018	3.35	0.819	-0.012
3	AKAW3722	83.69	1.642	-0.952	7.54	1.571	0.252	2.40	-0.062	0.047	3.10	1.225	-0.010
4	AKW1071	83.29	1.174	-2.594	7.68	1.742	0.908*	2.45	3.013	-0.034	2.94	0.844	0.017
5	NIDW295	81.85	0.956	1.801	6.47	-0.243	0.175	2.77	1.700	0.078	3.32	2.145	-0.008
6	AKAW3997	84.42	1.225	-1.583	9.01	3.125	0.265	1.93	0.564	-0.028	3.73	-0.534	0.019
7	AKAW4210-6	84.70	1.237	-0.734	9.42	0.904	0.810	1.83	0.461	-0.024	3.64	0.609	0.001
8	Pop. mean	83.39			7.83			2.37			3.31		

S.N.	Genotypes	Spikelet's spike^{-1}			Grains spike^{-1}			Grain yield (kgm^{-1})			Grain yield (qha^{-1})		
		13			14			15			16		
		M	β_i	$\delta^2 d_i$	M	β_i	$\delta^2 d_i$	M	β_i	$\delta^2 d_i$	M	β_i	$\delta^2 d_i$
1	AKAW4627	18.64	0.445	0.364**	51.60	0.811	0.482	0.33	0.304*	0.0002	33.373	0.304*	-171.666
2	AKDW4021	17.80	1.685*	-0.038	50.77	1.618	-1.704	0.36	1.952	0.0001	36.318	1.952	68.924
3	AKAW3722	17.88	0.681*	-0.038	50.11	-0.590*	-2.184	0.35	0.808	0.0016**	35.244	0.808	155.26**
4	AKW1071	18.32	0.905	0.211*	48.82	1.183	-1.160	0.38	0.512	0.0002	38.097	0.512	209.25
5	NIDW295	17.92	1.139	0.004	48.95	1.054	-2.180	0.34	1.658	0.0028**	34.081	1.658	282.99**
6	AKAW3997	17.64	1.595	0.090	50.95	2.761	0.964	0.39	0.974	0.0003	39.132	0.974	-155.67
7	AKAW4210-6	18.33	0.549	0.054	52.15	0.163	1.505	0.38	0.792	0.0001	38.937	0.792	-317.21
8	Pop. mean	18.07			50.48			0.36			36.455		

S.N.	Genotypes	Yield day^{-1} plant^{-1}(g)			Biomass day^{-1} plant^{-1}(g)		
		17			18		
		M	β_i	$\delta^2 d_i$	M	β_i	$\delta^2 d_i$
1	AKAW4627	0.021	0.110	-0.0002	0.090	0.083*	-0.011
2	AKDW4021	0.042	6.192*	-0.0002	0.171	-0.238	0.023
3	AKAW3722	0.023	0.198*	-0.0002	0.089	0.134	-0.011
4	AKW1071	0.022	0.184	-0.0002	0.094	0.135	-0.011
5	NIDW295	0.022	0.129	-0.0002	0.180	3.338	-0.006
6	AKAW3997	0.024	-0.054	-0.0002	0.184	3.348	-0.003
7	AKAW4210-6	0.024	0.242	-0.0002	0.084	0.202*	-0.011
8	Pop. mean	0.025			0.127		

**Significant at 1% probability level, * Significant at 5% probability level, b_i = Regression coefficient, $ä^2 d_i$ = Deviation from regression coefficient.

is possible. The results are in agreement with Najeeb *et al*.(2004), Gowda *et al*.(2010). Ashraf *et al*. (2001) also reported significance of both linear and non linear components and indicated the presence of both predictable and unpredictable components of G × E. Jena *et al*.(2005) has reported the predominance of linear and non linear components for plant height, spike length and grains spike^{-1}, whereas predominance of non linear components for all most all the characters except spike length which are in agreement with the present findings.

Stability parameters of genotypes

Finlay and Wilkinson (1963) considered linear regression slope as a measurement of stability. However, Eberthart and Russell (1966) emphasized the need of considering both linear (bi) and non linear (S^2di) components of G x E interaction in judging the stability of genotype.

An ideal genotype is defined as, one possessing high mean performance, with regression coefficient around unity (bi=1) and deviation from regression (S^2di) close to zero. In present investigation on the basis of grain yield qha^{-1} parameters only three genotypes AKAW 3997 in late group, AKAW 1071 in medium group and AKAW 4210-6 in early group exhibited better grain yield as compared to the mean over the environments (36.45 q ha^{-1}) and the order of genotypes became as AKAW 3997 (39.13 q ha^{-1}) followed by AKAW 4210-6 (38.93 qha^{-1}) and then AKW 1071 (38.09 q ha^{-1}) similarly those three genotypes exhibited regression coefficient values as AKAW 3997 (bi= 0.97), AKAW 4210-6 (bi=0.79) and AKW 1071(bi=0.51) in that order which are being non significant and further the deviation from regression values are also non significant. There by indicating the highly stable performance of those genotypes for grain yield over the environments tested. Present findings are in close agreement with Shirpurkar *et al*. (2006), Yadav and Sharma, (2008), Gohil and Jadeja (2009), Gowda *et al*.(2010) and Kamal Tripura *et al*. (2011).

First high yielding genotype AKAW3997 from late maturing group showed above average stability for the traits days to maturity, 1000 grain weight and root length 45 DAS, spike density and grain yield kgm^{-2} indicating that it may perform well in different environments for these characters. Whereas, it showed below average stability for the traits days to heading, flowering and physiological maturity, plant height, spike length, spikelet's spike^{-1}, grains spike^{-1} and finally biomass g day^{-1}plant^{-1}. Second high yielding genotype AKAW4210-6 from early group showed above average stable performance for days to heading, days to 50 per cent flowering, days to maturity, spike length, spike density, spike weight, spikelet's spike^{-1}, grains spike^{-1}, grain yield qha^{-1} and yield g day^{-1} plant^{-1} and below average performance for the traits physiological maturity, root length (30 and 45 DAS) and plant height.

Third high yielding genotype AKW 1071 from mid late group showed above average stability performance for the traits days to 50 per cent flowering, days to maturity, root length at 45 DAS, spike weight, spikelet's spike^{-1} and grain yield kgm^{-2} with high mean performance but showed below average stability for the traits germination percentage, days to physiological maturity, 1000grain weight and plant height, spike length, spike density and grains spike^{-1}. Such kind of differential performances of various yield contributing characters by the stable genotypes were also reported by Satishkumar *et al*. (2005), Graussgruber *et al*. (2006) and Yadav and Sharma, (2008).

Gohil and Jadeja (2009) performed stability analysis and reported that none of the genotype was stable for evaluated traits; however genotypes depicting stable performance for yield g plant^{-1}, offered the possibilities of exploitation for varietal improvement program in durum wheat. Since, segregates' combining high mean and stable performance could be expected in the advance generations.

Therefore, it is concluded that the genotype AKAW 3997, AKAW 4210-6 and AKW 1071 could be included in the hybridization program to converge the stability characteristics of grain yield for the development of stable cultivar adapted to a wide range of environments. While the fourth genotype AKAW 4627 exhibited above average stable performance for days to heading, days to 50 per cent flowering, days to physiological maturity and maturity, root length at 45 DAS, spike length and spikelet's spike^{-1}, grains spike^{-1} with better mean performance and regression coefficient less than unity indicating that it is specifically adapted to the favorable environments.

Thus any generalization regarding stability of genotypes for all characters it is too difficult since the genotypes may not simultaneously exhibit uniform responsiveness and stability for all the characters.

Several authors have reported stability for various characters. Some of them were Mahak Singh *et al.* (2002) for the traits plant height, biological yield spike^{-1}, grains spike^{-1} and 1000 grain weight; Negi *et al.* (2003) for the traits tillers plant^{-1} and gains ear^{-1}; Tyagi *et al* (2003) for the traits grain yield and biological yield; Jaydeep *et al.*(2006) for the traits grains spike^{-1},1000 grain weight and yield gplant^{-1}; Gohil and Jadeja (2009); Shah *et al.* (2009) for the traits spike length, spikelet's spike^{-1}, grains spike^{-1} and maturity.

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Effect of Herbicides on Weed, Nutrient Uptake, Soil Micro Flora and Yield of Mungbean

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ABSTRACT

Mungbean is recommended for cultivation mainly in *Kharif* season under Vidarbha condition. Weed management is an important factor for enhancing the productivity of mungbean as weeds compete for nutrients, water, light and space with crop during early growth period. Yield losses in mungbean due to weeds have been estimated to range between 30-50 per cent (Kumar *et al*, 2004). Mechanical practices such as hand weeding and interculturing are effective but unavailability of labour, and incessant rains during the early crop season normally limit the weeding operations. Therefore chemical weeding under such circumstances become indispensible and can be the excellent alternative. Pendimethalin is most commonly used as pre-emergence herbicides in mungbean and control weeds by inhibiting seedling development, it will not control established weeds. The higher moisture content of the soil, better the control efficacy of pendimethalin. Manual weeding or spraying of recommended pre-emergence herbicides is some time difficult in rainy season for efficient weed control. This warrants the use of post-emergence herbicides for weed control, therefore, herbicides were used alone and in combinations to widen the weed-control spectrum, including grasses and broadleaf weeds and their phytotoxicity, if any, to the crop. Although herbicide provides improvement in plant growth, it can also have side effects and adversely influence soil microbial activities. Since herbicides are formulated to kill weeds, it is not surprising that some of these compounds are toxic to specific organisms such as *Cynobcateria* sp. *Bacillus* sp., *Pseudomonas* sp. for bacteria and fungi e.g. *Penicillium*, *Mucor*, *Fusarium* and *Aspergillus* species (MacNaughton *et al.* 1988) and actinomycetes affecting various soil microbial process such as nitrogen fixation, nitrogen metabolism, respiration and organic matter decomposition (White *et al*. 1998). The present study was, therefore, conducted to evaluate the effect of different herbicides for mungbean, which can be cost effective and acceptable to the growers of this crop.

A field trial was conducted to evaluate the effect of post emergence herbicides viz. Imazethapyr, Quizalofop-ethyl, Fenoxoprop-ethyl, Chloromuron-ethyl and pre-emergence Pendimethalin on growth and yield of mungbean cultivar PKV Green gold (AKM-9911) was carried out at Pulses Research Unit, Dr.Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during the *Kharif* season 2010-11. The soil of experimental site is clayey with pH 7.8, medium in available nitrogen, phosphorous, and potassium and organic carbon 4.1 g kg^{-1}. The experiment was laid out in randomized block design having three replications. The treatment comprised of weedy (without removal of weeds), weed free (weeding done annually to keep the plot free of weeds), hand weeding twice at 15 and 30 DAS and chlorimuron-ethyl as soil incorporated applications of commercial formulations to moist soil 24 hr before sowing the seeds. All the herbicides alone or in mixture were applied 20 days after sowing (DAS) with knapsack sprayer fitted with flat-fan nozzle using 500 litres water/ha. Data on weed density and dry weight of weeds were recorded at 30 DAS and at harvest using quadrates 1 x 1 m. The phytotoxicity scoring was taken as per the method suggested by Rao (2000). Serial dilution plate technique was used for isolation and enumeration of soil fungi, actinomycetes and bacteria as described by Pahwa *et al.* (1996). The total rainfall received during the crop growth was 552.3 mm in 28 rainy days.

The weed flora in the experimental field consisted of grasses like *Echinochloa colona, Dinebra arabica*, *Poa annua*, sedges like *Cyperus rotundus* and broad-leaved weeds like *Commelina benghalensis, Parthenium hysterophorus, Digeria arvensis, Phyllanthus niruri, Portulaca oleracea, Euphorbia geniculata, Euphorbia hirta, Lagasca mollis* etc. However, sedges like *Cyperus rotundus* and broad-leaved weed like *Commelina benghalensis, Digeria arvensis, Euphorbia geniculata* and *Phyllanthus niruri* were dominated over other weeds in the mungbean field and *Portulaca oleracea, Euphorbia geniculata* and *Euphorbia hirta* were not effectively controlled by any of the herbicides whereas growth of *E. geniculata, E. hirta* and *Phyllanthus niruri*

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was inhibited with the application of imazethapyr. The result revealed that among herbicides and cultural methods of weed control, application of imazethapyr @ 100 g ha^{-1} at 20-25 DAS followed by imazethapyr @ 75 g ha^{-1} at 20-25 DAS, and pendimethalin 1.0 kg ha^{-1} as pre-emergence recorded lowest dry weight of weeds at all the growth stages. However, imazethapyr was effective against annual broadleaf weeds like *Commelina benghalensis*, *Parthenium hysterophorus*, *Physalis minima*, *Digeria arvensis* and grassy weeds like *Bracharia* sp. *Echinochloa colona*, perennial sedge like *Cyperus rotundus*. Richburg *et al*. (1996) reported that imazethapyr controlled C*yperus rotundus* more effectively when applied to weeds 5 to 20 cm tall compared with weeds 30 cm tall.

The highest yield attributes, viz. branches/plant, pods $plant^{-1}$, grain weight $plant^{-1}$ and 1000-grain weight were recorded with the application of imazethapyr @ 100 and 75 g ha^{-1} @ 20-25 DAS, respectively, over hand weeding twice (HW). Harvest index was higher with weed free followed by imazethapyr @ 100 g ha^{-1} and HW twice, however, difference between the treatments did not influenced significantly. Application of chlorimuron-ethyl as PPI showed a greater phytotoxic effect and reduced the total dry matter production as compared with the control. The results pertaining to phytotoxicity scoring revealed slight stunting injury or discoloration, but no plants died from the treatment. Conversely, weed free and HW twice showed normal growth which was on par with imazethapyr @ 75 g ha^{-1} at 20-25 DAS and quizalofop-ethyl @ 75 g ha^{-1} at 20-25 DAS. The weed free treatment produced significantly maximum mungbean yield (999 kg ha^{-1}) over remaining treatments excepting hand weeding twice (920 kg ha^{-1}). Among the herbicides imazethapyr @ 100 g ha^{-1} recorded higher grain yield closely followed by imazethapyr 75 g ha^{-1} at 20-25 DAS which in turn found at par with quizalofop-ethyl @ 75 g ha^{-1}. However, pre emergence application of pendimethalin @ 1.0 kg ha^{-1} did not influenced grain yield. Tank mixture of herbicides did not prove to be efficient in weed control. Antagonism between chemicals in herbicide mixtures is not uncommon and can result in poor weed control (Devine *et al*. 1993; Zhang *et al*. 1995). Weed free and HW twice recorded significantly higher weed control efficiency over all other treatments. Higher weed control efficiency was observed with post-emergence application of imazethapyr @ 100 g (71.85 %) followed by 75 g ha^{-1} (69.75 %) at 20-25 DAS, respectively. Weed index was computed as the yield reduction comparative to highest yielding treatment i.e. weed free. In case of weed management practices hand weeding showed minimum weed index (7.97) followed by post-emergence application of imazethapyr @ 100 g ha^{-1} (7.32) and imazethapyr @ 75 g ha^{-1} (9.12). Post emergence application of fenoxoprop-ethyl @ 75 g ha^{-1} and chlorimuron-ethyl @ 4 g ha^{-1} as PPI recorded maximum weed index i.e. 48.64 and 42.14 per cent, respectively, indicating the reduction in mungbean grain yield due to presence of weeds throughout crop growth period.

The highest nutrient uptake by weeds was recorded with unweeded check followed by fenoxoprop-ethyl @ 75 g ha^{-1}, mainly because of higher dry matter accumulation of weeds. Uptake of nutrients in HW was statistically at par with imazethapyr @ 100 g ha^{-1}, quizalofop-ethyl @ 75 g ha^{-1} has recorded lesser nutrient uptake by weeds than rest of the weed management practices. The unweeded check removed 13.91 kg nitrogen, 4.63 kg phosphorous and 23.00 kg potassium ha^{-1}, whereas in HW the weeds removed only 2.57 kg nitrogen, 0.32 kg phosphorous and 3.70 kg potassium ha^{-1}. Similar findings were also reported by Kumara *et al*. (2007). Application of fenoxoprop-ethyl @ 75 g ha^{-1}, quizalofop-ethyl 50 g ha^{-1} + chlorimuron-ethyl @ 4 g ha^{-1} and fenoxoprop-ethyl @ 50 g ha^{-1} + chlorimuron-ethyl @ 4 g ha^{-1} recorded higher nutrient uptake by weeds next to the unweeded check due to its sub-lethal dose and lack of synergistic effect between them in combinations. These results are corroborating with the findings of Dalavai *et al*. (2008). The effective control of weeds by imazethapyr @ 100 g ha^{-1} provided a competition-free environment, which led to increased growth of the crop and thereby increase in nutrient uptake by increasing the grain and straw yields of mungbean.

Among the herbicides their application alone or with combinations has recorded higher monetary returns over weedy check. Among the weed-control treatments, imazethapyr @ 100 g ha^{-1} and imazethapyr @ 75 g ha^{-1} gave the maximum monetary returns, due to excellent control of grassy and broad-leaf weeds without any adverse effect on crop growth. Lower monetary returns was recorded with tank mixture of quizalofop-ethyl @ 50 g ha^{-1} + chlorimuron-ethyl @ 4 g ha^{-1} due to inability of the herbicides to control weeds. Weed free treatment recorded lower monetary returns and benefit cost ratio than imazethapyr @ 100 g ha^{-1}, mainly due to the high cost involved in repeated manual weedings to keep the

Table 1. Grain and straw yield, yield attributing characters and economics of mungbean as influenced by different weed management treatments

Treatments		Yield (kg ha^{-1})		Plant	Branches	Pods	Grain	1000	Harvest	Total	Net	B:C
			height	plant^{-1}	plant^{-1}	weight	seed	index	cost	return	ratio	
	Grain	Straw	(cm)			plant^{-1} (g)	weight(g)	(%)	(Rs ha^{-1})	(Rs ha^{-1})		
T_1	Chlorimuron-ethyl @ 4.0g/ha PPI	579	1025	69.90	3.70	15.76	6.03	35.33	36.07	7294	11524	1.58
T_2	Pendimethalin 1.0 kg/ha as PE	760	1200	89.56	3.43	18.90	6.80	37.75	38.82	8551	16149	1.89
T_3	Quizalofop-ethyl @ 75 g/ha 20-25DAS	809	1425	88.03	3.43	21.20	8.10	39.10	38.90	8470	17823	2.10
T_4	Chlorimuron-ethyl @ 4.0 g/ha20-25 DAS	615	1040	83.90	3.40	18.05	6.02	35.77	37.17	7294	12694	1.74
T_5	Fenoxaprop-ethyl @ 75 g/ha 20-25 DAS	650	1066	83.88	3.43	17.69	6.73	36.11	37.90	8060	13065	1.62
T_6	Imazethapyr @ 75 g/ha 20-25 DAS	880	1200	91.56	3.26	20.10	7.56	37.28	38.34	8560	20040	2.34
T_7	Imazethapyr @ 100 g/ha 20-25DAS	907	1440	93.90	3.96	22.03	8.33	39.66	39.20	8962	20516	2.29
T_8	Quizalofop-ethyl @ 50 g/ha +	600	1050	83.66	3.50	17.23	5.98	35.67	36.35	8053	11447	1.42
T_9	Chlorimuron-ethyl @ 4.0 g/ha 20-25 DAS											
T_{10}	Fenoxaprop-ethyl @ 50 g/ha+	665	1100	84.33	3.26	17.81	6.95	35.90	37.91	7950	13663	1.72
T_{11}	Chlorimuron-ethyl @ 4.0 g/ha 20-25 DAS											
T_{12}	Unweeded check	271	500	95.80	2.90	9.80	3.05	35.62	35.20	5871	2937	0.50
T_{13}	HW 15 and 30 DAS	920	1435	90.93	3.73	21.36	8.26	39.15	39.08	13100	16800	1.28
T_{14}	Weed free	999	1485	86.43	4.36	22.44	8.80	40.15	40.37	14179	18289	1.29
	SE (m) ±	28	80	3.10	0.13	0.73	0.32	4.3	1.77	--	1365	--
	CD at 5%	82	227	9.18	0.39	2.16	0.96	NS	NS	--	4034	--

Table 2. Effect of different weed management treatment on dry weight of weeds, weed control efficiency, weed index and nutrient uptake at harvest in mungbean

Treatment	Dry weight of weeds (g/m^2)		Weed	Weed control	Nutrient uptake (kg/ha)					
					index	Mungbean				Weeds
30 DAS	At harvest	efficiency (%)	(%)							
					N	P	K	N	P	K
Chlorimuron-ethyl @ 4.0 g/ha PPI	27.33	41.67	55.07	42.14	24.46	11.11	13.15	4.80	1.04	9.08
Pendimethalin 1.0 kg/ha PE	21.91	29.73	67.95	23.99	35.13	16.62	16.81	3.15	0.53	4.75
Quizalofop-ethyl @ 75 g/ha 20-25 DAS	21.10	36.00	61.19	26.95	31.10	14.07	16.07	2.95	0.42	3.34
Chlorimuron-ethyl @ 4.0 g/ha 20-25 DAS	26.33	34.00	63.34	38.47	28.20	12.77	13.34	3.74	1.02	7.34
Fenoxaprop-ethyl @ 75 g/ha 20-25 DAS	30.27	43.67	52.92	48.64	28.51	13.57	13.14	5.00	1.52	7.95
Imazethapyr @ 75 g/ha at 20-25 DAS	21.33	28.06	69.75	9.12	42.68	20.25	20.09	2.90	0.72	7.92
Imazethapyr @ 100 g/ha at 20-25 DAS	20.94	26.11	71.85	7.32	45.09	21.12	21.07	2.60	0.33	3.91
Quizalofop-ethyl @ 50 g/ha + Chlorimuron -ethyl @ 4.0 g/ha at 20-25 DAS	24.33	42.44	54.24	39.95	26.06	12.55	13.36	4.83	1.23	8.87
Fenoxaprop-ethyl @ 50 g/ha + Chlorimuron -ethyl @ 4.0 g/ha 20-25 DAS	22.00	40.00	56.87	33.47	29.59	13.08	13.65	4.20	1.36	6.68
Unweeded check	81.33	92.75	--	72.93	10.83	4.71	5.65	13.91	4.63	23.0
HW 15 and 30 DAS	20.33	25.03	73.02	7.97	43.82	20.5	20.52	2.57	0.32	3.70
Weed free	0	0	100	--	49.10	23.56	22.78	0	0	0
SE (m) ±	1.72	2.59	--	--	1.39	0.67	1.18	0.36	0.12	0.51
CD at 5%	5.09	7.69	--	--	4.12	1.98	3.50	1.06	0.36	1.52

crop weed free in spite of higher grain yield. Among the weed-control treatments, highest benefit :cost ratio (2.34) was recorded with imazethapyr @ 75 g ha^{-1} followed by imazethapyr @ 100 g ha^{-1} (2.29) and least with quizalofop-ethyl @ 50 g ha^{-1} + chlorimuron-ethyl @ 4 g ha^{-1}.

The experimental findings reveal that imazethapyr @ 100 g ha^{-1} applied 20-25 days after sowing was the most remunerative and effective herbicide for controlling the complex weed flora in mungbean under eastern Maharashtra conditions. The study has evidently shown that umazethapyr herbicides did not have inhibitory effect on soil microbial community, while Chlorimuron-ethyl as PPI had inhibitory effect on the yield of the crop.

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Productivity of Soybean + Pigeonpea Intercropping System Under Dryland Condition

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ABSTRACT

An experiment was carried out at the research field of AICRP for Dryland Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra) during *Kharif* seasons 2011-12 to 2013-14. The experiment was laid out in RBD with three replications. Treatments consisted of sole soybean, sole pigeonpea, soybean + pigeonpea row proportion of 1:1, 2:1, 3:1,4:1,4:2, 5:1, 6:1 and 8:1. The pooled results revealed that, soybean + pigeonpea (4:2) row proportion recorded highest soybean seed equivalent yield (3277 kg ha^{-1}) and found to be at par with soybean + pigeonpea (2:1) row proportion. Among the various intercropping treatments, row proportion of soybean + pigeonpea (4:2) registered the highest gross monetary returns (96006/- Rs ha^{-1}), net monetary returns (72792/- Rs ha^{-1}), B:C ratio (4.31) and LER (1.47) . Slightly higher build up of organic carbon and available nitrogen was recorded in sole soybean., Total uptake of nitrogen, phosphorus, potassium was found to be significantly higher in soybean + pigeonpea (4:2) row proportion, than sole soybean. Sole pigeonpea recorded more than double K uptake that of sole soybean.

Intercropping of pulses and oilseeds helps to augment the pulse and oilseed production in the country. The area under soybean in the country at present is over 8.90 million hectares with an annual production of 9.47 million tonnes and a normal productivity of 1075 kg ha^{-1}. However, productivity of soybean can further be increased by intercropping or with potential crop sequence. Area under soybean is increasing enormously in Maharashtra state due to better yield potential and market price. Pigeonpea being a predominantly rainfed crop is one of the most important and potential component of intercropping in semi-arid region. It is generally intercropped with sorghum, cotton and soybean in Vidarbha region of Maharashtra. Singh and Rajput (1996) advocated that intercropping of pulses and oilseeds is more advantageous than growing them as sole crops.

The farmers are adopting different row proportion of soybean + pigeonpea intercropping system rather than the recommended one. Hence, it was felt necessary to study the different row proportions of the soybean + pigeonpea in the intercropping system and assess the economics of the system. Further, in order to minimize the risk, it was thought worthwhile to test these row proportions so, that system identified will be less susceptible to aberrant weather conditions of the region and able to utilize the natural resources more efficiently. Soybean can be intercropped with pigeonpea for enhancing the potential of soybean productivity. In view of above facts, an experiment was conducted to study the effect of row proportion of soybean in pigeonpea intercropping system under rainfed conditions.

MATERIAL AND METHODS

The experiment was carried out at the research field of AICRP for Dryland Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra) during *Kharif* seasons 2011-12 to 2013-14. The experiment was laid out in RBD involving ten treatments with three replications. Treatments consisted of sole soybean, sole pigeonpea, soybean + pigeonpea 1:1, 2:1, 3:1,4:1,4:2, 5:1, 6:1 and 8:1 row proportions.

The soil of the experimental site was deep black clayey with 1.39 g cm^{-3} bulk density, 22.18 per cent field capacity and 12.26 per cent permanent wilting point. Soil pH and EC were7.95 and 0.21 dSm^{-1}, respectively. As regards nutrient status , organic carbon (4.55 g kg^{-1}), available N (174.8 kg ha^{-1}), available P_2O_5 (12.2 kg ha^{-1}) were low while available K_2O was high (337.8 kg ha^{-1}) ·Sole soybean (Cv.JS-335) and pigeonpea (C-11) were sown at a spacing of 45 x 5 cm and 60 x 30 cm ,respectively. However, intercrops are sown at the distance of 45 cm. Rainfall received during the year 2011-12 , 2012-13 and 2013-14 for the crop growth period was 339.4 , 672.9 and 860.7 mm in 25,43 and 45 rainy days, respectively.

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RESULTS AND DISCUSSION

A. Grain and straw yield

The pooled results indicate that, the highest seed yield and straw yield of soybean (2058 and 1817 kg ha^{-1}) and pigeonpea (2463 and 6695 kg ha^{-1}), respectively were recorded from sole cropping system (Table 1 and 2). Soybean and pigeonpea intercropping system recorded lower seed yield of both the crops at all row proportions as compared to soybean and pigeonpea alone. Ved Prakash *et al.* (2004) also reported that soybean and pigeonpea yields reduced in intercropping treatments compared to their sole crops. This might be due to competition effect between the legumes. Similar results were reported by Joshi *et al.* (1997) and Havlankar *et al.*(2000).

Table1. Seed yield of soybean and pigeonpea as influenced by various treatments

Treatments		Seed Yield (kg ha^{-1})							
		Soybean				Pigeonpea			
		2011-12	2012-13	2013-14	Mean	2011-12	2012-13	2013-14	Mean
T_1	Sole Soybean	1937	2309	1928	2058	-	-	-	-
T_2	Sole Pigeonpea	-	-	-	-	1669	1828	1955	1817
T_3	Soybean + pigeonpea (1:1)	975	1459	1433	1289	1490	1440	1075	1335
T_4	Soybean + pigeonpea (2:1)	1274	1745	1532	1517	1379	1232	975	1195
T_5	Soybean + pigeonpea (3:1)	1478	2031	1661	1723	998	971	758	909
T_6	Soybean + pigeonpea (4:1)	1814	2164	1844	1941	575	819	537	644
T_7	Soybean + pigeonpea (4:2)	1281	1894	1463	1546	1250	1552	1145	1315
T_8	Soybean + pigeonpea (5:1)	1439	1905	1722	1689	613	864	625	701
T_9	Soybean + pigeonpea (6:1)	1638	2050	1795	1828	469	500	553	507
T_{10}	Soybean + pigeonpea (8:1)	1745	2115	1997	1952	465	550	591	535

Table 2. Straw/stalk yield of soybean and pigeonpea as influenced by various treatments

Treatments		Straw Yield of Soybean (kg ha^{-1})				Stalk Yield of Pigeonpea (kg ha^{-1})			
		2011-12	2012-13	2013-14	Mean	2011-12	2012-13	2013-14	Mean
T_1	Sole Soybean	2673	2690	2027	2463	-	-	-	-
T_2	Sole Pigeonpea	-	-	-	-	5952	6097	8036	6695
T_3	Soybean + pigeonpea (1:1)	1235	1513	1459	1402	4530	4885	4972	4796
T_4	Soybean + pigeonpea (2:1)	1850	1875	1569	1765	3345	3264	4464	3691
T_5	Soybean + pigeonpea (3:1)	1913	2275	1814	2001	2279	2381	3464	2708
T_6	Soybean + pigeonpea (4:1)	2073	2370	1870	2104	1787	2077	2499	2121
T_7	Soybean + pigeonpea (4:2)	1843	1840	1593	1759	3437	2639	5090	3702
T_8	Soybean + pigeonpea (5:1)	1800	2324	1814	1979	1406	1574	2928	1969
T_9	Soybean + pigeonpea (6:1)	2286	2065	1850	2067	1055	1252	2544	1617
T_{10}	Soybean + pigeonpea (8:1)	2218	2153	2183	2185	1440	1279	2581	1767

B. Soybean seed equivalent yield

In terms of soybean seed equivalent yield (soybean yield + grain yield of pigeopea intercrop equated to soybean), during the year 2011-12, intercropping of two rows of soybean with one row of pigeonpea registered the highest soybean seed equivalent yield (3351kg ha^{-1}) which was significantly superior to other treatments and being at par with soybean + pigeonpea intercropping system of 1:1, 4:2 and 3:1 row proportion i.e. 3280, 3162 and 2981kg ha^{-1}, respectively (Table 3). During the year 2012-13, four rows of soybean with two rows of pigeonpea recorded highest soybean seed equivalent yield (3704kg ha^{-1}) and was at par with 2:1, 3:1 and 1:1 row proportion i.e. 3182, 3164 and 3139kg ha^{-1}, respectively. During the year 2013-14, soybean + pigeonpea (4:2) row proportion recorded significantly higher soybean seed equivalent yield 2966 kg ha^{-1} than the treatments of 6:1 row proportion and sole soybean .

However, in pooled analysis, data showed that soybean + pigeonpea (4:2) row proportion recorded highest soybean seed equivalent yield and found to be at par with soybean + pigeonpea (2:1) row proportion. It is inferred that according to the plant architecture (genetic makeup) of both the crops (main and intercrop) the base crops yield is either increased or decreased due to intercropping. More over the population level of intercrop also decides the yield advantage or disadvantage in terms of soybean seed equivalent yield. It is very obvious that intercropping in general increased the soybean seed equivalent yield compared to that of sole crop. However, the degree of increase or decrease of soybean seed equivalent yield due to the intercropping depends on the population levels. The higher soybean equivalent yield in soybean + pigeonpea (4:2) row proportion was also reported by Patil and Joshi (2003).

Table 3. Soybean seed equivalent yield, as influenced by various treatments

Treatments	Soybean Seed Equivalent Yield (kg ha^{-1})			Pooled
	2011-12	2012-13	2013-14	
T_1-Sole Soybean	1937	2309	1928	2058
T_2-Sole Pigeonpea	2512	2133	2566	2385
T_3-Soybean + pigeonpea (1:1)	3280	3139	2843	3041
T_4-Soybean + pigeonpea (2:1)	3351	3182	2812	3086
T_5-Soybean + pigeonpea (3:1)	2981	3164	2656	2917
T_6-Soybean + pigeonpea (4:1)	2680	3120	2549	2786
T_7-Soybean + pigeonpea (4:2)	3162	3704	2966	3277
T_8-Soybean + pigeonpea (5:1)	2362	2914	2542	2609
T_9-Soybean + pigeonpea (6:1)	2344	2634	2520	2499
T_{10}-Soybean + pigeonpea (8:1)	2444	2756	2772	2657
S.Em. ±	202	193	149	75
C.D. at 5%	602	573	444	221
C.V. %	13.01	11.49	9.66	9.94

C.Economics

During the year 2011-12, the economics of intercropping system revealed that the intercropping of two rows of soybean and one row of pigeonpea (2:1) registered the highest gross monetary returns and net monetary returns (Rs. 74,802/- and Rs.56,877/- ha^{-1}) and was at par with the treatments 1:1,4:2 and 3:1 row proportion of soybean + pigeonpea (Table 4 and 5).

Table 4. Gross monetary returns as influenced by various treatments

Treatments	GMR (Rs ha^{-1})			Pooled
	2011-12	2012-13	2013-14	Mean
T_1-Sole Soybean	43083	71581	63218	59594
T_2-Sole Pigeonpea	57116	66163	90135	71138
T_3-Soybean + pigeonpea (1:1)	72234	97344	97043	88874
T_4-Soybean + pigeonpea (2:1)	74802	98670	95627	89700
T_5-Soybean + pigeonpea (3:1)	66341	98101	89802	84748
T_6-Soybean + pigeonpea (4:1)	59680	96723	85482	80628
T_7-Soybean + pigeonpea (4:2)	70780	114842	*102395*	96006
T_8-Soybean + pigeonpea (5:1)	52510	90340	85648	76166
T_9-Soybean + pigeonpea (6:1)	52183	81658	84567	72803
T_{10}-Soybean + pigeonpea (8:1)	54517	85457	92917	77630
S.Em. ±	6380	5978	4913	2069
C.D. at 5%	13404	17762	14596	6168
C.V. %	12.95	11.42	9.35	7.16

Market Rates (Rs q^{-1})	2011-12	2012-13	2013-14
Soybean grain	2150/-	3100/-	3200/-
Pigeonpea grain	3150/-	3615/-	4200/-
Soybean straw	50/-	50/-	75/-
Pigeonpea straw	75/-	75/-	125/-

During the year 2012-13, results showed that, intercropping of soybean and pigeonpea (4:2) row proportion recorded significantly highest gross monetary returns and net monetary returns i.e. Rs. 1,14,842/- and 90,844/- ha^{-1}, respectively. This treatment was at par with soybean + pigeonpea 2:1, 3:1 and 1:1 row proportion. During the year 2013-14, results showed that ,gross monetary returns and net monetary returns recorded significantly higher in soybean + pigeonpea (4:2) row proportion and was found at par with the treatments with soybean + pigeonpea 1:1, 2:1, 8:1, 3:1 row proportions and with sole pigeonpea.

Pooled data revealed that, significantly higher gross monetary returns were recorded in treatment soybean + pigeonpea (4:2) row proportion than rest of the treatments. As regards net monetary returns through soybean + pigeopea (4:2) row proportion recored highest net monetary return, it was at par with (2:1) row proportion.

Table 5. Net monetary returns as influenced by various treatments

Treatments	NMR (Rs ha^{-1})			PooledMean
	2011-12	2012-13	2013-14	
T_1 - Sole Soybean	23154	49165	36919	36413
T_2 - Sole Pigeonpea	39120	46755	67163	51013
T_3 - Soybean + pigeonpea (1:1)	54662	73829	70069	66187
T_4 - Soybean + pigeonpea (2:1)	56877	75191	68653	66907
T_5 - Soybean + pigeonpea (3:1)	48434	74393	62569	61799
T_6 - Soybean + pigeonpea (4:1)	41733	72898	58109	57580
T_7 - Soybean + pigeonpea (4:2)	53043	90844	74496	72792
T_8 - Soybean + pigeonpea (5:1)	34473	66774	58309	53185
T_9 - Soybean + pigeonpea (6:1)	34111	58293	57052	49819
T_{10} - Soybean + pigeonpea (8:1)	36170	61977	65917	54688
S.E. (m) ±	6380	5978	4913	2069
C.D. at 5%	13404	17762	14596	6168
C.V. %	18.5	15.4	12.3	9.61

In respect of B:C ratio (Table 6) during the year 2011-12 row proportion of soybean+ pigeonpea (2:1) recorded highest value of B:C ratio (4.17). However, during 2012-13, 2013-14 and in three years mean, soybean + pigeonpea (4:2) row proportion, recorded highest value of B:C ratio i.e. 4.79 , 4.15 and 4.31, respectively. An increase in net returns and B:C ratio with intercrops of pigeonpea was due to increased value of soybean equivalent yield and different cost of cultivation. Generally, intercropping was found to be more remunerative than sole crops. Dubey *et al.* (1991) reported that 32 per cent more net returns due to cultivation of soybean and pigeonpea compared to sole crop. Similar trend was observed due to the 4:2 row proportion of soybean + pigeonpea intercropping system by Tomar *et al*. (1990), Halvankar *et al*. (2000), Patil and Joshi (2003), Billore and Joshi (2004) and Sree and Dhurua (2009) also reported that five rows of soybean with pigeonpea recorded maximum net returns.

Table 6. B:C and Land equivalent Ratio as influenced by various treatments

Treatments	B:C Ratio			Mean	Land equivalent ratio			Mean
	2011-12	2012-13	2013-14		2011-12	2012-13	2013-14	
T_1 - Sole Soybean	2.16	3.19	2.60	2.65	1.00	1.00	1.00	1.00
T_2 - Sole Pigeonpea	3.17	3.41	3.50	3.36	1.00	1.00	1.00	1.00
T_3 - Soybean + pigeonpea (1:1)	4.11	4.14	3.95	4.07	1.40	1.42	1.29	1.37
T_4 - Soybean + pigeonpea (2:1)	4.17	4.20	3.97	4.11	1.48	1.43	1.29	1.40
T_5 - Soybean + pigeonpea (3:1)	3.70	4.14	3.71	3.85	1.36	1.41	1.25	1.34
T_6 - Soybean + pigeonpea (4:1)	2.65	4.06	3.50	3.40	1.28	1.39	1.23	1.30
T_7 - Soybean + pigeonpea (4:2)	3.99	4.79	4.15	4.31	1.41	1.67	1.34	1.47
T_8 - Soybean + pigeonpea (5:1)	2.91	3.83	3.29	3.34	1.11	1.30	1.21	1.21
T_9 - Soybean + pigeonpea (6:1)	2.89	3.49	3.15	3.18	1.13	1.16	1.21	1.17
T_{10} - Soybean + pigeonpea (8:1)	2.97	3.64	3.35	3.32	1.18	1.22	1.34	1.24

C. Land Equivalent Ratio (LER)

Among the various intercropping treatments, during the year 2011-12 , row proportion of soybean + pigeonpea (2:1) recorded highest value of land equivalent ratio (1.48). However, during 2012-13,2013-14 and in pooled results, row proportion of soybean + pigeonpea (4:2) recorded highest value of land equivalent ratio i.e. 1.67,1.34 and 1.47, respectively (Table 6) Significantly higher value of LER were also recorded by Tomar *et al*. (1990) and Halvankar *et al*.(2000). In soybean + pigeonpea (4:2) intercropping system. Sree and Dhurua (2009) also reported that pigeonpea with six rows of soybean recorded maximum LER.

D. Important soil chemical properties

The data (Table 7) on chemical properties of soil, under soybean+pigeonpea intercropping system were found to be non significant in case of pH, EC and organic carbon of the soil.However, organic carbon content showed slight variation in different treatments of soybean + pigeonpea intercropping system. The higher organic carbon content (4.91g kg^{-1}) was recorded with the sole soybean and soybean + pigeonpea (4:2) intercropping system (4.90g kg^{-1}), indicating the significant role of legume crops and dropping of the leaves of the both the crops which was probably helpful in buildup of soil organic carbon.

The available nitrogen status of soil due to different treatments was found to be significant. However, phosphorus and potassium status of soil was non-significant. The highest available nitrogen (178.5kg ha^{-1}) was recorded with the sole soybean crop and being at par with soybean + pigeonpea (4:2) intercropping system (177.5kg ha^{-1}).

Table 7. Chemical properties of soil as influenced by various treatments

Treatments	pH (1:2.5)	EC (dSm^{-1})	OC ($g\ kg^{-1}$)	Available nutrients ($kg\ ha^{-1}$)		
				N	P	K
T_1 - Sole Soybean	8.02	0.25	4.91	178.5	11.3	333.4
T_2 - Sole Pigeonpea	8.03	0.26	4.83	171.5	11.3	334.5
T_3 - Soybean + pigeonpea (1:1)	8.03	0.25	4.84	173.5	11.3	333.1
T_4 - Soybean + pigeonpea (2:1)	8.03	0.26	4.85	172.5	11.3	332.4
T_5 - Soybean + pigeonpea (3:1)	8.03	0.26	4.88	174.5	11.3	332.6
T_6 - Soybean + pigeonpea (4:1)	8.02	0.25	4.85	175.0	11.3	334.5
T_7 - Soybean + pigeonpea (4:2)	8.04	0.26	4.90	177.5	11.4	334.2
T_8 - Soybean + pigeonpea (5:1)	8.00	0.26	4.85	175.0	11.3	333.1
T_9 - Soybean + pigeonpea (6:1)	8.03	0.26	4.87	174.0	11.4	332.9
T_{10} - Soybean + pigeonpea (8:1)	8.02	0.26	4.88	174.0	11.4	333.5
S.E. (m) ±	0.009	0.004	0.037	0.39	0.04	0.88
C.D. at 5%	NS	NS	NS	1.15	NS	NS
Initial	7.95	0.21	4.55	174.8	12.2	337.8

E. Uptake by crops

Total nitrogen uptake by the soybean and pigeonpea seed and straw was found to vary significantly. Data revealed that soybean + pigeonpea (1:1) recorded highest uptake N but being at par with the sole pigeonpea ,soybean + pigeonpea intercropping of 2:1,3:1 4:1 4:2,5:1 and 8:1 row proportions. Whereas, sole pigeonpea recorded significantly higher uptake of total nitrogen by seed and straw than sole soybean. (Table 8).

Table 8. Nitrogen uptake by seed and straw of soybean and pigeonpea as influenced by various treatments

Treatments	Nitrogen uptake ($kg\ ha^{-1}$)						Total nitrogen uptake ($kg\ ha^{-1}$)
	Soybean			Pigeonpea			
	Seed	Straw	Total	Seed	Straw	Total	
T_1 - Soybean	100.65	14.75	115.40	-	-	-	115.40
T_2 - Pigeonpea	-	-	-	66.85	100.45	167.30	167.30
T_3 - S+ P (1:1)	79.48	11.26	90.74	36.53	59.66	96.20	186.93
T_4 - S+ P (2:1)	82.92	11.92	94.84	32.97	54.46	87.43	182.27
T_5 - S+ P (3:1)	96.57	13.79	110.36	25.76	43.64	69.40	179.76
T_6 - S+ P (4:1)	95.45	12.89	108.34	18.27	30.99	49.25	157.59
T_7 - S+ P (4:2)	77.22	11.82	89.05	36.42	60.36	96.78	185.83
T_8 - S+ P (5:1)	91.47	13.30	104.77	21.31	36.31	57.62	162.39
T_9 - S+ P (6:1)	93.30	13.22	106.52	18.67	31.03	49.71	156.23
T_{10} - S+ P (8:1)	106.91	16.21	122.98	19.14	31.49	50.63	173.60
S.E (m) ±			7.20			3.19	8.62
C.D. at 5%			21.39			9.49	26.16

Higher total nitrogen uptake in soybean + pigeonpea 1:1 and 4:2 row proportion was due to higher yield and higher nodulation. The seed treated with *Rhizobium*, increased the number of nodules in soybean and pigeonpea, which causes higher availability of nitrogen to crop. Ganneshmurthy (2009) reported that, legumes in symbiotic with *Rhizobial* bacteria are mini nitrogen producing factories.

Total uptake of P by the soybean and pigeonpea crops was highest in case of 4:2 and 8:1 by soybean row proportion but being at par with rest of the treatments except the treatments of sole soybean and sole pigeonpea. Legumes required larger quantity of phosphorus for symbiotic nitrogen fixation, root development and energy driven process that are responsible for high phosphorus utilization (Table 9).

Table 9. Phosphorus uptake by seed and straw of soybean and pigeonpea as influenced by various treatments

Treatments	Phosphorus uptake (kg ha^{-1})						Total phosphorus uptake (kg ha^{-1})
	Soybean			Pigeonpea			
	Seed	Straw	Total	Seed	Straw	Total	
T_1 - Soybean	11.18	7.91	19.09	-	-	-	19.09
T_2 - Pigeonpea	-	-	-	6.65	9.00	15.65	15.65
T_3 - S+ P(1:1)	7.88	5.54	13.42	3.44	5.47	8.91	22.33
T_4 - S+ P(2:1)	8.73	5.81	14.54	3.12	5.04	8.17	22.70
T_5 - S+ P(3:1)	10.13	7.07	17.21	2.65	4.05	6.70	23.91
T_6 - S+ P(4:1)	11.07	7.11	18.17	1.88	2.87	4.75	22.92
T_7 - S+ P(4:2)	9.07	6.37	15.44	4.86	5.11	9.97	25.41
T_8 - S+ P(5:1)	9.99	6.53	16.52	2.12	3.25	5.37	21.89
T_9 - S+ P(6:1)	10.59	7.03	17.62	1.93	2.82	4.76	22.37
T_{10} - S+ P(8:1)	12.18	8.08	20.26	2.07	2.87	4.93	25.19
S.Em. ±			1.32			0.29	1.58
C.D. at 5%			3.92			0.88	4.81

Total K uptake was highest in 4:2 row proportion, followed by sole pigeon pea and 1:1, 2:1 row proportions. Other treatments showed significantly lower uptake of K. Higher K uptake by pigeon pea and 4:2 row proportion might be probably due to higher dry matter production.(Table 10).

Table 10. Potassium uptake by seed and straw of soybean and pigeonpea as influenced by various treatments

Treatments	Potassium uptake (kg ha^{-1})						Total potassium uptake (kg ha^{-1})
	Soybean			Pigeonpea			
	Seed	Straw	Total	Seed	Straw	Total	
T_1 - Soybean	17.35	24.93	42.29	-	-	-	42.29
T_2 - Pigeonpea	-	-	-	16.42	73.13	89.55	89.55
T_3 - S+ P(1:1)	12.61	17.80	30.40	9.13	43.75	52.89	83.29
T_4 - S+ P(2:1)	13.63	19.61	33.25	8.39	39.29	47.67	80.92
T_5 - S+ P(3:1)	15.62	22.13	37.74	6.21	31.17	37.38	75.13
T_6 - S+ P(4:1)	16.60	22.07	38.67	4.51	22.99	27.50	66.17
T_7 - S+ P(4:2)	13.75	19.75	33.50	11.83	42.61	54.44	89.94
T_8 - S+ P(5:1)	15.16	21.58	36.74	5.25	26.06	31.31	68.05
T_9 - S+ P(6:1)	16.51	21.82	38.34	4.75	22.89	27.65	65.98
T_{10} - S+ P(8:1)	18.17	25.76	43.93	5.08	22.97	28.05	71.98
S.Em. ±			2.85			1.90	3.75
C.D. at 5%			NS			5.65	11.39

Hence, it is concluded that, for convenience in sowing, interculture operations, for obtaining higher production and economic returns soybean + pigeonpea (4:2) intercropping system sown with 45 cm spacing between the rows was found superior to sole crops soybean and pigeonpea and intercropping with other row proportions under dryland condition.

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Effect of Plant Geometry and Fertilizer Management on Growth and Yield of Pigeonpea

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ABSTARCT

A field experiment was conducted during *Kharif* season 2008-09 at Pulses Research Unit , Dr.Panjabrao Deshmukh Krishi Vidyapeeth, Akola to observe the response of pigeonpea to spacing and fertility levels. The results revealed that the pigeonpea cv PKV TARA recorded significantly higher grain yield with wider row (90 cm) and plant spacing (30 cm) as compared to with closer spacing and the difference between them was at par. The significantly higher grain yield was recorded with fertility level of 35:70 N:P_2O_5 kg ha^{-1} (1550 kg ha^{-1}) closely followed by 30:60 N:P_2O_5 kg ha^{-1} (1520 kg ha^{-1}) as compared to lower fertility level of 25:50 N:P_2O_5 kg ha^{-1} (1172 kg ha^{-1}). The growth and yield parameters followed the similar trend. Photosynthetic active radiation (PAR) was also highest at wider row spacing of 90 cm and plant spacing of 30 cm.

Pigeonpea (*Cajanus cajan Millsp.*) is an important pulse crop of Maharashtra, grown over 12.33 M.ha with a production of 8.71 MT and productivity of 706 kg ha^{-1} (Anonymous, 2011). Pigeonpea plant is known to provide several benefits to soil such as fixing atmospheric nitrogen, adding organic matter and micro nutrients, and breaking hard plough pan with its long tap roots and thereby sometimes referred as "biological plough". Pigeonpea can be grown successfully in a wide range of soil types and is capable of producing reasonable quantities of nutritive food even in the degraded soils and with minimum external inputs. The yield of pigeonpea is limited by a number of factors such as agronomic, pathogenic, entomological, genetic and their interaction with environment. Among the different agronomic practices limiting the yield, choice of a suitable geometry and population for a particular genotype is one of the important factors. Adaptation of proper planting geometry to a particular genotype will go a long way in making efficient use of limited growth resources and thus to stabilize yield.

The plant density is another important factor in increasing yield. However closer spacing brings variation in microclimatic factors such as light intensity, evapotranspiration and temperature of soil surface (Sinha *et al.* 1988). This study was conducted to obtain the suitable plant spacing and fertilizer for variety PKV TARA.

MATERIAL AND METHODS

A field experiment was conducted during *Kharif* season of 2008-09 at Pulses Research Unit, Akola on clayey soil having 205, 19.30 and 354 kg ha^{-1} of available N, P_2O_5, K_2O, respectively with the soil pH of 8.28 and organic carbon content of 0.54 per cent. The treatments consisted of two row spacing (60 and 90 cm), two plant spacing (20 and 30 cm) and four fertilizer levels (Absolute control, 25:50:00 kg NPK ha^{-1}, 30:60:00 kg NPK ha^{-1}, 35:70:00 kg NPK ha^{-1}). The experiment was laid out in factorial randomized block design and replicated thrice with a plot size of 4 m x 9 m. The crop was fertilized as per the treatments with application of urea, diammonium phosphate at the time of sowing. The variety used was PKV TARA and other cultural operations were done as per recommendation and crop requirements. The crop was sown on 4 July 2008 and harvested on 17 December 2008. During crop growth period about 528.7 mm rainfall was received in 42 rainy days. Observations on growth parameters like plant height, number of branches, number of pods, grain yield per plant and 100-grain weight was recorded. The transmission of Photosynthetically active radiation (PAR) through the canopy was recorded with a 1 m long line quantum sensor (Li-Cor, Lincoln, NE, USA).

RESULTS AND DISCUSSION

Yield

The row spacing of 90 cm recorded grain yield of 14.54 q ha^{-1} and it was at par with the grain yield obtained with 60 cm. The grain yield did not influenced significantly due to within row spacing. However, numerically higher grain yield was recorded when pigeonpea was maintained within row at 20 cm over 30 cm. The better availability of growth resources like water, nutrients, air, better cultural practices and effective weed

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control in wider plant geometry were helped the plants to exhibit their full potential and produced higher yield than closely spaced plants. Similar results were reported by Puste, *et al.* (1996). Increasing the plant density per unit land area increases the interplant competition, because higher competition between plants contribution of yield components per plant with 60 cm were lower when compared to 90 cm spacing. The results are in conformity with the findings of Mahajan *et al*. (1997).

Among nutrient levels grain yield increases progressively with the increasing levels of fertilizer. The significantly highest grain yield was recorded with the application of 35:70:00 NPK kg ha^{-1} (F_4) had given 32.23 per cent over lower level of fertilizer (F_2-25:50:00 NPK kg ha^{-1}) which in turn found at par with 30:60:00 NPK kg ha^{-1} (F_3). The higher grain yield at higher fertilizer dose was due to availability of additional amount of nutrients favoured the growth and development of better root system, which might have helped in better uptake of nutrients. Further, it might have improved the rate of photosynthesis, as indicated in terms of higher values of growth and yield components (Table 1) that resulted in higher grain yield of pigeonpea with higher fertility levels. The higher grain yield was closely related to superior performance referred in terms of yield components such as number of pods plant^{-1} (83.31), grain weight plant^{-1} (23.0 g) and test weight (9.85 g). The higher yield components with higher fertility level was attributed to higher growth parameters like higher primary, secondary and total branches plant^{-1}, which can be attributed to higher nutrients availability for plant at higher fertility levels. These results were in conformity with the findings of Nivedita and Narasa (1990). The interaction effects showed no significant difference.

Phtosynthetically active radiation

Absorption of photosynthetically active radiation (PAR) was also higher under 90 cm of inter-row spacing and 30 cm intra-row spacing. This might be attributed to more branching and bigger leaf size under wide spacing which offered more barrier to the transmission of light. The PAR of the pigeonpea increased with the increase in spacing which recorded higher plant height and lesser number of leaves which offered more resistance to the penetration of light because of higher leaf size. As the plant height increased, it created more impasse to the transmission of light to the lower layer of the canopy which ultimately increased the PAR value. In case of fertility levels, PAR absorption of Photosynthetically active radiation interception was higher under higher fertility level and lowering with decreasing fertility level. Similar results were reported by Singh *et al*. (2012). Usually pigeonpea at flowering stage fully covered the ground with dense canopy so that light could not penetrate into the ground surface or canopy beneath the middle level.

Correlation

The coefficient of simple correlations and regression were computed for ascertaining the quantitative and qualitative association between the yield and other plant characters as presented in Table 2. It revealed that yield showed significantly positive association with all the independent plant characters. Among the yield attributes, the yield showed the highest impact on the number of pods plants^{-1}, followed by number of branches plant^{-1}, grain weight plant^{-1} and 100-grain weight. These findings are in accordance with the results obtained by Siddique *et al.* (2006) for mungbean.

Economics

Among different spacings, the row spacing of 60 cm recorded higher cost of cultivation (Rs.20073 ha^{-1}) as it required higher seed rate when compared to 90 cm row spacing. Wider spacing of 90 cm recorded higher gross returns (Rs.65430 ha^{-1}), net returns (Rs.45474 ha^{-1}) than closer spacing of 60 cm, however, with respect to within row spacing higher gross (Rs.64485 ha^{-1}) and net return (Rs.44370 ha^{-1}) was obtained with 20 cm spacing over 30 cm spacing due to its higher seed yield. In case of fertilization application of 35:70:00 N:P:K kg ha^{-1} recorded higher gross (Rs.69750 ha^{-1}) return closely followed lower fertility level of 30:60:00 N:P:K kg ha^{-1} (gross return Rs.68400 ha^{-1}) and 25:50:00 N:P:K kg ha^{-1} (gross return Rs.65070 ha^{-1}). Application of different fertility levels influenced net return significantly, however, higher fertility levels (35:70:00 N:P:K kg ha^{-1}) recorded statistically equivalent net return with lower fertility levels (30:60:00 and 25:50:00 N:P:K kg ha^{-1}). Benefit cost ratio was found significantly higher in a row spacing of 90 cm (3.28) when compared to 60 cm (3.12) for within row spacing of 20 cm (3.21) and 30 cm (3.19). In case of fertilization higher BCR was obtained with 25:50:00 N:P:K kg ha^{-1}. A similar finding was reported by Nedunzhiyan and Sambasiva Reddy (1993).

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

Treatment	Grain yield (kg/ha)	Plant height (cm)	No. of branches plant^{-1}	No. of pods plant^{-1}	Grain yield plant^{-1} (g)	100-grain weight (g)	PAR absorption (%)	Cost of cultivation (Rs/ha)	Gross Return (Rs/ha)	Net return (Rs/ha)	B:C ratio
Row spacing											
60 cm	1391	191.74	5.62	77.19	20.86	9.75	93.92	20073	62595	42522	3.12
90 cm	1454	194.95	6.23	80.00	22.03	9.85	94.42	19956	65430	45474	3.28
CD at 5%	NS	2.62	0.09	1.97	1.07	0.02	--	--	NS	NS	--
Plant spacing											
20 cm	1433	192.89	5.86	77.93	21.03	9.79	93.08	20115	64485	44370	3.21
30 cm	1411	193.80	5.99	79.24	21.86	9.82	95.26	19914	63495	43581	3.19
CD at 5%	NS	NS	NS	NS	NS	NS	--	--	NS	NS	--
Fertilizer levels											
Absolute Control	1172	188.09	5.62	72.62	20.04	9.74	92.92	18812	52740	33928	2.80
25:50:00::NPK kg/ha	1446	192.36	5.87	77.54	21.04	9.80	94.21	20076	65070	44994	3.24
30:60:00::NPK kg/ha	1520	195.31	6.03	80.88	21.69	9.82	94.52	20478	68400	47922	3.34
35:70:00::NPK kg/ha	1550	197.62	6.18	83.31	23.00	9.85	95.00	20694	69750	49056	3.37
CD at 5%	88.74	3.71	0.12	2.79	1.52	0.03	--	--	3285	3285	--
Interaction											
CD at 5%	NS	NS	NS	NS	NS	NS	--	--	--	--	--

Selling price: Grain-Rs.4500/q.

It seems from the study that variety PKV TARA favoured row spacing of 90 and plant spacing 20 cm with fertilizer dose of 25:50:00 N:P:K kg ha^{-1}.

Table 2: Correlation studies between yield and yield attributes in pigeonpea

Yield attributes	'r' value
100 grain weight	0.426*
Grain weight $plant^{-1}$	0.660**
No. of Branches $plant^{-1}$	0.721**
Plant height at maturity	0.928**
No. of pods $plant^{-1}$	0.948**

* Significant at 5% level of probability

** Significant at 1% level of probability

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Impact of Bioclimate on Cotton Productivity

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ABSTRACT

Eight sites were selected in four different bio-climatic conditions such as semi-arid (dry) and semi-arid (moist), sub humid (dry), sub humid (moist) of major cotton growing soils (Vertisols) in Nagpur, Wardha, Amravati and Akola districts under variable climate in Vidarbha region of Maharashtra. The soil pedons were exposed on selected sites and studied for various characteristics and for knowing taxonomically classified soils (Typic Haplusterts). *Gossypium hirsutum* Hybrid-4 cotton was raised under standard levels of management and assessed production potential of cotton by measuring plant population, number of bolls per plant and weight of seed cotton per boll and correlated with potential and actual yield of cotton.

The potential yield of cotton (q ha^{-1}) varied from 13.4 to 16.3 at semi-arid (dry); 17.7 to 24.8 at semi-arid (moist); 14.6 to 15.6 at sub-humid (dry); 12.4 to 15.2 at sub-humid (moist) bio-climatic situations while actual yield (q ha^{-1}) at semi-arid (dry) 11.0 to 12.5; semi-arid (moist) 12.5 to 21.0; sub-humid (dry) 12.5 to 13.5; sub-humid (moist) 12.5 to 13.5 and estimated cost : benefit ratio in the range of 1:0.86 to 1:1.05 (S3 to S1); 1:1.08 to 1:1.81 (S2 to Sl); 1:0.84 to 1:0.97 (S3) and 1:0.91 to 1:1.02 (S3 to S2) for semi-arid (dry), semi-arid (moist); sub-humid (dry) and sub-humid (moist) respectively. They are related to distribution and amount of rainfall intensity, temperature, solar radiation and moisture status of soils. They are highly correlated with potentials, actual yield of cotton, cost: benefit ratio and soil suitability classes.

Cotton is the most important cash crop in India. It is a major fiber crop grown under a very broad range of climate, soil and cultural practices in India. The climatic set up plays an important role from crop production point of view. The annual rainfall and its distribution affect the bio-climatic make up of the area. Soil is basic natural resource and has immense importance for crop production. To study the impact of bio-climate on cotton grown in Vertisols of Maharashtra with an objective to identify cotton growing agro-climatic regions of Maharashtra, characterized, classified and correlated soil and to evaluate soil suitability for cotton cultivation in the State .There is a need to evaluate impact of bio-climate and soil families for suitability evaluation because the crop is grown in various soil families, climate and management practices. Therefore, the present investigation was undertaken to study impact of bio-climate on cotton productivity in the region of Maharashtra.

MATERIAL AND METHODS

The present study was conducted in cotton growing area of Maharashtra with different agro-climatic regions where rainfall and temperature varied under bio-climate. The rainfall of the study area varies from 600 to 1200 mm. The soil pedons were exposed on selected sites of region viz. Washim, Akola, Amravati, Nagpur, Wardha and studied for various soil-site characteristics and taxonomically classified (Soil Survey staff, 1993). The soil families identified were fine and very fine of Typic Haplusterts. The suitability parameters of soils have been assessed by different approaches like Storie (1978), Riquier *et al* (1970), FAO (1983), and Sys (1985) and categorized the soils under various soil suitability classes. Soil samples were analyzed for different physical and chemical properties by standard procedures (Jackson 1973).

The yield of cotton was recorded by taking the interview of cultivators and the potential yield of cotton crop was estimated by measuring spacing (plant to plant and row to row), no. of bolls $plant^{-1}$, weight of seed cotton in bolls, (average of 10 plants) and correlated with actual yield (q ha^{-1}) of cotton and Cost: Benefit ratio was worked out.

RESULTS AND DISCUSSION

Based on variability of rainfall (<600 to >1200 mm), temperature (26 to 33 ^{o}C), relative humidity (50-60 %) at annual in different stages of cotton crop under semi arid and subhumid (dry, moist) conditions. Eight representative pedons were selected from different cotton growing locations of Maharashtra. The landform identified

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Table 1. Bio-climate and soil- site characteristics

Soil pedon No.	Location (Dist) Bio-climate*	Soil Depth (cm)	Rainfall (mm/ annum)	Elevation above MSL(m)	Land forms	Slope (%)	Erosion	Drainage	LandUse
1.	Malegaon (Washim) SA(D)	0-85+	581	340-400	Lower piedmont	1-3	Moderate	Moderately well drained	Cotton, pigeonpea wheat, gram
2.	Sarole (Solapur) SA(D)	0-127+	743	400-440	Lower piedmont	1-3	Moderate	Moderately well drained	Cotton, jowar, wheat gram
3.	Mandoli (Akola) SA (M)	0-140+	777	400-440	Lower piedmont	1-3	Moderate	Moderately well drained	Cotton, pigeonpea, wheat
4	Karanja (Wardha) SA(M)	0-150+	882	340-440	Lower piedmont	1-3	Moderate	Moderately well drained	Cotton, pigeonpea, wheat, gram
5	Walgaon (Amravati) SH(D)	0-150+	796	300-340	Lower piedmont	1-3	Moderate	Moderately well drained	Cotton, Pigeonpea, jowar, wheat, gram
6	Panubali (Nagpur) SH(D)	0-150+	1074	300-340	Lower piedmont	1-3	Moderate	Moderately well drained	Cotton, jowar wheat
7	Kalajana (Wardha) SH(M)	0-150+	1141	300-340	Lower piedmont	1-3	Moderate	Moderately well drained	Cotton pigeonpea wheat, gram
8	Surabardi (Nagpur) SH(M)	0-150+	1242	300-340	Valley bottom	1-3	Moderate	Moderately well drained	Cotton, pigeonpea, wheat, gram

*SA(D) : Semi-arid (dry); SA(M): Semi-arid (moist) : SH(D) : Sub-humid(dry): SH(M): Sub-humid (moist)

are lower piedmont and valley bottom with moderately well drained soils developed from basaltic alluvium, having 85-150 cm depth with very gently to gently sloping (1-3%) topography at an elevation of 300 to 440 m above MSL and mostly under cotton , pigeonpea, wheat and gram cultivation. The site characteristics comprising of locations, landforms, parent material and land use are presented in Table 1.

The results revealed that most of the soils were clay in texture, with clay content ranging from 44.3 to 76.7 per cent and it usually increases in sub soils, which decreases again in lower horizon in most of the soils (Table 2). The silt content ranging from19.3 to 44.5 per cent, the highest value was observed in pedon 1 and 8 whereas the lowest value was noticed in pedon 1.The sand content ranging from 3.9 to 34.0 percent. The bulk density of soils ranged from 1.60 to 1.87 Mg m^{-3}. Lower bulk density was observed in surface soil due to cultivation practices and higher values (> 1.7 Mg m^{-3}) in sub-surface horizon because of its compactness and less exposure to atmosphere. Dudal (1965) reported similar results in Vertisols.

The organic carbon varied from 0.15 to 0.90 per cent in the decreasing trend in the profile. Sys (1985) reported >1.2 per cent organic carbon in soils is highly suitable for cotton cultivation. The pH varied from 8.1 to 8.4 except in pedon -3 where it was 8.4 to 8.9 in sub-surface layer due to presence of calcinated geogenic calcium. (Martin *et al.,* 1975).

The CEC of the soil is one of the important chemical property and it ranged from 42 to 56 cmol(p+) Kg^{-1} indicating that the soils have high fertility status. Similar observations were reported by Magar (1990) and Murthy *et al.* (1982) while studying the soils of Maharashtra.

Table 2 . Physico-chemical properties of the selected soil profiles

Depth (cm)	Particle size distribution			Texture	Bulk density ($Mg\ m^{-3}$)	Organic Carbon (%)	pH (1:2.5/Soil :water)	CEC cmol ($(p+)kg^{-1}$)
	Sand (%) (2-0.02)	Silt (%) (0.02-0.002)	Clay (%) (<0.002)					
	----------(mm)----------							
Pedon-1 Malegaon (Washim) Very fine,mont. Hyperthermic (cal) family of Typic Haplusterts								
0-8	8.4	24.2	67.4	Clay	1.65	0.90	8.1	59.41
8-21	4.1	27.5	68.3	Clay	1.84	0.67	8.1	59.53
21-34	4.2	27.7	68.0	Clay	1.84	0.42	8.1	56.72
34-54	3.9	19.3	76.7	Clay	1.84	0.28	8.1	53.00
54-85+	34.0	21.5	44.3	Gravelly Clay	1.89	0.16	8.1	54.64
Pedon-2 Sarole (Solapur)) Fine,mont. iso-Hyperthermic family of Typic Haplusterts								
0-13	15.3	32.8	51.8	Clay	1.60	0.34	8.4	41.65
13-31	13.7	38.6	47.6	Clay	1.65	0.26	8.4	42.60
31-54	11.7	38.8	49.4	Clay	1.77	0.24	8.4	46.95
54-87	10.0	42.5	47.5	Clay	1.83	0.27	8.4	47.45
87-127+	9.2	43.9	46.8	Clay	1.87	0.25	8.5	48.60
Pedon-3 Mandoli (Akola) Fine,mont. Hyperthermic (cal) family of Typic Haplusterts								
0-15	21.5	32.8	45.5	Clay	1.62	0.44	8.4	42.11
15-32	12.9	38.9	48.1	Clay	1.62	0.43	8.5	42.90
32-53	11.9	38.9	49.9	Clay	1.71	0.34	8.8	49.62
53-90	10.7	37.9	51.3	Clay	1.80	0.32	8.9	45.76
90-118	9.2	35.9	54.8	Clay	1.81	0.28	8.9	42.93
118-140+	9.0	25.3	65.5	Clay	1.83	0.15	8.9	58.69
Pedon-4 Karanja (Wardha) Very fine,mont. Hyperthermic (cal) family of Udic Haplusterts								
0-12	10.2	24.2	65.5	Clay	1.69	0.80	8.3	58.41
12-26	7.8	25.5	66.5	Clay	1.73	0.58	8.3	51.02
26-53	4.9	23.2	71.7	Clay	1.77	0.56	8.3	50.62
53-76	5.2	36.6	58.0	Clay	1.80	0.54	8.3	50.54
76-105	10.3	32.8	58.8	Clay	1.80	0.53	8.3	56.01
105-150+	11.5	25.6	62.8	Clay	1.87	0.34	8.4	49.32

Cont....

Depth (cm)	Particle size distribution			Texture	Bulk density	Organic Carbon	pH	CEC
	Sand (%) (2-0.02)	Silt (%) (0.02-0.002)	Clay (%) (<0.002)		(Mg m^{-3})	(%)	(1:2.5/Soil :water)	cmol ((p+)kg^{-1})
	----------(mm)----------							
Pedon-5 Walgaon (Amravati) Very fine,mont. Hyperthermic (cal) family of Typic Haplusterts								
0-15	6.1	27.2	66.6	Clay	1.71	0.86	8.3	48.06
15-32	5.4	31.3	63.2	Clay	1.74	0.43	8.3	55.68
32-48	5.4	35.2	59.3	Clay	1.77	0.44	8.3	50.81
48-65	5.3	42.6	51.9	Clay	1.81	0.35	8.4	42.13
65-94	6.4	32.7	60.7	Clay	1.82	0.33	8.4	45.91
94-150+	7.4	33.0	72.2	Clay	1.82	0.20	8.4	42.83
Pedon-6 Panubali (Nagpur) Very fine,mont. Hyperthermic (cal) family of Typic Haplusterts								
0-12	5.7	30.0	64.3	Clay	1.72	0.53	8.4	58.91
12-30	5.0	27.8	67.1	Clay	1.76	0.44	8.4	52.14
30-47	7.8	21.3	70.7	Clay	1.81	0.46	8.4	54.76
47-80	4.9	23.8	71.1	Clay	1.84	0.28	8.4	55.78
80-150+	4.5	22.2	73.2	Clay	1.87	0.40	8.5	56.43
Pedon-7 Kalajana (Wardha) Fine,mont. Hyperthermic (cal) family of Typic Haplusterts								
0-15	7.7	42.9	49.2	Clay	1.71	0.75	8.3	49.00
15-38	9.5	42.7	47.7	Clay	1.76	0.57	8.3	47.14
38-58	9.9	40.4	49.6	Clay	1.77	0.44	8.3	40.55
58-80	10.2	37.4	52.0	Clay	1.83	0.46	8.4	45.78
80-109	10.2	37.3	52.4	Clay	1.86	0.44	8.4	47.32
109-150+	11.7	34.2	54.0	Clay	1.87	0.42	8.4	47.79
Pedon-8 Surabardi (Nagpur) Fine,mont. Hyperthermic (cal) family of Typic Haplusterts								
0-14	10.5	44.5	45.1	Clay	1.71	075	8.4	49.93
14-33	9.7	43.5	46.7	Clay	1.73	0.56	8.4	48.71
33-58	8.4	40.4	51.0	Clay	1.73	0.48	8.4	47.23
58-66	8.3	40.6	51.0	Clay	1.75	0.44	8.4	48.53
66-108	10.7	37.2	51.9	Clay	1.76	0.44	8.4	54.85
108-150+	11.28	31.6	57.0	Clay	1.77	0.40	8.6	47.82

Table 3. Plant population, potential yield, actual yield and soil suitability classes

Soil pedon No.	Plant population	No. of bolls/ plant	Wt. of seed cotton (g boll^{-1})	Potential yield (q ha^{-1})	Actual Yield (q ha^{-1})	Soil suitability class	Cost: benefit ratio	Soil Taxonomy (Soil sub-group)
1.	36300	20	1.85	13.4	12.5	S3	1:0.86	Typic Haplusterts
2.	27225	25	2.40	16.3	11.0	S2	1:1.06	Typic Haplusterts
3.	12100	55	2.60	17.7	12.5	S2	1:1.08	Typic Haplusterts
4.	12100	55	3.74	24.8	21.0	Sl	1:1.8	Udic Haplusterts
5.	12100	47	2.75	15.6	13.5	S3	1:0.97	Typic Haplusterts
6.	14520	30	3.35	14.6	12.5	S3	1:0.84	Entic Haplusterts
7.	17420	30	3.30	12.4	12.5	S2	1:1.02	Tvpic Haplusterts
8.	21780	25	2.79	15.2	12.5	S3	1:0.91	Typic Haplusterts

Sl-Highly suitable [C:B >1:1.51; S2-Moderately suitable [C:B 1:1 to 1.5], S3-Marginally suitable [C:B <1:1.0](based on cost: benefit ratio).

The results presented in table 3 revealed that the plant population varied from 12100 to 36300 because of different spacing (row to row and plant to plant). The no. of bolls per plant were in the range of 20 to 55 because of soil condition and bio-climate, while the weight of seed cotton per boll was in the range of 1.85 to 3.74 g boll^{-1}.The estimated potential yield was in the range of 13.43 to 24.88 q ha^{-1} and actual yield was in the range of 12.5 to 21.0 q ha^{-1} due to inherent properties of soils, distribution of rainfall and bio-climatic make up of the area. Similar observations were reported by Hole (2000) while studying the soils around Nagpur, Maharashtra. The cost: benefit ratio varied from 1:0.84 to 1:1.8 which are sustainable for the evaluation of soil suitability classes. Accordingly the high cost: benefit ratio in pedon-4 (1:1.8) seems to be highly suitable soils for cotton cultivation followed by pedon-7 (1:1.02), pedeon-2 (1:1:06), pedon-3(1:1.08),pedon-6(1:0.84),pedon-1(1:0.86),pedon-8(1:0.91) and pedon-5 (1:0.97) in increasing trend is concluded. The soil suitability have been categorized based on cost: benefit ratio which was in the pedon-1under semi-arid (dry); moderately suitable (S3); 1:1.08 to 1:1.80 semi-arid (moist) moderate to highly suitable (S2 to S1) in pedon 2 and 3; 1:0.84 to 1:0.97 sub-humid (dry) marginally suitable (S3) in pedon 5 and 4 and 1:0.91 to 1:1.02, sub-humid (moist) (marginally to moderately suitable (S3 to S2) in pedon 7 and 8 for studied Vertisols are concluded. These classes are highly correlated with actual and potential yield of cotton. The soils have been classified as Typic Haplusterts (pedon 1, 2, 3, 5, 7, 8) Udic Haplusterts (pedon- 4) and Entic Haplusterts (pedon-6) for cotton productivity are concluded.

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Effect of Different Herbicides on Weed Control And Yield of Indian Mustard (*Brassica juncea*)

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ABSTRACT

A field experiment was conducted on mustard at Shankar Nagar Farm, College of Agriculture, Nagpur during *Rabi* 2011-2012. The ten treatments of weed management practices like application of Pendimethalin @ 1.0 kg a.i. ha^{-1} PE (T_1), Oxadiargyl @ 0.09 kg a.i. ha^{-1} PE (T_2), Trifluralin @ 0.75 kg a.i. ha^{-1} PPI (T_3), Oxyfluorfen @ 0.15 kg a.i. ha^{-1} PE (T_4), Quizalofop @ 0.06 kg a.i. ha^{-1} POE (T_5), Clodinafop @ 0.06 kg a.i. ha^{-1} POE (T_6), Isoproturon @ 1.0 kg a.i. ha^{-1} PE (T_7), Isoproturon @ 1.0 kg a.i. ha^{-1} POE (T_8), Weedy Check (T_9) and Weed-free (T_{10}) were tried in RBD with three replications. Weed-free practice recorded highest yield of mustard. Among the chemical weed control pre-emergence application of oxadiargyl, oxyflurofen, isoproturon and post emergence of clodinafop were at par and recorded seed yield in decreasing order. The weedy check recorded the lowest seed yield but found at par with trifluralin PPI and isoproturon POE. While all other treatments recorded significantly higher seed yield. However, from weed control point of view isoproturon PE recorded better weed control efficiency throughout the crop growth period, followed by oxadiargyl PE and pendimethalin PE. The herbicide treatments oxadiargyl PE recorded highest seed yield followed by isoproturon PE, oxyflurofen PE and clodinafop. Similar trend of weed index in increasing order was recorded.

Mustard crop growth in early stage is very slow. Therefore weeds which emerge before crop offer severe competition, results in low yield, if not controlled. So, it is very important to keep the crop weed free in early stage for a month. Thus control of weeds is very necessary for getting higher yield. Traditionally the weeds are controlled by manual weeding. There is scarcity of labour for weeding and also the wages for the labourer for weeding are increasing day by day. Thus the cost of cultivation is increasing. With the herbicidal control there is possibility of saving time and money with effective weed control. There are few herbicides that can be used as pre-emergence or post emergence. However, there is less information of these herbicides and their doses against weeds in mustard. Herbicidal control is one of the potent means of controlling the weeds. Fluchloralin, pendimethalin and isoproturon are the most common herbicides used in oilseeds. Considering these aspects the present study was planned with an objective to study the effect of herbicides on crop yield and effective weed control in mustard.

MATERIAL AND METHODS

A field experiment was conducted at the farm of College of Ariculture, Nagpur, during *Rabi* season of 2011-2012 in randomized block design with ten treatments and three replications. The soil of experimental field was clayey, medium in organic carbon (0.63%), low in available nitrogen (261.25 kg ha^{-1}) and phosphorus (22.43kg ha^{-1}) and high in available potassium (359 kg ha^{-1}) with pH 7.17 . The treatments were viz., T_1 - Pendimethalin @ 1.0 kg a.i. ha^{-1} PE , T_2 - Oxadiargyl @ 0.09 kg a.i. ha^{-1} PE, T_3 - Trifluralin @ 0.75 kg a.i. ha^{-1} PPI, T_4 - Oxyfluorfen @ 0.15 kg a.i. ha^{-1} PE, T_5 - Quizalofop @ 0.06 kg a.i. ha^{-1} POE (25-30 DAS), T_6 - Clodinafop @ 0.06 kg a.i. ha^{-1} POE (25-30 DAS), T_7 - Isoproturon @ 1.0 kg a.i. ha^{-1} PE, T_8 - Isoproturon @ 1.0 kg a.i. ha^{-1} POE (25-30 DAS), T_9 - Weedy Check (Un-weeded control) and T_{10} – Weed-free (2 weeding at 20 DAS and 40 DAS). The crop spacing was 30 cm x 10 cm with fertilizer dose of 50:40:00 NPK kg ha^{-1}. Pusa bold variety was sown on 28th Oct, 2011 and harvested on 22nd Feb., 2012. The herbicide treatment application did not show any adverse effect on crop except isoproturon PE treated plot which initially showned some chloratic patches on border of leaves of mustard plant. The weed count was recorded in one square meter area periodically and presented stage wise. Other observations were recorded as per standard procedure.

RESULTS AND DISCUSSION

The data regarding the weeds and yield are given in Table 1 and results are interpreted.

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Table 1: Effect of different herbicide on weed count , weed dry matter, weed index, weed control efficiency and yield of mustard

Treatments		Monocot weedcount (No./m^2)			Dicot weedcount (No./m^2)			Total weedcount (No./m^2)			Weed drymatter (g/m^2)			WI (%)	WCE (%)			Seed yield
		30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest		30 DAS	60 DAS	At harvest	(kgha^{-1})
T_1	Pendimethalin @	2.6	2.3	3.0	6.0	8.1	3.8	6.6	8.4	4.9	37	131	59	22.6	70	54	27	606
	1.0 kg a.i. ha^{-1} PE	(7)	(5)	(9)	(40)	(75)	(14)	(47)	(80)	(24)								
T_2	Oxadiargyl @	2.3	2.6	3.1	6.0	8.0	4.1	6.4	8.5	5.3	28	129	81	14.9	80	55	0	667
	0.09 kg a.i. ha^{-1} PE	(5)	(7)	(10)	(39)	(65)	(18)	(43)	(71)	(28)								
T_3	Trifluralin @	3.0	2.3	2.2	8.7	8.0	4.9	9.3	8.4	5.4	42	102	57	34.4	66	64	30	514
	0.75 kg a.i. ha^{-1} PPI	(9)	(5)	(4)	(78)	(70)	(24)	(87)	(75)	(28)								
T_4	Oxyflurofen @	5.1	1.6	2.5	7.9	6.5	3.2	10.3	6.7	4.2	59	56	47	21.2	52	80	42	617
	0.15 kg a.i. ha^{-1} PE	(34)	(2)	(7)	(73)	(43)	(10)	(10)	(45)	(17)								
T_5	Quizalofop @	3.3	1.9	1.0	11.8	9.1	5.3	12.3	9.3	5.4	81	145	65	37.8	34	49	20	487
	0.06 kg a.i. ha^{-1} POE	(11)	(3)	(1)	(141)	(84)	(30)	(153)	(87)	(30)								
T_6	Clodinafop @	5.3	2.1	2.8	10.8	8.0	4.0	12.5	8.4	4.9	94	105	44	21.5	23	63	46	615
	0.06 kg a.i. ha^{-1} POE	(37)	(6)	(9)	(138)	(67)	(17)	(175)	(73)	(26)								
T_7	Isoproturon @	4.5	2.8	3.2	4.3	4.5	2.6	6.3	5.3	4.1	25	40	25	20.5	77	86	69	623
	1.0 kg a.i. ha^{-1} (PE)	(20)	(8)	(10)	(20)	(20)	(6)	(40)	(28)	(16)								
T_8	Isoproturon @	4.2	1.7	2.7	10.4	8.2	3.2	11.2	8.4	4.2	86	135	39	39.3	30	53	52	476
	1.0 kg a.i. ha^{-1} POE	(18)	(3)	(7)	(109)	(70)	(11)	(127)	(73)	(18)								
T_9	Weedy check	5.4	2.7	3.2	13.5	11.8	5.0	14.6	12.1	5.9	122	285	81	54.2	0	0	0	359
	(No Weeding)	(29)	(7)	(10)	(186)	(140)	(25)	(216)	(147)	(35)								
T_{10}	Weed free	3.2	1.5	2.9	5.1	7.9	3.2	6.0	8.1	4.3	27	81	44	0.0	78	72	46	783
	(2 W at 20 & 40DAS)	(10)	(2)	(8)	(26)	(62)	(10)	(36)	(65)	(18)								
	S.E.(m)±	0.87	0.49	0.48	1.68	1.16	0.58	1.35	1.10	0.51	17	41	14	-	-	-	-	57
	C.D(=0.05)	NS	NS	NS	4.98	3.45	1.72	4.01	3.28	NS	50	122	NS	-	-	-	-	170

* Figures in parenthesis are original values and out of parenthesis sqare root transformed values. i.e. “(original values+0.5)

Effect on monocot weeds

The data revealed that there was no significant effect of all the weed control treatments on monocot weed population at 30, 60 DAS and at harvest. However at 30 DAS pre-emergence (PE) application of pendimethalin and oxadiargyl and pre-plants incorporation (PPI) of trifluralin recorded numerically less number of monocot weeds m^{-2} compared to weed free which might be due to initial application of these treatments. But pre-emergence application of isoproturon not showed reduction in monocot weed population. At 60 DAS and at harvest all these treatments did not show much numerical deviation. Prusty *et al.* (1996) also reported non control of monocot weed like *Cyperus rotundus* and *Cynadon dactylon* due to trifluralin or isoproturon.

Effect on dicot weeds

At 30 and 60 DAS pre-emergence application of isoproturon showed least and significantly less number of dicot weeds and it was at par with pre-emergence application of oxyflurofen and weed-free check. However, compared to weedfree check all the weed control treatments were at par in controlling the dicot weed population except isoproturon POE, clodinafop POE quizalofop POE at 30DAS. At harvest pre-emergence application of isoproturon showed least dicot weed population and weed-free check, post-emergence application of isoproturon, oxyflurofen, oxydiargyl and pre-emrgence application of pendimethalin showed statistically at par dicot weed population. Thus showing better weed control. This might be due to their ability to control the dicot weeds. Pre-emergence application of isoproturon showed continuous effect on dicot weed population throughout the crop growth period.

Effect on total weed population

At 30 DAS, weed-free check recorded significantly less total weed population. However, pre-emergence application of isoproturon, pendimethalin, oxadiargyl and pre-plant incorporation of trifluralin also showed at par total weed population. At 60 DAS pre-emergence application of isoproturon recorded significantly lesser total weed count and found at par with weed free check and pre-emergence application of oxyflurofen. At harvest none of the herbicide influenced weed population significantly.

Effect on weed dry matter

At 30 DAS the weed dry matter was less in pre-emergence application of isoproturon than the post emergence application treatments (viz., quizalofop, clodinafop and isoproturon). Where as all other herbicidal treatments recorded statistically similar weed dry matter. Thus lower weed dry matter in these treatments might be due to lower total weed count. Higher weed dry matter in post emergence application treatment might be due to non application of treatment early at this stage. However, at 60 DAS though pre-emergence application of isoproturon recorded least weed dry matter, all the herbicidal treatments along with weed free check also recorded statistically at par dry matter indicating the better weed control as evidenced by the lower total weed count in same treatment. At harvest weed dry matter was not influenced significantly. But numerically the pre-emergence application of isoproturon recorded least weed dry matter. Sharma and Chauhan (1995) also found reduced weed dry matter significantly due to two hand weeding.

Weed index

The data indicated that pre-emergence application of oxadiargyl showed least weed index (14.9 %) compared to weedy check followed by pre-emergence application of isoproturon (20 .5%), pre-emergence application of oxyflurofen (21.2%), post-emergence application of clodinafop (21.5%) and pre-emergence application of pendimethalin (22.6%). All the herbicidal treatments showed lower and better weed index than the un-weeded control. Thus these herbicides were found effective in controlling weed with different intensity.

Weed control efficiency (WCE)

The WCE data at 30 DAS showed higher WCE with pre-emergence application of isoproturon (80%) and this was followed by oxadiargyl pre-emergence application (77 %) as compared to weed free (78%). At 60 DAS pre-emergence application of isoproturon showed highest WCE (86%) followed by pre-emergence application of oxyflurofen (80%) and were more than the weed-free check. At harvest the WCE due to pre-emergence application of isoproturon was highest (69 %) followed by post-emergence application of isoproturon and these two treatments recorded higher WCE than weed free check (46%). This might be due to lower weed dry

matter compared to un-weeded check. The isoproturon pre-emergence application showed continuous weed suppression from 30 days to harvest (80, 86 and 69 per cent at 30, 60 DAS and at harvest respectively) while oxadiargyl PE showed weed control upto 60 DAS but PE application of oxyflurofen showed better weed control at 60 DAS only. Yadav *et al.* (1999) and Nepalia & Jain (2000) also reported control of weed dry matter by oxyflurofen, pendimethalin, isoproturon similar to that of hand weeding. These results are in line with present findings. Sharma and Jain (2002) also reported significant weed dry matter reduction due to isoproturon PE @ 1 kg a.i. ha^{-1}.

Seed yield (kg ha^{-1}) of mustard

The weed-free check recorded maximum and significantly higher seed yield (783 kg ha^{-1}) over other treatments except oxadiargyl PE (667 kg ha^{-1}), oxyflurofen PE (617 kg ha^{-1}), isoproturon PE (623 kg ha^{-1}) and clodinafop POE (615 kg ha^{-1}) which were at par and recorded seed yield in decreasing order. Compared to un-weeded check except trifluralin PPI and isoproturon POE, all other treatments recorded significantly higher seed yield. Among the herbicide treatments oxadiargyl PE recorded highest seed yield (667 kg ha^{-1}) followed by isoproturon PE (623 kg ha^{-1}), oxyflurofen PE (617 kg ha^{-1}) and clodinofop POE (615 kg ha^{-1}). The increased seed yield ha^{-1} in these treatment might be the cumulative effect of more number of siliquae $plant^{-1}$, more test weight and more seed yield (g) $plant^{-1}$. Yadav (2004) also found highest seed yield with weed-free treatment and trifluralin PPI. Similarly Chauhan *et al.* (2005) found higher seed yield with 2 hand weeding and oxyflurofen PE. Singh and Sinsinwar (2002) and Anonymous(2012) also found increase in seed yield with weed-free treatment and isoproturon PE. The findings of present investigation are in line with the results reported by previous workers (Annonymous, 2012).

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Effect of Long Term Manuring and Fertilization on Soil Chemical Properties and Yield of Sorghum on Vertisols under Sorghum-Wheat Sequence

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ABSTRACT

The present investigation was conducted to assess the vertical distribution of soil chemical properties as influenced by long term manuring and fertilization under sorghum–wheat sequence in Long Term Fertilizer Experiment on Vertisols during 2009-2010 (after 22nd cycle) at Akola (M.S.). The experiment comprised of twelve treatments laid out in randomized block design and replicated four times. The results revealed that, highest organic carbon was recorded in 0-15 cm layer and it decreased with increase in soil depth. The highest organic carbon at 0-15 cm (6.41 g kg^{-1}), 15-30 cm (6.12 g kg^{-1}) and 30-45 cm (5.92 g kg^{-1}) depths were recorded with the application of 100 per cent NPK + FYM @ 10 t ha^{-1} which was significantly superior over all other treatments. Calcium carbonate content found to increased with depth, which ranged from 8.33 to 10.79 per cent in 0-15 cm layer, 8.70 to 10.59 per cent in 15-30 cm layer and 8.72 to 10.88 per cent in 30-45 cm layer of soil. The pH of soil increase with depths, varied from 7.73 to 7.93, 7.8 to 8.06 and 7.87 to 8.26 in 0-15, 15-30 and 30-45 cm soil layer respectively. The application of 100 per cent NPK + FYM @ 10 t ha^{-1} recorded the pH to the tune of 7.73 (0-15 cm), 7.87 (15-30 cm) and 7.87 (30-45 cm). However, the highest pH was reported in control. Continuous application of 150 per cent NPK resulted significant increase in the electrical conductivity of soil at 0-15 cm (0.38 dS m^{-1}), 15-30 cm (0.41 dS m^{-1}) and 30-45 cm (0.45 dS m^{-1}). Highest grain (65.92 q ha^{-1}) and fodder yield (150.95 q ha^{-1}) of sorghum was recorded with the application of 100 per cent NPK + FYM @ 10 t ha^{-1}.

The balanced supply of plant nutrients is prerequisite to maximize the crop production. During the initial years of green revolution, with the introduction of high yielding varieties, crop response to applied nitrogen, followed by phosphorus was observed. In the present situation even the application of NPK at optimal levels or super optimal dose did not maintain the productivity at sustainable level. This has been attributed to nutrient imbalance caused by fertility depletion through decrease in recycling of crop residues and animal manures. Fertilizer use is a key factor for increasing agricultural production and its consumption increasing rapidly. Need was felt for studying the effect of fertilizer not only on the crop productivity and grain quality but also on the soil properties under intensive cropping system. This necessitates for long term studies at fixed site for monitoring the long term changes in nutrient dynamics to develop strategies for sustainable productivity by incorporating the nutrient management interventions.

It is well proven that long-term experiments generate extensive and valuable information which is used for studying sustainability of intensive agriculture. Perceptible changes in soil fertility as a result of imbalanced fertilizer use and unscientific management practices may take several years to appear. In addition to management practices, the climatic factors also alter the physical, chemical and biological properties and condition of soil. It also provides the best possible means of identifying emerging trends in nutrient imbalances and deficiencies and to formulate future strategies and policies for maintaining soil health. The availability of some nutrients to plant is also influenced by its vertical distribution within the soil. Therefore, knowledge of vertical distribution of nutrients is important as roots of many plants go beyond the surface layer to draw a part of their nutrient requirement from sub surface layers of soil. It is high time of the scientific community to introspect about the sustainability of the present cropping system under high input use. Increasing cropping intensity to feed the ever growing population had led to persistent nutrient mining from the soil causing serious hazard to soil health. Nutrient removal generally exceeds its addition to soil in respect of some nutrients and causes their depletion. In view of the above, the present investigation on "Vertical distribution of chemical properties as influenced by long term manuring and fertilization under sorghum-wheat sequence in Vertisols" was undertaken.

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MATERIAL AND METHODS

The twenty second cycle (2009-10) of the long term fertilizer experiment on sorghum-wheat sequence was studied for vertical distribution of soil chemical properties as influenced by long term manuring and fertilization. The experiment was laid out in Randomized Block Design with 12 treatments replicated four times. The treatments consists of T1 – Control, T2 – 50 per cent NPK, T3 – 75 per cent NPK, T4 – 100 per cent NPK, T5 – 150 per cent NPK, T6 – 100 per cent N, T7 – 100 per cent NP, T8 – 100 per cent NPK + Zn @ 2.5 kg ha^{-1}, T9 – 100 per cent NPK (S free), T10 – 100 per cent NPK + S @ 37.5 kg ha^{-1} , T11 – 100 per cent NPK + FYM @ 10 t ha^{-1}, T12 – FYM @ 10 t ha^{-1}.The RDF for sorghum were used as 100:50:40 kg N,P_2O_5 and K_2O ha^{-1}. N, P and K was applied respectively through urea, SSP and MOP except in treatments T9 and T10 where, P was applied through DAP. Sulphur and zinc were applied through gypsum and zinc sulphate, respectively.

The soil of experimental field was classified as Vertisols, montmorillonitic type, hyperthermic a family of Typic Haplustert. It has smectite clay minerals with swell- shrink properties. The soil at the start of experiment was slightly alkaline in reaction (pH 8.1), low in available nitrogen (120 kg N ha^{-1}), medium in available phosphorus (8.4 kg P ha^{-1}), very high in available potash (358 kg K ha^{-1}) with 11.8 mg kg^{-1} available sulphur and 0.62 mg kg^{-1} DTPA extractable zinc. The crop was sown in *Kharif* 2009-10 and all the recommended package of practices were performed as necessity. Grain and fodder yield of sorghum were recorded. The treatmentwise soil samples were collected before sowing and after harvest of sorghum from 0-15, 15-30 and 30-45 cm depths. The samples were air dried in shade, ground and screened through 2 mm sieve and used for chemical analysis. These sieved samples were further passed through 0.5 mm sieve for estimation of organic carbon. The pH was determined by glass electrode pH meter using 1:2.5 soil-water ratio and supernatant suspension was also used for measuring electrical conductivity (Jackson, 1973). The organic carbon was determined by Walkley and Black's wet oxidation method (Nelson and Sommers, 1982). Calcium carbonate was estimated by rapid titration method (Jackson, 1973).

RESULTS AND DISCUSSION

Soil reaction

The data pertaining to pH before sowing of sorghum ranged from 7.76 to 7.88 (0-15 cm) , 7.88 to 7.97 (15-30 cm) and 7.87 to 8.26 (30-45 cm) indicated that there was significant effect of various treatments on soil pH (Table 1). The pH of soil was increased with increase in soil depths up to 30 cm. In surface soil (0-15

Table 1. Effect of long term manuring and fertilization on soil chemical properties before sowing of sorghum

Treatments		pH		EC (S m^{-1})		Organic carbon (g kg^{-1})		$CaCO_3$ (%)	
		Depths, cm							
		0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
T_1	Control	7.82	7.91	0.24	0.27	3.83	3.3	9.08	9.33
T_2	50% NPK	7.87	7.94	0.27	0.28	4.44	4.30	9.46	9.91
T_3	75% NPK	7.82	7.88	0.32	0.32	5.00	4.71	9.47	9.85
T_4	100% NPK	7.86	7.95	0.28	0.30	5.09	4.75	9.53	10.29
T_5	150% NPK	7.86	7.97	0.30	0.31	5.57	5.05	9.75	10.23
T_6	100% N	7.88	8.00	0.30	0.31	4.04	3.68	9.84	10.06
T_7	100% NP	7.82	7.93	0.29	0.31	4.97	4.56	10.22	10.4
T_8	100% NPK + Zn @ 2.5 kg ha^{-1}	7.81	7.88	0.32	0.33	4.35	4.15	10.01	10.22
T_9	100% NPK (S free)	7.86	7.97	0.30	0.31	5.00	4.63	9.75	10.44
T_{10}	100% NPK + S @ 37.5 kg ha^{-1}	7.8	7.89	0.29	0.30	4.30	3.85	9.74	10.03
T_{11}	100% NPK + FYM @ 10 t ha^{-1}	7.76	7.88	0.31	0.31	6.14	5.64	10.04	10.2
	FYM @ 10 t ha^{-1}	7.78	7.90	0.31	0.32	5.10	4.65	8.29	8.48
	SE (m±)	0.02	0.03	0.007	0.009	0.10	0.12	0.05	0.06
	CD at 5%	0.07	0.09	0.02	0.028	0.30	0.36	0.16	0.18

Table 2. Effect of long term fertilization on soil properties after harvest of sorghum in different depth

Treatments		pH			EC(dS m^{-1})			Organic carbon(g kg^{-1})			$CaCO_3$(%)			Yield q ha^{-1}	
		Depths, cm												Grain	Fodder
		0-15	15—30	30-45	0-15	15—30	30-45	0-15	15—30	30-45	0-15	15—30	30-45	2.51	5.32
T_1	Control	7.93	8.06	8.26	0.29	0.31	0.38	2.97	2.98	2.95	9.12	9.45	10.10	32.74	74.80
T_2	50% NPK	7.86	7.94	8.00	0.31	0.34	0.39	4.30	4.26	4.18	9.44	9.85	10.37	36.81	92.40
T_3	75% NPK	7.77	7.8	8.16	0.32	0.34	0.39	4.78	4.71	4.67	9.46	9.96	10.50	48.17	109.8
T_4	100% NPK	7.81	7.96	8.12	0.34	0.36	0.43	5.34	5.26	5.14	9.57	10.11	10.54	59.12	139.5
T_5	150% NPK	7.82	7.94	8.10	0.38	0.41	0.45	5.96	5.86	5.79	9.75	10.18	10.66	27.01	59.82
T_6	100% N	7.80	7.95	8.05	0.31	0.34	0.37	4.45	4.56	4.47	9.91	10.54	10.88	34.95	85.62
T_7	100% NP	7.76	7.92	8.04	0.30	0.30	0.32	5.03	4.95	4.90	10.30	10.46	10.80	49.68	112
T_8	100% NPK + Zn @ 2.5 kg ha^{-1}	7.83	8.01	8.11	0.33	0.35	0.45	4.38	4.11	4.19	10.09	10.59	10.83	45.06	104
T_9	100% NPK (S free)	7.73	7.84	8.00	0.32	0.34	0.39	5.29	5.18	5.13	9.78	9.90	10.33	49.25	110
T_{10}	100% NPK + S @ 37.5 kg ha^{-1}	7.81	7.90	8.03	0.36	0.38	0.45	4.35	4.19	4.02	10.79	10.12	10.51	65.92	151
T_{11}	100% NPK + FYM @ 10 t ha^{-1}	7.73	7.87	7.87	0.35	0.4	0.44	6.41	6.12	5.92	10.07	10.31	10.58	20.35	44.56
	FYM @ 10 t ha^{-1}	7.77	7.97	8.11	0.37	0.39	0.41	5.94	5.00	4.81	8.33	8.70	8.72	1.20	1.27
	SE (m±)	0.04	0.038	0.03	0.020	0.02	0.02	0.09	0.06	0.18	0.39	0.34	0.56	3.45	3.66
	CD at 5%	0.12	0.11	0.11	0.058	0.06	0.06	0.27	0.19	0.53	1.13	1.00	1.63		

cm) pH varied from 7.81 to 7.88 while 7.90 to 8.00 in the sub surface (15-30 cm). This may be attributed to the restricted vertical translocation of soluble fertilizer ingredient and humic substances. Data further indicated that Vertisols have high buffering capacity against any changes of soil pH caused by chemical inputs and organic material. The findings are in line with the results reported by Tyagi and Bhardwaj (1994) and Sinha and Sinha (1997). The application of 100 per cent NPK + FYM @ 10 t ha^{-1} and FYM @ 10 t ha^{-1} alone resulted decrease in pH. This decrease in the pH could be attributed to the fact that, release of certain organic acids during decomposition, which create acidic environment in the soil.

The pH of soil after harvest of sorghum followed trend as indicated before sowing of sorghum. The pH increased with increase in the depths of soil upto 45 cm and there was slight variation among the treatments. This could be attributed to the restricted vertical movement of fertilizers and humic substances. The pH varied from 7.73 to 7.93, 7.8 to 8.06 and 7.87 to 8.26 in 0-15, 15-30 and 30-45 cm soil depths, respectively. It was also observed that the pH were higher in control treatment with no fertilizer application. This might be due to no addition of fertilizers and manures which led to very less growth of root biomass.

Electrical conductivity

The data in respect of electrical conductivity before sowing of sorghum indicated that, EC was influenced significantly with the continuous application of manure and fertilizer over long period. The increase in the electrical conductivity was reported with the increase in the depths of soil. It varied from 0.24 to 0.32 dS m^{-1} and 0.27 to 0.33 dS m^{-1} in surface (0.15 cm) and subsurface (15-30 cm) soil, respectively. The continuous use of FYM reported higher values of EC than control which can be ascribed to solubilizing effect of organic acids on various compounds in soil (Bhrigavanshi, 1988). Sharma *et al*. (1980) reported that the salt content of soil remained unaffected due to application of organic acid.

The results throw light on the fact that by addition of fertilizer, 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 which might be ascribed 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). The electrical conductivity of soil was increased as compared to initial status (before sowing) due to various fertilizer and manure treatments. The increase in electrical conductivity with increase in depths of soil has also been observed after harvest of sorghum. Significantly higher electrical conductivity was observed in the treatment where 150 per cent NPK, 100 per cent NPK + FYM and FYM alone was applied. Thus, the magnitude of electrical conductivity due to various manure and fertilizer treatments were observed in the order of 150 per cent NPK > 100 per cent NPK + S > FYM alone > 100 per cent NPK + FYM > 100 per cent NPK > 100 per cent NPK + Zn in surface (0-15 cm) soil.

Calcium carbonate

The $CaCO_3$ varied from 8.29 to 10.22 and 8.48 to 10.44 per cent in 0-15 and 15-30 cm soil layer respectively. The $CaCO_3$, however, increased with increase in depth of soil up to 30 cm. It was observed that, continuous application of FYM reported comparative decrease in per cent $CaCO_3$. During decomposition of organic manure various organic acids released which reduces the concentration of $CaCO_3$. Similar findings were reported by Bellaki and Badanur (1997) showed slight decrease in the $CaCO_3$ content due to application of organics.

The $CaCO_3$ ranged from 8.33 to 10.79 per cent in 0-15 cm depths of soil, 8.70 to 10.59 per cent in 15-30 cm depths and 8.72 to 10.88 in 30-45 cm depths of soil. Organic manure incorporated treatment recorded less amount of $CaCO_3$ content than other treatments. The organic acids released during decomposition of FYM reacted with $CaCO_3$ to release CO_2 there by reducing the concentration of $CaCO_3$ in soil. High content of free lime greatly influences the availability of nutrients and their supply to crops.

Organic carbon

Organic carbon was recorded higher in 0-15 cm which decreased with increase in soil depth. The higher organic carbon in surface layer may be attributed to the addition of plant biomass in the form of roots and crop residues as well as application of FYM over the years. The highest organic carbon (6.41 g kg^{-1}) was recorded in 100 per cent NPK + FYM @ 10 t ha^{-1} which was significantly superior over all other treatments at the harvest of sorghum. Bhandari *et al*. (1992) and Ravankar *et al*. (1998) observed build up of organic carbon content due to application of NPK + FYM. The relative increase

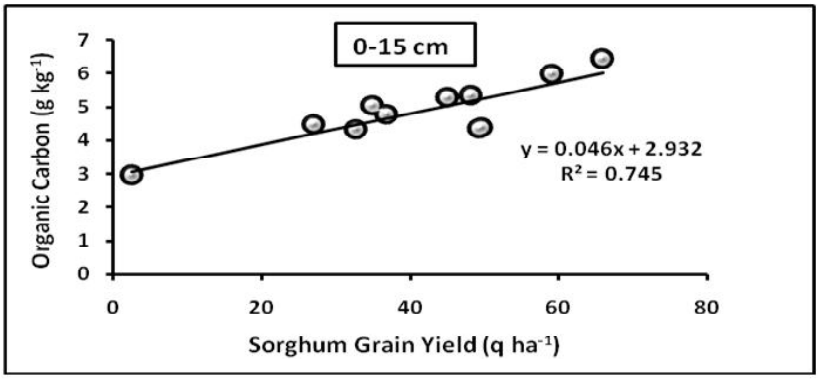

Fig. 1. Relationship between soil organic carbon (0-15 cm) and sorghum grain yield

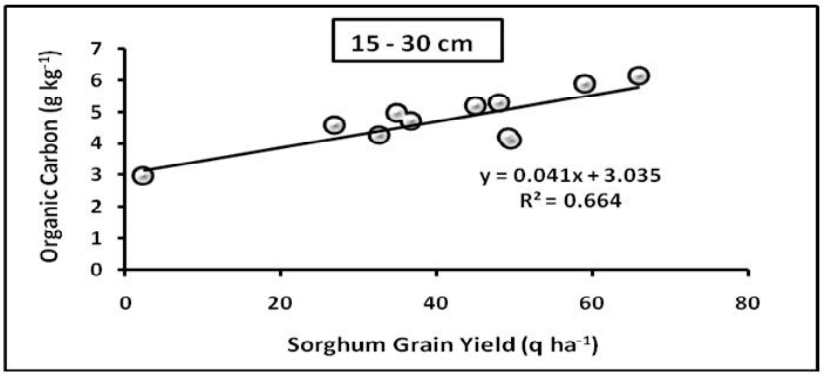

Fig. 2 Relationship between soil organic carbon (15-30 cm) and sorghum grain yield

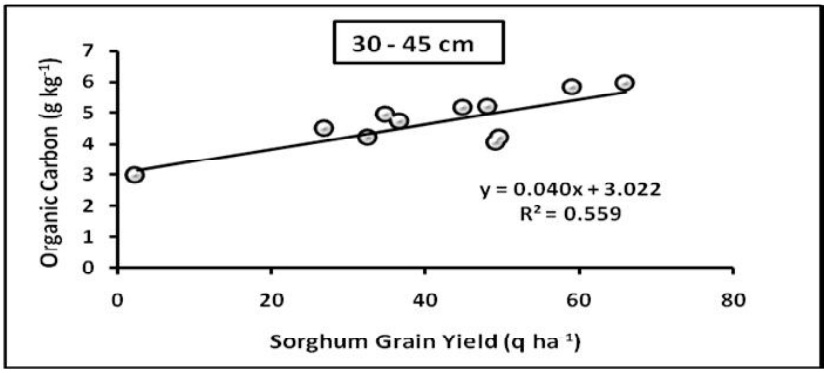

Fig. 3 Relationship between soil organic carbon (15-30 cm) and sorghum grain yield

in organic carbon due to FYM can be attributed to direct supply of organic matter through FYM along with recommended dose of NPK (Bharadwaj and Omanwar, 1994 and Santhy *et al.* 2001). The organic carbon content was increased significantly with the application of 150 per cent NPK. Hence, it is worth mentioning that, continuous application of only chemical fertilizer in balanced form could not depress soil organic carbon. The use of recommended doses or super optimal doses in balanced form help to increase the root biomass which might led to increase in organic carbon.

Grain and fodder yield of sorghum

The highest grain yield of sorghum (65.92 q ha^{-1}) was recorded with the integrated application of 100 per cent NPK + FYM @ 10 t ha^{-1} followed by 150 per cent NPK which were significantly superior over 100 per cent NPK, whereas lowest yield was recorded in control treatment. Application of sulphur had beneficial effect on grain yield of sorghum over no sulphur application. The treatment of FYM @ 10 t ha^{-1} only recorded significantly higher grain and fodder yield over control but was significantly lower than 100 per cent NPK.

The grain yield of sorghum was significantly higher in the treatment of 100 per cent NPK + S as compared to 100 per cent NPK (S free). The application of sulphur through SSP recorded 6.90 per cent increase in grain yield of sorghum as compared to no sulphur. The significant increase in yield of sorghum due to application of sulphur could be attributed to the marginal level of sulphur in soil which have been replenished through sulphur addition favouring balanced nutrient supply to the crop.

More or less similar trend in respect of fodder yield of sorghum was observed to that of grain yield. All the treatments showed significant response of the fodder yield over the control treatment. Highest yield (150.95 q ha^{-1}) was observed in the 100 per cent NPK + FYM @ 10 t ha^{-1} followed by 150 per cent NPK (139.52 q ha^{-1}) and 100 per cent NPK (109.82 q ha^{-1}). Inclusion of S or Zn along with 100 per cent NPK showed favorable response in respect to fodder yield of sorghum. A significant increase of the fodder yield (109.82 q ha^{-1}) was noted due to application of 100 per cent NPK + S (with source of P as SSP) over that of 100 per cent NPK (S free).

Relationship between soil organic carbon and sorghum grain yield

There was a positive and significant relationship between soil organic carbon and grain yield of sorghum (Fig. 1, 2 and 3). The significant relationship among soil organic carbon and grain yield of sorghum, existed in surface layer (R^2 = 0.745*) followed by 15-30 cm (R^2 = 0.664*) and non significant correlation was observed in 30-45 cm (R^2 = 0.559). This indicates that least contribution of subsurface (30-45 cm) organic carbon towards sorghum grain yield. The contribution of subsurface organic carbon with yield decreased with depth of soil.

CONCLUSION

Application of 100 per cent NPK+FYM @ 10 t ha^{-1} increased the grain and fodder yield of sorghum and resulted an improvement in the status of organic carbon in soil. The organic carbon was comparatively higher in the surface as compared to the sub-surface soil.

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Effect of Integrated Nutrient Management on Productivity, Residual Soil Fertility and Nutrient use Efficiency in Soybean Under Subtropics of Vidarbha

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ABSTRACT

An experiment was conducted at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. during 2007-08 and 2008-09 to work out effect of sole and integrated use of nutrients on productivity of soybean and efficiency of nutrients. The twelve different treatments consisting farmyard manure, sunflower stalk and micronutrients along with recommended doses of fertilizer were imposed in three replications in randomized block design. The highest pooled grain (28.23q ha^{-1}) and straw yield (40.92 q ha^{-1}) of soybean was obtained in the treatment T7 (100NPK+5t FYM). The availability of major nutrients was significantly enhanced due to different treatments. FYM and sunflower stalk helped to build up residual soil fertility after soybean. The availability of nitrogen was increased by 5.71 per cent and 6.88 per cent over recommended dose of fertilizer after harvest of soybean. The incorporation of farmyard manure enormously helped to maintain the sulphur content in soil. The available micronutrients (Fe, Mn, Zn, Cu) significantly increased due to different treatments in both the years of experimentation. The highest content of Fe, Mn, Zn, Cu was observed in the treatment receiving100 per cent NPK + FYM. The highest NUE and Partial factor productivity was noticed in the treatment receiving100 per cent NPK + FYM followed by 100 per cent NPK where S + B + Zn was added during rabi season to sunflower.

Integrated nutrient management strategies have been proved to be useful to sustain soil health universally. Use of these strategies in commercially grown cropping system has greater importance to enhance soil health. Soybean based cropping system is widely adopted in Vidarbha.

Soybean being a legume, helps in improving soil fertility by fixing atmospheric nitrogen symbiotically in root nodules. Soybean fixes 125 – 150 kg N ha^{-1} and about 30-40 kg N ha^{-1} become residually available to succeeding crop (Chandel *et al.*, 1989). Secondly oilseed crops are energy rich crops, hence the requirement of major nutrients including secondary and micronutrients is high. A critical appraisal of oilseed production and nutrient removal revealed that a large quantity of N, P_2O_5, K_2O (682, 224, 525 thousand tonnes respectively) is removed to produce targeted oilseed production of 11467 thousand tonnes (Katyal *et al.*, 1997). Therefore, proper fertilizer management of oilseed crops with a knowledge of right kind of fertilizer nutrient, appropriate quantity, interaction with other nutrients, time and method of application are the key factors in harnessing their yield potential and enhancing the use efficiency of the applied fertilizers. Hence, the study was undertaken to know the effect of nutrient management on productivity, residual soil fertility and nutrient use efficiency of soybean under soybean- sunflower cropping system.

MATERIAL AND METHODS

An experiment was conducted at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during 2007-08 and 2008-09 with Soybean under Soybean- sunflower cropping system. The experimental site was clay in texture, medium in organic carbon, low in available nitrogen and phosphorus and high in available potassium. The soil was categorized as Typic Haplustept (Inceptisol). The experiment was laid out in Randomised Block Design with three replications. The experiments consist of twelve treatments, T_1 (100% P), T_2 (100% NP), T_3 (50% NPK), T_4 (100% NPK), T_5 (150% NPK), T_6 (100% NPK+4t sunflower stalk),T_7 (100% NPK+5t FYM), T_8 (100% NPK), T_9(100% NPK), T_{10}(100% NPK), T_{11}(100% NPK) and T_{12}(Control). While, the set of treatments for sunflower were T_1 (100% N), T_2 (100% NP), T_3 (50% NPK), T_4 (100% NPK), T_5 (150% NPK), T_6 (100% NPK),T_7 (100% NPK), T_8 (100% NPK+S), T_9 (100% NPK+S+B), T_{10}(100% NPK+S+B+Zn), T_{11}(100% NPK+S+Zn) and T_{12} (Control). Soybean followed by sunflower was sown in *Kharif* and *Rabi* season respectively. The fertilizer dose for soybean was 30:75:30 $kgha^{-1}$ NPK while for sunflower it was 80:60:40 $kgha^{-1}$

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NPK. The N, P and K were applied in the form of urea, single super phosphate, diammonium phosphate and muriate of potash respectively. Elemental sulphur, zinc sulphate and borax (For boron) were applied only before sowing of sunflower crop for alternate year. Organic manures were applied before sowing of *Kharif* soybean by broadcasting method. After harvesting of sunflower, the stalk was incorporated @ 4 t ha^{-1} in treatment T_6 and thoroughly mixed in the soil.

The treatmentwise soil samples were collected before sowing of soybean and after harvest of soybean in *Kharif* and sunflower in *Rabi* season using soil auger. While, the initial fertility status was documented in year 2007, when the experiment was started. The initial status of soil is placed in table 1. The residual nutrient status was evaluated by adopting standard methods. The organic carbon from sunflower stalk and FYM was determined by dry combustion method (Chopra and Kanwar, 1991). While available nitrogen, phosphorous and potassium was analyzed by using microprocessor based automatic distillation system (Subbiah and Asija, 1956), UV based double beam spectrophotometer (Olsen and Sommer, 1982), neutral normal ammonium acetate method using flame photometer (Knudsen and Peterson, 1982) respectively. The available sulphur was determined by using Turbidimetric method (Chesnin and Yien, 1950) and boron was estimated by hot water soluble method by using azomethine – H (John *et al.*,1975)

RESULTS AND DISCUSSION

Yield of Soybean

The grain and straw yield of soybean was influenced significantly by different nutrient management treatments (Table 1a). The highest grain yield of soybean (28.23 q ha^{-1}) was recorded with application of FYM + 100 per cent NPK, which was at par with T5 (150 % NPK). The grain yield of soybean was relatively low in treatment where only phosphorus (20.46 q ha^{-1}) and 50 per cent recommended dose (23.06 q ha^{-1}) was applied. The grain yield recorded in 100 per cent NPK was 23.80 per cent and 8.20 per cent higher over only P and 50 per cent NPK was given. Similar observations were recorded by Singh (1991), Chaudhary and Das (1996), Patil *et al.* (1997) and Babhulkar *et al.* (2000).

More or less similar trend was observed in respect of straw yield of soybean, however the maximum straw yield (40.92q ha^{-1}) was recorded in the treatment 100 per cent NPK + FYM which was closely followed by treatments 150 per cent NPK and 100 per cent NPK (Table 1 b). These results corroborate with the findings of Sharma (1997) and Patil *et al.* (2002). In spite of stressed condition observed during 2008, because of less rainfall, the integration of organic and inorganic helped to sustain the productivity of soybean. This could be attributed to incorporation of organic manure which enhanced the soil fertility as well as better soil condition for root penetration

Residual fertility

The data pertaining to the availability of major and micronutrients revealed that, the maximum availability of nitrogen, phosphorus and potassium was found in the treatment receiving 100 per cent NPK + FYM which was at par with 150 per cent NPK, followed by 100 per cent NPK + sunflower stalk. The increase in available nitrogen in treatment 100 per cent NPK + FYM was 39.37 per cent and 6.52 per cent over control and recommended dose of fertilizer, respectively. Similarly, the availability of phosphorous and potassium potentially increased with the use of 100 per cent NPK + FYM. The available phosphorous was increased by 1.76 per cent in treatment FYM+ NPK after 2008. Similar trend was noticed in respect of potassium. In case of available sulphur, it was found highest (12.67 mg kg^{-1}) in treatment receiving 100 per cent NPK +S+Zn, which was followed by 100 per cent NPK+S+B (12.46 mg kg^{-1}). The increase in available sulphur where sunflower stalk (SF) and FYM was incorporated, might be due to solubilizition of the nutrients from native sources during the process of decomposition. Similarly the integration of fertilizers of secondary nutrients and sunflower stalk also played important role in enhancing the status of secondary nutrients. Similar results were also noted by Babhulkar *et al.* (2000) and the results are in conformity with Chaudhary and Das (1996).

The micronutrients (Fe, Mn, Zn, Cu) availability were found highest in the treatment 100 per cent NPK + FYM, except zinc which was superior in treatment receiving 100 per cent NPK + S +Zn. In respect of boron, considering its initial values varied from 0.33 to 0.41 mg kg^{-1}, it was marginally increased (0.42 mg kg^{-1}) after harvest of soybean in 2008 or maintained in treatments where it was supplied either through inorganics or through organic manure. This could be probably due to presence of lime in soil which may reduce the availability of hot water soluble B due to formation of Ca-borate and B-

Table 1 a. Effect of nutrient management on pooled yield (q ha^{-1}) of soybean

Treatments		Grain yield			Straw yield		
		2007	2008	Pooled	2007	2008	Pooled
T_1 -	100% P	21.03	19.89	20.46	28.91	23.23	26.07
T_2 -	100% NP	24.14	22.67	23.41	32.72	28.78	30.75
T_3 -	50% NPK	23.29	22.84	23.06	30.65	27.25	28.95
T_4 -	100% NPK	26.70	23.95	25.33	36.60	34.52	35.56
T_5 -	150% NPK	29.36	25.17	27.27	40.02	39.19	39.60
T_6 -	100% NPK+ SF	25.90	23.92	24.91	39.50	37.41	38.45
T_7 -	100% NPK+ FYM	29.47	26.98	28.23	40.69	41.16	40.92
T_8 -	100% NPK	26.58	24.54	25.56	37.42	39.39	38.40
T_9 -	100% NPK	25.17	22.90	24.04	36.80	40.26	38.53
T_{10} -	100% NPK	26.07	25.39	25.73	37.73	40.81	39.27
T_{11} -	100% NPK	25.85	24.26	25.05	35.69	40.62	38.15
T_{12} -	Control	13.20	11.96	12.58	22.09	16.84	19.46
	SE(m) ±	0.73	0.95	0.61	0.94	0.92	0.70
	CD at 5%	2.14	2.78	1.80	2.77	2.69	2.05

Table 1b. Effect of nutrient management on pooled yield (q ha^{-1}) of sunflower

Treatments		Seed yield			Stalk yield		
		2007	2008	Pooled	2007	2008	Pooled
T_1 -	100% P	7.54	4.84	6.19	24.72	14.53	19.63
T_2 -	100% NP	8.62	6.08	7.35	27.12	19.07	23.09
T_3 -	50% NPK	8.22	5.09	6.65	25.77	16.85	21.31
T_4 -	100% NPK	9.92	7.25	8.58	31.22	21.22	26.22
T_5 -	150% NPK	12.09	9.06	10.58	34.25	23.93	29.09
T_6 -	100% NPK	10.77	8.07	9.42	32.00	22.97	27.48
T_7 -	100% NPK	12.93	8.74	10.84	35.85	24.02	29.94
T_8 -	100% NPK + S	12.30	8.33	10.32	33.03	22.97	28.00
T_9 -	100% NPK + S+B	12.64	8.39	10.52	33.63	22.86	28.25
T_{10} -	100% NPK+ S+B+Zn	13.44	9.64	11.54	35.07	22.75	28.91
T_{11} -	100% NPK+S+Zn	12.98	8.58	10.78	34.43	23.06	28.75
T_{12} -	Control	5.50	3.57	4.54	16.32	11.37	13.85
	SE(m) ±	0.58	0.36	0.32	1.00	0.53	0.63
	CD at 5%	1.72	1.08	0.93	2.93	1.56	1.84

silicate. The available boron has negative correlation with calcium carbonate content (Grewal *et al* 1999).

Nutrient use efficiency

The nutrient use efficiency (NUE) and Partial Factor productivity (PFP) were assessed. The highest NUF (52.15 kg grain kg^{-1} N applied) and PFP(94.09) were observed under the treatment 100 per cent NPK + 5 t ha^{-1} FYM which was closely followed by the treatment 100 per cent NPK where residual effect of S + B + Zn was noticed (Fig 1). The NUE and PFP were enhanced by 22.76 per cent and 11.45 per cent in 100 per centNPK

Table 2. Effect of nutrient management on residual fertility of major nutrients (Kgha^{-1})

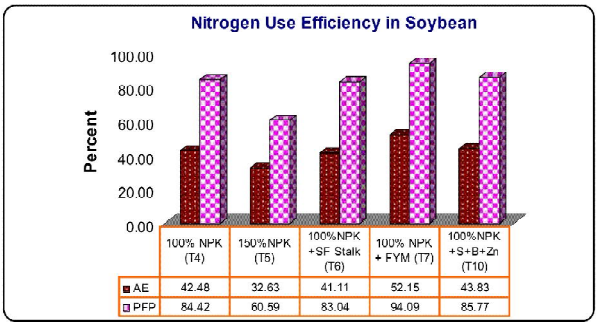
Treats.	After Soybean		Nitrogen		Phosphorous		Potassium1	
	Soybean	Sunflower	2007	2008	2007	2008	2007	2008
T_1	100% P	100% N	178.69	181.03	14.34	13.1	287.47	283.73
T_2	100% NP	100% NP	185.15	187.15	17.29	16.97	291.20	287.47
T_3	50% NPK	50% NPK	179.50	180.25	14.90	14.98	276.27	282.40
T_4	100% NPK	100% NPK	190.54	192.36	17.14	17.4	308.87	309.67
T_5	150% NPK	150% NPK	204.12	203.45	19.22	19.72	343.47	342.53
T_6	100% NPK +SF Stalk	100% NPK	197.52	198.85	18.70	18.28	324.80	328.53
T_7	100% NPK + FYM	100% NPK	203.69	204.91	20.80	19.95	339.73	346.67
T_8	100% NPK	100% NPK +S	190.62	191.82	18.08	17.76	313.60	321.07
T_9	100% NPK	100% NPK S+B	189.83	190.07	18.16	17.67	317.33	324.80
T_{10}	100% NPK	100% NPK +S+B+Zn	193.34	192.14	18.50	17.95	317.33	328.53
T_{11}	100% NPK	100% NPK +S+Zn	190.94	191.85	18.57	18.13	313.60	324.80
T_{12}	Control	Control	150.23	147.02	10.85	9.3	261.33	261.23
	SE m (±)	1.66	1.95	0.418	0.29	4.877	5.501	
	CD at 5%	4.86	5.72	1.23	0.85	14.30	16.13	

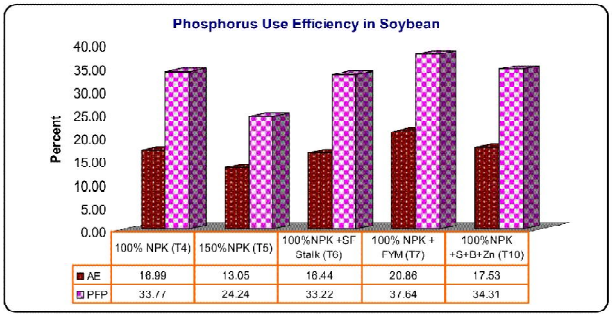
Table 3. Effect of nutrient management on residual fertility sulphur and boron (mgkg^{-1})

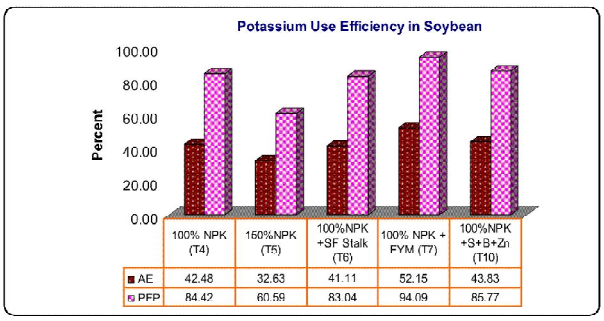
Treatments			After Soybean			
			Sulphur		Boron	
Soybean		Sunflower	2007	2008	2007	2008
T_1	100% P	100% N	9.27	9.11	0.36	0.37
T_2	100% NP	100% NP	11.11	10.91	0.35	0.36
T_3	50% NPK	50% NPK	10.49	10.26	0.34	0.35
T_4	100% NPK	100% NPK	11.11	10.72	0.35	0.37
T_5	150% NPK	150% NPK	12.18	11.92	0.38	0.39
T_6	100% NPK +SF Stalk	100% NPK	11.60	11.22	0.38	0.39
T_7	100% NPK + FYM	100% NPK	12.52	12.28	0.41	0.40
T_8	100% NPK	100% NPK +S	12.42	12.27	0.39	0.40
T_9	100% NPK	100% NPK S+B	12.62	12.46	0.40	0.40
T_{10}	100% NPK	100% NPK +S+B+Zn	12.58	12.36	0.40	0.42
T_{11}	100% NPK	100% NPK +S+Zn	12.82	12.67	0.38	0.39
T_{12}	Control	Control	9.08	8.64	0.33	0.32
	SEm (±)	0.200	0.097	0.009	0.009	
	CD at 5%	0.59	0.29	0.03	0.03	

Table 4. Effect of nutrient management on residual fertility of micronutrients (mgkg^{-1})

Treatments			After Soybean							
			Fe		Mn		Zn		Cu	
Soybean		Sunflower	2007	2008	2007	2008	2007	2008	2007	2008
T_1	100% P	100% N	4.62	4.62	3.08	3.08	0.61	0.61	0.45	0.45
T_2	100% NP	100% NP	4.63	4.64	3.08	3.09	0.61	0.61	0.46	0.45
T_3	50% NPK	50% NPK	4.64	4.62	3.08	3.09	0.61	0.62	0.44	0.44
T_4	100% NPK	100% NPK	4.64	4.65	3.07	3.08	0.62	0.62	0.47	0.46
T_5	150% NPK	150% NPK	4.64	4.65	3.08	3.11	0.63	0.63	0.48	0.49
T_6	100% NPK +SF Stalk	100% NPK	4.66	4.67	3.07	3.08	0.65	0.66	0.49	0.51
T_7	100% NPK + FYM	100% NPK	4.68	4.69	3.12	3.13	0.67	0.66	0.52	0.53
T_8	100% NPK	100% NPK +S	4.64	4.64	3.06	3.08	0.63	0.63	0.46	0.47
T_9	100% NPK	100% NPK S+B	4.64	4.65	3.06	3.08	0.63	0.65	0.46	0.45
T_{10}	100% NPK	100% NPK +S+B+Zn	4.65	4.66	3.07	3.09	0.67	0.66	0.47	0.48
T_{11}	100% NPK	100% NPK +S+Zn	4.65	4.65	3.08	3.09	0.68	0.67	0.46	0.47
T_{12}	Control	Control	4.59	4.59	2.97	2.96	0.58	0.58	0.41	0.41
		SEm (±)	0.006	0.004	0.021	0.01	0.010	0.007	0.008	0.013
		CD at 5%	0.02	0.01	0.06	0.04	0.03	0.02	0.02	0.04







+ FYM, respectively over 100 per cent NPK treatments. Similar results were also observed in respect of phosphorous and potassium where the MUE and PFP were increased by 16.99 per cent and 33.77 per cent under 100 per cent NPK treatments, respectively.

CONCLUSION

It is concluded that the integrated nutrient management envisaging conjunctive use of chemical fertilizers along with FYM was found useful way of nutrient management to maintain soil health and productivity of soybean under soybean sunflower cropping system.

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Effect of Long Term Manuring and Fertilization to Sorghum-Wheat Sequence on Physical Properties of Soil

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ABSTRACT

A long term fertilizer experiment is continued since 1988-89 at Akola to study the changes in soil quality, crop productivity and sustainability. The present study was undertaken to assess the impact of long term fertilization on soil physical properties under sorghum-wheat sequence grown on Vertisols. The experiment comprised twelve treatments viz; 50 ,100,150 per cent NPK, 100 per cent NPK (- S), 100 per cent NPK, 100 per cent NP, 100 per cent N alone, 100 per cent NPK + FYM @ 5 t ha^{-1}, 100 per cent NPK + S @ 37.5 kg ha^{-1} ,FYM @ 10 t ha^{-1} 75 per cent NPK + 25 per cent N through FYM and control replicated four times in RBD. The results of the present study indicate that, continuous application of 100 per cent RDF + FYM @ 5 t ha^{-1} significantly reduced bulk density (1.23 Mg m^{-3}) and improved porosity (54%), hydraulic conductivity (0.78 cm hr^{-1}) and mean weight diameter (0.82 mm) followed by FYM @ 10 t ha^{-1} and 150 per cent NPK over the long-run. The water retention at 33 kPa (39.60%) and 1500 kPa (19.73%) increased significantly with the application of 100 per cent NPK + FYM @ 5 tonnes ha^{-1} with improvement in the available water content (19.86%). The grain yield of sorghum was significantly correlated with the hydraulic conductivity (r^2 = 0.426**) and mean weight diameter (r^2 = 0.595**) whereas, the hydraulic conductivity and available water are correlated significantly with r square value of 0.977**.

Over-exploitation and unscientific management of limited soil resource without considering long-term sustainability have resulted in different kinds of soil degradation, which is a worldwide phenomenon, posing a serious threat to soil productivity and food security. The degradation of soil health in many intensively cultivated areas is manifested in terms of loss of soil organic matter, depletion of native soil fertility due to imbalanced and unscientific use of fertilizer, which is now one of the major constraints in improving crop productivity. Soil degradation is a major concern in agriculture because of non judicious use of agricultural inputs and over exploitation of natural resources which has emerged as great threat to sustain crop productivity and soil quality. The physical properties of soil are largely influenced by management and the change in physical properties of soil is exhibited only under long-term adoption of management measures. The important physical properties of soil *viz.*, bulk density, porosity, hydraulic conductivity, water retention, available water capacity and mean weight diameter are generally considered as soil quality indicators.

The most important soil degradation processes in agricultural systems are decline in nutrient supplying capacity, fertility depletion and loss of soil organic carbon. Use of organic manure with optimum rate of fertilizer under intensive farming systems increases the turnover of nutrients in the soil plant system (Nambiar and Abrol, 1989). Long-term experiments have indicated the favorable effects of FYM on physical properties of soil and also as a source of plant nutrients, which are released on mineralization and become available to plants. Incorporation of organic manures alone and in combination with inorganic fertilizers resulted into decrease in the pH, bulk density and penetration resistance and increased organic carbon content, porosity, infiltration rate, hydraulic conductivity and water stable aggregates (Chalwade *et al*. 2006). Managing organic source of plant nutrients with mineral fertilizer and their incorporation into the soil in a cropping system has certain favorable and augmenting effects on soil physical properties for sustainability and high productivity of crop. In view of the above, present study was undertaken to assess the effect of long term manuring and fertilization on physical properties under sorghum-wheat sequence grown on Vertisol.

MATERIAL AND METHODS

The long term fertilizer experiment was initiated at Research Farm, Department of Soil Science and Agricultural Chemistry, Dr. P. D. K. V., Akola (MS) during

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1988-89.The experiment comprised of twelve treatments replicated four times in RBD. The treatments consists of 50 per cent RDF (T1), 100 per cent RDF (T2), 150 per cent RDF (T3),100 per cent RDF (-S) (T4), 100 per cent RDF + 2.5 kg Zn ha^{-1} once in two years to wheat crop only (T5), 100 per cent RD of NP (T6),100 per cent RD of N (T7),100 per cent RDF + FYM @ 5 tonnes ha to sorghum only (T8), 100 per cent RDF + S @ 37.5 kg ha^{-1} (T9), FYM @ 10 tonnes ha^{-1} to sorghum and wheat (T10), 75 per cent RDF + 25 per cent N through FYM (T11) and Control (T12). The 25th cycle of the experiment during 2012-13 was studied in the present investigation. The recommended dose of fertilizer was 100:50:40 kg N, P_2O_5, K_2O ha^{-1} applied to sorghum while 120:60:60 N, P_2O_5, K_2O kg ha^{-1} to wheat. Farmyard manure (0.50 % N, 0.16 % P, and 0.52 % K) was added on oven dry basis one month before sowing of sorghum.

The soil of experimental site was classified as fine, smectitic, calcareous, hyperthermic family of Typic Haplusterts, having low (5.47mmhr^{-1}) hydraulic conductivity bulk density 0-15 cm (1.26),15-30 cm (1.31Mgm^{-3})and high water holding capacity (50-53%). The initial analysis indicated that soils are low in organic carbon and available N, very low in available P and high in available K.

Treatment wise soil samples collected from 0-20 cm depth after harvest of *Sorghum* during 2012-13 were air dried in shade and stored in polythene bags for further analysis. The air dried samples were carefully and gently ground with the wooden pestle to break soil lumps (clods) and were passed through sieve of 2 mm diameter. For mean weight diameter analysis, 8 mm size aggregates were retained on the sieve and used. Bulk density was determined by clod coating technique as described by Blake and Hartge (1986). Percent porosity was determined by technique as described by Baver (1949). Water retention of soil was determined by pressure plate membrane apparatus method as described by Klute (1986). Hydraulic conductivity of soil was determined by constant head method as described by Klute and Dirksen (1986). Mean weight diameter of soil was determined by Yoder's apparatus method as per Kemper and Rosenau (1986).

RESULTS AND DISCUSSION

Bulk Density

The bulk density of soil varied from 1.23 to 1.45 (Mg m^{-3}) under various treatments (Table 1). The lowest bulk density was recorded in the treatment of integrated nutrient management (INM) comprising of use of 100 per cent NPK along with FYM (1.23 Mg m^{-3}) followed by FYM @ 10 t ha^{-1} (1.25 Mg m^{-3}). The reduction in bulk density may be attributed to better aggregation, increased porosity and improvement in soil structure caused due to increased in soil organic matter under the treatment of integrated use of chemical fertilizers and organic manures. Selvi *et al*. (2005) conducted long term fertilizer experiment at Coimbatore for 26 years and observed that soil porosity, hydraulic conductivity and water holding capacity were significantly higher in organo-inorganic combination (FYM + 100% NPK) than in unmanured control excluding bulk density. The similar findings were reported by Sharma *et al*. (2007) and Gayatri Verma *et al*. (2010). The physical properties of soil changes very slowly and shows gradual variations during short period. However, in the present study, it was observed that continuous use of organics in combination with inorganics for period of 25 years recorded significant change in bulk density. The significant reduction in bulk density from 1.45 to 1.23 Mg m^{-3} was recorded due to integrated nutrient management indicating importance of organics in improvement of physical properties of soil. The bulk density showed declining trend due to conjoint use of chemical fertilizers and FYM than that of only chemical fertilizers.

Porosity

The porosity varied from 45.32 per cent (control) to 53.81 per cent (100% NPK +FYM) (Table 1). Amongst the chemical fertilizers treatments 100 per cent RDF recorded significantly higher porosity as compared to the control. Significantly highest porosity of the soil was observed in the treatment of 100 per cent NPK + FYM @ 5 t ha^{-1}(53.81%) which was on par to treatment of FYM @ 10 t ha^{-1}(T_{10}) (52.91%). It might be due to addition of organic matter which increased the organic carbon content of soil. Singh *et al*. (2009) conducted field experiment during *kharif* seasons of 2007 and 2008 at Pantnagar to evaluate the effect of three cropping systems on soil properties of Mollisols of the Tarai region and reported that, application FYM up to 5.0 t ha^{-1} was found to be significant in reducing bulk density and increased porosity in both years due to increase in organic carbon content of the soil. The similar findings were reported by Gayatri Verma *et al*. (2010).

Hydraulic Conductivity

The hydraulic conductivity varied from 0.45 cm hr^{-1} (control) to 0.78 cm hr^{-1} (100% NPK + FYM) (Table 1). The hydraulic conductivity showed considerable improvement under treatment of INM comprising of 100 per cent NPK + FYM (0.78 cm hr^{-1}) as compared to the treatments of only chemical fertilizers. The treatment receiving FYM @ 10 t ha^{-1} also shows significant increase in hydraulic conductivity. Amongst chemical fertilizers treatments, the treatment receiving 100 per cent NPK recorded highest hydraulic conductivity over control. Improvement in hydraulic conductivity is due to the continuous addition of organics in combination with inorganics as compared to inorganics alone was reported by Prasad and Sinha (2000). The better aggregation and increased porosity as a consequence of the addition of organics have a favourable influence on the physical properties such as hydraulic conductivity which influence water dynamics. It was interesting to note the drastically low value of hydraulic conductivity under all the treatments of chemical fertilizers as compared to the integrated nutrient management treatment. The value of hydraulic conductivity at control was hardly around 0.45 cm hr^{-1} as that of the 0.78 cm hr^{-1} of INM treatment. This helps to suggest the sensitiveness of hydraulic conductivity in long run to management practices, which is beneficial to indicate quality of soils.

Mean weight diameter

The mean weight diameter is an important indicator of soil aggregates and soil quality. The mean weight diameter was significantly highest 0.82 mm in 100 per cent NPK + FYM @ 5 t ha^{-1} which is superior over all remaining treatments (Table 1). The mean weight diameter of soil varied from 0.45 mm to 0.82 mm under various treatments and showed significant variation. There is considerable improvement in mean weight diameter from 0.45 mm (control) to 0.65 mm (100% NPK) and further increased to 0.80 mm (FYM alone). Tiwari *et al*. (2000) studied the physical properties of Typic Haplusterts after 18 years under long-term use of fertilizers and manures and found that application of FYM @ 15 t ha^{-1} yr^{-1} along with recommended NPK dose significantly improved the soil aggregation. This may be ascribed to the improvement in physical condition of soil and to the increased organic carbon content which might be responsible for stabilization of aggregates and hence higher mean weight diameter with application of FYM and inorganic fertilizers. This observation is in conformity with the findings of Sharma *et al.* (2007). The added organics could supply additional fresh organic residues (water soluble and hydrolysable substrates) and carbon to soil resulting in the production of microbial polysaccharides that increase aggregate cohesion, which could explain the progressive increase in aggregate stability to mechanical breakdown. The structure in black clayey smectitic soils is considerably hard and many times moderate to coarse in the form of large hard clods. The continuous application of only chemical fertilizers did not show much improvement in the mean weight diameter in the long run indicating an immense need of organics to improve such an important soil physical property which is reflected in the treatments of INM.

Water retention

The water retention at 33 kPa and 1500 kPa varied significantly due to treatments under study (Table 2). The significant highest water retention at 33 kPa (39.60 percent) and at 1500 kPa (19.73 percent) was recorded in 100 per cent NPK + FYM followed by FYM @ 10 t ha^{-1}. The lowest water retention (33.92%) at 33 kPa and (17.88%) at 1500 kPa was recorded in control. It was observed that, water retention increased slightly under the chemical fertilizer treatments. The treatment of control avoiding regular use of organics did not show increase in water retention. Thus, it was observed that the available soil moisture content was significantly enhanced due to integrated use of FYM along with chemical fertilizers as compared to treatments of only chemical fertilizers. Similar results were also reported by Bhattacharyya *et al*. (2004). The increased soil available moisture might be attributed to increased organic matter status of soil and improved soil structure. These results are in agreement with the findings of Singh *et al*. (2009) who reported that the treatment receiving 100 per cent NPK + FYM showed significantly higher water holding capacity as compared to 100 per cent NPK + Zn, NP + Zn, N + Zn and control plots.

Relationship among grain yield and physical properties

The relationship among sorghum grain yield and various soil physical properties as well as hydraulic conductivity and available water content are depicted in Table 3 and Figure 1, the data revealed that grain yield of sorghum was significantly correlated with hydraulic

Table 1 Soil physical properties as influenced by effect of long-term manuring and fertilization

Tr. No.	Treatments	Bulk density (Mg m^{-3})	Porosity (%)	Hydraulic conductivity (cm hr^{-1})	Mean weight diameter (mm)
T_1	50% NPK	1.37	48.42	0.65	0.58
T_2	100% NPK	1.33	49.92	0.70	0.65
T_3	150% NPK	1.36	48.72	0.68	0.63
T_4	100% NPK (S free)	1.35	49.14	0.67	0.60
T_5	100% NPK	1.34	49.53	0.66	0.61
T_6	100% NP	1.36	48.71	0.65	0.58
T_7	100% N	1.39	47.67	0.62	0.55
T_8	100% NPK + FYM @ 5 t ha^{-1}	1.23	53.81	0.78	0.82
T_9	100% NPK + S @ 37.5 kg ha^{-1}	1.34	49.54	0.68	0.62
T_{10}	FYM @ 10 t ha^{-1}	1.25	52.91	0.75	0.80
T_{11}	75% NPK + 25% N through FYM	1.35	49.14	0.68	0.60
T_{12}	Control	1.45	45.32	0.45	0.45
	SE (m) ±	0.011	0.65	0.008	0.010
	CD at 5%	0.031	1.87	0.024	0.029

Table 2 Water retention as influenced by effect of long- term manuring and fertilization

Tr. No.	Treatments	Water retention		
		33 kPa	1500 kPa	AWC (%)
T_1	50% NPK	36.22	18.25	17.96
T_2	100% NPK	37.97	19.23	18.74
T_3	150% NPK	37.16	18.67	18.49
T_4	100% NPK (S free)	37.42	18.92	18.50
T_5	100% NPK	37.49	18.94	18.56
T_6	100% NP	36.71	18.50	18.21
T_7	100% N	36.19	18.31	17.88
T_8	100% NPK + FYM @ 5 t ha^{-1}	39.60	19.73	19.86
T_9	100% NPK + S @ 37.5 kg ha^{-1}	37.51	18.97	18.53
T_{10}	FYM @ 10 t ha^{-1}	39.07	19.53	19.54
T_{11}	75% NPK + 25% N through FYM	37.05	18.63	18.42
T_{12}	Control	33.92	17.88	16.04
	SE (m) ±	0.49	0.45	0.44
	CD at 5%	1.42	1.29	1.26

Table 3 Relationship among grain yield and soil physical properties

Physical Properties	Correlation Coefficient
Bulk Density	0.414
Porosity	0.413
Hydraulic Conductivity	0.426
Mean Weight Diameter	0.389
Available Water Content	0.595

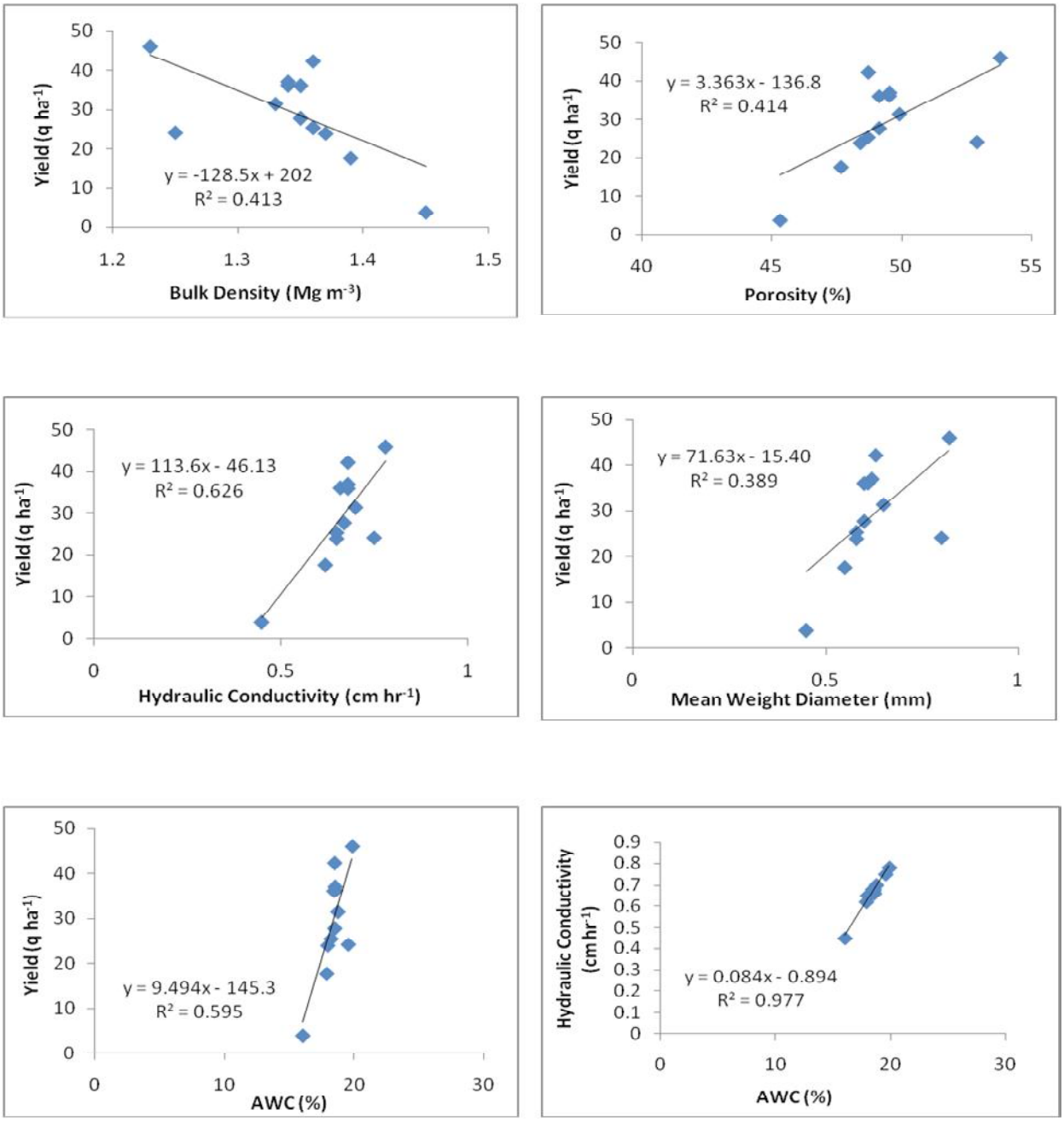

Figure 1. Relationship among grain yield and (a) bulk density (b) porosity (c) hydraulic conductivity (d) Mean weight diameter (e) water content and (f) relationship among hydraulic conductivity and water content

conductivity (r^2 = 0.426**) and available water content (r^2 = 0.595**). The hydraulic conductivity was significantly correlated with available water content (r^2 = 0.977**). From the correlation study, it is revealed that hydraulic conductivity and available water content are largely influenced by management practices and the change under these properties is exhibited only under long-term adoption of management measures and hence these soil physical properties are considered as soil quality indicators.

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Influence of Potassium Fertilizer on Chickpea Under Rainfed Condition in Vertisols

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ABSTRACT

A field investigation was started carried out 2009-10 to 2011-12 to study the response of chickpea to potassium under rainfed condition. The seed yield was significantly increased due to application of 40 kg K_2O ha^{-1} along with RDF (25 N: 50 P_2O_5 kg ha^{-1}),. Further it is noted that the yield was decreased with higher levels of K_2O. The significantly highest uptake of nitrogen, phosphorous and potassium was also observed with the application of 40 kg K_2O ha^{-1}. The seed protein content increased gradually with increased potassium level and maximum protein content was recorded with the application of 40 $kgha^{-1}$ along with RDF. The foliar application of potassium through 2 per cent KNO_3at flowering and 15 days thereafter also significantly increased the seed yield and protein content as compared to absolute control; , RDF and 20 kg K_2O ha^{-1}. The soil fertility status after harvest of chickpea was significantly improved with the application of RDF with and without potassium levels.

Potassium is a key nutrient in the plants tolerance to stress such as high/low temperatures, drought, disease and pest occurrences. It has a critical role to play in osmoregulation-regulation of water use in plants and most importantly regulates opening and closing of stomata which affect transpiration cooling and carbon dioxide intake for photosynthesis. In Maharashtra chickpea is a major pulse crop in *Rabi* season grown after soybean on residual soil moisture on medium deep swell shrink soils. The introduction of high yielding fertilizer responsive crop cultivars grown under intensive cultivation is likely to result into depletion of soil nutrients like potassium at an alarming rate. At present, as per the existing fertilizer recommendation, potassium is not recommended to chickpea. Chickpea removes about 49.6 kg K_2O $tonne^{-1}$ grain higher than nitrogen (46.3 kg $tonne^{-1}$ grain) and phosphorous (8.4 kg $tonne^{-1}$ grain) as per the findings of Velayutham and Reddy (1987). Since, chickpea is normally cultivated on residual soil moisture without potassium fertilization, it becomes imperative to study the effect of potassium on growth, yield, quality, soil fertility and economics.

MARERIAL AND METHODS

The experiment was conducted at Central Demonstration Farm, Wani Rambhapur, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during the *Rabi* season of 2009-10 to 2011-12. The experimental soil was clay loam in texture and medium deep, low in available N (188 kg ha^{-1}) and P (15.20 kg ha^{-1}) and high in K (331 kg ha^{-1}) with pH 7.62 and organic carbon 4.9 g kg^{-1}. Eight different treatments in three replications were laid out in randomized block design comprised of absolute control (T1), RDF : 25:50 N:P_2O_5 kg ha^{-1} (T2), RDF + 20 kg K_2O ha^{-1} (T3), RDF + 30 kg K_2O ha^{-1} (T4), RDF + 40 kg K_2O ha^{-1} (T5), RDF + 50kg K_2O ha^{-1}(T6) RDF+ 2 per cent KNO_3 at flowering (T7), RDF + 2 per cent KNO_3 at flowering and 15 thereafter (T8). The crop was sown on 22, 21 and 23 November 2009-10, 2010-11 and 2011-12, respectively, using a seed rate of 65 kg ha^{-1} with hand drill at 30 cm. Chickpea seed was treated with *Rhizobium* and PSB each at the rate of 2.5 g kg^{-1} seed. Similarly. the seed treatment of trichoderma (4 g kg^{-1} seed) was also followed as a part of best management practices. The nutrients viz., N, P_2O_5 and K_2O were applied to soil through urea, single super phosphate and muriate of potash. The other package of practices recommended for raising the crop were followed.

RESULTS AND DISCUSSION

The application of different potassium levels through soils as well as foliar sprays significantly influenced growth and yield attributes significantly over absolute control (Table 1). The highest plant height, branches $plant^{-1}$ and pods $plant^{-1}$ was recorded at 40 kg K_2O ha^{-1} which in turn found at par with higher (50 kg K_2O ha^{-1}) and lower (30 kg K_2O ha^{-1}) level.

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Table 1. Growth parameters, nodulation, protein content and physical properties of chickpea as influenced by different treatments

Treatment	Plant height (cm)	Branches plant^{-1}	Pods plant^{-1}	Nodule plant^{-1}	100-seed weight(g)	Protein content(%)	Physical properties (mm)		
							Length	Breadth	Thickness
T_1 - Absolute control	24.83	3.72	27.44	5.44	13.74	16.23	7.53	5.28	5.18
T_2 - RDF (25:50 N:P_2O_5 kg ha^{-1})	27.08	4.85	34.78	8.22	15.70	17.45	7.80	5.43	5.34
T_3 - RDF+20 kg K_2O ha^{-1}	29.43	5.37	37.45	8.78	17.09	17.85	7.87	5.55	5.36
T_4 - RDF+30 kg K_2O ha^{-1}	31.02	5.94	38.66	9.56	18.15	18.47	7.92	5.71	5.44
T_5 - RDF+40 kg K_2O ha^{-1}	32.29	6.86	40.33	10.00	19.23	19.00	7.99	5.73	5.54
T_6 - RDF+50 kg K_2O ha^{-1}	28.44	5.91	36.00	9.33	18.13	18.40	7.95	5.74	5.56
T_7 - RDF+2% KNO_3 at flowering	27.67	5.31	34.00	8.45	15.98	18.19	7.83	5.44	5.32
T_8 - RDF+2% KNO_3 at flowering and 15 days Thereafter	29.16	5.81	34.56	8.89	16.44	18.53	7.86	5.49	5.36
SE(m)±	0.56	0.14	0.60	0.12	0.05	0.07	0.02	0.01	0.01
CD (P=0.05)	1.61	0.42	1.75	0.35	1.14	0.22	0.04	0.016	0.018

Table 2. Seed yield of chickpea as influenced by different treatments

Treatments	Grain yield (q ha^{-1})			
	2008-09	**2009-10**	**2010-11**	**Pooled**
T_1 - Absolute control	11.90	12.46	12.95	12.44
T_2 - RDF (25:50 N:P_2O_5 kg ha^{-1})	14.58	14.50	15.70	14.93
T_3 - RDF+20 kg K_2O ha^{-1}	15.96	15.43	16.99	16.13
T_4 - RDF+30 kg K_2O ha^{-1}	19.59	17.32	20.02	18.97
T_5 - RDF+40 kg K_2O ha^{-1}	20.83	18.30	21.98	20.37
T_6 - RDF+50 kg K_2O ha^{-1}	18.85	15.17	18.23	17.42
T_7 - RDF+2% KNO_3 at flowering	16.37	14.68	17.46	16.17
T_8 - RDF+2% KNO_3 at flowering and 15 days thereafter	17.11	15.33	18.31	16.92
SE (m)±	**1.44**	**1.69**	**1.11**	**0.78**
CD (p=0.05)	**9.10**	**9.73**	**5.00**	**5.58**

Table 3. Uptake of nutrients and soil fertility status after harvest of chickpea as influenced by different treatments (Pooled Means)

Treatments	Nutrient uptake (kg ha^{-1})			OC	Available nutrients (kg ha^{-1})		
	Nitrogen	**Phosphorus**	**Potassium**	**(g kg^{-1})**	**Nitrogèn**	**Phosphorus**	**Potassium**
T_1 - Absolute control	43.24	6.89	11.66	4.66	177	12.45	325
T_2 - RDF (25:50 N:P_2O_5 kg ha^{-1})	60.71	10.45	17.78	5.55	216	21.68	340
T_3 - RDF+20 kg K_2O ha^{-1}	67.43	12.50	20.22	5.62	224	22.56	346
T_4 - RDF+30 kg K_2O ha^{-1}	81.62	15.04	25.10	5.73	230	23.61	361
T_5 - RDF+40 kg K_2O ha^{-1}	88.99	16.45	27.59	5.76	236	26.49	384
T_6 - RDF+50 kg K_2O ha^{-1}	72.27	13.53	20.21	5.76	236	25.75	394
T_7 - RDF+2% KNO_3 at flowering	66.25	12.38	18.76	5.58	213	21.30	340
T_8 - RDF+2% KNO_3 'at flowering and 15 days after	70.40	13.81	20.48	5.66	212	20.65	341
SE (m)	0.97	0.23	0.33	0.05	1.38	0.46	2.09
CD (P=0.05)	2.82	0.67	0.95	0.11	4.02	1.35	6.11
Initial status				4.47	185	18.83	314.7

Application of potassium along with RDF (25 kg N + 50 kg K_2O ha^{-1}) significantly increased seed yield over absolute control and RDF (Table 1). The significantly higher seed yield of chickpea was recorded with application of 40 kg K_2O ha^{-1} with RDF over lower (30 kg K_2O ha^{-1} + RDF) and higher level (50 kg K_2O ha^{-1} + RDF) of potassium. Application of two foliar sprays of potassium nitrate @ 2 per cent also recorded significantly higher seed yield over RDF alone, however, it was significantly lower with soil application of potassium. Two foliar application of K through KNO_3 with RDF registered statistically equivalent seed yield with single foliar spray with RDF. Application of 40 kg K_2O ha^{-1} + RDF recorded 36 per cent increase in yield of chickpea as compared to RDF alone. Higher response of pulse crops to potassium as compared to cereals and oil seeds has been reported by Tiwari and Nigam, (1985) and Srinivas Rao *et al.* (1999). It is further reported that cereals deplete more soil K whereas legumes depend more on applied K for their K needs.

Total uptake of nutrients in respect of N, P and K was significantly increased with increasing levels of potassium up to 40 kg K_2O ha^{-1} (Table 3). The highest uptake of nitrogen, phosphorous and potassium was observed at 40 kg K_2O ha^{-1} which was at par with the uptake recorded with 30 kg K_2O ha^{-1}. Among foliar application of KNO_3 twice at flowering and 15 days

thereafter recorded higher uptake of nutrients (P and K) excluding nitrogen. Uptake of potassium was highest in chickpea with increasing level of potassium due to its higher root cation exchange capacity and higher potassium utilization efficiency.

The protein content of chickpea seed improved significantly with increase in potassium level with RDF and maximum was recorded with 40 kg K_2O ha^{-1} + RDF foliar application was superior to control, RDF and RDF + 20 kg K_2O ha^{-1}. As potassium has synergistic effect on nitrogen uptake, facilitates protein synthesis resulted in higher protein content with each level of potassium. Similar results have also been reported by Srinivas-Rao *et al*. (2003). The observations in respect of physical quality of chickpea seed revealed that the length, breadth and thickness of chickpea seed were slightly increased with the increasing levels of potassium with RDF compared to absolute control and RDF alone (Table 1). The soil application of potassium with RDF was found superior over foliar spray of KNO_3 with RDF in respect of physical parameters of chickpea seed.

The residual fertility status of experimental soil after harvest of chickpea (Table 3) revealed that significantly higher nitrogen, phosphorous and potassium were observed due to application of potassium @ 40 kg K_2O ha^{-1} along with recommended N and P_2O_5. The significant increase in available nitrogen status can be attributed to the effect of added K which has synergistic effect with N and also *rhizobium* inoculation which is beneficial in increasing the N fixation (Ali and Srinivas Rao, 2001).

The chickpea (SAKI 9516) responded to application of potassium up to 40 kg ha^{-1} along with recommended dose of N (20 kg ha^{-1}) and P_2O_5 (40 kg ha^{-1}) in swell shrink soils leading to higher yield, improved quality and residual soil fertility improvement. Application of two foliar sprays of potassium nitrate @ 2 per cent along with recommended N and P_2O_5 was also found beneficial for yield as compared to only N and P_2O_5 with no potassium. But, looking to the sustenance of soil health and higher yield levels, the application of potassium through soil is most beneficial.

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Effect of Long Term Fertilization and Manuring to Sorghum-Wheat Sequence on Micronutrient Availability and their Uptake Pattern in Inceptisol

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ABSTRACT

A permanent field experiment is continuing from 1984-85 at Research Farm, AICRP on Cropping Systems Research Unit, Dr. PDKV, Akola (M.S.) with a view to find out effect of integrated nutrient management on soil quality and productivity of sorghum-wheat crop sequence. The long term impact of organic, inorganic and integrated nutrient management practices on micronutrient availability and uptake pattern in an Inceptisol was studied during 2010-11 (27th cycle). The treatment comprises of different levels of RDF viz; 50, 75 and 100 per cent along with FYM, wheat straw, leuceana lopping and farmer's practice. The application of various levels of RDF (50, 75 and 100 %) along with organics (FYM, wheat straw, leucaena lopping) exhibited profound influence on the uptake and availability of different micronutrients as compared to chemical fertilizers alone. The continuous cropping for 27 years without addition of organics under control and farmers practice recorded depletion of micronutrients.

Long-term fertilizer experiments usually provide the best practical test of sustainability of crop management system. The complex problem of· soil fertility management can only be examined by long-term field trials as it takes time for the crops, crop rotations, fertilizers and manures to have a reasonable impact on soil fertility. Improving and maintaining soil quality for enhancing and sustaining agricultural production is of utmost importance for India's food and nutritional security. Due to increasing population pressure, the demand for food, feed, fodder, fibre, fuel, pulses and oilseed products is rapidly increasing. To meet the future demand we would need better planning and resource management as well as intensification of crop production.

The overall strategy for increasing crop yields and sustaining them at a high level must include an integrated approach to the management of soil nutrients, along with other complementary measures. An integrated approach recognizes that soils are the store house of most of the plant nutrients which are essential for plant growth and that the way in which nutrients are managed will have a major impact on plant growth, soil fertility and agricultural sustainability.

Several workers reported widespread deficiency of zinc followed by iron in alkaline calcareous swell-shrink soils of Maharashtra which necessitates appropriate management options under intensive cropping. The micronutrient deficiency is emerging in swell-shrink soil due to intensive agriculture, use of high analysis NPK fertilizers and lack of addition of organic manures. In order to maintain the native soil fertility and for balanced fertilization, monitoring of changes in micronutrient status of the soil becomes inevitable. Fertilizer recommendations are often derived from nutrient uptake pattern of crops that focus on optimizing nutrient inputs with regards to achieving high net return from the crop to which the nutrient was applied. Nutrient monitoring is a method that quantifies system's nutrient inflows and outflows resulting in nutrient balance.

The present experiment is mainly focused on impact of long term manuring and fertilization on micronutrients status and their uptake in sorghum-wheat cropping sequence.

MATERIAL AND METHODS

A long-term field experiment on sorghum-wheat cropping sequence was initiated during 1984-85 at AICRP on Integrated Farming System Research, Central Research Station, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The present investigation was carried out to study the long-term effect of integrated nutrient management to sorghum-wheat sequence on micronutrient availability and its uptake pattern in an Inceptisol (2010-11- 27th cycle). The twelve treatments were laid out in a randomized block design with four replications. The various combinations

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of chemical fertilizers with organics like FYM, green manure and crop residues were studied. FYM was applied before sowing to sorghum which contains 0.63 per cent N, 0.25 per cent P and 0.74 per cent K. The Leucaena loppings were applied to sorghum to substitute 25 and 50 per cent N. Leucaena loppings (3.36% N) were applied @ 0.90 and 1.8 tonnes/ha to substitute 25 and 50 per cent N. The recommended dose of fertilizers was 100:50:50 and 120:60:60 kg N, P_2O_5 and K_2O ha^{-1} for sorghum and wheat respectively. The micronutrients were analyzed in soils and plants using standard procedure and their uptake was determined. The content of micronutrients in grain and fodder/straw was determined by atomic absorption spectrophotometer from di-acid extract as described by Isaac and Kerber (1971). The available micronutrients of soil were determined by atomic absorption spectrophotometer using DTPA extract method as described by Lindsay and Norvell (1978).

RESULTS AND DISCUSSION

Soil available micronutrient status

Available zinc (Zn)

The available zinc status of soil was found to be lowest and just above the critical level of zinc (0.6 mg kg^{-1}) under the use of only chemical fertilizers (Table 1). It was observed that the zinc status of soil was highest and found to be maintained at conjoint use of chemical fertilizers with FYM which were applied for the substitution of 50 per cent N over the treatments involved in integrated use of organics with chemical fertilizers (T_6 to T_{11}), only inorganic application (50% to 100% NPK) and no manure, no fertilizer plot (T_1). The farmers practice (T_{12}) involving only chemical fertilizers also recorded deficient Zn status (0.50 mg kg^{-1}) after a period of 27 years. The zinc status was maintained under integrated nutrient management for a long period which might be due to the addition of organics. The organic materials form chelates and increase the availability of zinc (Verma *et al.*, 2005 and Masto *et al.*, 2007).

The results thus clearly indicated that due to continuous cropping with only chemical fertilizers without addition of organics there is considerable depletion of zinc and soils show depletion of zinc which indicate immense necessity of regular application of organics either FYM or crop residues and /or green manures to maintain the zinc status of soils. The widespread deficiency of zinc in alkaline calcareous soils has been often encountered under intensive cropping and needs regular use of green manures, crop residues and FYM which can maintain the zinc status of soils.

Available iron (Fe)

The available Fe content in the soil ranged between 9.52 to 11.30 mg kg^{-1} and 10.72 to 12.68 mg kg^{-1} mg kg^{-1} after harvest of sorghum and wheat respectively due to application of various levels of RDF along with organics (FYM, wheat straw and LL) as compared to chemical fertilizers alone. However, available Fe content in soil was found significantly higher in case of the application of 50 per cent N through FYM with chemical fertilizers after harvest of sorghum (11.33 mg kg^{-1}) and wheat (12.68 mg kg^{-1}). While wheat straw and Leucaena loppings applied for the substitution of 25 and 50 per cent of N with chemical fertilizers were found at par with each other and recorded significantly superior values over the treatments of only chemical fertilizers and control. The availability of Fe in calcareous black soil is often a problem causing lime induced chlorosis. The results of long term studies in the present experiment justify the need of regular organics for maintaining Fe status of soils.

The increase in Fe status under INM might be due to organic acids released with the mineralization of FYM which might have solubilized the precipitated iron minerals in soil. The available iron shows emerging deficiencies in alkaline calcareous soils due to intensive cropping and the INM is therefore imperative to maintain the Fe status of soils.

Available manganese (Mn)

The data revealed that the available Mn status was significantly influenced with various treatments varying between 15.12 to 20.99 mg kg^{-1} and 15.14 to 21.41 mg kg^{-1} after harvest of sorghum and wheat respectively. The available Mn content of soil was found to be significantly highest under FYM with inorganic fertilizers (20.99 to 21.41 mg kg^{-1}) and it was superior over chemical fertilizers along with wheat straw, leucaena loppings and control. Thus, the results indicated, the beneficial effect of organics especially FYM in combination with NPK over only chemical fertilizers in maintaining the available manganese in soil.

Available copper (Cu)

The data in respect of available Cu revealed that

application of various levels of RDF along with organics (FYM, wheat straw and LL) favorably influenced the available Cu in the soil. The significantly highest content of Cu (4.09 to 4.14 mg kg^{-1}) was recorded under the treatment of RDF + 50 per cent N through FYM.

The results thus suggest that the use of FYM, wheat straw and green manure along with chemical fertilizers helps in maintaining available micronutrient status of soil over a long-term cropping period. These findings are in agreement with the results obtained by Bellakki *et al.* (1998) in rice-rice cropping system under long-term fertilizer experiments on Vertisol. Addition of organic materials might have enhanced the microbial activity in the soil and consequently the release of complex organic substances like humic and fulvic acids acting as chelating agents during the decomposition of organic manure and crop residue. This could have prevented micronutrients from precipitation, fixation, oxidation, leaching and augmented the solubility, mobility, availability of insoluble micronutrients. Prasad and Sinha (2000) in their studies on long term effect of fertilizers and organic manures on soil properties in rice – wheat cropping systems in calcareous soils of Pusa (Bihar) also reported that available Zn, Fe, Cu and Mn increased in soil when different levels of fertilizers were applied along with crop residues and organic manure.

Application of FYM significantly increased availability of micronutrients over rest of the treatments due to the decomposition of FYM and consequent release of micronutrients (Swarup, 1991). The emerging deficiency of zinc followed by iron in black soils of Maharashtra necessitates alternate options like green manure and crop residues.

Uptake of micronutrients by crops

Uptake of zinc (Zn)

The uptake of Zn by sorghum (581 g ha^{-1}) and wheat (161 g ha^{-1}) was increased significantly under 50 per cent RDF along with 50 per cent N through FYM (Table 2). The uptake of zinc was increased under organics (517 to 581 g ha^{-1}) in combination with chemical fertilizers over only chemical fertilizers (99.8 to 564 g ha^{-1}). As regards zinc uptake in wheat, it was considerably higher under combined application of organics plus chemical fertilizers (120 to 161) over chemical fertilizers (20.2 to 133.4 g ha^{-1}) alone.

The uptake of Zn by sorghum and wheat was considerably reduced under 50 per cent RDF, control and farmer's practice. The increase in uptake of micronutrients may be due to the availability of these nutrients in organic sources. Tetarwal *et al*. (2011) also reported that the application of 150 per cent RDF also recorded maximum and significantly higher Zn uptake but it was on par with RDF + FYM @ 10 t ha^{-1} in rainfed maize.

Uptake of iron (Fe)

The uptake of iron was increased in general under conjoint use of chemical fertilizers along with organics over only chemical fertilizers. The application of 100 % RDF recorded significantly higher uptake of iron by sorghum (1726.4 g ha^{-1}), whereas, combined application of organics along with chemical fertilizers (with 100 % RDF to rabi) favourably influenced the absorption of more Fe in the grain and straw of wheat, thereby increased its uptake in wheat (639.4 g ha^{-1}) In general, it was also observed that, the uptake of wheat increased under the integrated nutrient management as compared to only chemical fertilizers. Lal and Mathur (1989) in long-term fertilizer experiment reported that, the uptake of micronutrients by maize and wheat in acid red loam soil was improved under the application of FYM along with fertilizers significantly.

Uptake of manganese (Mn)

The uptake of manganese also showed similar trend (Table 2). However, since the manganese are sufficient in soil, their uptake at integrated nutrient management and only chemical fertilizers varied narrowly. However, the uptake of both the micronutrients was found to be improved under integrated nutrient management as compared with chemical fertilizers.

Uptake of copper (Cu)

The uptake of copper by sorghum (127 g ha^{-1}) and wheat (87 g ha^{-1}) was increased significantly with the application of organics along with chemical fertilizers (with 100 per cent RDF to *Rabi*).The application of only chemical fertilizers reduced the uptake of copper over conjoint use of chemical fertilizers along with organics (FYM, wheat straw, leucaena loppings).

The results of present investigation suggest that the practice of green manuring and crop residue management is more appropriate management practice from soil sustainability point of view rather than only

Table 1. Effect of long term manuring and fertilization on micronutrient status under sorghum-wheat sequence (27th cycle)

Treatments		Available Micronutrients (mg kg^{-1})							
		After harvest of sorghum (2010-11)				After harvest of wheat (2010-11)			
Sorghum	Wheat	Zn	Fe	Mn	Cu	Zn	Fe	Mn	Cu
Control	Control	0.46	6.53	15.12	2.60	0.47	6.73	15.14	2.65
50 % RDF	50 % RDF	0.51	8.74	16.74	3.34	0.53	9.10	16.86	3.37
50 % RDF	100 % RDF	0.61	9.00	17.68	3.37	0.62	9.38	17.72	3.41
75 % RDF	75 % RDF	0.63	9.27	17.85	3.38	0.65	9.66	17.97	3.44
100 % RDF	100 % RDF	0.68	9.64	18.20	3.53	0.71	9.78	18.31	3.62
50 % RDF + 50 % N -FYM	100 % RDF	0.81	11.33	20.99	4.09	0.84	12.68	21.41	4.14
75 % RDF + 25 % N -FYM	75 % RDF	0.71	9.76	18.92	3.63	0.74	10.42	18.99	3.65
50 % RDF + 50 % N –WS	100 % RDF	0.75	10.28	20.15	3.75	0.76	11.77	20.21	3.83
75 % RDF + 25 % N - WS	75 % RDF	0.72	10.06	18.67	3.60	0.72	11.60	18.77	3.71
50 % RDF + 50 % N – LL	100 % RDF	0.73	9.80	19.90	3.71	0.74	11.26	19.93	3.78
75 % RDF + 25 % N - LL	75 % RDF	0.70	9.52	18.70	3.54	0.70	10.72	18.74	3.66
FP (50 :25 :00)	FP (40:25:12.5)	0.50	8.08	16.46	3.27	0.50	8.09	16.58	3.32
SE(m) ±	0.023	0.269	0.190	0.099	0.016	0.278	0.270	0.087	
CD at 5%	0.065	0.775	0.546	0.284	0.045	0.800	0.779	0.250	

Table 2 Effect of long term manuring and fertilization on uptake of micro nutrients by sorghum and wheat under sorghum-wheat sequence (27th cycle)

Treatments		Total Uptake (g ha^{-1})							
		Sorghum				Wheat			
Sorghum	Wheat	Zn	Fe	Mn	Cu	Zn	Fe	Mn	Cu
Control	Control	99.8	340.4	90.1	15.4	20.2	118.3	72.3	11.9
50 % RDF	50 % RDF	433.4	1316.4	421.2	83.4	80.5	352.4	211.6	46.9
50 % RDF	100 % RDF	451.0	1359.1	439.6	93.9	103.9	408.2	249.0	56.1
75 % RDF	75 % RDF	478.3	1432.8	465.7	98.4	105.5	435.6	262.5	59.8
100 % RDF	100 % RDF	564.0	1726.4	570.7	122.7	133.4	524.9	324.7	74.0
50 % RDF + 50 % N -FYM	100 % RDF	580.6	1612.9	548.2	127.2	161.0	639.4	369.0	86.6
75 % RDF + 25 % N -FYM	75 % RDF	542.5	1577.6	521.5	113.8	126.2	511.5	292.4	67.1
50 % RDF + 50 % N –WS	100 % RDF	485.1	1405.0	471.0	104.9	131.6	530.1	305.4	70.2
75 % RDF + 25 % N - WS	75 % RDF	516.7	1511.8	501.2	109.5	120.1	489.0	280.0	63.5
50 % RDF + 50 % N – LL	100 % RDF	537.9	1553.1	523.2	115.3	139.0	574.8	330.1	75.8
75 % RDF + 25 % N - LL	75 % RDF	545.4	1588.4	529.9	115.1	129.9	547.0	310.1	68.5
FP (50 :25 :00)	FP (40 :25 :12.5)	397.8	1210.9	384.9	75.7	62.6	247.9	153.3	34.2
CD at 5%	62.89	190.89	63.31	15.45	12.67	64.17	35.94	7.83	

depending upon the chemical fertilizers like zinc sulphate, ferrous sulphate, etc. These practices of green manuring and crop residues are beneficial for maintaining status of micronutrients in soils under continuous cropping besides useful for enhancing soil physical and biological health.

CONCLUSION

It can be concluded that the use of Lecaceana loppings as green manuring, wheat straw as crop residue recycling and FYM as organic manure in conjunction with chemical fertilizers is beneficial for maintaining micronutrient status in soils under continuous cropping in Inceptisols.

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Response of Mustard (*Brassica Juncea*) to Water Soluble Spray Fertilizer Sujala (19:19:19)

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ABSTRACT

The experiment was conducted at Agronomy farm, Agriculture college, Nagpur during Rabi 2009-10 in randomized block design with four replications and seven treatments viz.,T_1- RDF 100 per cent, T_2- RDF 75 per cent, T_3- RDF 50 per cent, T_4- Three Sujala spray, T_5-RDF 100 per cent + Three Sujala spray, T_6- RDF 75 per cent + Three Sujala spray, T_7- RDF 50 per cent + three Sujala spray. Three sprays of 0.5 per cent concentration of sujala (19:19:19) water soluble spray fertilizer each through 500 litres of water ha^{-1} were applied at 30, 45 and 60 DAS as per the treatments. The RDF used was 50:40:0 kg NPK ha^{-1}.

The plant height, number of branches, dry matter accumulation plant $^{-1}$ at harvest, number of siliqua plant^{-1} , seed yield plant^{-1}, the seed yield, stover yield, protein yield ha^{-1}, GMR (Rs 23078) and NMR (Rs14127) were maximum with application of 100 per cent RDF + 3 Spray of Sujala (19:19:19) at 30, 45 and 60 DAS, but was at par with 100 per cent RDF alone and 75 per cent RDF + 3 Spray of sujala (19:19:19) at 30,45 and 60 DAS. The protein content and NPK uptake also showed similar trend. The B:C ratio was maximum with 100 per cent RDF+ three sprays of Sujala (19:19:19) at 30, 45 and 60 DAS (2.57), followed by 100 per cent RDF(2.54) and 75 per cent RDF + three spray of Sujala (19:19:19) at 30, 45 and 60 DAS (2.45) . The oil content was not influenced significantly.

Mustard is an important *Rabi* oilseed crop. Nutrients are applied as basal and top dressed. Sometime the top dressing of nutrient may not be effective because of non availability of moisture in the top layer of soil due to which the nutrient could not reach to the active root zone of the crop. Foliar spray can be help in nutrients balancing without lapse of time. Nutrients when applied as a foliar spray are taken up by the plant and become helpful for the growth of the plants. Due to readily efficient nutrient management the full potential of mustard regarding the yield can be achieved. Considering above said view the present study was undertaken with objective of finding out the effect of foliar spray of water soluble Sujala fertilizer on mustard, its economics and uptake of nutrients by the crop.

MATERIAL AND METHODS

The experiment was conducted at Agronomy farm, Agriculture college, Nagpur during *Rabi* 2009-10 in randomized block design with four replications and seven treatments viz., T_1- RDF 100 per cent, T_2- RDF 75 per cent, T_3- RDF 50 per cent, T_4- Three Sujala spray, T_5-RDF 100 per cent + Three Sujala spray, T_6- RDF 75 per cent + three Sujala spray, T_7- RDF 50 per cent + three sujala spray. Three sprays of 0.5 per cent concentration of sujala (19:19:19) water soluble spray fertilizer each through 500 litres of water ha^{-1} were applied on 30, 45 and 60 DAS as per the treatments. The soil was clay in texture and low in available nitrogen (222.65 kg ha^{-1}), medium in available phosphorus (14.58 kg ha^{-1}) and very high in available potash (368.80 kg ha^{-1}). The organic carbon content of soil was 0.52 per cent with 7.9 pH. Variety ACN-9 (shatabdi) was sown at spacing of 45 X10 cm with recommended fertilizer dose of 50: 40:0 kg NPK ha^{-1} with half nitrogen and full phosphorus as a basal dose and remaining half nitrogen as top dressing.

RESULTS AND DISCUSSION

The data regarding growth, yield attribute, yield, economics, quality and uptake are presented in the table 1 and 2.

Growth attributes

Plant height, number of branches and dry matter accumulation plant^{-1} at harvest were maximum with application of 100 per cent RDF + 3 Spray of Sujala (19:19:19) at 30, 45 and 60 DAS but at par with 100 per cent RDF and 75 per cent RDF + 30,45 and 60 DAS significantly superior to other treatments.

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Table 1. Growth, yield attributes and quality of mustard as influenced by the various treatments

Treatments	Growth attributes at harvest			Yield attributes			Quality		
	Plant height at (cm)	Number of branches	Dry matter plant^{-1} (g)	Number of siliqua plant^{-1}	Number of seed siliqua^{-1}	Seed yield plant $^{-1}$ (g)	Test weight (g)	Oil content %	Protein content %
T_1- RDF 100%	162.2	16.0	24.9	269	11.4	8.40	4.17	40.5	2.42
T_2- RDF 75 %	152.1	14.6	21.4	247	11.2	7.42	4.08	39.8	2.01
T_3- RDF 50%	141.4	12.3	17.4	218	11.0	5.87	3.95	39.6	1.45
T_4- Three sujala spray	142.7	12.7	17.8	224	10.9	6.19	3.99	39.7	1.55
T_5- RDF 100% + Three sujala spray	166.1	16.6	26.2	272	11.4	8.99	4.20	40.8	2.60
T_6- RDF 75% + Three sujala spray	161.7	15.6	24.2	267	11.3	8.20	4.13	40.1	2.34
T_7- RDF 50 % + Three sujala spray	148.8	14.1	20.2	241	11.2	6.91	4.05	39.9	1.86
SE(m)±	1.83	0.36	0.74	1.72	0.06	0.27	0.07	0.40	0.13
CD at 5%	5.43	1.07	2.10	2.10	0.19	0.81	NS	NS	0.37

Table 2. Yield, economics and uptake of mustard as influenced by the various treatments

Treatments	Yield (q ha^{-1})			Economics (Rs ha^{-1})			Uptake (kg ha^{-1})		
	Seed yield	Stover yield	GMR	COC	NMR	B:C ratio	N	P	K
T_1- RDF 100%	12.29	27.74	21665	8514	13151	2.54	44.53	10.11	62.07
T_2- RDF 75 %	10.61	25.02	18751	8222	10529	2.28	38.42	9.42	60.50
T_3- RDF 50%	7.95	20.73	14153	7879	6274	1.79	33.92	8.13	55.17
T_4- Three sujala spray	8.46	21.07	15012	7781	7231	1.92	34.57	8.38	56.43
T_5- RDF 100% + Three sujala spray	13.12	28.60	23078	8951	14127	2.57	45.69	10.73	62.83
T_6- RDF 75% + Three sujala spray	12.05	26.84	21224	8660	12564	2.45	42.91	10.03	61.72
T_7- RDF 50 % + Three sujala spray	9.9	24.91	17586	8316	9270	2.11	37.86	9.33	57.85
SE(m)±	0.52	1.01	623	-	623	-	0.94	0.25	0.39
CD at 5%	1.55	3.00	1867	-	1867	-	2.83	0.74	1.18

Seed cost Rs. 1650 q^{-1} and stover cost Rs 50 q^{-1}

Yield and yield attributes:

The number of siliqua plant^{-1} was significantly more with application of 100 per cent RDF + 3 Spray of Sujala (19:19:19) at 30, 45 and 60 DAS than the remaining treatments. The number of siliqua^{-1} and seed yield plant^{-1} were maximum and significantly higher with application of 100 per cent RDF + 3 Spray of Sujala(19:19:19) at 30, 45 and 60 DAS than other treatments except 100 per cent RDF and 75 per cent RDF + 3 Spray of Sujala (19:19:19) at 30, 45 and 60 DAS. However, test weight was not influenced significantly due to various treatments.

The seed yield and stover yield were maximum and significantly more with application of 100% RDF + 3 Spray of Sujala (19:19:19) at 30, 45 and 60 DAS over all other treatments except than treatments 100% RDF and 75 per cent RDF + three spray of Sujala (19:19:19) at 30, 45 and 60 DAS which recorded statistically equal yield. This might be due to higher values of growth parameters and yield attributes due to judicious use of nutrients. Vir and Verma (1979) found significant increase in yield with 75 per cent recommended dose of nitrogen as basal + remaining through foliar spray. Similar results observed by Borthkumar and Borthkumar (1980) when nitrogen was applied two splits or through foliar spray while in another experiment, application of 87.5 per cent RDF + Sujala (19:19:19) and 75 per cent RDF +Sujala (19:19:19) spray were found better on chilly (Anonymous, 2009).

Economics

The GMR (Rs 23078) and NMR (Rs14127) were significantly higher with application of 100 per cent RDF + 3 Spray of sujala (19:19:19) at 30, 45 and 60 DAS, but at par with 100 per cent RDF and 75 per cent RDF + 3 Spray of Sujala (19:19:19) at 30, 45 and 60 DAS. The B:C ratio was maximum with 100 per cent RDF+ three sprays of Sujala(19:19:19) at 30, 45 and 60 DAS (2.57), followed by 100 per cent RDF (2.54) and 75 per cent RDF + 3 Spray of Sujala(19:19:19) at 30, 45 and 60 DAS (2.45) .

Quality and nutrient uptake

The oil content was not influenced significantly. The protein content was found significantly more with 100 per cent RDF + 3 Spray of Sujala (19:19:19) at 30, 45 and 60 DAS followed by 100 per cent RDF and 75 per cent RDF + 3 Spray of Sujala (19:19:19) at 30, 45 and 60 DAS. Similar trend was also reported by Vir and Verma (1979).

The N, P, and K uptake was found maximum and significantly more with application of 100 per cemt RDF + 3 Spray of sujala (19:19:19) at 30, 45 and 60 DAS than other treatments except 100 per cemt RDF and 75 per cemt RDF + 3 Spray of sujala (19:19:19) at 30, 45 and 60 DAS. Vir and Verma(1979) also reported more nitrogen uptake due to 75 per cemt RDN as basal and remaining through foliar spray.

Thus, it can be interred that application of 100 per cemt RDF + three Spray of sujala (19:19:19) at 30, 45 and 60 DAS was superior for maximum return, but 100 per cemt RDF alone and 75 per cemt RDF + three Spray of sujala (19:19:19) at 30, 45 and 60 DAS were also equally effective.

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Correlates of Socio-psycho Risk Factors Associated with Suicidal Farmers of Vidarbha

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ABSTRACT

The field survey was conducted with an exploratory design of social research in suicide hit six districts of Vidarbha region of Maharashtra. These districts were Yavatmal, Washim, Buldana, Akola, Amravati and Wardha. The 200 families of deceased farmers were selected by proportionate random sampling method covering 178 villages and 34 Tahsils of six districts. The data were collected through structured personal interview schedule. Over two third victims were co-existed with three common risk factors, these were increased indebtedness (94.00%), drop in economic status (84.50%) and hopelessness due to crop failure (78.50%). Majority 71.50 per cent of the cases were associated with 5 to 10 risk factors to divert the aggression upon them in the form of suicide. A correlational analysis revealed that the decrease in income and irrigation facilities with the victims there had been increasing risk factors of suicide with the victims. In addition to this increase in the extent of fulfilling the various family responsibilities there is an increase in risk factors of suicide. In group of socio-psychological characteristics, the victim's habits, victim's health problem, other family members' health problem and family disputes increased in family, there was increase in the risk factors of suicides with the victims. The regression analysis revealed that among all variables annual income, socio-economic status, irrigation facilities, extent of family responsibility fulfilled, victim's habit, victim's health, family health, and family disputes were the major determinants for aggregation of identified risk factors of suicide among the victims, hence there is a need to take care of these triggers for avoiding suicides in future by applying various planning and developmental measures in agriculture and with the families of suicide farmers.

Agriculture in India is the most important sector in terms of providing employment and reducing poverty, but the poor performance of the sector after mid-1990s and the distress of the farmers highlighted the need to focus and analyse the problems and steps needed to revitalize agriculture. (Dev 2007). During the last one decade, some 150,000 farmers are reported to have committed suicides across the country and the relief package offered by the Government failed to have the desired effect.

MATERIAL AND METHODS

The present study was based on Exploratory Design of Social Research and carried out in suicide hit six districts of Vidarbha region of Maharashtra. These districts were Yavatmal, Washim, Buldana, Akola, Amravati and Wardha. In this study respondents were the households of selected victim who committed suicide during 1st January 2006 to 31st December 2006 and had declared as a legal victims by district level committee headed by Collector of the respective district, for allotting compensation of Rs. 1 lakh and had got Rs. 1 lakh compensation. The time period 1st January to 31st December 2006 was selected purposively as in this period maximum numbers of suicides were occurred in selected districts of Vidarbha. Before sampling researcher had contacted personally to the collector offices of these selected districts, and obtained the complete list of farmers those who committed suicide during 1st January to 31st December 2006. In all, there were 1448 total suicide cases in selected six districts, out of which 874 cases were declared as illegal and 574 cases were declared as legal victims. From the list of 574 legal suicide cases, researcher had selected 200 victims by proportionate method of random sampling. It covers 178 villages and 34 *tahsils / talukas* of six districts.

As suicide is a sensitive social issue and thus the investigation has to be made with very guarded and careful manner, and without hurting the sentiments of the family. Data were collected by personal interview method with the help of structured and unstructured interview schedule. Interview was conducted at residence of respondent so as to review over all situation of the family by researcher. In addition to personal interview, RRA technique, time line study for historical perspectives,

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observations, discussions with family members and discussions with key informants (*Police Patil, Sarpanch*, local leaders, other farmers of that village), reviewing victims' actual records of institutional debts etc. were some important methods used for data collection. The objectives of the study were as follows:

1. To study the various socio-psycho risk factors associated with suicidal farmers of Vidarbha.
2. To study the correlation and regression analysis of selected characteristics of the victims with their identified number of socio-psycho risk factors of suicides.

RESULTS AND DISCUSSION

Socio-psycho risk factors of suicides

Distribution of selected victims according to their identified socio psychological risk factors of suicide is shown in Table 1. A critical look of data presented in Table 1 reveals that total 22 socio psychological risk factors were associated with the selected deceased farmers, who committed suicide. A number of risks factors can coexist and one particular individual can come across all or none of the risk factors identified by the researcher. In selected sample, the minimum number of risk factors was one and the maximum was ten. The identified risk factors are presented in a descending order based on frequency of their occurrence in total sample.

The most common risk factor was 'increased indebtedness' that was found in 94.00 per cent deceased farmers. Out of 200 victims 91.00 per cent victims were defaulters as they availed the credit facility from various banks but not repaid the loans in time due to crop failures. Hence they were also not eligible for getting the fresh institutional credit.

In more than three fourth of the cases (78.50%), crop failure due to monsoon vagaries was mentioned. Crop failure can lead to economic downfall and make it difficult to repay the existing loans of institutional and non-institutional sources. Introvert personality was identified in 71.00 per cent deceased farmers, as they did not discuss or share their problems with other family members, leading to more frustration. In sizable number of cases (42.00%), alcohol use disorder was associated. This might be to overcome the inability to face the hard realities of life. Change in the individual's behaviour was identified in more than one third (37.50%) cases due to stressful life events. These indicate that the individual need some psychosocial help or treatment on depression or counseling.

Effect of suicides in the adjoining villages was identified as an additional risk factor in 34.00 per cent cases. In one-fourth deceased farmers (25.00%) their family members suffered from ill health. Daughter/ sister of marriageable age was found as reason in 22.00 per cent deceased farmers. The personal health problem of the deceased was identified in 19.00 per cent of the cases. The ill health can lead to a loan from non-institutional agencies to meet medical expenses and also reduce the ability to work, aggravating the economic condition. In 32 (16.00%) victims, disputes/ quarrel was noticed with their family members due to domestic reasons. Out of this, in 16 victims (50.00%) alcoholic tendency was noticed as the main reason for quarrel or disputes.

Family history of suicide or suicide attempt was identified as one of the additional risk factors in 5.50 per cent of the cases. This could be indicative of genetic factor, followed by disgraceful events happened in 4.00 per cent cases. This created a loss of face in the society. Death of family member before the incident was identified in 4.00 per cent of the cases. The near one's death could have been because of not receiving appropriate health care. Inability to provide care is largely because of the poor economic condition rooted in the largest agrarian crisis, while two per cent victims had given the verbal clues of suicide before the incidence of suicide. It showed the self-harming behavior of the victims due to poor economic condition.

Meager (1.50 %) victims were depressed due to land / domestic disputes in court, 1.50 per cent cases had disputes with the neighbours, 1.00 per cent each had disputes with moneylenders, were depressed over unemployment after education and suicide by close friend. In addition to this, in 1.00 per cent victims, their self-esteem was decreased due to disgraceful events done by the family members and 1.00 per cent victims had no children due to infertility in spouse.

Above findings indicate that the risk factors can co-exist and can be interrelated and that they feed into each other and aggravate each other. They are not mutually exclusive, and hence, will be more than 100 per cent. The average number of risk factor was observed 5.4.

Table 1. Distribution of victims according to their identified socio-psycho risk factors of suicides

S. N.	Risk factors	No (200)	Percentage
1	Increased indebtedness.	188	94.00
2	Drop in economic status	169	84.50
3	Hopelessness	157	78.50
4	Introvert ness	142	71.00
5	Alcohol use disorder	84	42.00
6	Change in behaviour	75	37.50
7	Effect of suicides in the adjoining villages	68	34.00
8	Family members chronically ill /handicapped	50	25.00
9	Daughter / sister of marriageable age	44	22.00
10	Deceased having health problem	38	19.00
11	Disputes/quarrel with the family members	32	16.00
12	Family history of suicide / suicide attempt	11	5.50
13	Disgraceful events	08	4.00
14	Death of family member before incident	08	4.00
15	Given verbal clues of suicide	04	2.00
16	Depressed due to disputes in court	03	1.50
17	Disputes with the neighbours or others	03	1.50
18	Dispute with moneylender	02	1.00
19	Depressed over unemployment after education	02	1.00
20	Decreased self esteem events	02	1.00
21	No children	02	1.00
22	Suicide by close friend	02	1.00
	Average number of risk factors	5.4	547.00

(The risk factors are not mutually exclusive, and hence, will not add up to 100 per cent.)

Table 2. Distribution of victims according to identified number of socio-psycho risk factors of suicides

S.N.	Number of risk factors	Number	Percentage
1	1-4	57	28.50
2	5-6	86	43.00
3	7-10	57	28.50
	Total	**200**	**100.00**

Mean = 5.47

The above findings are in conformity with the findings of Mishra (2006), who observed that average number of risk factors associated with victims was 4.8 and the most common risk factors were, indebtedness (86.00%), followed by economic status deteriorated (73.90%) and deceased not shared the problems with other family members (55.00%).

Number of risk factors and suicide cases

Distribution of selected victims according to identified number of risk factors associated with their suicide is shown in Table 2. It is apparent from the data in Table 2 that in maximum percentage of the deceased farmers (43.00%) five to six risk factors were associated, while one to four and seven to ten risk factors were

associated in 28.50 per cent each of the cases. Thus it is concluded that over two third (71.50 %) of the cases were associated with 5 to 10 risk factors to divert the aggression upon them in the form of suicide. This finding is in line with the finding of Madan (1965) and Mishra (2006) that many factors combine to cause one particular individual to divert his aggression upon himself in the form of suicide.

Correlational analysis

A closer look at the values of correlation coefficient Table 3 brings into light that the personal characteristics namely, the age, education, caste, family size, family type and farming experience of the victims did not show any significant relationship with the identified number of risk factors of suicide. As regards the socio-economic variables, the land holding, subsidiary occupation and socio-economic status were found to have non significant relationship with the identified number of risk factors of suicide, whereas annual income was observed to have high negative significant relationship with the identified number of risk factors of suicide. This shows that with the decrease in income, the risk factors of suicide with the victims are more prominent and hence presence of low income has been proved as one of the specified causes of suicide of farmers in Vidarbha.

In the group of situational characteristics, the type of land, agriculture infrastructure and indebtedness were non-significantly related with the identified number of risk factors of suicide, whereas irrigation facilities available with victims were having negatively significant relationship with identified number of risk factors of suicides. This indicates that with the decrease in irrigation

Table 3. Coefficient of Correlation of selected characteristics of the victims with their identified number of socio-psycho risk factors of suicides

S. N.	Characteristics	"r" value
A.	**Personal**	
1	Age	-0.0116
2	Education	0.0443
3	Caste	0.0781
4	Family size	-0.0500
5	Family type	-0.0663
6	Farming experience	-0.0052
B	**Socio-economic**	
7	Land holding	-0.1108
8	Subsidiary occupation	0.0630
9	Annual income	-0.2026**
10	Socio-economic status	-0.0597
C	**Situational**	
11	Type of land	-0.0659
12	Irrigation facilities	-0.1467*
13	Agriculture infrastructure	-0.1196
14	Indebtedness	0.0619
15	Extent of family responsibility fulfilled	0.2238**
D	**Socio-psychological**	
16	Victim's habits	0.2596**
17	Victim's health	0.2340**
18	Family health	0.2869**
19	Family disputes	0.1630*

** Significant at 0.01 level of probability *Significant at 0.05 level of probability

facilities with victims, there had been an increase in risk factors of suicides among the victims.

In addition to this, extent of family responsibility fulfilled by the victims had shown positive significant relationship with identified number of risk factors of suicide. This shows that with increase in the extent of fulfilling the various family responsibilities there is an increase in risk factors of suicide.

In group of socio-psychological characteristics, the victim's habit, victim's health, family's health had highly and positively significant relationship with identified number of risk factors of suicide of the victims at 0.01 level of probability, whereas family disputes had shown positive and significant relationship at 0.05 level of probability. This indicates that as the victim's habits, victim's health problem, other family members' health problem and family disputes increased in family, there was increase in the risk factors of suicides with the victims. According field survey observations, this is indicative of poor economic condition of the victims.

Multiple regression analysis

With a view to find the significant contribution of independent variables in identified risk factors of suicide all the selected variables were fitted into the simple linear regression model. The results pertaining to the regression analysis were given in Table 4. The result reveals that there is negative and highly significant contribution of annual income with identified risk factors of suicide of the victims. While, irrigation facilities has negative and significant contribution with identified risk factors of suicide. It means that lowering annual income and irrigation facilities has produces additional risk factors of suicide with the victims.

Table 4. Regression analysis of selected characteristics of the Victims with their identified number of socio-psycho risk factors of suicides

S. N.	Characteristics	Regression coefficient 'b'	SE (b)
A.	**Personal**		
1	Age	-0.010	0.018
2	Education	-0.024	0.034
3	Caste	0.042	(0.047)
4	Family size	0.035	(0.059)
5	Family type	-0.061	(0.256)
6	Farming experience	0.005	(0.019)
B	**Socio-economic**		
7	Land holding	0.017	(0.099)
8	Subsidiary occupation	-0.027	(0.136)
9	Socio-economic status	0.336*	(0.143)
10	Annual income	-0.000**	(0.000)
C	**Situational**		
11	Type of land	-0.126	(0.107
12	Irrigation facilities	-0.266*	(0.119)
13	Agriculture infrastructure	0.01	(0.015
14	Indebtedness	0.000	(0.000)
15	Extent of family responsibility fulfilled	0.103**	(0.030)
D	**Socio-psychological**		
16	Victim's habits	0.552**	(0.125)
17	Victim's health	1.231**	(0.275)
18	Family health	0.910**	(0.254)
19	Family disputes	1.048**	(0.292)
		R^2_{Value} = 0.3876**	F value = 6.00

The variable socio-economics status has positive and significant contribution with identified risk factors of suicide. While extent of family responsibilities fulfilled, victim's habits, victim's health, family health and family dispute had positive and highly significant contribution with identified risk factors of suicide of the victims. It means that increasing socio-economic status, extent of family responsibility fulfilled, victim's habit, victim's and family members' health problem and family disputes, there is increase in risk factors of suicide with the victim. The contribution of age, education, caste, family size, family type and farming experience, land holding, subsidiary occupation, type of land, agriculture infrastructure and indebtedness was not found significant with identified risk factors of suicide.

When all the 19 variables were fitted in multiple regression equation the Coefficient of Multiple Determination (R^2) comes to 0.3876 and the obtained R^2 value was tested for its significance by computing "F" value and comparing it with "t" table value at n-k-1 degrees of freedom and was found significant. This shows that all the selected 19 variables contributed 38.76 per cent significant variation in identified risk factors of suicide of the victims.

CONCLUSION AND IMPLICATIONS

The distribution of identified risk factors associated with an individual deceased farmer leads to conclude that over two third were co-existed with three common risk factors, these were increased indebtedness (94.00%), drop in economic status (84.50%) and hopelessness due to crop failure (78.50%) and these risk factors show the deteriorated economic condition of the deceased farmers. Over two third (71.50 %) of the cases were associated with 5 to 10 risk factors to divert the aggression upon them in the form of suicide.

A correlational analysis revealed that the decrease in income and irrigation facilities with the victims, there had been increasing risk factors of suicide with the victims and hence presence of low income and lack of irrigation facilities had been proved as one of the specified causes of suicide of farmers in Vidarbha. In addition to this increase in the extent of fulfilling the various family responsibilities there is an increase in risk factors of suicide. In group of socio-psychological characteristics, the victim's habits, victim's health problem, other family members' health problem and family disputes increased in family, there was increase in the risk factors of suicides with the victims.

The regression analysis revealed that among all variable annual income, socio-economic status, irrigation facilities, extent of family responsibility fulfilled, victim's habit, victim's health, family health, and family disputes were the major determinants or 'events' 'actors' 'stressors' or 'triggers', for aggregation of identified risk factors of suicide among the victims, hence there is a need to take care of these triggers for avoiding suicides in future by applying various planning and developmental measures in agriculture and with the families of suicide farmers.

This study suggests that the situation can be improved, if economic empowerment is ensured by creating subsidiary occupations. It was observed that 99 per cent suicide victims had no subsidiary occupations to support their livelihood and majority of them had medium to large family size. This implies that efforts are needed by respective line departments to involve such farmers in goat farming, dairy, small dairy unit with one or two milch animals and small poultry unit. While going through results of this research study, very dreadful condition of the households came out that majority victims had low income level. With very low and low socio-economic status level, near about cent percent were defaulters and indebted. The income that they got from all sources, was not even enough to meet the essential expenditure of the households; hence these farmers were in severe distress. The relational analysis showed that the present spate of suicides in Vidarbha region is due to economic crisis, i.e. due to low income level of the deceased farmers. For improving this situation, policy makers have to think critically about the change in economic condition of the farmers of Vidarbha. For this some measures are suggested. In short-term measures there is an urgent need to declare remunerative prices for all crops of farmers in consonance with the cost of cultivation. In selected six districts of Vidarbha, 85.00 per cent area is rainfed, hence farming is most vulnerable to the vagaries of nature. So the farmers take only kharif crops. If the crops fail, the farmers become incapable of paying back the loan and when crops fail in two or more consecutive seasons, farmers invariably find themselves in a debt trap. Hence it is suggested to provide crop insurance facilities with low premium affordable by the farmers for all crops and to all farmers, and insurance unit should be reduced to Village Panchayat for at least for major crops. Some

households also reported about regular trouble of wild animals that created huge losses to victims' households. For avoiding this condition, the Government should give immediate financial help to affected farmers in natural calamities like flood, drought and in losses by wild animals.

In addition to the above mentioned short term measures, the policy makers should have to apply following long term measures for uplifting the farmers socially and economically. In long-term measure bring more land under irrigation by completing ongoing irrigation projects and plan about the new irrigation projects, increasing network of canals, tanks; wells and micro irrigation systems. Motivates the farmers through gross root Government and social functionaries for taking benefit of Mass Marriage Scheme of Government it will definitely help to curtail huge expenses on marriages and other related social functions. NGO's can play a very crucial role in this regard. Similarly provide good quality low cost health care at Govt. hospitals to small and marginal farmers. Sizable, 42.00 per cent victims were observed under alcohol addiction, this might be due to hard real life situations, liquor shops can be closed by passing resolution by more than 50.00 per cent women in the community as a lawful action may help a big way to refrain people from alcohol consumption. Disputes/ quarrel were observed in 16.00 per cent victims with their family members particularly with his spouse, due to domestic reason and alcoholic tendency of the victims. Hence, socio-psycho counseling of such disputed families is essential, through forming special body of local leaders and eminent persons at each village level for solving family problems.

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Taxonomic Studies on Parasitoids of sub family Tetrastichinae belonging to Uttarakhand

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ABSTRACT

Insects subfamily Tetrastichinae (Eulophidae :Hymenoptera) is ecologically and economically important for controlling crop pests. Only 5 per cent of the hymenopteran fauna has been recorded in India. Eulopidae is large family of the superfamily Chalcidoidea consisting of about 350 genera and more than 3,000 species. The present study on subfamily Tetrastichinae (Eulophidae : Hymenoptera) has been elaboratively studied for 3 genera and 4 species *Leptocybe invasa* Fisher and LaSalle, *Neotrichophoroides viridimaculatus* (Fullaway), *Neotrichophoroides tonimus* (Narendran), *Citrostichus phyllocnistoides* (Narayanan) were redescribed.

Due to lack of the information, entomologists are unable to use the beneficial insects fauna to the fullest, surveying species diversity is a prerequisite for strengthening biological disciplines. Parasitic Hymenoptera, wasps belonging to super family Chalcidoidea are ecologically and economically important insects for the control of other insect pest population (LaSalle, 1993). According to Gibson *et.al.* (2000) the species of Chalcidoidea, were distributed in 20 families and 86 subfamilies and the estimated number of species have ranged between 60,000 and 1, 00,000. Among these families, the members of Eulophidae are promising for controlling of insect pests of agricultural importance worldwide. Eulophidae is large family of the superfamily Chalcidoidea comprising of about 300 genera in the World, among these 150 genera are found in the Indo-Australian region and about 60 genera in the Indian subcontinent (Narendran and Fousi, 2002).Under Eulophid Tetrastichinae subfamily is one of the largest and most widespread of all parasitic Hymenoptera. Species occur in virtually all terrestrial habitats in all geographic realms, and constitute an important component of terrestrial ecosystems. The first taxonomic work on Tetratsichinae was done by Burks (1943), who provided key to North American species of *Tetrastichus.* The member of subfamily Tetrastichinae are important parasitoids of number of pests in agriculture and horticulture crop ecosystem such as *Tetrastichus pyrillae* on sugarcane leafhopper, *Tetrastichus schoenobii* on eggs of Rice stem borer, *Citrostichus phyllocnistoids* on leaf miner which is a devastating pest of citrus. Recently, Hayat and Shahi (2004) and Narendran (2007) included 34 genera and 272 species of subfamily Tetrastichinae. Still many species are waiting to be discovered and employed in pest management system as a part of it and to furnish more information on basic studies of parasitoids, the present work on taxonomic studies on parasitoids of subfamily Tetrastichinae (Eulophidae : Hymenoptera) collected from Uttarakhand (India) has been carried out.

MATERIAL AND METHODS

Collection of parasitoids

Parasitized eggs and different stages of host insects along with healthy host and damaged material like pieces of barks, leaves, stems, twigs, pods and other plant parts were collected from selected areas of Uttarakhand (India) during 2010-11 to facilitate their correct identification. Different other methods of collections were also used in order to collect large amount and variety of microhymenoptera. Complete record of collected specimen has been maintained.

The collected pieces of barks, leaves, stems twigs, pods and other plant parts were cut into small pieces and put in rearing jars with due care so that live insect should not escape. A slip was fixed to each jar indicating the reference number.Constant temperature cabinet running at 70°F and with 70 per cent RH to expedite the emergence of parasitoids, otherwise the parasitoids were reared under room temperature. The rearing jars were examined daily for the emerged parasitoids.

Emerged parasitoids were collected from jars and preserved in 75 per cent alcohol in glass vials. Whenever

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larger number of parasitoids emerged in plastic tubes, specimens were transferred to empty vials then separated to generic level under binocular microscope as suggested by Narendran (2007) on Indian Tetrastichinae.

Preparation of permanent slides, measurements and illustrations

Permanent slides were prepared by following normal process of dehydration. Dissection was carried out in clove oil for various parts in Canada balsam. The slides were examined drawings and detailed study of each structure was made with the help of Camera Lucida. Description of eulophid parasitoids was carried out by using conventional terminology has been followed.

RESULT AND DISCUSSION

Redescription of the species is discussed here in detail.

Subfamily- Tetrastichinae

GENUS *Leptocybe* Fisher and LaSalle

(Type species: *Leptocybe invasa* Fisher and LaSalle)

***Leptocybe invasa* Fisher and La Salle**

Leptocybe differs from *Oncastichus* in having the postmarginal vein less than 0.25 the length of the stigmal vein (0.6–1.0 in *Oncastichus*).

PLATE-1 (Fig,1-9)

Female. Length 1.1–1.4mm. Head and body brown with slight to distinct, blue to green metallic shine; mouth margin light brown to yellow. Fore coxa yellow, middle and hindcoxae the same colour with the body; legs and tarsi yellow, last tarsal segment brown apically. Antenna with scape yellow (darkened apically); funicle and club (brown to light brown).Wings hyaline or very faintly and evenly infumated, vein slight brown.

Head:(fig.2) Generally strongly collapsing, particularly along weakened areas associated with a deep sulcus around the ocellar triangle. POL distinctly longer than OOL. Antennal torulus inserted about halfway between clypeal margin and median ocellus, and above level of ventral eyemargin. Scrobal cavity with median line. Head weak, with distinct groove and weakened area around ocellar triangle; frontofacial suture deep,forming anterior part of groove around ocellar triangle. Malar sulcus distinctly curved. Gena relatively large and rounded behind malar sulcus. Clypeus weakly bilobed.

Antenna : (fig.1) With 4 anelli; 3 funicular segments;3 club segments. Scape slightly expanded ventrally. Pedicel long, over half the length of the scape. Funicular segments all roughly quadrate.

Mesosoma:(fig.5) Pronotum short. Midlobe of mesoscutum without median line, with 2–3 weak, short adnotaular setae at lateral margin. Scutellum with submedian and sublateral lines. Dorsellum somewhat elongate, medially as long as propodeum.Propodeum without median lines or lateral carinae or plicae. Propodeum with a raised lobe of the callus that partially overhangs the outer rim of the spiracle; spiracular depression open to anterior margin of propodeum.

Forewing : (fig. 8, 9) Submarginal vein generally with 3–4 dorsal setae, but may have 2 or 5. Postmarginal vein short, less than 0.25 length of stigmal vein. Veins brown, witha faint hyaline area between parastigma and marginal vein. Basal cell without setae; basal vein usually with 1 seta. Speculum small;cubital row of setae not extending to basal vein (speculum open behind).

Gaster : (fig.6))Short, ovate. Hypopygium extending just over half the length of the gaster. Two longest cercal setae subequal in length and straight or only slightly curved. Ovipositor sheaths short, not reaching apex of abdomen.

Material studied: 2 female one dissected and mounted on a slide, India, Uttarakhand.,Agroforestry Reaserch station 24-11-2011,Pantnagar, Hym. (Eulophidae: Tetrastichinae),N0-14.

Genus *Neotrichoporoides* Girault

This genus comes very near to *Aprostocetus* Westwood in having one of the cercal setae longer than others; rim of callus partially covering propodeal spiracle and SMV with 4 or more dorsal setae. It differs from *Aprostocetus* in the combination of characters given above under diagnosis, mainly in the long MV and in having relatively stronger sculpture on propodeum than on the scutellum.

(Type species: *Neotrichoporoides uniguttatus* Girault)

***Neotrichophoroides Viridimaculatus* (Fullaway)**

(PLATE NO. 2, Fig. 1-9)

Female: Yellow species with characteristic pattern of black or metallic green markings that form the broken

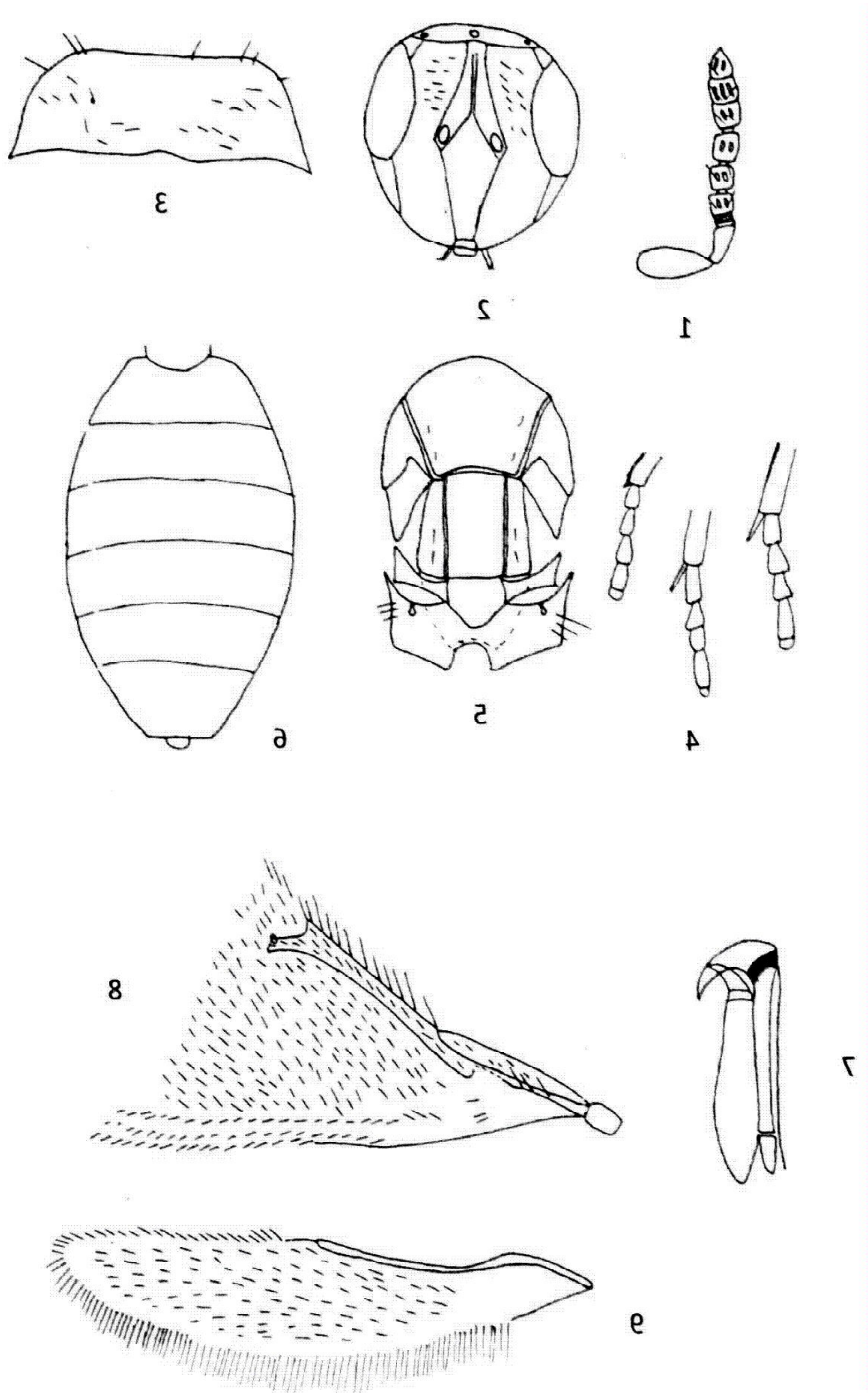

Plate1: ***Leptocybe invasa*** **1. Antennae 2. Head 3. Pronotum 4. Legs 5. Thorax 6. Abdomen 7. Ovipositor 8.Forewing 9.Hindwing**

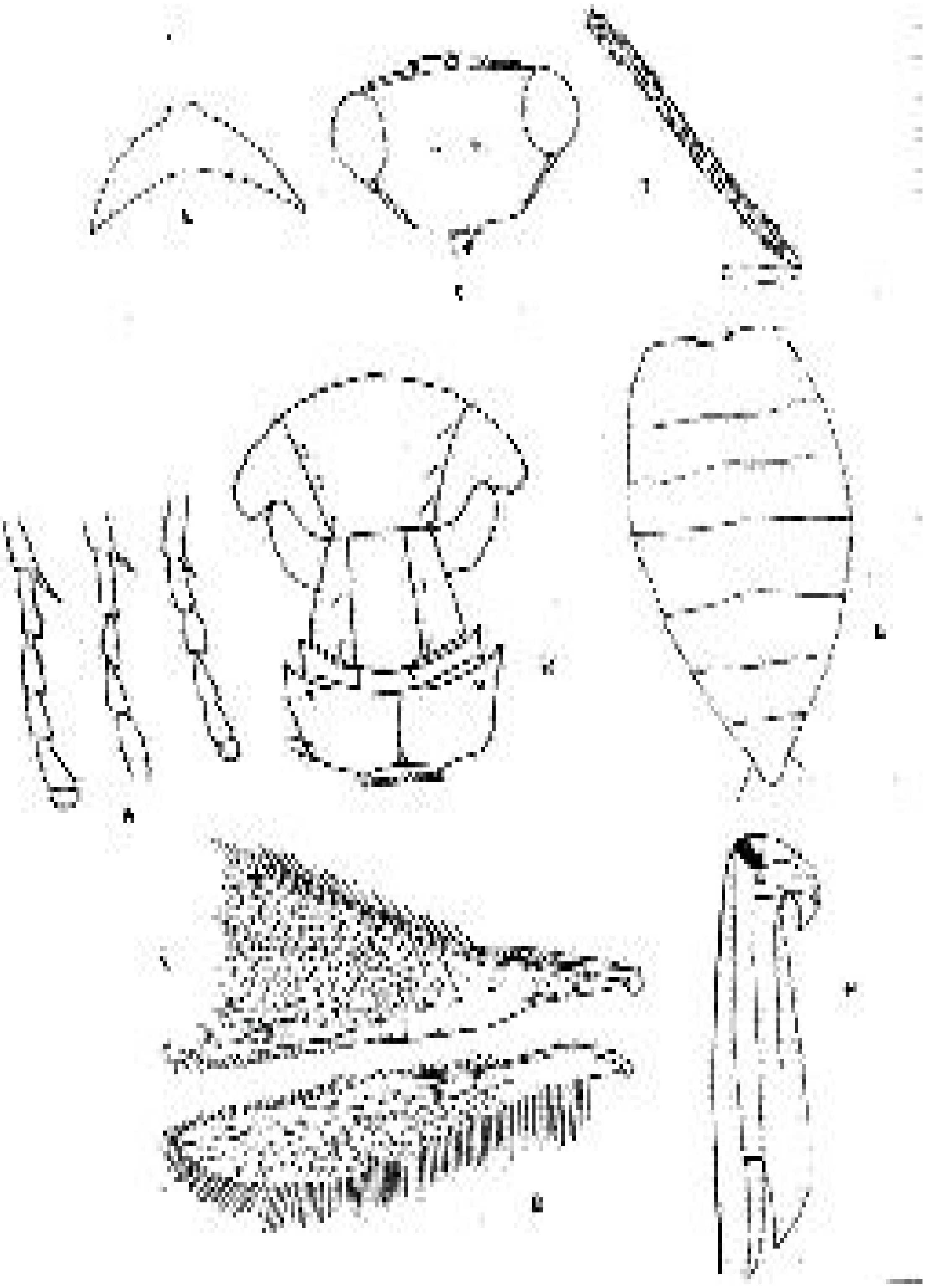

Plate 2 : *Neotrichophoroides viridimaculatus* (Fullaway) 1. Antenna 2. Head, in frontal aspect 3. Pronotum 4. Abdomen 5.Thorax 6. Forewing 7. Hindwing 9. Ovipositor

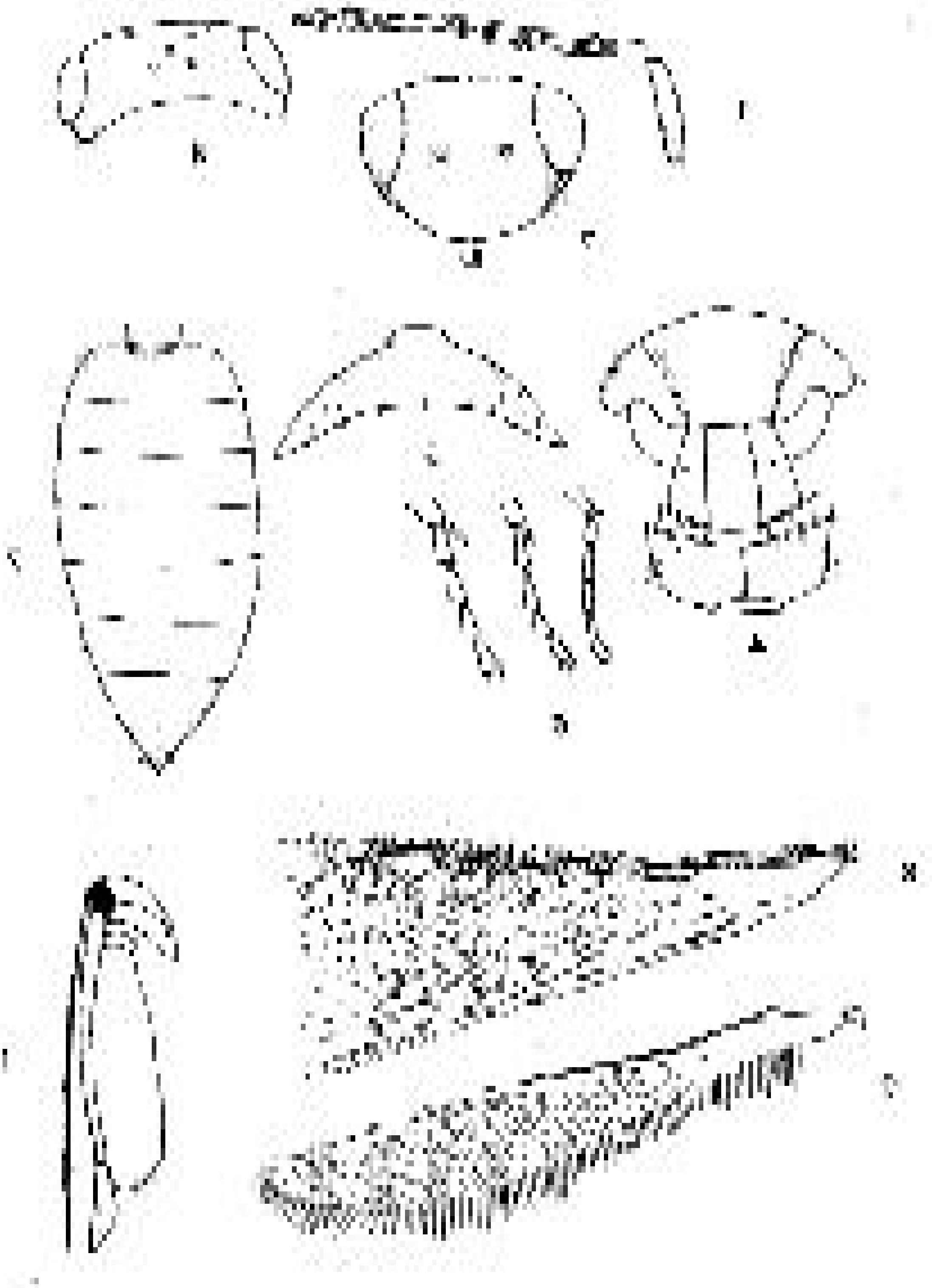

Plate 3: *Neotrichophoroides tominus*(Narendran) **1. Antenna 2. Head, 3 Head in dorsal view 4. Thorax 5. Pronotum 6. Leg 7. Abdomen 8. Forewing 9. Hindwing 10. Ovipositor**

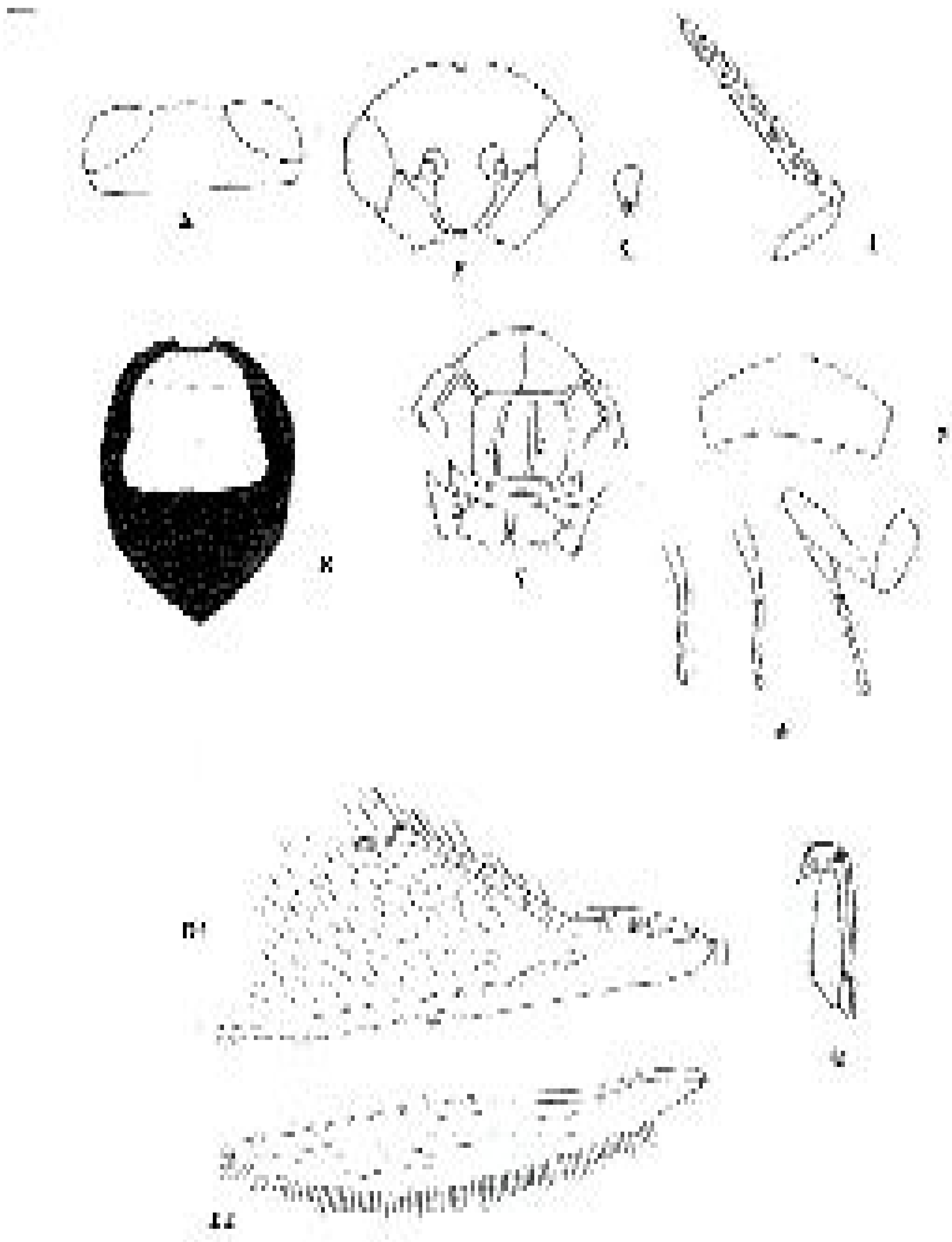

Plate 4 : *Citrostichus phyllocnistoides* (Narayanan): 1. Antenna 2. Mandible 3. Head 4. Head, Dorsal view 5. Pronotum 6. Legs 7. Thorax 8. Abdomen 9. Ovipositor 10. Forewing 11.Hindwing

longitudinal stripes, upper part of frons, vertex and occiput slightly darker; eyes blackish brown with posterior margin pale yellow; antenna dark brown with scape and pedicellus pale brownish yellow; pronotum submarginal groove of scutellum absent or faintely indicated in part; surface relatively smooth and shinywith fine engraved reticulation. Legs completely yellow.

Head : fig(2) 2.44x as wide as long as in dorsal view; head width in anterior view 1.8x its length;POL 1.3x OOL ;OOL2x OD;MS with triangular fovea, not reaching half length of MS.

Mesosoma : (fig.5) 3 adnotaular setae on either side mesoscutum. a little longer than the width between SLG ,callus with 3 setae. Pronotum about 0.5x length of mesoscutum; anterior pair of scutellar setae placed little above middle.

Wing : (fig.7,8) SMV with 6 dorsal setae .;MV 7.71x as long as STV; front age of MV with 12-13 setae;PMV absent;speculum setose and closed behind by cubital line of setae which reaches near base of wing.PMV rudimentary.speculum setose,open behind.

Legs(fig.6): Legs completely yellow with slight reticulation,hind coxa distinctely reticulate 1.4x as long as broad. Spur of midtibia about 0.67x length of basitarsus.

Gaster:(fig.4) Slightly longer than head plus mesosoma,2.8x as long as broad.tip of hypopigium always reaching middle of gaster.

Male: Not known

Materials studied : 2 female one dissected and mounted on a slide, India, Uttarakhand., Pantnagar, H.R.C., sweepnet collection, Ber orchard, 23-8-2010.Hym.(Eulophidae:Tetrastichinae).N0-21(Gajbe Nitin Dadaji).

***Neotrichophoroides tonimus* (Narendran) (PLATE NO.3 Fig.1-10)**

Female : Length 2.18mm.Head yellow with upper part of of frons, vertex slightly yellow, front ocellus reflecting red,hind ocellus yellow, antennae dark brown with scape and ventral side of pedicel pale brownish yellow; pronotum metallic green with ventral side yellow, legs completely yellow with hind coxa dark brown gaster dark brown with base of dorsellum slightly pale. Wing hyaline; veins yellowish brown.

Head: (fig.1) Distinctly wider; than mesoscutum;2.22x as wide as long in dorsal view; head width in anterior view 1.1x its length; POL 1.5x OOL ;OOL3x OD. Eye length about 1.28x its width in side view; MS with triangular fovea. Antenna with scape 0.86x length of eye, slightly exceeding the level of vertex. pedicellus plus flagellum 1.75x width of mesoscutum; pedicellus 2.5x as long as wide, about 0.61x length of F1.Relative length:width of antennal segment:scape=21:4;pedicellus =10:4F1=15:5,F2=14:5,F3=13:5;Clava=20:6.

Mesosoma:(fig4,5) Pronotum about as long as mesoscutum, hind margin hardly arched; mid lobe of mesoscutum 1.3x its width,moderately shiny 4 adnotaular setae on either side, posterior pairs longer than other pairs; scutellum as long as mesoscutum, a little longer than the width between SLG sculptured as mesoscutum;SMG nearer to SLG than to each other. Spiracle situated a distance less than its diameter from metanotum; callus with 3 setae.

Leg: (fig.6) Hind coxae weakly reticulate,1.71x as long as wide .

Wing:(fig.8,9) Forewing 3.13x as long as wide;CC 0.72x length of MV ;SMV with 4 dorsal setae;MV 7.71x as long asSTV;front age of MV with 18-20 setae; PMV absent; speculum setose and closed behind by cubital line of setae which reaches near base of wing.

Gaster:(fig.7) Ovate at apex,1.24x as long as combined length of head plus mesosoma.

Male: Not known

Material studied: 2 female one dissected and mounted on a slide, India, Uttarakhand., Pantnagar, H.R.C., sweepnet collection, Ber orchard, 23-8-2011. Hym. (Eulophidae:Tetrastichinae) (Gajbe Nitin Dadaji).

Genus *Citrostichus* Boucek

This species was first described by Narayanan in 1960 as *Cirrospilus phyllocnistoides*. Although recorded as parasitoid of Citrus leaf miner (Boucek,1998),it also has been reported to parasitize nymphs of *Trioza obsolete* Buckton(Homoptera : psyllidae).

Head and Pronotum very densely and distinctly granulate. Body dark, gaster with yellow spot. Foramen magnum situated very low. Lower face with longitudinal pits. Clypeal margin slightly produced.

(Type Species: *Cirrospilus phyllocnistoids*)

***Citrostichus phyllocnistoides* (Narayanan)**

(Plate No.4 Fig.1-11)

Female : Body length about 1.15-1.4mm; body colour Brown to black;non metallic head brownish black in colour, almost as wide as mesosoma and eyes are redish brown, moderately pilose POL 1.2-1.6x OOL; antenna flagellum brown,pedicellus and scape testaceous,antennal formula 11133 scape long and more than twice as long as pedicellus, pedicellus shorter than F1, F2 longer than F2. thorax; wings pale yellowish veins brown;legs including coxae testaceous; gaster light brown with hyaline patch occupying most of tergal area of T1,T2andT 3.

Head (Fig3) : fronto vertex width more than ½ the total head width;vertex suture present with ,POL slightly more than 2 times as long as OOL; compound eyes small and smooth, antennal toruli situated just at the lower level of eye margin; malar sulcus straight; malar space shorterlarger than eye width; mandibles tridentate, maxillary and; lower margin of clypeus narrow truncate.

Antennae (Fig.1): 8 segmented excluding 2anelli, apical tip of antenna with spicule, antennal formula 1,113,3; scape cylindrical,slightly less than 2 times as long as wide, scape apex touching to mid ocelli; pedicel more than 2times as long as wide and shorter than the length of the FS1; funicle3 segmented, FS1 less than 1.5 times as long as wide, FS2 more than 1.5 times as long as wide, FS3 more than 1.5 times as long as wide, club3 segmented, more than 2 times as long as wide, shorter than preceding two funicle segments combined.

Mesosoma (Fig7.) : anterior margin concave in the middle; mesoscutum less than 2 times as wide as long; mesoscutum having single setae, notauli complete, axilla slightly advanced; scutellum,longer than mesoscutum with longitudinal grooves and 2 pairs of setae situated on scutellum; metanotum broad; propodeum with Y' without paraspiracular carinae; propodeal spiracles small and well separated from the anterior margin of propodeum, spiracle rim not fully exposed.

Fore wings (Fig10) : less than 2 times as long as wide; more than 1.5 times longer than hind wing length; costal cell long, narrow; SMV with one setae directed upwards, MV bearing long setae on front edge; PMV reucedless than one third times longer than SV; marginal fringe short; basal vein present;cubital vein present, subcubital line of hairs also present. **Hind wings (Fig. 11):** more than2times as long as wide with blunt apex.

Fore Legs (Fig6): Legs hairy/smooth, tibial spur short. **Mid legs (Fig6)**: Tibial spur small; spur shorter than basitarsi. **Hind legs (Fig.6)**: Shortest tibial spur sub equal in length to the first basal segment.

Gaster : (fig8,9) Ovate; less than 2 times as wide as long, gaster surface hairy, ovipositor sheaths not exerted; first valvifers triangular; anterior margin of basal part of second valvifers not much curved; third valvulae rudimentary; cercal setae short.

Male : Not known.

Material studied: Two female, one dissected and mounted on a slide, India,Uttarakhand., Pantnagar, HRC, Pattarchatta, 21-9-2010.Hym. (Eulophidae:Tetrastichinae) S10 (Gajbe Nitin Dadaji).

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PKV Res. J. Vol. 38 (2), July 2014

Integrated Management of Pests Infesting on Rice

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ABSTRACT

A trial on integrated pest management (IPM) in rice was conducted at AICRIP, Agriculture Research Station, Sakoli, Dist. Bhandara during 2012-13 with an objective to validate IPM practices from a basket of options available and demonstrate to farmers the management of pests in a holistic way (including insects, diseases and weeds). The results revealed that gall midge damage (silver shoot) was high in farmer's practices (FP) (11.32 %) as compared to IPM (8.11 %). Incidence of stem borer, leaf folder, leaf blast and bacterial leaf blight were high in FP as compared to IPM. Population of BPH and WBPH numbers were also high in FP as compared to IPM, which could be mainly due to wider spacing, provision of alley ways and mid season drainage. The weed population was significantly low in IPM plot with nearly three times less population than in FP plot. The weed dry weight also indicated similar trend. Grain yield was significantly high in IPM (28.00 q/ha) as compared to FP (17.60 q ha^{-1}). Similarly, B:C ratio was high in IPM (1.72) than FP (1.32).

Rice (*Oryza sativa* L.) is very important staple food crop for 65 per cent of the population in India. It plays a vital role in our national food security and is a means of livelihood for millions of rural households. One of the major constraints in achieving the desired level of rice production is the menace of insect pests which causes about 30 per cent yield loss (Dale, 1994, Grist and Lever, 1969). More than 100 species of insects have been reported attacking the rice crop (Heinrichs *et al.* 1979). There is major change in the status of several rice insect pests and diseases in the recent past in Eastern Vidarbha zone. Several relatively minor pests such as leaf folder, army worm and cutworm are gaining importance, the brown plant hopper and white backed plant hopper besides gall midge and stem borer becoming major ones. Blast is a major disease of rice in this region. Intensive cultivation of rice has resulted in the frequent outbreaks of pests and diseases. To mitigate these problems adoption of integrated pest management modules is primary option in implementation of pest management strategies at present.

Concerted efforts have been made in the last two decades to develop and implement location specific integrated pest management strategies across the diverse ecosystem in rice (Razak, 1986, Sankaran, 1987, Krishnaiah and Reddy, 1989). Though, the validation of effectiveness of IPM in rice has been carried out in farmers fields, there is still adequate scope for enhancing the use of ecofriendly components within the framework of IPM thereby possibly minimizing or avoiding the use of toxic chemicals, for long term economic, ecological and social benefits to farmer.

As IPM involves a number of components, farmers must have capability of taking decisions and selecting IPM options accordingly for economical and long term management.

Most of these options also need to be refined at individual farm level keeping in view the availability and feasibility of farmers accordingly, a trial on IPM was conducted with an objective to validate IPM practices from a basket of options available and demonstrate to farmers the management of pests in a holistic way (including insects, diseases and weeds).

MATERIAL AND METHODS

Treatments	:	Two treatments. i) IPM ii) Farmers Practices (FP)
Replications	:	Five replications
Area	:	0.40 ha
Variety	:	PKV HMT
Fertilizers applied	:	Single Super Phosphate 100 kg + Urea 50 kg
Treatments Details	:	The package of practices to be followed in each block are given below:

1. Assistant Prof. and 2, 3 & 4. Associate Prof., Department of Entomology, Dr. PDKV, Akola

A) IPM

1. Seed treatment done with carbandezim @ 10 g for 10 kg seeds (wet seed treatment). The treated seed were soaked overnight in 10 litre water and kept in gunny bag for germination.
2. Applied carbofuran @ 1.1kg a.i. ha^{-1}, 5 days before pulling seedlings from nursery for transplantation.
3. Seedlings were transplanted at a spacing of 20 x 15 cm.
4. Left alleyways of 30 cm after every 2 m 10^{-1} rows.
5. Applied fertilizer dose at the time of transplanting.
6. Applied butachlor 1.5 kg a.i. ha^{-1} at 3rd day after transplantation. Observations were taken starting from 15 DAT at 10 day interval.
7. At 15 DAT, installed pheromone traps with 5 mg lure (scripolure) @ 8 traps ha^{-1} for stem borer monitoring.
8. The field was manually weeded at 35 DAT.
9. N top dressing was done. Cartap hydrochloride 50 WP @ 600g ha^{-1} was sprayed at 60 DAT.
10. Blanket application of propiconazole 0.1per cent was done.
11. Mid season drainage was followed for management of BPH.

B) Farmers practices

1. Seed treatment done with 3 per cent salt solution and thirum @ 30 g for 10 kg seeds.
2. Seedlings were transplanted at a spacing of 20 x 15 cm.
3. Applied fertilizer dose at the time of transplanting chlorpyriphos 20 EC was sprayed @ 20 ml 10^{-1} liter of water.
4. Two spraying of copper oxychloride @ 25 gm 10^{-1} liter of water and streptocycline @ 0.5 gm 10^{-1} liter of water.
5. The field was manually weeded at 35 DAT.
6. N top dressing was done.

Starting from 15 DAT, observations on pest incidence were recorded on 10 randomly selected hills in each replication (50 hills / each block) at 10 day interval. Recorded numbers of tillers damaged by stem borers (DH/ WE), gall midge (SS), number of damaged leaves (leaf folder) and plant hoppers from the selected hills. Recorded incidence of leaf blast and bacterial leaf blight disease, weeds and yield from each replication.

RESULTS AND DISCUSSION

PKV HMT variety of paddy was grown. Stem borer, gall midge, leaf folder, BPH, WBPH, leaf blast and BLB was recorded (Table 1). Gall midge damage (silver shoot) was high in FP (11.32 %) as compared to IPM (8.11 %). Incidence of stem borer (% dead heart and white earhead), leaf folder, leaf blast and bacterial leaf blight were high in FP as compared to IPM. BPH and WBPH numbers were also high in FP as compared to IPM, which could be mainly due to wider spacing, provision of alley ways and mid season drainage. These practices were not followed in FP plot. The weed population was significantly low in IPM plot with nearly three times less population than in FP plot. The weed dry weight also indicated similar trend. Grain yield was significantly high in IPM (28.00q ha^{-1}) as compared to FP (17.60 q ha^{-1}). Similarly BC ratio was high in IPM (1.72) than FP (1.32) (Table 2).

The present findings are in accordance with Dash *et al* . (2006) who found IPM module was best for irrigated rice against major insect pests and for getting highest yield and highest number of spiders in Sambalpur, Orrisa. Similarly, Tripathy and Kanungo (2008) demonstrated IPM technology in Kulei village of Anguli district of Orrisa and revealed lower incidence of stem borer and BPH and get higher monetary benefit in IPM farmers' field than non IPM farmers' field. Samiayyan *et al.* (2010) also indicated adoption of rice IPM module confirmed the significantly higher yield, natural enemies and lesser pests than the farmers practice. Jena *et al.* (2012) found lower incidence of insect pests of rice and produce highest grain yield in chemical + non chemical base module in comparison with farmers' practice. Nalini *et al.* (2013) evaluated IPDM module in four villages at Madurai East block and revealed that both the insect pests such as BPH, WBPH, stem borer, leaf folder and gall midge and bacterial leaf blight disease decreased and higher grain yield and cost benefit ratio were recorded in IPDM module compare to farmer practice.

The insect pest incidence was high in FP than in IPM plots. Similarly, weed population and weed dry weight were high in FP as compared to IPM plots indicating efficient weed management practices. Grain yield was significantly high in IPM plots resulting in high

Table 1 : Effect of IPM and farmers practices on pest incidence.

Treatment		% Dead Heart	% White Ear-head	% Silver Shoot Damage	% Leaf Folder	Population/ hills		Disease incidence (%)		Weed Count (No.)	Dry Weight (gram) 4 DA
						BPH*	WBPH*	Leaf Blast	BLB 30 DAT	Uprooting	
T_1	**IPM**	2.84	11.58	8.11	1.67	11.83	15.31	0.80	2.56	117.2	16.40
		(1.68)		(2.81)	(1.25)	(3.30)	(3.79)				
T_2	**Farmers practice (FP)**	6.62	15.58	11.32	5.03	20.70	28.66	0.93	2.69	300.4	42.40
		(2.57)		(3.32)	(2.22)	(4.95)	(4.95)				
	LSD(p=0.05)	0.36	-	0.20	0.49	0.87	1.32	-	-	28	4.73
	CV(%)	16.79	-	6.09	19.10	15.41	23.06	-	-	7.68	9.16

*= Number per 10 hills; Figures in the parenthesis are square root transformed values.

Table 2 : Grain yield of rice and monetary returns

Treatment		Yield(q ha^{-1})	Gross return (Rs.)	Cost of cultivation (Rs.)	Net returns (Rs.)	B:C ratio
T_1	**IPM**	28.00	39,200	22,820	16,380	1.72
T_2	**Farmers Practice (FP)**	17.60	24,640	18,638	6,003	1.32
	LSD(p=0.05)	6.83				
	CV(%)	17.07				

Price of Paddy = Rs. 1400/q,

BC ratio. There is a need to give more emphasis for operationalisation of IPM in rice with good support from other stakeholders.

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Efficacy of Various Aqueouseed Extracts Against Major Pests of Okra

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ABSTRACT

Experiment was conducted in Randomized block design with ten treatments consisting of aqueous seed extract replicated thrice during *Kharif* season of 2013-14 on Akola bahar variety against major pests of okra.on the farm of Deptt. of Entomology, Dr. PDKV., Akola. The results revealed that treatment azadirachtin 10,000 ppm @ 2ml l^{-1} and neem seed extract 10 per cent were found most effective in minimizing the population of sucking pests (viz. aphid, leaf hopper and whitefly)and infestation of shoot and fruit borer.During the study, deleterious effect of aqueous seed extracts were found on natural enemies viz. lady bird beetle, chrysopa and spider may be due to seven applications of aqueous seed extracts of various botanicals. As regards yield of okra fruit, azadirachtin 10,000 ppm @ 2ml l^{-1} and neem seed extract 5 per cent and recorded highest yield of 46.37 and 44.16 q ha^{-1} and highest net monetary return of Rs. 35169 and Rs. 29302 and ICBR of 5.23, 4.14 and 2.67, respectively.

'Okra' or 'Lady's finger' *Abelmoschus esculentus* (L.) Monech commonly known as "Bhendi" belongs to the family Malvaceae is one of the important vegetable crops of India. India stands top in area and production with an area of 530.54 thousand hectares and production of 6350.30 MT.Maharashtra occupies an area of 22 thousand hectares with production of 328 thousand MT (Anonymous, 2013). Commonly it is cultivated in *Kharif* and summer. The crop has two distinct growing stages i.e. vegetative and fruiting stages. About 72 species of insect pests have been reported to affect the crop (Srinivasa Rao and Rajendran, 2002).

This crop is infested with a number of insect pests like aphid (*Aphis gossypii* Glover), leaf hopper (*Amrasca biguttulabiguttula* Ishida), whitefly (*Bemisiatabaci* Gennadius), Mite (*Tetranychuscinnabarinus* Boisduval) and shoot and fruit borer (*Earias vitella*Fabricious) from initial stage to flowering and fruiting stage of the crop which causes significant damage to the crops and reduce yield and quality of fruits.

Krishnaiah (1980) reported about 40-56 per cent losses in Okra due to leaf hopper. Reduction of 49.8 and 45.1 per cent in height and number of leaves, respectively due to attack of leaf hopper reported by Rawat and Sadu, (1973). Aphids and leaf hoppers are important pests in the early stage of the crop which desap the plants, make them weak and reduce the yield. Failure to control them in the initial stages was reported to cause yield loss to the tune of 54.04 per cent (Chaudhary and Dadeech, 1989).

Due to unjudicious and indiscriminate use of chemicals, pesticide has created problems like environmental pollution, insecticidal resistance, pesticidal hazards, toxic residue, pest resurgence and destruction of natural enemies.

To prevent the toxic effect of chemical pesticide day by day farmers interest is increasing towards organic farming for better quality of vegetables and fruits for consumption and export purpose. Therefore, it needs to use plant origin insecticides that play an important role in organic pest management which are ecofriendly and safe to the non-targeted organism.Hence, present investigation on efficacy of various aqueous seed extract against major pest of okra was conducted in order to find out effective,ecofriendly and economical plant protection measures.

MATERIAL AND METHODS

The field experiment was conducted at Experimental Farm of Dept. of Agricultural Entomology Dr. PDKV, Akola during 2013-14. Akola bahar variety of okra was planted in plot size of 3.6 m x 2.7 m. Trial consists of ten treatments replicated thrice in Randomized Block Design to evaluate the efficacy of various aqueous seed extracts against major pests of okra. The treatments consist of use of aqueous extracts of neem seeds, custard apple seeds, black pepper seeds and ajwain seeds and azadirachtin 10,000 ppm.

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Preparation of aqueous seed extracts :

One hundred gram of black pepper seed was ground and immersed in 1 lit. boiled water and it was kept for a night. Next day it was stirred well and filtered through double muslin cloth and the filtrate made to up volume 5 lit. to give 2 per cent black pepper seed extract. Similarly, 5 per cent black pepper seed extract was prepared by making final volume 2 lit. The same procedure was carried out for the preparation of ajwain seed extract.

Neem seeds extract and custard apple seed extract were prepared as per usual procedure. Overall, seven sprays of each treatment were undertaken from 15 days after emergence of crop at an interval of 10 days.

The observations on the infestation of major sucking pests were recorded at 7^{th} and 10^{th} days after each spray. The total number of aphid, leaf hopper, whitefly and mite were recorded on three leaves (one each from top, middle and bottom) from each of randomly selected five plants in each plot. For shoot and fruit borer damage, number ofhealthy plant and number of damaged plant by shoot and fruit borer were recorded at 7^{th} and 10th day after spraying. Also at the time of each picking, damaged fruits and healthy fruits were counted on number and weight basis. Yield data were also recorded from all pickings taken from time to time.The observations of predators like lady bird beetles, chrysopa, and spider were recorded at 7^{th} and 10^{th} days after each treatment spray on randomly selected 5 plants from net plot on whole plant.

The data obtained on the pests and predator were subjected to statistical analysis after suitable transformations as per statistical guidelines given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The data presented in Table 1 were interpreted and discussed under different headings as below:

Effect of treatments on population of Aphid at 7 and 10 Days After Spraying

The treatment azadirachtin 10000 ppm @ 2ml L^{-1} was found most effective at 7 and 10 days after spray in minimizing population of aphid (12.53 3^{-1} leaves $plant^{-1}$,12.68 $3L^{-1}$ $pl.^{-1}$, respectively) and it was at par with neem seed extract 10 per cent (14.59 3 $pl.^{-1}$, 15.03 3^{-1}L $pl.^{-1}$) and superior over remaining treatments. Rest of the treatments like ajwain seed extract 5 per cent, custard apple seed extract 5 per cent &10 per cent and black pepper seed extract 5 per cent stood second and were statistically at par with one another 7 and 10 days after spraying.

The above results are in agreement with Singh *et al* (2004) who noted that among the various neem products viz., Azadirachtin 1per cent, Eucalyptus oil each at 0.2 per cent , 0.5 per cent and found effective against aphid and showed over 60 per cent pest control efficacy. Similar results were reported by Nboyineet al (2013) whoreported that the 10 per cent NSKE significantly reduced the aphid (*Aphis gossypii*) population on cotton.

Effect of treatments onpopulation of leafhopper at 7 and 10 Days After Spraying

. The treatment azadirachtin 10000 ppm @ 2ml L^{-1} was found most effective in minimizing the population of leaf hopper (6.00and (7.30 3$leaves^{-1}$ $plant^{-1}$.) at par with neem seed extracts 10 per cent (7.15 and 8.27 LH 3 $leaves^{-1}$ $plant^{-1}$. at 7 and 10 DAS, respectively) and superior over remaining treatments. Rest of the seed extracts viz. neem seed extracts 5 per cent , ajwain seed extract 5 per cent , custard apple seed extract 5 per cent were found statistically at par and stood second at 7 and 10 days after spray.

The results quoted above are in confirmation with those of Singh and Kumar (2008) and Vinodhini and Malaikozundan (2011) whoreported the efficacy ofAchook (0.07%) and NSKE 5 per cent in controlling okra leaf hopper.

Results are also supported by Nboyineet.al (2013) who reported that the NSKE 10 per cent significantly reduced the leaf hopper population on cotton.

Effect of treatments on population of Whitefly at 7 and 10 Days After Spraying

Treatment azadirachtin 10000 ppm @ 2ml L^{-1} was found to be significantly most effective in minimizing the cumulative mean population of whitefly (1.09 and 1.20 3$Leaves^{-1}$ $plant^{-1}$) at 7 and 10 days after spray and superior over remaining treatments. However, neem seed extracts 10 per cent and neem seed extracts 5 per cent were found statistically at par with each other at 7 DAS in keeping minimum population of whitefly (1.39 $3L^{-1}$ $pl.^{-1}$) and (1.66 $3L^{-1}$$pl.^{-1}$) whereas neem seed extracts 10 per cent (1.73WF $3l^{-1}$ $pl.^{-1}$) was found at par with neem seed extracts 5 per cent (1.82WF^{-1} $3L^{-1}$ pl), ajwain seed extract 5 per cent (1.91WF $3L^{-1}pl^{-1}$), ajwain seed extract 2 per cent (2.05WF

Table 1 Effect of various treatmenton cumulative mean population of sucking pest on okra.

S. N.	Treatments	Nymphs of Aphid /3 leaves/plant		Nymphs of Leaf hopper /3 leaves/ plant		Whitefly adults /3leaves/plant		Mites/3 leaves /plant		Predator population /plant	
		7 DAS	10 DAS	7 DAS	10 DAS	7 DAS	10 DAS	7 DAT	10 DAT	7 DAS	10 DAS
1	Neem seed extract 5%	15.03	15.71	8.05	9.10	1.66	1.82	3.81	3.79	0.60	0.63
		(3.88)	(3.96)	(2.84)	(3.02)	(1.29)	(1.35)	(1.95)	(1.95)	(0.77)	(0.79)
2	Neem seed extract 10%	14.59`	15.42	7.15	8.27	1.39	1.73	4.68	3.14	0.58	0.61
		(3.82)	(3.93)	(2.67)	(2.88)	(1.18)	(1.32)	(2.16)	(1.77)	(0.76)	(0.78)
3	Custard apple seed extract 5%	17.58	18.35	8.68	9.99	2.06	2.57	3.60	2.93	0.67	0.70
		(4.19)	(4.28)	(2.95)	(3.16)	(1.44)	(1.60)	(1.90)	(1.71)	(0.82)	(0.84)
4	Custard apple seed extract 10%	17.14	17.36	8.59	9.68	1.93	2.09	4.54	4.14	0.64	0.67
		(4.14)	(4.17)	(2.93)	(3.11)	(1.39)	(1.45)	(2.13)	(2.03)	(0.80)	(0.82)
5	Black pepper seed extract 2%	19.04	19.35	9.30	10.73	2.15	2.59	3.88	2.27	0.69	0.72
		(4.36)	(4.40)	(3.05)	(3.28)	(1.47)	(1.61)	(1.97)	(1.51)	(0.83)	(0.85)
6	Black pepper seed extract 5%	17.50	18.09	8.65	9.84	1.97	2.48	3.28	2.05	0.65	0.68
		(4.18)	(4.25)	(2.94)	(3.14)	(1.40)	(1.58)	(1.81)	(1.43)	(0.81)	(0.83)
7	Ajwain seed extract 2%	16.95	17.14	8.47	9.28	1.77	2.05	4.47	2.76	0.62	0.66
		(4.12)	(4.14)	(2.91)	(3.05)	(1.33)	(1.43)	(2.11)	(1.66)	(0.79)	(0.81)
8	Ajwain seed extract 5%	16.24	16.40	8.16	9.18	1.72	1.91	4.87	2.12	0.61	0.65
		(4.03)	(4.05)	(2.86)	(3.03)	(1.31)	(1.38)	(2.21)	(1.46)	(0.78)	(0.80)
9	Azadirachtin 10,000 ppm @ 2ml/L	12.53	12.68	6.00	7.30	1.09	1.20	6.02	4.58	0.55	0.57
		(3.54)	(3.56)	(2.45)	(2.70)	(1.04)	(1.10)	(2.45)	(2.14)	(0.74)	(0.76)
10	Untreated control	24.46	25.07	11.08	12.96	2.82	3.48	5.14	4.74	1.11	1.17
		(4.95)	(5.01)	(3.33)	(3.60)	(1.68)	(1.86)	(2.27)	(2.18)	(1.05)	(1.08)
	SE(m)±	0.13	0.12	0.09	0.10	0.04	0.04	0.26	0.27	0.04	0.04
	CD at 5 %	0.39	0.36	0.27	0.31	0.12	0.13	—	—	0.11	0.12
	CV %	5.46	5.08	5.37	5.90	5.25	5.30	21.33	25.91	8.14	8.47

Figures in parentheses indicates square root values. DAS- Days After Sowing DAT- Days After Treatment

Table 2: Effect of various treatments on yield of okra and economics of treatments

S.N.	Treatments details	% Infestation of Shoot and Fruit borer		Fruit yield q/ha)	Cost of treatment (A) (Rs./ ha) (Rs./ha)	Increase yield over control (q/ha)	Value of increased yield (Rs/ha) (B)	Net monetary return (Rs/ha) (C) (B-A)	ICBR (C/A)
		Number basis	Weight basis						
1	Neem seed extract5%	2.69 (1.64)	1.88 (1.37)	44.16	7070	14.55	36372	29302	4.14
2	Neem seed extract 10%	2.50(1.58)	1.84(1.36)	45.13	10570	15.52	38803	28233	2.67
3	Custard apple seed extract 5%	6.32(2.51)	3.64(1.91)	37.11	21095	7.50	18760	-2335	-0.11
4	Custard apple seed extract 10%	4.85(2.20)	3.07(1.75)	38.92	38620	9.31	23274	-15346	-0.40
5	Black pepper seed extract 2%	6.39(2.53)	4.05(2.01)	36.21	31580	6.60	16504	-15076	-0.48
6	Black pepper seed extract 5%	5.29(2.30)	3.12(1.77)	38.07	73595	8.46	21152	-52443	-0.71
7	Ajwain seed extract 2%	4.72(2.17)	2.80(1.67)	40.56	10570	10.95	27364	16794	1.59
8	Ajwain seed extract 5%	4.16(2.04)	2.47(1.57)	42.90	21070	13.29	33228	12158	0.58
9	Azadirachtin 10,000 ppm @ 2ml/L	1.62(1.27)	0.81(0.90)	46.37	6720	16.76	41889	35169	5.23
10	Untreated control	12.74(3.57)	8.17(2.86)	29.61	-	-	-	-	-
	SE(m)±	0.21	0.19	1.15					
	CD at 5 %	0.63	0.56	3.70					
	CV %	16.77	19.01	5.26					

$3L^{-1}pl^{-1}$) and custard apple seed extract 10 per cent (2.09WF $3L^{-1}pl^{-1}$) at 10 DAS compared to 2.82 and 3.48 WF $3L^{-1}pl^{-1}$ in untreated control at 7 and 10 DAS, respectively.

The above results are in agreement with Naik et al (2012) who revealed that Neemazol @ 3.5 per cent followed by Neem oil @ 2 per cent , NSKE 5 per cent were found superior over other botanicals to control whitefly population. Present finding also supported by Jat and Jaykumar (2006) who reported that neem products (neem oil 3 per cent and NSKE 5 per cent) were found to reduce whitefly population.

Effect of Various Treatments on the Incidence of Mites

The data on cumulative mean population of mites recorded at 7 and 10 days after spray was non-significant. However numerically minimum infestation of mites 3.28 3 L^{-1} pl^{-1} in black pepper seed extract 5 per cent was recorded while maximum population of 6.0 23leaves^{-1}plant^{-1} was recorded in azadirachtin 10,000 ppm @ 2ml L^{-1} at 7 days after spray.

Effect of treatments on infestation of shoot and fruit borer

The treatment azadirachtin 10,000 ppm @ 2ml L^{-1} was found to be significantly most effective in recording minimum infestation of shoot and fruit borer 1.62 per cent and 0.81 per cent followed by neem seed extract 10 per cent (2.50% & 1.84%) and neem seed extract 5 per cent (2.69% & 1.88%) on number and weight basis over all other remaining treatments compared to maximum infestation in untreated control (13.91% & 8.17%), respectively. Rest of the treatments were found statistically at par with one another.

The results regarding the shoot and fruit borer infestation are in agreement with Sardana and Krishnakumar (1989) who reported that Neem oil 2 per cent was found to be effective in controlling *Eariasvittella* on okra and lower fruit damage with higher yield (82.44 q/ha). Similarly Gabhane (1993) reported that NSKE 4 per cent + endosulfan 0.03 per cent reduced the damage of shoot and fruit borer and increased the yield next to endosulfan.

Effect of Various Treatments on Population of Predators

The data on cumulative mean population of predators recorded at 7 and 10 days after spray indicate that all treatments were found deleterious at 7 and 10 days after spray.

Yield of okra fruits

It is revealedfromTable 2 that, amongst all treatments, azadirachtin 10,000 ppm @ 2ml L^{-1} was found most effective and on par with neem seed extract 5 per cent and 10 per cent and ajwain seed extract 5 per cent in recording highest yield of Okra fruit (46.37 q ha^{-1}, 45.13 q ha^{-1}, 44.16 q ha^{-1} and 42.90 q ha^{-1}, respectively) and superior over remaining treatments.

The above yield trend is in line with Singh and Kumar (2003) who revealed that, Achook treated plots gave the highest yield of 50.20 q ha^{-1} followed by NSKE 3 per cent (49.67 q ha^{-1}). Similarly Adilakshmi *et al* (2008) who reported that NSKE 5 per cent proved to be more effective against sucking insect infesting okra and relatively more yield 83.27 q ha^{-1}.

Highest net monetary return of Rs 35169 ha^{-1} with highest ICBR (1:5.23) were obtained in azadirachtin 10,000 ppm @ 2ml L^{-1} closely followed by NMR of Rs 29302 ha^{-1} with ICBR of (1:4.14) in neem seed extract 5 per cent, NMR of Rs. 28233 ha^{-1} with ICBR (1:2.67) in neem seed extract 10 per cent and NMR of Rs 12158 ha^{-1} with ICBR (1: 0.58) in ajwain seed extract 5 per cent was obtained. Rest of treatments like custard apple seed extract 5 per cent, 10 per cent, black pepper seed extract 2 per cent and 5 per cent were found to be economically ineffective. The lowest ICBR of (1: -0.71) with net monetary loss of Rs – 52443 ha^{-1} was noticed in black pepper seed extract 5 per cent due to comparatively lower yield and highest cost of seed incurred on preparation of black pepper seed extract 5 per cent.

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Evaluation of Newer Molecules Against Sucking Pests in Bt Transgenic Cotton

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ABSTRACT

The field experiment was conducted to evaluate the effectiveness of newer insecticides as foliar spray against major sucking pests of Bt transgenic cotton during *Kharif* season of 2012-13. The results revealed that Fipronil 5 SC @ 0.02 per cent was most effective treatment against aphids, leaf hoppers and thrips in transgenic Bt cotton followed by imidacloprid 30.5 SC @ 0.005 per cent and diafenthiuron 50 WP @ 0.08 per cent which gave equal efficacy whereas diafenthiuron 50 WP @ 0.08 per cent was found promising for the management of cotton whitefly. Highest seed cotton yield (12.22 q ha^{-1}) was obtained from Fipronil 5 SC @ 0.02 per cent followed by imidacloprid 30.5 SC @ 0.005 per cent (12.04 q ha^{-1}) and diafenthiuron 50 WP @ 0.08 per cent (11.85 q ha^{-1}). However, highest ICBR i.e. 1:10.31 was recorded in Acetamiprid 20 SP @ 0.004 per cent indicating most economically viable treatment followed by Imidacloprid 30.5 SC @ 0.005 per cent and Acephate 75 SP @ 0.058 per cent recording 1:10.13 and 1: 7.81 ICBR, respectively.

Cotton is the most important cash crop in India. It plays a dominant role in the industrial and agricultural economy of the nation and has a unique place in Indian economy and social affairs. It provides livelihood to about four million families. (Mayee and Rao, 2002). India has the largest area under cotton and second largest producer of cotton next to China with 35.29 per cent and 24 per cent of world cotton area and production, respectively. India also sustained the position of being the second largest consumer and exporter of cotton and is expected to export 7.5 million bales and expected to consume 23 million bales in 2013-14. World cotton production is estimated at 116.67 million bales of 480 lb in 2013-14 which is 6.402 million bales lesser than the previous year 2012-13 and cotton area decreased to the tune of 1.191 million ha compared to 2012-13. (Annonymus, 2013-14).

Cotton is an important commercial crop designated as king of fiber crops and prone to insect pests attack at various stages of crop growth (Patel *et.al*, 2014). Cotton hybrids and high yielding varieties are more susceptible to insect pests like bollworms and sucking pests. With the introduction of Bt cotton hybrids insecticides are not applied against main insects i.e. bollworm complex but additional applications are required against sucking pests to avoid yield losses (Dhawan *et. al*. 2008). The sucking pests viz. Aphids (*Aphis gossypii*), Leaf hoppers (*Amrasca biguttula biguttula*) Whiteflies (*Bemisia tabaci*) and Thrips (*Thrips tabaci*) are most serious and destructive pests with regular occurrence. Amongst various reasons of low productivity of Bt transgenic cotton, the sucking pests gain much importance due to havoc created by most of the sucking pest in the recent years. A broad range of insecticides available in market have proved as effective in reducing the pest population. However, negligence in following the principles of crop protection, indiscriminate and extensive use of synthetic insecticides led to development of insecticidal resistance, pest resurgence, residue, destruction of natural enemies etc. Hence, it is required moving on other molecules with different mode of action to overcome such types of consequences (Patel, *et. al.*, 2014). Application of the newer group insecticides through foliar sprays are effective, economic, ecofriendly and may prove less interfering with the natural fauna. Keeping this hypothesis in mind, present study was therefore carried out with objectives to study effectiveness of newer insecticides against major sucking pests of Bt transgenic cotton and also to find out most cost effective insecticidal treatments.

MATERIAL AND METHODS

The field experiment was conducted at Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *Kharif* season of 2012-13. The trial was laid out in randomized block design with eight treatments and three replications. The Transgenic cotton variety Rasi 2 (BG II) was transplanted on 11h July, 2012 at 90 x 60 cm spacing. The Net plot size was kept 4.5 x 4.8 m. All recommended packages and agronomic practices were followed to raise the crop, except plant protection measures. The eight different treatments of newer insecticides viz. (T_1) Imidacloprid 30.5 SC @ 0.005 per cent, (T_2) Fipronil 5 SC @ 0.02 per cent, (T_3) Acetamiprid 20 SP @ 0.004 per cent, (T_4) Acephate 75 SP @ 0.058 per cent, (T_5) Diafenthuiron 50 WP @ 0.08 per cent, (T_6) Ethion 50 EC @ 0.2 per cent, (T_7) Triazophos 40 EC @0.16 per cent and (T_8) Control

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(Unsprayed) were evaluated against sucking pests on cotton viz., aphids (*Aphis gossypii*), leaf hoppers (*Amrasca biguttula biguttula*), thrips (*Thrips tabaci)* and whitefly (*Bemisia tabaci*). The first treatment spray against sucking pests was given after attaining the ET level by sucking pests and repeated at an interval of 15 days. Overall all 3 treatment sprays were given with knapsack sprayer.

The observations on the population of sucking pests' i.e. total no. of leaf hoppers, aphid nymphs, thrips and whiteflies adults were recorded 3, 7 and 10 days after each treatment spray on randomly selected five plants from each net plot and three leaves (top, middle and bottom) per selected plant. Seed cotton yield obtained at each picking from each net plot was recorded and yield of seed cotton in kg/ha was also calculated. On the basis of total yield obtained in each insecticidal treatment and untreated control, the increase in seed cotton yield was calculated and accordingly Incremental Cost Benefit Ratio (ICBR) in each treatment has been worked out. The data obtained on the pests and yield were subjected to statistical analysis after suitable transformations as per statistical guidelines given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Cumulative data on aphids population averaged out of 3, 7 and 10th DAT (Table 1) revealed significantly lower populations i.e. 1.86 to 4.95 aphids/leaf in all treated plots than the untreated control (13.65 aphids leaf^{-1}). Minimum population (1.86 aphids leaf^{-1}) was recorded due to the treatment of Fipronil 5 SC @ 0.02 per cent and it was at par with Imidacloprid 30.5 SC @ 0.005 per cent and Diafenthiuron 50 WP @ 0.08 per cent. Acetamiprid 20 SP @ 0.004 per cent was next effective treatment reducing aphids population and it was followed by Ethion 50 EC @ 0.2 per cent, Acephate 75 SP @ 0.058 per cent and Triazophos 40 EC @ 0.16 per cent. Choudhari *et al*. (2005) noticed that, three foliar sprays of imidacloprid 17.8 SL offered very good protection against sucking pests of cotton. Patil (2000) also reported the superiority of imidacloprid at similar spray concentration against aphids. Kolhe *et al.* (2009) reported the superiority of acetamiprid 20 SP @ 0.003 per cent against aphids on cotton. Patil *et al*. (2009) revealed that, higher dosage of thiamethoxam (Cruiser) 70 WS was very effective in reducing the pest population and providing higher yield of seed cotton and its efficacy was also as good as imidacloprid 70 WS. These reviews supported the findings of the present study.

The Cumulative averaged population of leaf hoppers (Table 1)) after third spray in all treated plots was significantly lower and ranging between 0.73 to 1.65

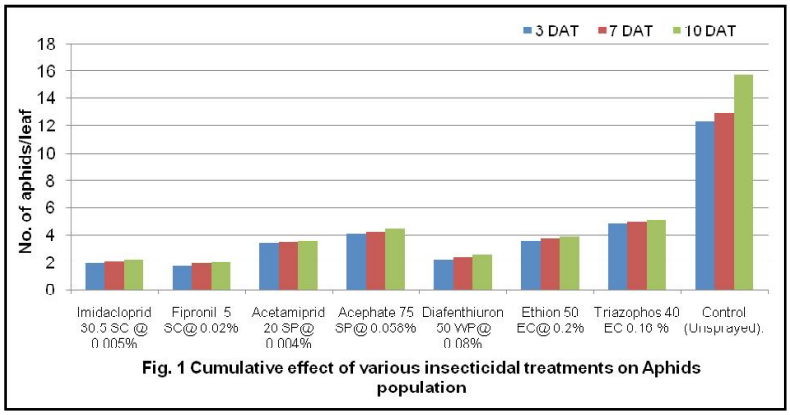

Fig. 1 Cumulative effect of various insecticidal treatments on Aphids population

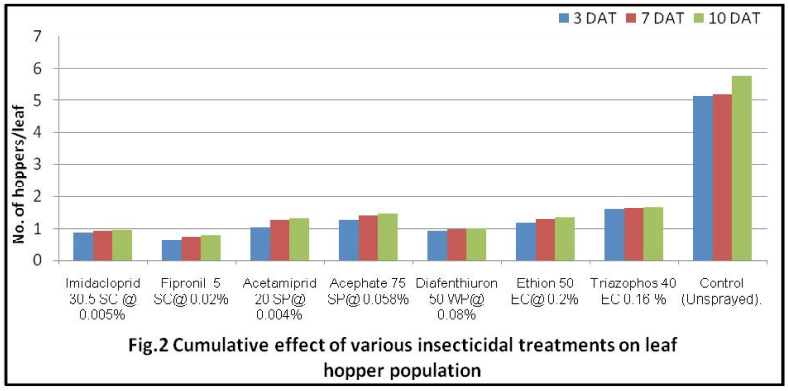

Fig.2 Cumulative effect of various insecticidal treatments on leaf hopper population

Table 1: Cumulative effect of various insecticidal treatments on aphid and leaf hopper populations.

Treatments		Conc.	Population of aphid nymphs (No. / leaf) at			Mean	Population of leaf hopper nymphs (No. / leaf) at			Mean
			3 DAT	7 DAT	10DAT		3 DAT	7DAT	10DAT	
T_1	Imidacloprid 30.5 SC	0.005%	1.85	2.02	2.18	2.02	0.88	0.94	0.98	0.93
			(1.36)*	(1.42)*	(1.47)*	(1.42)*	(0.94)*	(0.97)*	(0.99)*	(0.97)*
T_2	Fipronil 5 SC	0.02%	1.70	1.89	2.00	1.86	0.64	0.75	0.81	0.73
			(1.30)	(1.37)	(1.41)	(1.36)	(0.80)	(0.87)	(0.90)	(0.86)
T_3	Acetamiprid 20 SP	0.004%	3.35	3.46	3.56	3.46	1.05	1.27	1.34	1.22
			(1.83)	(1.86)	(1.89)	(1.86)	(1.02)	(1.13)	(1.16)	(1.10)
T_4	Acephate 75 SP	0.058%	4.03	4.14	4.44	4.20	1.26	1.41	1.46	1.38
			(2.01)	(2.03)	(2.11)	(2.05)	(1.12)	(1.19)	(1.21)	(1.17)
T_5	Diafenthiuron 50 WP	0.08%	2.15	2.32	2.50	2.32	0.93	1.00	1.03	0.99
			(1.47)	(1.52)	(1.58)	(1.52)	(0.96)	(1.00)	(1.01)	(0.99)
T_6	Ethion 50 EC	0.2%	3.55	3.76	3.88	3.73	1.18	1.30	1.37	1.28
			(1.88)	(1.94)	(1.97)	(1.93)	(1.09)	(1.14)	(1.17)	(1.13)
T_7	Triazophos 40 EC	0.16%	4.82	4.91	5.11	4.95	1.59	1.66	1.69	1.65
			(2.19)	(2.22)	(2.26)	(2.22)	(1.26)	(1.29)	(1.30)	(1.28)
T_8	Control (Unsprayed).	-	12.33	12.89	15.73	13.65	5.15	5.18	5.78	5.37
			(3.48)	(3.53)	(3.94)	(3.65)	(2.25)	(2.26)	(2.39)	(2.30)
	SE (m)±		0.11	0.14	0.11	0.12	0.06	0.07	0.06	0.06
	CD at 5%		0.34	0.44	0.34	0.37	0.20	0.22	0.21	0.21
	CV %		10.25	12.91	9.33	10.83	9.76	10.37	9.25	9.79

*Square root transformations

Table 2: Cumulative effect of various insecticidal treatments on thrips and whitefly populations

Treatments		Conc.	Population of thrips (No / leaf) at			Mean	Population of whitefly (No / leaf) at			Mean
			3 DAT	7 DAT	10DAT		3 DAT	7DAT	10DAT	
T_1	Imidacloprid 30.5SC	0.005%	2.50	2.77	3.04	2.77	2.63	2.79	3.04	2.82
			(1.58)	(1.66)	(1.74)	(1.66)	(1.61)	(1.66)	(1.74)	(1.67)
T_2	Fipronil 5 SC	0.02%	2.27	2.50	2.81	2.53	2.36	2.55	2.84	2.58
			(1.50)	(1.57)	(1.67)	(1.58)	(1.53)	(1.58)	(1.68)	(1.60)
T_3	Acetamiprid 20 SP	0.004%	3.09	3.27	3.61	3.32	3.36	3.71	4.08	3.72
			(1.75)	(1.80)	(1.90)	(1.82)	(1.83)	(1.92)	(2.02)	(1.92)
T_4	Acephate 75 SP	0.058%	3.41	3.76	4.07	3.75	3.51	3.88	4.25	3.88
			(1.84)	(1.93)	(2.02)	(1.93)	(1.87)	(1.96)	(2.06)	(1.96)
T_5	Diafenthiuron 50 WP	0.08%	2.56	2.88	3.30	2.91	2.06	2.33		
			(1.60)	(1.70)	(1.82)	(1.71)	(1.43)	(1.52)	2.63(1.61)	2.34(1.52)
T_6	Ethion 50 EC	0.2%	3.21	3.59	3.89	3.56	3.44	3.83	4.13	3.80
			(1.79)	(1.89)	(1.97)	(1.88)	(1.85)	(1.96)	(2.03)	(1.95)
T_7	Triazophos 40 EC	0.16%	3.98	4.26	4.59	4.28	3.80	4.20	4.50	4.17
			(1.99)	(2.06)	(2.14)	(2.06)	(1.95)	(2.05)	(2.12)	(2.04)
T_8	Control (Unsprayed).	-	5.54	5.75	5.89	5.73	8.62	9.64	10.00	9.42
			(2.35)	(2.39)	(2.42)	(2.39)	(2.93)	(3.10)	(3.16)	(3.06)
	SE (m)±		0.07	0.08	0.06	0.07	0.09	0.09	0.09	0.09
	CD at 5%		0.21	0.26	0.19	0.22	0.27	0.28	0.29	0.28
	CV %		6.82	8.10	5.47	6.80	8.30	8.21	7.95	8.15

Figure in paranthesis are root transformations

The lowest population was recorded in Fipronil 5 SC @ 0.02 per cent which was at par with Imidacloprid 30.5 SC @ 0.005 per cent and Diafenthiuron 50 WP @ 0.08 per cent. These insecticidal treatments showed consistent efficacy from 3 to 10 DAT. Acetamiprid 20 SP @ 0.004 per cent was ranked second in checking thrips population and it was on par with Ethion 50 EC @ 0.2 per cent and Acephate 75 SP @ 0.058 per cent. Triazophos 40 EC @ 0.16 per cent was found to be least effective for controlling thrips population. Patil *et. al*. (2009) reported that Fipronil 5 per cent SC @ 800g ha^{-1} registered least number of thrips (8.47 / 3 leaves) and found to be on par with acetamiprid 20 SP @ 100 g ha^{-1}, (7.80 /3 leaves). Udikeri *et. al*. (2009) observed lowest population of thrips in acetamiprid 20 SP (100 ml ha^{-1}) against standard insecticidal check, triazophos 40 EC (1500 ml ha^{-1}) and untreated check.

The average population of whitefly at 3, 7 and 10th DAT in all treated plots (Table 2) was ranged between 2.34 to 4.17 whitefly $leaf^{-1}$ and was found significantly lower than untreated control (9.42 whitefly/leaf). Minimum population (2.34 whitefly $leaf^{-1}$)) was recorded in diafenthiuron 50 WP @ 0.08 per cent which was at par with fipronil 5 SC @ 0.02 per cent and imidacloprid 30.5 SC @ 0.005 per cent. Acetamiprid 20 SP @ 0.004 per cent was ranked second in controlling whitefly population and it was on par with Ethion 50 EC @ 0.2 per cent, Acephate 75 SP @ 0.058 per cent and Triazophos 40 EC @ 0.16 per cent. Similarly Kalyan *et. al*. (2012) reported that Spinosad 45 SC, imidacloprid 70 WG @ 50 a.i. ha^{-1}, acephate 75 SP @ 500 a.i. ha^{-1}, and fipronil 5 SC @ 40 a.i. ha^{-1}, effectively controlled the population of leaf hoppers and whiteflies and gave significantly higher seed

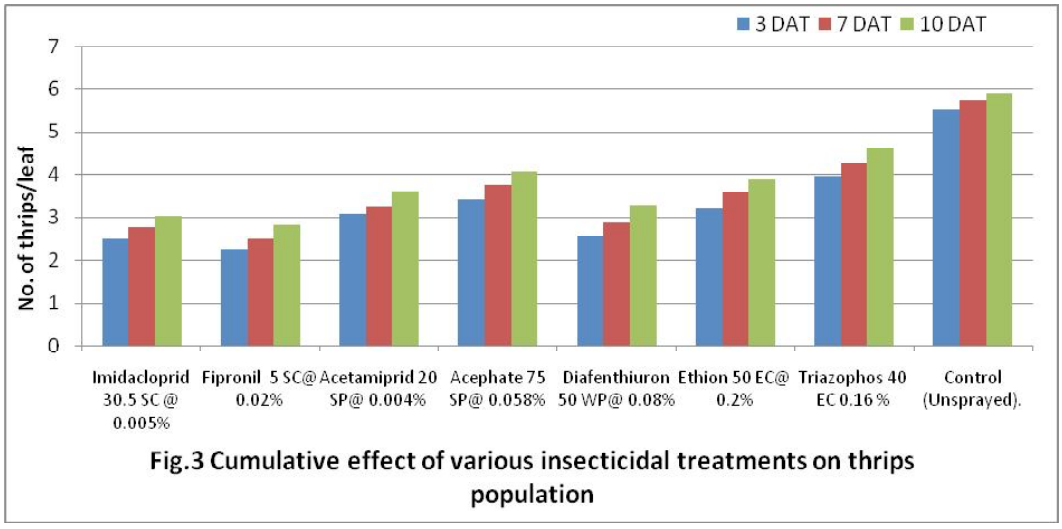

Fig.3 Cumulative effect of various insecticidal treatments on thrips population

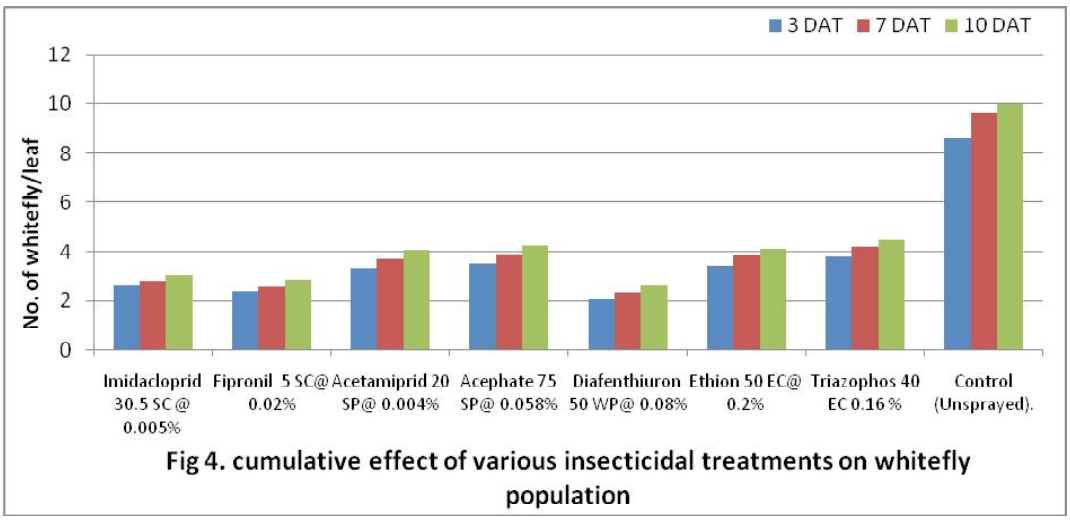

Fig 4. cumulative effect of various insecticidal treatments on whitefly population

that Spinosad 45 SC, imidacloprid 70 WG @ 50 a.i. ha^{-1}, acephate 75 SP @ 500 a.i. ha^{-1}, and fipronil 5 SC @ 40 a.i. ha^{-1}, effectively controlled the population of leaf hoppers and whiteflies and gave significantly higher seed cotton yield over the untreated and standard check. Jat *et. al*. (2004) found that thiamethoxam @ 100 g a.i ha^{-1} and diafenthiuron @ 300 and 400 g a.i. ha^{-1} significantly reduced whitefly population than the standard checks. Raghuraman and Gupta (2008) reported that imidacloprid 17.8 SL @ 100 g ai ha^{-1} was found significantly superior in checking the population of cotton whitefly. These findings are in agreement with the results obtained in the present study.

Seed cotton yield (q ha^{-1}) in all the insecticidal treatments (Table 3) was ranging between 12.22 to 9.44 q ha^{-1} and were significantly higher than untreated control (7.73 q ha^{-1}). However, highest seed cotton yield i.e. 12.22 q ha^{-1} was obtained in Fipronil 5 SC @ 0.02 per cent treatment followed by Imidacloprid 30.5 SC @ 0.005 per cent (12.04 q ha^{-1}) and Diafenthiuron 50 WP @ 0.08 per cent (11.85 q ha^{-1}). Patil *et. al*. (2009) reported that significantly highest seed cotton yield of 27.23 q ha^{-1} (2007) and 27.50 g ha^{-1} (2008) was harvested with higher dosage of fipronil 5 SC @ 800 g ha^{-1}, respectively, which were on par with acetamiprid 20 SP. These results are in line with the present findings. However, highest ICBR i.e. 1:10.31 was recorded in acetamiprid 20 SP @ 0.004 per cent followed by Imidacloprid 30.5 SC @ 0.005 per cent (1:10.13) and Acephate 75 SP @ 0.058per cent (1:07:81).

In case of Diafenthiuron 50 WP @ 0.08 per cent and Fipronil 5 SC @ 0.02 per cent they got 4th and 5th Rank, respectively in term of ICBR because of their high plant protection cost as compared to acetamiprid 20 SP @ 0.004 per cent though they are most effective treatments in respect of control of sucking pests on cotton. Thus, from the present investigation it is concluded that Fipronil 5 SC @ 0.02 per cent was most effective treatment against all sucking pest followed by imidacloprid 30.5 SC @ 0.005 per cent and diafenthiuron 50 WP @ 0.08 per cent which gave equal efficacy but as compared to all the treatments, Acetamiprid 20 SP @ 0.004 per cent was recorded highest ICBR (1:10.31) due to its less market price.

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Effect of Culture Filtrates of *Trichoderma* spp. on Sporulation of *Alternaria lini*

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ABSTRACT

Linseed blight caused by *Alternaria lini* (Dey) is an economically important and major fungal disease of linseed (*Linum usitatissimum* L.). In the present study, variations in respect of morphological and cultural traits were observed among the ten isolates of *A. lini* collected from different genetic backgrounds of linseed. The effect of culture filtrates of *Trichoderma viride, T. hamatum, T. harzianum* and *T. virens* were tested *in vitro* on sporulation intensity of *A. Lini*. The maximum sporulation inhibition was recorded in culture filtrate of *T. viride* (10%) that was ranging from 66.67% to 84.40% among the *A. lini* isolates with highest inhibition observed in isolate ALP-10.

Alternaria blight caused by *Alternaria lini* is a major fungal disease of Linseed and it affects all aerial parts of the plant including leaves, bud, capsules etc. The disease was first reported from India (Dey, 1933). In India, yield losses in range of 28-60 per cent are reported (Arya and Prasad, 1952; Chauhan and Srivatava, 1975). Bud infection may cause losses upto 90 per cent (Chauhan and Srivatava, 1975). There is negative correlation between disease intensity and grain yield (Garg, 1982). Disease affects seed weight, fibre quality and decreases oil percentage. The disease is a major threat in Uttar Pradesh (India) causing avoidable loss upto 40.65 per cent (Singh and Singh, 2002). Biological control is among the most preferred eco-friendly management practices. Till date several bio-control agents have been reported to manage plant diseases. Among them *Trichoderma* spp is the most effective antifungal antagonist. Ten isolates of *A. lini* having different morphological and cultural characteristics were selected for this study. Culture filtrates of *Trichoderma* spp were evaluated for antifungal effect on sporulation intensity of *A. lini* by poisoned food technique.

MATERIAL AND METHODS

Collection of diseased samples and antagonist

Fresh naturally infected diseased plant parts and seeds of different germplasm lines of linseed were collected from the disease screening nursery of AICRP (Linseed), Nagpur during *Rabi* 2007. The pathogen *A. lini*, was isolated aseptically on PDA media at 28±2°C. Species was confirmed by observing the germ tube characteristics under microscope and published literature.

Four species of the known antagonist *Trichoderma i.e. T. viride, T. hamatum, T. harzianum* and *T. virens* were collected from the Department of Plant Pathology, Dr.PDKV, Akola (MS).

Cultural and morphological characteristics of *A. lini*

The fungal lawn culture of *A. lini* was grown for nine days aseptically on PDA media at 28±2°C. Observations of fresh cultures were recorded for colony colour, nature of growth, colony diameter, measurements for spore length, width, beak length, number of transverse and longitudinal septa and sporulation intensity. Conidial measurements were recorded by using ocular and stage micrometers under 40X magnification of microscope (Arya and Prasad, 1952). Six milimeter disc of nine days old culture was suspended in nine ml distilled water and one drop of the suspension was taken on the slide to record the microscopic observations.

Sporulation intensity was recorded using Haemocytometer. Six milimeter discs from centre, middle and periphery of the fungal lawn of nine days old culture were separately taken into 10 ml distilled water and spores were counted under microscope (40X) in central square of Haemocytometer and spore load/ml of water was calculated.

Preparation of culture filtrates of antagonist

For preparation of culture filtrates antagonists were grown in 150 ml potato dextrose broth (PDB) in 250 ml conical flask for 20 days. Broth containing mycelium and spores were filtered through Whatman no. 4 filter paper, and then these filtrates were centrifuged at 5000 rpm for 10 minutes to collect cell free supernatant and considered as 100 per cent concentration which was used in poisoned food technique @ 5 per cent and 10 per cent concentrations (Mane and Pal, 2008).

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Table 1: Morphological and cultural characteristics of pathogenic isolates of *Alternaria lini* on PDA (28±2°C)

Isolate No.	Radial mycelial growth 9 days after inoculation (mm)	Colony colour	Nature of growth	Sporulation intensity (x 10^5/cm^2)	Length (µm)	Breadth (µm)	Beak length (µm)	No. of transverse septa	No. of longitudinal septa	Constriction at the septa
ALP-1	85.66	Olivaceous	Submerged	5.97	17.6-31.8	9.6-12.8	2.3-6.5	1-4	1-3	+
ALP-2	81.88	Light Grey	Effused	5.64	22.8-41.8	10.1-12.7	3.7-12.9	1-4	1-3	+
ALP-3	74.99	Light Grey	Effused	5.73	19.3-26.0	7.1-9.2	4.4-9.9	2-3	1-2	+
ALP-4	65.77	Grey	Submerged	5.92	26.0-33.0	7.5-10.1	5.0-7.6	2-4	1-2	+
ALP-5	83.77	Dark black	Submerged	5.45	23.7-42.2	9.7-14.8	4.1-13.9	2-4	1-3	+
ALP-6	83.10	Brown	Effused	4.85	31.3-44.5	7.8-11.2	7.2-10.5	1-3	1-2	+
ALP-7	80.55	Dark brown	Submerged	4.55	14.9-29.9	7.0-10.3	5.1-15.6	1-4	1-2	+
ALP-8	81.44	Black	Submerged	5.60	27.3-38.0	10.2-15.3	5.1-13.2	2-4	1-3	+
ALP-9	74.99	Brown	Effused	3.83	27.8-44.4	8.6-12.2	5.2-12.1	2-4	1-2	+
ALP-10	83.22	Dark Grey	Cottony	6.25	19.3-30.0	9.2-14.3	3.5-11.1	1-4	1-2	+

ALP=*Alternaria lini* pathogen

Table 2: Effect of *Trichoderma* spp. on the sporulation of *Alternaria lini* isolates *in vitro*

Treatments		Sporulation intensity (x 10^5 /cm^2)																			
		ALP-1		ALP-2		ALP-3		ALP-4		ALP-5		ALP-6		ALP-7		ALP-8		ALP-9		ALP-10	
		5%	10%	5%	10%	5%	10%	5%	10%	5%	10%	5%	10%	5%	10%	5%	10%	5%	10%	5%	10%
T-1	*T. hamatum*	1.44	1.33	1.30	1.06	2.21	1.41	1.24	1.06	2.12	1.44	1.38	1.18	2.18	1.30	1.94	1.47	1.62	1.36	2.21	1.59
T-2	*T. harzianum*	2.03	1.41	1.50	1.12	1.50	1.15	1.47	1.36	1.62	1.53	1.18	1.06	1.50	1.12	2.00	1.44	1.18	1.06	2.06	1.33
T-3	*T. virens*	1.83	1.24	1.47	1.24	1.36	1.21	1.62	1.38	2.36	1.71	1.62	1.24	1.68	1.03	1.47	1.21	1.12	1.09	1.86	1.62
T-4	*T. viride*	1.36	1.21	1.41	1.03	1.41	1.21	1.18	1.03	1.97	1.18	1.68	1.15	1.30	1.18	2.68	**1.00**	1.92	1.09	1.86	**1.00**
T-5	Control	5.57	5.57	5.10	5.10	5.54	5.54	5.69	5.69	6.13	6.13	5.07	5.07	4.63	4.63	5.57	5.57	3.27	3.27	6.42	6.42
SE(m) ±		0.16	0.16	0.11	0.11	0.08	0.08	0.09	0.09	0.10	0.10	0.12	0.12	0.11	0.11	0.18	0.18	0.29	0.29	0.16	0.16
CD (P=0.01)		0.66	0.66	0.48	0.48	0.32	0.32	0.37	0.37	0.44	0.44	0.49	0.49	0.45	0.45	0.73	0.73	1.19	1.19	0.66	0.66

Table 3: Per cent inhibition of sporulation of *Alternaria lini in vitro* due to culture filtrate of *Trichoderma* spp.

Treatments		Per cent inhibition of sporulation intensity																	
		ALP-1		ALP-2		ALP-3		ALP-4		ALP-5		ALP-6		ALP-7		ALP-8		ALP-9		ALP-10	
		5%	10%	5%	10%	5%	10%	5%	10%	5%	10%	5%	10%	5%	10%	5%	10%	5%	10%	5%	10%
T-1	*T. hamatum*	74.07	**76.19**	74.57	**79.19**	60.11	**74.47**	78.24	**81.35**	65.38	**76.44**	72.67	**76.74**	52.87	**71.97**	65.08	**73.54**	50.45	**58.56**	65.60	**75.23**
T-2	*T. harzianum*	63.49	**74.60**	70.52	**78.03**	72.87	**79.26**	74.09	**76.17**	73.56	**75.00**	76.74	**79.07**	67.52	**75.80**	64.02	**74.07**	63.96	**67.57**	67.89	**79.36**
T-3	*T. virens*	67.20	**77.78**	71.10	**75.72**	75.53	**78.19**	71.50	**75.65**	61.54	**72.12**	68.02	**75.50**	63.69	**77.71**	73.54	**78.31**	65.77	**66.67**	71.10	**74.77**
T-4	*T. viride*	75.66	**78.31**	72.25	**79.77**	74.47	**78.19**	79.27	**81.87**	67.79	**80.77**	66.86	**77.33**	71.97	**74.52**	51.85	**82.01**	41.44	**66.67**	71.10	**84.40**
T-5	Control	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**	0.00	**0.00**

Effect of culture filtrates on sporulation of *A. lini*

Sporulation intensity in treatments and control of replicated experiment was recorded using Haemocytometer as described earlier. After recording sporulation intensity per cent inhibition of sporulation was calculated (Vincent, 1927).

Statistical analysis

Statistical analysis was done as per the procedure laid down for completely randomized design (CRD) (Gomez and Gomez, 1983).

RESULTS AND DISCUSSION

Morphological and cultural characteristics

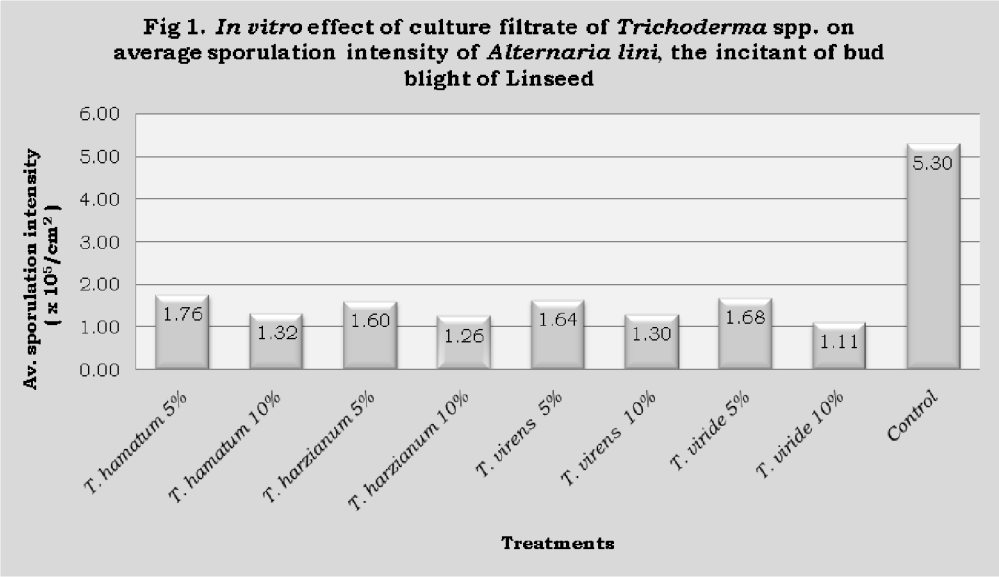
The morphological and cultural variations of the *A. lini* isolates grown on PDA are summarized in Table-1. Among the ten isolates, ALP-9 was observed to be slow growing and had sparse sporulation whereas ALP-10 was growing profusely and had abundant sporulation. Five isolates were having submerged colonies with darker colour (*i.e.* olivaceous to black), four isolates had effused colonies with lighter colour (*i.e.* light grey to brown) and one isolate had dark grey cottony colony on PDA.

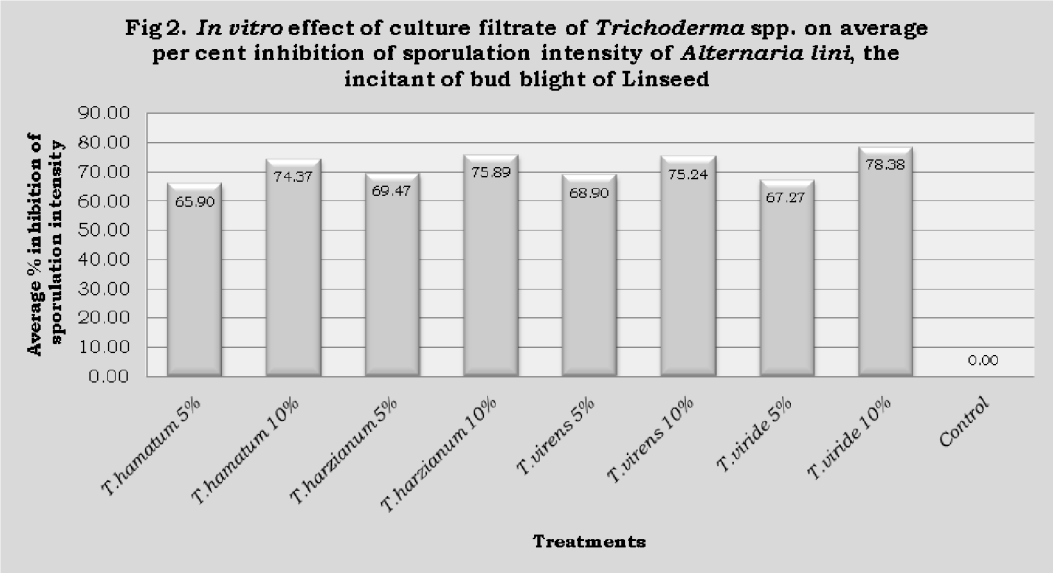
The mycelium of all the isolates was hyaline and septate. Conidiophores were olive brown and more closely septate. Conidia were 3-7 celled with 1-3 longitudinal and 1-4 transverse septation. The length (including beak) and breadth of conidia among ten isolates ranged from 14.9-44.5 x 7.0-15.3 µm with beak length ranging between 2.3-15.6 µm. Conidia were borne on conidiophores singly or in chains of 5-6 spores. These characteristics of *A. lini* were matching with the reports of Dey (1933) and Arya and Prasad (1952).

Effect of culture filtrates on sporulation of *A. lini*

Antagonistic potential of *Trichoderma* spp. has been reported due to competition, hyperparasitism and antibiosis (Harman, 2006). By its multimodal action Trichoderma restricts the growth of various species of genus Alternaria.

Sporulation intensity and percent spore inhibition of *A. lini* due to culture filtrates of bioagents are summarized in Table 2 and Table 3, respectively. All the four species of Trichoderma are found to reduce sporulation of *A. lini*, pathogen of bud blight of linseed. Among the four species of Trichoderma tested against *A. lini*, *T. viride* was found to have highest degree of inhibition of spore formation. The least sporulation intensity 1.0 x 10^5/cm^2 was recorded in *T. viride* (10 %) against the isolates ALP-8 and ALP-10 (Table 2). Among the Trichoderma species *T. viride* had most efficiently reduced the sporulation in all the ten isolates of *A. lini* with the least average sporulation intensity of 1.11 x 10^5/ cm^2 (Fig 1). Per cent spore inhibition achieved due to *T. viride* (10%) ranged from 66.67 to 84.40 per cent among the *A. lini* isolates with the highest inhibition observed in ALP-10 (Table 3). The maximum 78.38 per cent average inhibition of sporulation intensity was also recorded in *T. viride* (10%) (Fig-2).





Thus, it is concluded that the inhibition of spore formation is also an antagonistic property of fungal bio-control agents by which they restrict the further proliferation of fungal pathogens.

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Growth Performance of Cross bred Calves under Probiotic Supplementation

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ABSTRACT

An experiment of six months duration was undertaken at NDRI, Karnal ,Haryana, India to investigate the effect of probiotic supplementation @ 5 x 10^9 c.f.u day^{-1} on the growth performance of Karan Swiss and Karan fries crossbred calves of either sex. The analysis of variance revealed that the probiotic supplementation had non-significant effect ($P > 0.05$) on live weight gain , heart girth and width between pin bones. However, there was significant effect ($P < 0.05$) on biometric measurements viz. body length, abdominal girth and height at withers. Further, period was found to have highly significant effect ($P < 0.01$) on the overall values of growth parameters and biometric measurements.

Probiotics have been defined as live microbial supplements which benefits the host organism (Fuller, 1989). Flachowsky and Daaenicke (1996) defined probiotics as the dried microbial cultures or their spores that have a regulatory effect on intestinal microbes. Increased growth performance due to probiotic supplementation in the form of live cell suspension of yeast *Saccharomyses cerevisiae* has been reported by Bonomi *et al*. (1978), Sharma and Malik (1992), Panda *et al*. (1995) , but a few workers have reported reverse (Wangner *et al*.1990; Edwards 1991, El Hasan, 1996; Quigly 1992 and Kamalamma , 1996). But still there are many research gaps and lot of scope to investigate the effect of supplementation of *Saccharomyses cerevisiae* on the growth parameters of Karan Swiss and Karan fries cross-bred calves .Hence in order to fill up these research gaps and to investigate the effect of probiotic supplementation on growth and certain biometric measurements viz. body length, heart girth abdominal girth and height at withers in Karan Swiss and Karan fries cross-bred calves, the present investigation was undertaken at NDRI, Karnal Haryana , India.

MATERIAL AND METHODS

Forty eight crossbred calves of either sex of Karan Swiss and Karan fries breed(s) aging five days were taken from Cattle yard, National dairy Research Institute, Karnal herd. The calves were allotted randomly into six groups. The six groups having eight calves each are given underneath. A 3x2 factorial randomized block design was used for the present study.

H_1P_0- Loose housing in group on pucca floor+ No probiotic supplementation (P_0)

H_1P_1 - Loose housing in group on pucca floor+ Probiotic supplementation (P_1)

H_2P_0 - Individual housing in cage on slatted floor+ No probiotic supplementation (P_0)

H_2P_1 - Individual housing in cage on slatted floor+ Probiotic supplementation (P_1)

H_3P_0 - Individual tying on partially pucca floor+ No probiotic supplementation (P_0)

H_3P_1 - Individual tying on partially pucca floor + Probiotic supplementation (P_1)

All the experimental calves were maintained under NDRI feeding schedule (Annonymous, 1979) except the experimental crossbred calves in group (s) H_1P_1, H_2P_1 and H_3P_1 which were supplemented with live cell suspension of yeast *Saccharomyses cerevisiae* (NCDC -47) fed @ 5 x 10^9 c.f.u day^{-1} by incorporating it into the milk offered to them (Panda *et al*., 1995).During the entire length of experimentation all the management practices were followed as per standard practices followed at NDRI, Karnal. The experiment was conduced during summer, rainy and autumn season(s).The maximum and minimum temperatures recorded during experimental period were 38 ^{0} and 15.5 ^{0}C, respectively. The live body weights of calves and various biometric measurements viz. body length, heart girth, abdominal girth and height at withers were recorded at birth and thereafter at weekly intervals till they attained six months age.The data were analyzed

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using analysis of variance technique (Snedechor and Cochran,1974).

RESULTS AND DISCUSSION

Effect of probiotic supplementation on live body weights

It was observed that , initially during first week of age, the average live body weights of crossbred calves supplemented with probiotic (P_1) were slightly more (27.67 ± 1.31 kg) than the live body weights of crossbred calves not supplemented with probiotic (P_0)(26.75 ± 1.25 kg) .At the end of 24 weeks period, the live body weights of crossbred calves supplemented with probiotic (P_1) were again observed to be slightly more (98.60 ± 4.51 kg) than live body weights of crossbred calves not supplemented with probiotic (P_0) (94.08 ± 4.66 kg) (Table-1) .The total change in live body weights of crossbred calves supplemented with probiotic (P_1) was slightly more (71.10 kg) than live body weights of crossbred calves not supplemented with probiotic (P_0) (67.33 kg) .In the first week, the average total gain in live body weights of crossbred calves supplemented with probiotic (P_1) were slightly more (0.304 kg) than the live body weights of crossbred calves not supplemented with probiotic (P_0)(0.222 kg) . At the end of 24 weeks period, the same averaged 0.401 ± 0.07 kg and 0.442 ± 0.01 kg respectively (Table-2). Though there was apparent difference in the average daily gain in live body weights of crossbred calves, the analysis of variance revealed no significant ($P > 0.05$) difference between live body weights of crossbred calves in P_0 and P_1 groups.

Similar to these results, Adams *et al*. (1981) ; Johnson 1985;Wagner *et al*. 1990;Edwards (1991) and Quigly *et al*. (1992) observed no significant effect of probiotic supplementation on gain in live body weights of calves. Further, Kamalamaa 1996) observed no significant difference in live body weights of cattle fed on diet of finger millet straw and commercial cattle fed with or without Yea Sacc ^{1026} (*Saccharomyses cerevisiae*) @ 30 g day^{-1} El^{-1}-Hasan (1996) also observed that effect of live body weight of cattle fed with yeast culture were similar to those cattle not fed with yeast culture.

But, contrary to these results, Bonomi *et al*. (1978) reported an increase in live body weight gain of Friesian calves fed with Zymoyeast (a commercial preparation for a period of 120 days. Similarly Fallen and Harte (1987) reported that addition of yeast culture @ 2 g kg^{-1} to the starter diet of calves results in an increase in live body weight gain by 25 per cent .Cole *et al*. (1992) also observed that supplementation of yeast culture tend to maintain higher live body weights .Further, Mallik(1993) reported that the average live body weights of crossbred calves was 67.1 kg in control group (non-probiotic group) and higher (76.7 kg) in probiotic supplemented group. Abe *et al*. (1995) too reported that , oral administration of *Bifidobacterium pseudolongum* or *Lactobacillus acidophilus* to calves improved live body weight gain over the control.

Effect of probiotic supplementation on biometric measurements

Effect of probiotic supplementation on body length

It was observed that ,during the first week of the age, the average body length of calves in non-probiotic group (P_0) and probiotic supplemented group (P_1) were 54.29 ± 0.71 and 54.21 ± 0.71 cm respectively. At the end of 24 weeks period the same averaged on somewhat higher side in probiotic supplemented group (P_1) (83.83 ± 1.22 cm) and less (80.00± 1.57 cm) in non-probiotic group (P_0) (Table-1) .The total gain in body length was more (0.280 cm) in probiotic supplemented group (P_1) and less (0.236 cm) in non-probiotic group (P_0).At the end of 24 weeks period, the average overall difference was more (0.195 ± 0.02 cm) in non-probiotic group (P_0) and comparatively less (0.188 ± 0.01 cm) in probiotic supplemented group (P_1) (Table-2).But analysis of variance revealed that ,these apparent differences were found to be non-significant ($P > 0.05$) .No reference on this aspect could be traced in literature.

Effect of probiotic supplementation on heart girth

It was observed that ,during the first week of the age, the average heart girth of calves in non-probiotic group (P_0) and probiotic supplemented group (P_1) were 67.83 ± 0.96 and 68.00 ± 1.13 cm respectively. At the end of 24 weeks period the same averaged on somewhat higher side (95.0 cm) in non-probiotic group (P_0) and less (92.57 cm) in probiotic supplemented group (P_1) (Table-1) .The average daily gain in heart girth of calves in non-probiotic group (P_0) and probiotic supplemented group (P_1) were 0.29 ± 0.02 and 0.27± cm respectively. At the end of 24 weeks period the average overall difference was observed to be more (0.304 ± 0.02 cm) in non-probiotic group (P_0) and comparatively less (0.294 ± 0.02 cm) in probiotic supplemented group (P_1) (Table-

Table 1 : Weekly means for live body weights and biometric measurements of crossbred calves with and without probiotic supplementation

Weeks	Live Body Weights(Kg)		Body length (cm)		Heart girth (cm)		Abdominal girth (cm)		Height at withers (cm)		Width between pin bones(cm)	
	P_0	P_1	P_0	P_1	P_0	P_1	P_0	P_1	P_0	P_1	P_0	P_1
1	26.75± 1.25	27.67± 1.31	54.29± 0.71	54.21± 0.71	67.83± 0.96	68.00± 1.13	67.17± 0.84	67.08± 1.44	68.13± 0.94	58.28± 4.85	7.90± 0.12	8.02± 0.13
8	43.48± 1.63	39.79± 1.70	65.08± 0.98	66.54± 1.08	78.96± 1.01	80.50± 1.23	83.46± 1.28	82.42± 1.67	78.17± 1.17	66.58± 5.57	8.90± 0.15	9.19± 0.14
16	67.79± 2.92	69.27± 3.14	72.79± 1.17	73.38± 2.96	88.29± 1.38	87.50± 5.07	103.42± 1.99	99.07± 4.31	85.33± 1.14	72.15± 6.00	9.21± 0.16	9.42± 0.16
24	94.68± 4.66	98.60± 4.51	80.00± 1.57	83.83± 1.22	95.00± 1.54	92.57± 5.38	118.28± 2.53	116.54± 4.97	90.38± 1.31	74.85± 6.25	10.17± 0.26	10.79± 0.26

Table-2: Average daily gain (kg) in live body weights and biometric measurements of crossbred calves with and without probiotic supplementation

Weeks	Live Body Weights(Kg)		Body length (cm)		Heart girth (cm)		Abdominal girth (cm)		Height at withers (cm)		Width between pin bones(cm)	
	P_0	P_1	P_0	P_1	P_0	P_1	P_0	P_1	P_0	P_1	P_0	P_1
1	0.304± 0.25	0.222.± 0.07	0.280± 0.71	0.236± 0.71	0.29± 0.02	0.27± 0.02	0.286± 003	0.346± 0.05	0.27± 0024	0.21± 0.02	0.071± 0.00	0.071± 0.00
8	0.491± 0.07	0.481± 0.07	0.167± 0.01	0.305± 0.13	0.27± 0.02	0.31± 0.03	0.410± 0.05	0.474± 0.05	0.28± 0.03	0.19± 0.02	0.071± 0.00	0.071± 0.00
16	0.562± 0.12	0.183± 0.5	0.183± 0.02	0.198± 0.02	0.30± 0.09	0.10± 0.02	0.448± 0.06	0.387± 0.05	0.18± 0.03	0.10± 0.11	0.071± 0.00	0.071± 0.00
24	0.578± 0.09	0610± 0.05	0.244± 1.57	0.189± 0.01	0.16± 0.01	0.18± 0.53	0.372± 0.07	0.463± 0.07	0.22± 0.03	0.12± 0.05	0.107± 0.04	0.194± 1.28

2) .But analysis of variance revealed that ,these apparent differences were found to be non-significant (P > 0.05) .No reference on this aspect could be traced in literature.

Effect of probiotic supplementation on abdominal girth

It was observed that ,during the first week of the age, the average abdominal girth of calves in non-probiotic group (P_0) and probiotic supplemented group (P_1) were 67.17 ± 0.84 and 67.08 ± 1.44 cm respectively. At the end of 24 weeks period the same averaged on somewhat higher side (118.28 ± 2.53 cm) in non-probiotic group (P_0) and less (116.54±4.97 cm) in probiotic supplemented group (P_1) (Table 1) .The average daily gain in abdominal girth of calves in probiotic supplemented group (P_1) was smomewhat more (0.346± 0.05 cm) in non-probiotic group (P_0) and less (0.286 ± 0.03 cm. At the end of 24 weeks period the average overall difference was observed to be more (0.463 ± 0.07 cm) probiotic supplemented group (P_1) and comparatively less (0.372 ±0.07 cm) in non-probiotic group (P_0) (Table 2) .But analysis of variance revealed that ,these apparent differences were found to be non-significant (P > 0.05) .No reference on this aspect could be traced in literature.

Effect of probiotic supplementation on height at withers

It was observed that ,during the first week of the age, the average height at withers of calves in non-probiotic group (P_0) and probiotic supplemented group (P_1) were 67.83 ± 0.96 and 68.00 ± 1.13 cm respectively. At the end of 24 weeks period the same averaged on somewhat higher side (95.0 cm) in non-probiotic group (P_0) and less (92.57 cm) in probiotic supplemented group (P_1) (Table 1) .

During the first week of the age, the average daily gain in body length of calves in non-probiotic group (P_0) was more (0.27 ± 0.02 cm) and less (0.21 ± 0.02 cm) in probiotic supplemented group (P_1) . At the end of 24 weeks period, the same trend was observed and the overall difference was observed to be more (0.15 ± 0.03 cm) in probiotic supplemented group (P_1) (Table-2) .But the analysis of variance revealed that ,these apparent differences were found to be non-significant (P > 0.05) .No reference on this aspect could be traced in literature.

Effect of probiotic supplementation on width between pin bones

It was observed that ,during the first week of the age, the average width between pin bones of calves in probiotic supplemented group (P_1) was slightly more (8.02± 0.13 cm) and more (7.90 ± 0.12 cm) in non-probiotic group (P_0).At the end of 24 weeks period the width between pin bones of calves in probiotic supplemented group (P_1) was found to be somewhat on higher side (10.79 ± 0.26 cm) and less (10.17± 0.26 cm)in non-probiotic group (P_0) (Table-1). During the first week of the age, the average daily gain in width between pin bones of calves in non-probiotic group (P_0) and probiotic supplemented group (P_1) were same (0.071 ± 0.00 cm each) .At the end of 24 weeks period, the average overall difference was observed to be more (0.030 ± 0.00 cm each) in probiotic supplemented group (P_1) and less (0.015 ± 0.04 cm) in non-probiotic group (P_0) (Table-2). The analysis of variance also revealed that there was significant (P <0.05) effect of probiotic supplementation on width between pin bones. No reference on this aspect could be traced in literature.

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Chemical composition of *Burfi* Blended with Honey

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ABSTRACT

An experiment was conducted to study the chemical composition of *Burfi* blended with honey. There were five treatments with combinations namely T1 (70% khoa + 30 % sugar), T2 (96% khoa + 4 % honey), T3 (95% khoa + 5 % honey), T4 (94% khoa + 6 % honey) and T5 (93% khoa + 7 % honey). Final product was analyzed for chemical composition and it was found that average moisture content in burfi was significantly increased with increasing proportion of honey from 20.63 to 22.71, while fat, protein, lactose and ash content were significantly decreased from 24.50 to 22.72, 17.23 to 14.74, 20.36 to 18.23, 79.37 to 77.29 and 3.03 to 1.94, per cent respectively from treatment T_1 to T_5, respectively.

The manufacturing of value added products like filled dairy products could be a better alternative to preserve valuable milk solids during the flush season. Thus the technology will boost the economy and efficiency of dairy industry. Burfi has been favoured as one of the most popular khoa based sweets all over India. The unique adaptability of khoa in terms of its flavour, body and texture to blend with a wide range of food had permitted for development of an impressive array of burfi varieties. Among these fruit, nut, chocolate, coconut, saffron, rawa, santraburfi are popular. The myriad combination include burfi prepared with cashew nut as Katli (a water thin slice), almond pistachio, coconut, mango, wood apple, bottle gourd and potato. The sub line manifestation of burfi is made with pistachios. It is soft and chewy resembling Halwa-burfi (Kamble *et al.*, 2010)

Honey is a natural sweetener, having medicinal properties. This makes the use of honey less harmful than sugar. If we replace sugar with honey in the sweets and deserts, it will certainly help to overcome various health problems and would provide the sweetmeat with therapeutic value. It is used as laxative, blood purifier, a preventive against cold, cough, fever, curative for sores, eye ailments, ulcers on tongue, sore throat and burns (Srivastava 1996). Honey is an excellent energy food, with an average of about 3,500 calories kg^{-1}. Considering the therapeutic and medicinal value of honey, efforts' were made to utilize honey in burfi as sugar replacer and find out its effect on chemical properties of burfi.

MATERIALS AND METHODS

Method of preparation of burfi suggested by De (1982) was used with slight modification. The standardized buffalo milk was concentrated to a dough stage by evaporating in iron *Karahi* on a gentle fire. At this stage the honey or sugar was added as per treatment as control treatment T_1-70 per cent khoa + 30 per cent sugar and other treatments with combination of khoa+ honey as 96+4, 95+5, 94+6 and 93+7 per cent as T_2, T_3, T_4 and T_5, respectively and mixed properly. The product was taken out and spread into a stainless steel tray and was allowed to cool and cut into pieces of desirable size.

The percentage of total solids in burfi was determined by using gravimetric method. The procedure recommended in B.I.S. Handbook of food analysis, IS: 1166, 1973).The fat content of burfi was determined by using Soxhlets extraction method as per the procedure recommended in A.O.A.C. (1990). Lactose was estimated as per the procedure described in (BIS SP Part-XI, 1981) for burfi with slight modification. The ash content of burfi was determined by IS:1167 (1965) and the protein content in burfi was determined as per the procedure recommended in B.I.S. Handbook of food analysis Dairy products IS:1166 (1973). Data obtained were statistically analyzed under completely randomized design by adopting standard method of analysis of variance as suggested by Amble (1975).

RESULTS AND DISCUSSION

The data obtained on chemical composition i.e. moisture, fat, protein, lactose, total solids and ash were tabulated and presented in Table 1.

Moisture (%) : The highest moisture content was noticed in treatment T_5 (22.71) with 7 per cent honey and lowest moisture content was noticed in control T_1 treatment. The moisture content in burfi significantly increased with increase in the different levels of honey. This might be due to more moisture content of honey i.e.17 percent. These results are in agreement with Kamble et al. (2010)

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Table 1: Chemical composition of burfi prepared with addition of honey.

Treatments	Chemical constituents (per cent)					
	Moisture	**Fat**	**Protein**	**Lactose**	**Total solids**	**Ash**
T_1	20.63	24.50	17.23	20.36	79.37	3.03
T_2	21.58	24.05	16.83	19.72	78.42	2.63
T_3	21.89	23.63	16.04	19.03	78.11	2.52
T_4	22.38	23.13	15.12	18.47	77.62	2.22
T_5	22.71	22.72	14.74	18.23	77.29	1.94
'F' test	Sig	Sig	Sig	Sig	Sig	Sig
SE (m)±	0.062	0.033	0.091	0.041	0.062	0.030
CD at 5%	0.186	0.100	0.273	0.125	0.186	0.089

who reported that the increase in different levels of pineapple pulp increased the moisture percentage in burfi.

Fat (%) : The average fat content in the burfi was significantly decreased with addition of honey which might be due to low fat content in honey. The mean score for fat content were 24.50, 24.05, 23.63, 23.13 and 22.72 given to the treatment T_1, T_2, T_3, T_4 and T_5, respectively. The fat content in plain burfi T_1 was highest among all the treatments i.e. 24.50 per cent and lowest fat content observed i.e.22.72 in T_5. These findings are in agreement with the result reported by Kamble *et al.* (2010) who noted that fat content was decreased by adding different levels of pineapple pulp.

Protein (%): Protein content in honey burfi ranged from 14.74 to 17.23. The control burfi (T_1) had highest protein content (17.23 %), while honey burfi with 7 per cent honey had lowest (14.74 %) protein content. This might be due to low protein content in honey. protein per cent decrease with an increase in the level of honey. These findings are in agreement with Gargade (2004), who reported that protein content was decreased due to use of the papaya pulp and orange concentrate in the preparation of burfi, respectively.

Lactose (%): Lactose per cent in treatment T_5 was lowest (18.23 %) where as higher lactose content was found in treatment T_1 (20.36 %). This indicates that, as honey level increases the lactose content decreases significantly. There seems to be linear decrease with the higher levels of honey addition.

Total solids (%): The average value of total solids content in the burfi under treatment T_1, T_2, T_3, T_4 and T_5 were 79.37, 78.42, 78.11, 77.62 and 77.29, respectively. Highest level of total solids was noticed in control burfi T_1 and the lowest level of total solids was noticed in 7 per cent honey added (T_5) burfi. This was due to the lower total solids content in the honey. As the level of honey increases the total solids in the burfi were decreased. These findings are in close agreement with the result reported by Gargade (2004) who observed that increase in the level of papaya pulp and orange concentrate adversely affected the total solids content in the burfi.

Ash (%): The ash content in treatment T_1, T_2, T_3, T_4 and T_5 were 3.03, 2.63, 2.52, 2.22 and 1.94 per cent, respectively. The ash content was the highest in treatment T_1 i.e. 3.03 per cent and lowest in treatment T_6 i.e.1.94 per cent. It indicates that, as the level of honey increases in burfi the ash content decreases. this might be due to low ash content in honey. These findings are in agreement with results reported in cashewnut burfi (1.13 per cent) by Rao *et.al.* (1993).

Conclusion: The ingradients composition of burfi i.e. fat, protein, total solids, lactose and ash per cent were decreased with addition of honey while moisture per cent was increased with increase in addition of honey.

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RESEARCH NOTES

Registration of Drought and Heat Tolerant Wheat Germplasm Line AKAW-3717

India achieved a record wheat production of 94.88 million tonnes during 2011-12out of which major contribution came from the North Western Plain Zone, wheat bowl of the country. Although majority of wheat area falls under timely sown irrigated crop conditions, a sizeable area comes under various cropping systems such as rice-wheat, cotton-wheat, sugarcane-wheat, soybean-wheat, sorghum-wheat, vegetable-wheat, etc. In all such cropping systems, late harvesting of preceeding crops make wheat cultivation delayed resulting in shorter crop period. In all these areas, early maturing and high yielding varieties of wheat are required that can fit in to prominent crop rotations and suitable for sowing during mid to late December. Nearly 22.5 m ha area is under bread and *durum* wheat in North -West, North-East and Central India, where early or late heat stress or both affects wheat productivity. Stagnant wheat production in recent years is partly due to climatic factors including heat stress characterized by an increasing trend in average temperature during winter months (Rane *et al* 2000 and Nagarajan 2005). For ameliorating these problems, short duration varieties having plasticity for sowing period, tolerance to early and terminal heat stress are required. Therefore for development of short duration temperature insensitive wheat varieties with tolerance to terminal heat, a cross between germplasm line HW-2035 and NI-5439 was performed at Wheat Research Unit, Dr. P.D.K.V., Akola. Further generations of cross HW-2035 x NI-5439 were advanced as per pedigree selection breeding method. After stabilization of genotype it was evaluated in

Table 1: Grain yield (q ha^{-1}) of AKAW-3717 in breeding trials NIVT-5A and AVT (RF-TS)

Trial/ Zone	NWP	NEP	CEN	PEN	Av. over zones
NIVT-5A, 2002-03	27.80 (4)	23.00 (6)	24.40 (2)	14.70 (4)	22.30 (16)
NIVT-5A, 2004-05	20.00 (4)	19.90 (8)	18.60 (4)	17.20 (6)	18.90 (22)
AVT (RF), 2005-06	-	-	-	18.80 (6)	18.80 (6)
			Av. over 44 locations		**20.00 q/ha**

Figures in parenthesis denotes No. of Locations

Table 2: Grain yields (g plot^{-1}) performance in DHTSN, Rank as revealed by pooled analysis

Rank	Genotype	Sagar	Hisar	Kanpur	Pune	Indore	Karnal	Kota	Bardoli	Dharwad	Dhanduka
A	**19th DHTSN, 2006-07**										
1	HI-1544	333.4	511.0	192.9	551.1	-	-	-	-	-	66.5
2	AKAW-3717	364.9	374.3	214.4	591.9	-	-	-	-	-	61.1
	G. Mean	**346.1**	**398.7**	**174.8**	**356.6**	**-**	**-**	**-**	**-**	**-**	**64**
	CD at 5%	91.2	70.3	50.0	-	-	-	-	-	-	9.6
B	**20th DHTSN, 2007-08**										
1	NI-5439	445.1	339.3	249.6	475.0	548.7	162.0	925.0	-	-	-
18	AKAW-3717	517.7	324.9	234.7	462.5	395.8	132.5	418.5	-	-	-
	G. Mean	**358.6**	**230.2**	**229.1**	**424.8**	**385.0**	**139.4**	**594.5**	**-**	**-**	**-**
	CD at 5%	87.3	63.2	127.1	121.0	91.6	Ns	60.1	-	-	-
C	**21st DHTSN, 2008-09**										
1	AKAW-3717	440.0	430.0	129.0	208.0	335.5	456.1	410.0	395.0	368.0	-
2	HI-1564	440.0	322.5	117.5	218.0	253.5	471.0	457.5	400.0	272.0	-
	G. Mean	**284.5**	**287.1**	**119.3**	**152.4**	**253.7**	**412.8**	**398.3**	**359.2**	**311.5**	**-**
	CD at 5%	183.9	66.3	6.28	73.13	58.8	189.3	0	58.35	31.0	-

SUGGESTIONS FOR AUTHORS

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