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Productivity of Soybean [*Glycine max* (L.) Merrill] Based Cropping Systems as Influenced by Staggered Sowing under Rainfed Conditions of *Krishna-Godavari* Zone of Andhra Pradesh

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ABSTRACT

The cropping system of pigeon pea + soybean (7:!) sown on 22nd July recorded higher soybean seed equivalent yield (SEY), production efficiency and net returns followed by double cropping systems of soybean – mustard, soybean – chickpea sown on 22nd July and pigeon pea + soybean sown on 8th June during 2001. On the other hand, during 2002, with below normal rainfall, sole pigeon pea sown on 30th July recorded higher soybean SEY followed by sole cotton and sole pigeon pea sown on 2ndJuly and 22nd August, respectively. The contribution of soybean to different systems decreased in 2002 due to severe drought conditions. The B:C ratio was higher with sole pigeon pea sown on 2nd fortnight of July during both the years. The land use efficiency of cropping systems involving pigeon pea and double cropping was almost constant in both the years (50%). However, it was 62 and 47 percent with cropping systems involving cotton during 2001 and 2002, respectively.

Key words: Cropping system, sowing date, seed equivalent yield, production efficiency, land use efficiency, B: C ratio, soybean

In rainfed black soils of *Krishna-Godavari* agro-climatic zone of Andhra Pradesh, mono-cropping of commercial crops like cotton and chillies with high input use increased the overall production cost and resulted in reduction in net returns. As an alternative, the area of soybean, which can be cultivated as an intercrop in cotton and pigeon pea and as component crop in double cropping, is on increase in Andhra Pradesh (Pramila Rani *et al.,* 1998). Soybean-chick pea sequence was reported to be more profitable as compared with that of soybean-wheat (Raskar and Bhoi, 2000). Further under rainfed situation, sowing of crops/cropping systems usually vary according to the onset and distribution of rains. Delayed sowing of *kharif* crops is linked with delay in sowing of sequential crops, thereby paving way for decreased productivity from the adopted cropping

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system. Hence, an effort has been made to evaluate various cropping systems involving soybean under staggered sowing and to ascertain an optimum time of raising these cropping systems under rainfed conditions in black soils of *Krishna-Godavari* zone.

MATERIAL AND METHODS

A field experiment was conducted at Regional Agricultural Research Station, Lam, Guntur, Andhra Pradesh during *kharif* and *rabi* seasons of 2001-02 and 2002-03. The main plot treatments consisted of four dates of sowing and the sub-plots treatments of six cropping systems viz., sole cotton, soybean as an intercrop in cotton (1:2), sole pigeon pea, soybean as intercrop in pigeon pea (1:7), and soybean–chick pea, soybean – mustard, laid out in split plot design and replicated thrice. The crop varieties used were JS 335 (soybean), LRG 30 (pigeon pea), L 604 (cotton), ICCV 2 (chick pea) and IBM 428 (mustard).

All the individual crops in different cropping systems received recommended levels of fertilizers. The crops were grown as rainfed and the first sowing was resorted to with the onset of monsoon during both the years. The later three sowings were taken up after 15 days of previous sowing, as and when soil conditions were favourable (with successive rains).

The rainfall received from June to March was 921 and 534 mm, respectively, during 2001-02 and 2002-03. The rainfall of the year 2002 was deficit by 36 percent than the normal rainfall of the region and resulted in severe moisture stress and consequent lower yields of crops.

Soybean seed equivalent yield was calculated by converting the seed yield of all the crops into soybean seed yield based on the prevailing market prices of inputs and market rates of respective crops on pooled basis. Per day productivity was obtained by dividing the soybean SEY by total duration of the crop in the sequence.

The soil of the experimental site belonged to very fine, montmorillonitic, udic Chromusterts (*Amaravati* series). It is slightly alkaline (pH – 7.9), low in available nitrogen (191 kg/ha), medium in available phosphorus (44 kg/ha) and high in available potassium (1008 kg/ha).

RESULTS AND DISCUSSION

The economic yield of crops under study was recorded and the productivity of the cropping systems was evaluated in terms of soybean seed equivalent yield (SEY), monetary returns, benefit: cost ratio, production efficiency and land use efficiency.

Soybean seed equivalent yield

The soybean equivalent yield was significantly higher with the crop sown on 22nd July as compared with that sown on 21st August and comparable with that sown on 8th and 23rd June 2001 (Table 2). The same in 2002 was significantly greater with 30th July than that sown on 2nd July which in turn recorded comparable soybean seed equivalent yield as that of 14th June (Table 1).

During 2001, intercropping of pigeon pea + soybean sown on 22nd July recorded significantly higher soybean equivalent yield over rest of the treatments combinations. The performance of both the component crops sown on 22nd July was better and thus contributed to higher soybean equivalent yield. The contribution of soybean in pigeon pea + soybean and doubling cropping systems was 33 and 54 percent, respectively (Fig. 1).

Table 1. Soybean seed equivalent yield (kg/ha) of different soybean-based cropping systems as influenced by date of sowing during 2001-02 and 2002-03

Cropping system	2001					2002				
	8th June	23rd June	22nd July	21 August	Mean	14th June	2nd July	30th July	22nd August	Mean
Sole cotton	3154	2432	2524	2186	**2574**	2077	2501	2218	1641	**2109**
Sole pigeon pea	3194	3389	3584	2944	**3278**	2227	2512	2715	2431	**2471**
Cotton + Soybean	3932	3099	2873	3285	**3297**	1614	1305	1886	1712	**1629**
Pigeon pea + soybean	4097	3788	4701	3783	**4092**	2009	1994	2111	1811	**1981**
Soybean – chick pea	3495	3351	4146	3613	**3651**	1226	1593	2063	1205	**1522**
Soybean - mustard	3484	3864	4163	2875	**3597**	1395	1209	1106	1018	**1182**
Mean	**3560**	**3321**	**3665**	**3114**		**1758**	**1852**	**2016**	**1636**	
	Date	System	Intera-ction			Date	System	Intera-ction		
SEm (±)	71	39	78			28	26	52		
(P = 0.05)	**247**	**111**	**223**			**97**	**74**	**144**		

On the other hand, sole pigeon pea sown on 30th July recorded significantly highest soybean equivalent yield over rest of the treatment combinations during 2002. Intercropping system recorded comparatively lower soybean equivalent yield that that of sole pigeon pea. The percent contribution of soybean in various cropping systems decreased as it suffered more due to moisture stress (Fig. 1) and was 14 and 23 per cent, respectively in cotton + soybean and pigeon pea + soybean systems and 35 and 44 per cent, respectively in soybean - chickpea and soybean-mustard cropping systems. Reduction of seed cotton yield due to soybean intercropping was also reported by Velayutham and Sambagavalli (2002). It indicates that the sole crop of cotton, pigeon pea and chick pea performed better during the years receiving below normal rainfall due to utilization of profile moisture by sole crop without any competition.

Further, because of deep root system, cotton and pigeon pea crop tolerated drought better, while chickpea survived on the residual soil moisture. However, in the year of abnormal rainfall, the pigeon pea + soybean stood next to sole cropping of pigeon pea and cotton. This indicates the superiority of pigeon pea + soybean system both in the year of well distributed rainfall and also in the year of below normal rainfall.

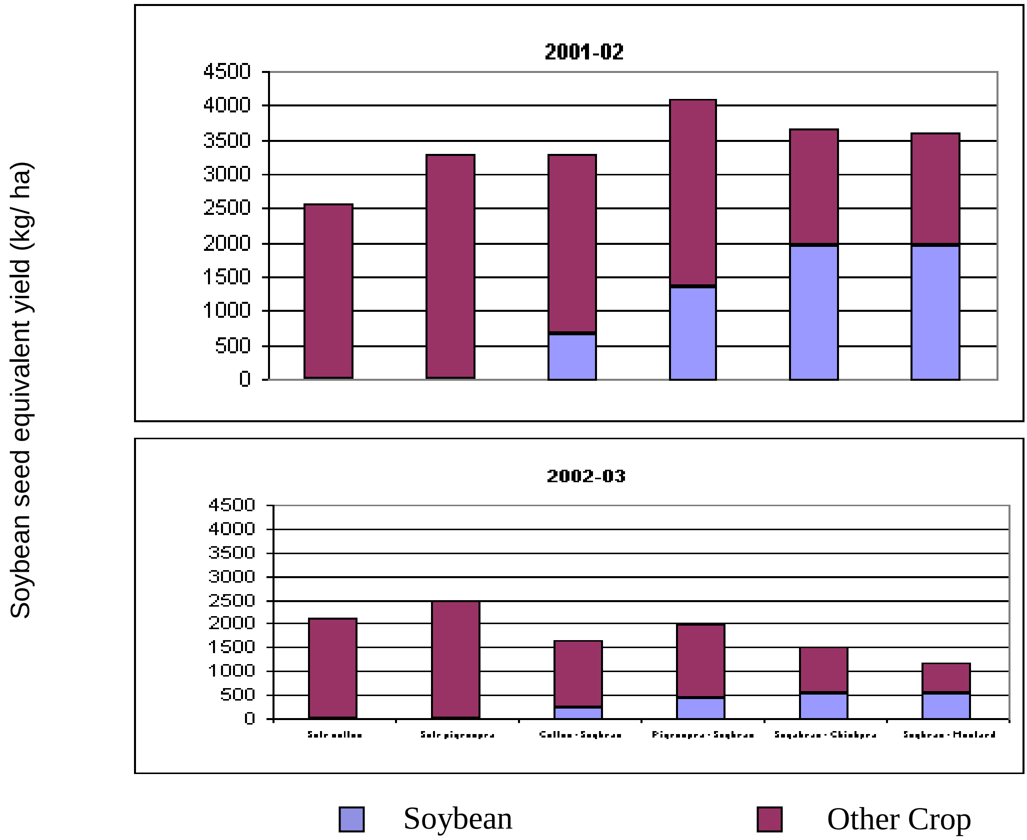

Fig. 1. Contribution of soybean in different cropping systems during 2001-02 and 2002-03

Net monetary returns and production efficiency

The crop sown on 22nd July 2001 and 30th July 2002 recorded higher net monetary returns and production efficiency than the other three dates of sowing in the respective years (Table 2). Pigeon pea + soybean was found better in terms of net monetary returns and production efficiency during 2001 while during 2002, sole pigeon pea recorded higher values for these parameters as compared to other cropping systems.

Table 2. Net monetary returns, benefit: cost ratio, production efficiency and land use efficiency of different soybean –based cropping systems as influenced by dates of sowing during 2001-02 and 2002-03

Treatment	Net monetary returns (Rs./ha)		Benefit: cost ratio		Production efficiency (kg soybean equivalent yield / ha / day)		Land use efficiency (%)	
	2001	2002	2001	2002	2001	2002	2001	2002
Cropping systems								
Sole cotton	12766	11732	1.23	1.62	11.32	12.51	62.3	46.6
Sole pigeon pea	23051	17741	3.58	3.94	16.48	13.24	54.8	51.7
Cotton + soybean	17265	4940	1.41	0.51	14.56	9.60	62.3	48.3
Pigeon pea + soybean	28331	11131	3.20	1.67	20.30	10.22	56.0	53.4
Soybean – chick pea	21526	3996	1.92	0.41	19.03	8.58	53.1	48.6
Soybean- mustard	22344	2314	2.23	0.28	18.89	6.60	52.3	50.0
Sowing dates								
8th June, 2001 and 14th June 2002	22194	8196	2.31	1.14	15.57	8.71	63.0	55.1
23rd June, 20011.17 and 2nd July 2002	19860	9029	2.15	1.49	15.21	9.81	60.5	51.7
22nd July 2001 and 30th July 2002	23262	10358	2.59	1.62	18.91	11.91	54.1	46.9
21st August 2001 and 22nd August 2002	18281	6985	1.99	1.17	17.32	10.07	49.6	44.8

Benefit: cost ratio

The B: C ratio from the cropping systems sown on 22nd July, 2001 and 30th July, 2002 was higher than the other three dates (Table 2). In both the years, sole pigeon pea recorded significantly recorded more profit for each rupee invested than all other cropping systems, followed by pigeon pea + soybean.

Land use efficiency

The land use efficiency decreased with delay in sowing in both the years (Table 2). During 2001, cotton based cropping systems occupied the land for more period of time than the other cropping systems followed by pigeon pea based systems. On the other hand, during 2002, pigeon pea based systems had higher land use efficiency than all other cropping systems.

The results indicated that in years with normal rainfall, intercropping pigeon pea with soybean in 2nd fortnight of July was more productive and form an alternative for commercial crops in the rainfed Vertisols of *Krishna-Godavari* zone. The double cropping of *kharif* soybean sown in 2nd fortnight of July followed by chick pea in 1st fortnight of November or mustard in 2nd fortnight of October was also profitable.

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Effect of Levels and Sources of Zinc on Yield, Agronomic Efficiency and Nutritional Value of Soybean and Wheat

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ABSTRACT

The experiment on evaluation of different doses and sources on zinc in soybean cv. JS 335 [Glycine max *(L.) Merrill*] *– wheat cv. Lok 1 (*Triticum aestivum *Linn.) cropping system in Madhya Pradesh was conducted at Farm of College of Agriculture, Indore on a Typic Haplustert (Sarol series) during 2004-05 in an randomized block design with 4 replications. Zinc was applied at 3 levels, @ 0, 1.8 and 5 kg Zn/ha in* kharif *and* kharif + rabi *season supplied through zinc sulphate heptahydrate (21% Zn) and complex fertilizer (10:50:0:1.5 N: P: K: Zn). Recommended dose of N: P_2O_5: K_2O to soybean and wheat was applied in all the treatments except one treatment where no phosphorus was applied. Incorporation of zinc in conjunction with N, P and K (N-30, P_20_5-60 and K_2O-20) for soybean has increased the yields by 6.3 to 8.6 percent and 29.9 to 33.9 percent with the application of zinc @ 1.8 and 5 kg/ha, respectively. Zinc @ 1.8 kg/ha to wheat through zinc containing complex fertilizer (10:50:0:1.5 N: P: K: Zn) and zinc sulphate has elevated the yields by 9.2 percent and 10.0 percent, respectively. Significant increase in yield levels was noticed due to increasing the level of zinc from 1.8 to 5 kg/ ha. Higher pooled agronomic efficiency of zinc application was observed with lower application rate of zinc (1.8 and 5 kg/ha once applied in* kharif*) than the higher application rate (3.6 and 10 kg/ ha) in case of total biomass and pooled soybean and wheat grain yield. The complex zinc fertilizer exhibited higher agronomic efficiency than $ZnSO_4 .7H_2O$ both at 1.8 and 3.6 kg/ha Zn. Application of zinc has resulted in increasing the DTPA extractable Zn significantly (35.9% over no zinc) even with one time application of 1.8 kg Zn/ ha during* kharif. *With increasing level (5.0 kg/ha), it was around 87% over no zinc. Application of Zn during both the seasons further increased the DTPA extractable Zn. The sources of zinc did not reveal any significant difference on DTPA extractable Zn. The application of zinc at lower rates (1.8 kg/ha) only in* kharif *has given higher returns than higher levels or application in both the seasons. The zinc containing complex fertilizers gave higher returns than $ZnSO_4 .7H_2O$.*

Key words: Zn nutrition, Soybean, 10: 50: 0: 1.5Zn*)*

Soybean [*Glycine max* (L.) Merrill] is the leading *kharif* (rainfed) crop of Madhya Pradesh and had 74 percent acreage (4.44 m ha) and 70 percent production (4.74 m t) in the country in the year 1999-2000 (Agricultural Statistics, 2001). It occupied about 67 percent of the acreage in Madhya Pradesh and had highest area in the agro-climatic zone X- *Malwa* Plateau (47%) and agro-climatic zone V –*Vindhyan* Plateau

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(20%) having Vertisols and associated soils, which have clay texture and higher water holding capacity. The *rabi* (winter season) crop is wheat (49.2%) followed by chickpea (27.2%) in this area, which is being cultivated under irrigated and rainfed conditions, respectively. Thus, the soybean- wheat cropping sequence is quite common in the region.

The importance of micronutrients has been realized during the past three decades. The micronutrient deficiency in soils has been attributed to continuous removal of micronutrients from soil by recently introduced fertilizer responsive improved varieties of crops, particularly cereals that produce high biomass on application. Use of micronutrient free high analysis fertilizers in modern agriculture also aggravated micronutrient deficiency. About 44 percent soils of Madhya Pradesh have been reported to be deficient in zinc. The soils of *Malwa* Plateau have been reported to reveal 50-75 percent samples deficient in zinc (Tomar *et al.,* 1995). There are reports to indicate that application of zinc sulphate @ 25 kg/ha gave highest return in wheat, rice and soybean (Parik *et al.,* 1992 and Rathore, 1992). Zinc application to soil prior to sowing was the most successful remedy to control zinc deficiency. Low efficiency of zinc sulphate was improved if it is placed below the seed and organic manures are incorporated with it. In a standing crop, the deficiency could be alleviated by foliar spray of zinc sulphate.

The problems faced by the farmer are: i) non-availability of complex formulation to provide zinc in addition to nitrogen and phosphorus, which can be drilled along with the seed, ii) difficult availability of zinc sulphate at village level shops, and iii) inconvenience in application of zinc sulphate available in powder form. A new complex fertilizer carrying 10-50-0-1.5 as N: P: K: Zn is being developed by M/S Mosaic India Pvt. Ltd. is in prilled form and may provide a good substitute for soybean-wheat farmers as it facilitates drilling along with seed. Thus, the experiment was devised to study the effect of doses and sources of zinc on agronomic efficiency and nutritional value of soybean and wheat was undertaken in Vertisols of *Malwa* Plateau of Madhya Pradesh.

MATERIAL AND METHODS

The experiment on effect of doses and sources of zinc on yield, agronomic efficiency and nutritional value of soybean cv. JS 335 [*Glycine max* (L.) Merrill] – wheat cv. Lok -1 (*Triticum aestivum* Linn.) cropping system was conducted on a Vertisol (Farm of College of Agriculture, Indore) belonging to fine montmorillonitic hyperthermic family of Typic Haplusterts – Sarol Series, which is amongst the bench mark soil series of Vertisols (Murthy *et al.*, 1982). The climate of the area is semi-arid subtropical monsoon type with an average annual rainfall of 979 mm, most of which is received between June – September.

The initial soil properties reveal that the soils are having alkaline soil reaction (pH - 7.7) and are non-saline non-alkali (EC– 0.37 dS/m) and clay in texture with high CEC (50.5 cmol(p+)/kg). The soils are having medium available P_2O_5 (36.3 kg/ha), low available nitrogen (143 kg/ha) and high available K_2O (382 kg/ha). The DTPA extractable zinc was (0.55 kg/ha), below the critical limit for black soil (0.6 mg/kg).

The treatments comprised of 3 doses @ 0, 1.8 and 5 kg/ha of zinc applied in *kharif* and *kharif* + *rabi* season supplied through zinc sulphate heptahydrate (21% Zn) and complex fertilizer (10:50:0:1.5 N: P: K: Zn). Thus, in all there were ten treatments (plot size 50 m^2) replicated four times under randomized block design in the experiment. Recommended doses of N and K_2O were applied uniformly to all the treatments. Soybean was sown after inoculation of seeds with *Rhizobium japonicum* culture on 17th July 2004, whereas, wheat was sown on 25th November 2004. The grain and biomass yields were recorded plot-wise and analyzed statistically (Panse and Sukhatme, 1954). The soil samples after harvest of soybean and wheat were collected from each plot and were analyzed as per standard methods for pH, EC (1:2), organic carbon, available N, P, K, S and DTPA extractable zinc. The agronomic efficiency was calculated as follows.

$$\text{Agronomic Efficiency (AE)} = \frac{\text{Yield in zinc treated plot} - \text{yield in } P_{60}Zn_0 \text{ plot}}{\text{zinc applied}} \times 100$$

RESULTS AND DISCUSSION

Biometrical parameters and agronomic efficiency

The yield attributes viz. number of pods per plant, and 100 seed weight of soybean (Table 1) registered a non-significant increase with the application of phosphorus and zinc as compared to control; however, seeds per pod were significantly affected by phosphorus as well as zinc application over control. The number of seeds was at par in different treatments comprising of doses and sources of zinc. Application of zinc registered significant increase in grain and straw yield of soybean. Incorporation of zinc @ 1.8 kg/ha has increased the grain yield significantly with both the sources of zinc i.e. complex fertilizer (10:50:0:1.5) and $ZnSO_4.7H_2O$ and ranged from 6.3 to 8.6 percent over control. The complex zinc had a higher increase but almost attain the level of significance. Application of 1.8 kg Zn either through complex fertilizer or through $ZnSO_4$ $.7H_2O$ has increased the yield over control ($P_{60}Zn_0$) and the increase ranged between 74 to 93 kg/ha while through 5 kg Zn from either sources, it ranged between 321 and 377 kg/ha. This indicates that application of 1.8 kg Zn/ha is not sufficient to increase productivity of soybean as compared to higher Zn dose (5 kg Zn/ha), which increased the yield significantly as in consonance with the findings of Singh (1999) who reported that increasing levels of Zn application increased the seed yield of soybean.

The grain and straw yield of wheat increased significantly with the application of phosphorus as compared to control. Thus is to an extent of 12 percent increase in grain and straw yield, respectively (Table 1). However, incorporation of zinc

@1.8 kg/ha once to soybean crop (*kharif*) has increased the grain and straw yield of wheat significantly with both the sources of zinc i.e. 10:50:0:1.5Zn and $ZnSO_4.7H_2O$ and ranged from 9.2–10.0 percent and 8.5-10.0 percent, respectively, over control. There was no significant difference between the sources of zinc. The zinc containing fertilizer (10:50:0:1.5Zn) had an edge over zinc sulphate. With an increase in zinc dose from 1.8 to 5 kg/ ha applied once in *kharif* had increased the wheat yield but not-significantly, irrespective of the source of zinc. However, application of zinc in *kharif* and *rabi* @ 1.8 and 5 kg/ ha does not produce significant increase yields over single application of 1.8 and 5 kg/ ha in *kharif*. Similar trend was also noted in case of straw yield. Reddy and Yadav (1994) reported significant increase in grain and straw yield of wheat with the application of zinc as well as phosphorus.

Table 1. Effect of different levels and sources of zinc application grain and straw yield and agronomic efficiency

Treatments	Zinc (kg/ha)		Yield (kg/ha)				Pooled soybean + wheat biomass (kg/ha)	Agronomic efficiency kg biomass /ha/ kg Zn applied	Agronomic efficiency kg grain/ha / kg Zn applied
	Time	Dose / annum	Soybean		Wheat				
			Grain	Straw	Grain	Straw			
P_0 Zn_0	None	0	1000	1272	3214	4109	9594.1	-	-
$P_{60}Zn_0$	None	0	1074	1364	3600	4603	10641.7	-	-
P_{60} Zn_5	*kharif*+	10			4121	5178			
	rabi		1395	1790			12483.9	184.2	84.2
$P_{60}Zn_5$	*kharif*	5	1407	1784	4008	5124	12323.8	336.4	148.3
$P_{60}Zn_{1.8+3.2}$	*kharif* +	10			4138	5206			
	rabi		1451	1852			12645.9	200.4	91.4
$P_{60}Zn_{1.8+3.2}$	*kharif*	5	1438	1839	4038	5163	12479.1	367.5	160.5
	kharif +	3.6			4014	5094			
$P_{60}Zn_{1.8}$ (F)	*rabi*		1167	1518			11792.1	319.6	140.6
P_{60} $Zn_{1.8}$ (F)	*kharif*	1.8	1160	1488	3961	5065	11674.8	574.0	248.7
$P_{60}Zn_{1.8}$	*kharif* +	3.6	1142	1438	4007	5083	11670.0	285.6	131.8
	rabi								
P_{60} $Zn_{1.8}$	*kharif*	1.8	1148	1444	3930	4994	11516.2	485.8	224.3
SEm (±)			20.2	21.9	39	35			
(P = 0.05)			**58.6**	**63.5**	**114**	**101**			
CV (%)			3.26	2.77	2.01	1.41			

Zn Fert. (F) - 10:50:0:1.5 ($N:P_2O_5:K_2O:Zn$), $ZnSO_4$. $7H_2O$ (21% Zn)

Pooled agronomic efficiency of zinc application revealed that lower application rate of zinc (may be 1.8 and 5 kg/ha) applied once in *kharif* had exhibited higher efficiency, as compared to higher application rate (3.6 and 10 kg/ha) with respect to total biomass and pooled soybean and wheat grain yield. The complex zinc fertilizer exhibited higher agronomic efficiency than zinc sulphate heptahydrate both at 1.8 & 3.6 kg/ha zinc.

Uptake of nutrients and protein and oil content

The uptake of nutrients *viz.*, N, P, K and Zn increased significantly with the application of Zn as compared to control (Table 2). The maximum uptake of nitrogen (88.5 kg/ha), phosphorus (6.6 kg/ha), potassium (24.0 kg/ha) and zinc (0.10 kg/ha) by grain of soybean was recorded with application of N_{30} $P_{60}K_{20}$ $Zn_{1.8+3.2}$, whereas, minimum values were recorded in control. However, in the case of wheat, maximum uptake of nitrogen (78.9 kg ha^{-1}), phosphorus (15.3 kg ha^{-1}), potassium (29.5 kg ha^{-1}) and zinc (0.14 kg ha^{-1}) by grain was recorded with N_{30} $P_{60}K_{20}$ $Zn_{1.8+3.2}$, whereas, minimum values were recorded in control. Application of increasing dose of zinc increased the uptake of N, P, K and Zn and was more pronounced with application of complex zinc fertilizer. The protein content increased with increasing

Table 2. Effect of different sources and levels of zinc application on nutrient uptake, protein and oil content

Treatments	Zn (kg/ha)		Uptake of nutrients (kg/ha)				Protein	Oil
	Time	Dose/ annum	N	P	K	Zn	(%)	(%)
			Soybean					
$P_0\,Zn_0$	None	0	58.50	4.28	13.60	0.043	36.64	18.79
$P_{60}Zn_0$	None	0	64.90	4.75	16.70	0.052	37.82	18.94
$P_{60}\,Zn_5$	*kharif+ rabi*	10	85.85	6.23	23.19	0.095	38.56	20.10
$P_{60}Zn_5$	*kharif*	5	86.00	6.36	23.43	0.096	38.20	20.12
$P_{60}Zn_{1.8+3.2}$	*kharif+ rabi*	10	88.48	6.57	24.01	0.103	38.13	21.17
$P_{60}Zn_{1.8+3.2}$	*kharif*	5	88.32	6.52	24.23	0.105	38.38	21.18
$P_{60}Zn_{1.8}$ (F)	*kharif+ rabi*	3.6	71.02	5.27	19.23	0.071	38.05	20.54
$P_{60}\,Zn_{1.8}$ (F)	*kharif*	1.8	70.38	5.25	19.21	0.071	37.91	20.53
$P_{60}Zn_{1.8}$	*kharif+ rabi*	3.6	69.02	5.10	18.80	0.069	37.78	20.27
$P_{60}\,Zn_{1.8}$	*kharif*	1.8	69.26	5.19	18.89	0.069	37.70	20.28
SEm (±)			0.87	0.07	0.22	0.001	0.65	0.05
(p = 0.05)			2.53	0.19	0.65	0.003	1.34	0.13
			Wheat					
$P_0\,Zn_0$	None	0	54.1	11.8	21.5	0.078	10.52	
$P_{60}Zn_0$	None	0	61.6	14.1	24.3	0.091	10.69	
$P_{60}\,Zn_5$	*kharif+ rabi*	10	77.8	15.2	29.1	0.132	11.80	
$P_{60}Zn_5$	*kharif*	5	71.3	15.3	27.6	0.119	11.13	
$P_{60}Zn_{1.8+3.2}$	*kharif+ rabi*	10	78.9	15.1	29.5	0.135	11.92	
$P_{60}Zn_{1.8+3.2}$	*kharif*	5	72.5	15.3	27.9	0.122	11.22	
$P_{60}Zn_{1.8}$ (F)	*kharif+ rabi*	3.6	74.2	14.9	28.1	0.126	11.55	
$P_{60}\,Zn_{1.8}$ (F)	*kharif*	1.8	69.6	15.3	27.1	0.116	10.98	
$P_{60}Zn_{1.8}$	*kharif+ rabi*	3.6	73.3	15.0	27.9	0.124	11.44	
$P_{60}\,Zn_{1.8}$	*kharif*	1.8	68.5	15.3	26.7	0.114	10.89	
SEm (±)			0.8	0.2	0.3	0.001	0.06	
(P = 0.05)			**2.2**	**0.5**	**0.9**	**0.003**	**0.117**	

Zn Fert. (F) - 10:50:0:1.5 ($N:P_2O_5:K_2O:Zn$), $ZnSO_4.\ 7H_2O$ (21% Zn) doses of zinc as well as sources of zinc application in both soybean and wheat. Maximum protein content of 38.4 percent and 11.92 percent in soybean and wheat grain, respectively, was noticed in case of $N_{30}P_{60}K_{20}$ $Zn_{1.8+3.2}$, while, the minimum values were recorded under control. The results corroborate with the findings of Singh *et al.*, 1986, where in, they reported increase in uptake of nutrients with zinc and sulphur application. Sakal *et al.* (1981) reported that zinc uptake by wheat grain as well as straw was increased with increasing levels of zinc.

Oil content in soybean grain increased with increasing doses of zinc application as well as when zinc was applied @ 1.8 kg/ ha through N: P_2O_5: K_2O: Zn (10:50:0:1.5) + 3.2 kg/ha through $ZnSO_4$. The highest oil content (21.18%) was recorded with the treatment $N_{30}P_{60}K_{20}$ $Zn_{1.8+3.2}$. Oil yield is directly related with seed yield and oil content in seeds.

Soil reaction, EC and available nutrients in soil after harvest of wheat

Non-significant increase in pH of the soil was recorded with the application of zinc and sources of zinc as compared to control (Table 3). The soil EC remained unaffected due to zinc application. In case of nitrogen, the application of sources and doses of zinc has resulted in more uptake of nitrogen, thereby decreased the available N status significantly. The soil phosphorus and potassium status remained unaffected due to zinc application as the differences were statistically non-significant. Higher doses of zinc (5 and 10 kg/ha) recorded non-significant lowering of available P. Significant difference in soil phosphorus and zinc with the application of zinc as well as with the sources of zinc was noticed. Application of zinc has resulted in increasing the DTPA extractable Zn significantly (35.9 % over no zinc), even with minimum dose (1.8 kg/ha) once in the *kharif* season. On

Table 3. Effect of levels and sources of zinc application on pH, EC and available nutrients status of the soil after harvest of wheat

Treatments	Zn (kg/ha) applied/ annum	pH	EC (dS/m)	N	P_2O_5	K_2O	Zn (mg/ kg)
				(kg/ha)			
P_0 Zn_0	0	7.63	0.35	139	34.80	381	0.50
$P_{60}Zn_0$	0	7.65	0.38	137	38.75	410	0.51
P_{60} Zn_5	10	7.75	0.42	130	38.35	452	1.10
$P_{60}Zn_5$	5	7.68	0.40	134	38.10	435	0.95
$P_{60}Zn_{1.8+3.2}$	10	7.79	0.42	128	38.20	456	1.10
$P_{60}Zn_{1.8+3.2}$	5	7.71	0.41	131	38.80	438	0.95
$P_{60}Zn_{1.8}$ (F)	3.6	7.73	0.42	131	39.00	447	0.91
P_{60} $Zn_{1.8}$ (F)	1.8	7.66	0.40	133	39.60	424	0.70
$P_{60}Zn_{1.8}$	3.6	7.72	0.41	132	38.40	444	0.90
P_{60} $Zn_{1.8}$	1.8	7.65	0.39	135	39.10	422	0.69
SEm (±)		0.008	0.01	1.28	0.64	10.86	0.01
(P = 0.05)		**NS**	**0.029**	**3.70**	**1.86**	**31.51**	**0.04**

Zn Fert. (F) - 10:50:0:1.5 (N:P_2O_5:K_2O:Zn), $ZnSO_4$. $7H_2O$ (21% Zn) increasing the dose to 5.0 kg/ha, it was around 87 percent over no zinc. Application of Zn in both the seasons further increased the DTPA extractable zinc. The sources of zinc did not reveal any significant differences on DTPA extractable zinc.

Nutrient balance studies

The nutrient balance studies with respect to zinc applied (Table 4) revealed that in treatment P_0Zn_0 and $P_{60}Zn_0$, there is removal of zinc from the soil pool. Application of phosphorus has further aggravated the decrease in content of zinc. With minimum zinc (1.8 kg/ha) application in one season to soybean - wheat crop sequence has caused removal of zinc from soil pool in $P_{60}Zn_{1.8}$ (F) due to increased uptake of zinc as compared to build up in P_{60} $Zn_{1.8}$ supplied through $ZnSO_4$ source. However, in treatments with higher doses of Zn, there was very little difference in the build up of DTPA zinc in soil due to source of zinc. The studies reveal that one time application of zinc in *kharif* @ 5 kg/ha has increased the DTPA- Zn beyond the critical limit of 0.6 mg/g, and has enriched the fixed Zn pool by 77 percent of the applied zinc, which increased to 85 percent on application of zinc in *kharif* and *rabi* season @ 5 kg per ha.

Table 4. Influence of levels and source of zinc application during *kharif* and *rabi* season to soybean and wheat crop sequence on the removal/ fixation of zinc

Treatments	Initial Available Zn (kg/ha)	Applied Zn (kg/ha) Soybean	Applied Zn (kg/ha) Wheat	Total Available Zn (kg/ha)	Total Zn Uptake (kg/ha) by soybean+ wheat	Balance Zn (kg/ ha)	Soil Available Zn (kg/ha) after wheat	Removal / fixation of Zn kg/ha
P_0 Zn_0	1.1	0	0	1.1	0.20	0.90	1.01	-0.10
$P_{60}Zn_0$	1.1	0	0	1.1	0.24	0.86	1.02	-0.16
P_{60} Zn_5	1.1	5	5	11.1	0.37	10.73	2.20	8.53
$P_{60}Zn_5$	1.1	5	0	6.1	0.35	5.75	1.89	3.86
$P_{60}Zn_{1.8+3.2}$	1.1	5	5	11.1	0.38	10.72	2.20	8.52
$P_{60}Zn_{1.8+3.2}$	1.1	5	0	6.1	0.36	5.74	1.90	3.84
$P_{60}Zn_{1.8}$ (F)	1.1	1.8	1.8	4.7	0.33	4.37	1.82	2.56
P_{60} $Zn_{1.8}$ (F)	1.1	1.8	0	2.9	0.31	2.59	1.41	1.19
$P_{60}Zn_{1.8}$	1.1	1.8	1.8	4.7	0.32	4.38	1.80	2.59
P_{60} $Zn_{1.8}$	1.1	1.8	0	2.9	0.30	2.60	1.37	1.23

Zn Fert. (F) - 10:50:0:1.5 ($N:P_2O_5:K_2O:Zn$), $ZnSO_4$. $7H_2O$ (21% Zn)

Economics of zinc application

The economics of zinc application was worked out by considering the cost of zinc applied @ Rs. 134 per kg zinc on the basis of the prevailing market rate of $ZnSO_4.7H_2O$. The results reveal that at higher rate of application (@ 5 kg per ha in both the cropping season) the return per rupee investment on zinc is minimum as compared to one time application of 1.8 kg per ha Zn in *kharif* which is around Rs. 15 for $ZnSO_4.7H_2O$ and Rs. 18 for zinc containing complex fertilizer (Table 5). The zinc containing complex fertilizer had given higher return/rupee investment than $ZnSO_4.7H_2O$ application.

Table 5. Return (Rs) / rupee investment on zinc application through of different sources and levels of zinc

Treatments	Zinc (kg/ha)		Soybean		Wheat		Total Income	Excess Income due to Zn applied	Cost of Zn added	Return (Rs)/ rupee invest-ment
	Time	Dose/ annum	Grain	Straw	Grain	Straw				
$P_0 Zn_0$	None	0	12000	1272	19284	8217	40772		0	
$P_{60}Zn_0$	None	0	12889	1364	21600	9207	45060	4287	0	
$P_{60} Zn_5$	*kharif+rabi*	10	16740	1790	24725	10356	53611	8551	1340	6
$P_{60}Zn_5$	*kharif*	5	16889	1784	24048	10249	52970	7910	670	12
$P_{60}Zn_{1.8+3.2}$	*kharif +rabi*	10	17407	1852	24825	10412	54496	9436	1340	7
$P_{60}Zn_{1.8+3.2}$	*kharif*	5	17259	1839	24230	10326	53654	8595	670	13
$P_{60}Zn_{1.8}$ (F)	*kharif +rabi*	3.6	14000	1518	24081	10187	49786	4727	482	10
$P_{60} Zn_{1.8}$ (F)	*kharif*	1.8	13926	1488	23768	10131	49312	4252	241	18
$P_{60}Zn_{1.8}$	*kharif +rabi*	3.6	13704	1438	24041	10166	49348	4289	482	9
$P_{60} Zn_{1.8}$	*kharif*	1.8	13778	1444	23579	9988	48788	3728	241	15
Cost/ kg			12	1	6	2			134	

Zn Fert. (F) - 10:50:0:1.5 (N:P_2O_5:K_2O:Zn), $ZnSO_4$. $7H_2O$ (21% Zn)

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Evaluation of Weed Control Efficacy of Oxyfluorfen in Soybean

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ABSTRACT

A field experiment was conducted for two years to study the bio-efficacy of oxyfluorfen against weeds in soybean. The weed competition reduced the soybean yield to the tune of 56.9 percent. Oxyfluorfen applied as pre-emergence produced higher seed yield by 21.6 percent as compared to pre-plant incorporation. Application of oxyfluorfen @ 0.75 kg/ha as pre-emergence was also found most effective to control weed load of both monocot as well as dicot in soybean as evidenced from the values of lowest weed density and dry biomass and the maximum weed control efficiency.

Key words: Oxyfluorfen, soybean, weed, weed control efficiency

Soybean is a predominant *kharif* cash crop in central India. Among the productivity constraints, weed management is one of the most crucial factors for low productivity. Soybean yield loss up to 68 percent due to infestation of weeds has been recorded under *Malwa* conditions (Billore *et al*., 1999). The magnitude of yield loss depends on nature, type and period of weed infestation during crop growth period. Consequent upon the high wages and non-availability of labour at the time of need, herbicidal/chemical weed control is gradually gaining popularity among the farmers. Presently, some pre-emergence and pre-plant incorporation and very few post- emergence herbicides are recommended to control weeds in soybean. To diversify the use of herbicides and provide more options of selecting the herbicides for managing weeds in soybean, the present investigation to study the bio-efficacy and mode of application of oxyfluorfen against major weeds of soybean was undertaken.

MATERIAL AND METHODS

A field experiment was conducted for consecutive two years during *kharif* 1999 and 2000 at Research Farm of National Research Centre for Soybean, Indore. The experimental soil belonged to fine, montmorillonitic, isohyperthermic family of Typic Haplusterts. It analyzed: pH - 7.8, EC - 0.14 dS per m, organic carbon - 0.3 percent, available phosphorus – 10.1 kg/ha and available potassium - 250 kg/ha. The experiment comprised of 10 treatments replicated thrice in a randomized block

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design (Table 1). Hand weeding was resorted to after 3 and 6th weeks of sowing. Oxyfluorfen was applied as pre-plant incorporation and pre-emergence. Soybean *cv*. JS 335 was sown on 3rd July 1999 and 26th June 2000 and was harvested in the month of October. The crop was raised following the recommended package of practices. The rainfall during 1999 and 2000 were 902 and 488 mm, respectively.

The yield and yield attributes were recorded at harvest. Weed population and their oven-dry weight were recorded at 30 and 60 days after sowing. The weed control efficiency (WCE) was computed by using the formula, WCE = (x-y/y) x 100; where x and y, respectively, refer to dry weight of weeds at specific sampling in weedy check and particular treatment for which the value is computed. Necessary statistical analyses were carried out by method of Sokal and Rohlf (1981).

RESULTS AND DISCUSSION

Influence on yield attributes and yield

Yield attributes and yield of soybean were significantly influenced by the evaluated treatments (Table 1). Pre-emergence application of oxyfluorfen @ 1.0 kg per ha produced the highest number of branches, pods and seeds per plant. The highest seed index was recorded in oxyfluorfen @ 0.25 kg per ha as pre-plant incorporation and remained at par when applied as pre-emergence @ 0.25 and 0.50 kg per ha. The highest seed yield was noted in oxyfluorfen @ 1.0 kg per ha applied as pre-emergence and closely followed by @ 0.75, 0.25 and 0.50 kg per ha applied as pre-emergence. The application of oxyfluorfen

Table1. Effect of oxyfluorfen on yield attributes and yield of soybean (mean of 2 years)

Treatment	Dose (kg/ha)	Application mode	Branches/ plant (No)	Pods/ Plant (No)	Seeds/ Plant (No)	Seed index	Seed yield (kg/ha)	Weed index
Oxyfluorfen	0.25	Pre-emergence	2.91	28.60	70.56	10.15	799	51.04
Oxyfluorfen	0.25	Pre-plant incorporation	3.30	32.03	50.39	10.68	704	33.08
Oxyfluorfen	0.50	Pre-emergence	3.17	30.65	50.46	10.12	790	49.33
Oxyfluorfen	0.50	Pre-plant incorporation	3.36	33.33	52.10	9.85	646	22.11
Oxyfluorfen	0.75	Pre-emergence	3.77	33.47	60.14	9.90	818	54.63
Oxyfluorfen	0.75	Pre-plant incorporation	3.13	32.77	64.61	9.47	644	21.74
Oxyfluorfen	1.00	Pre-emergence	4.76	45.00	71.25	9.18	830	56.90
Oxyfluorfen	1.00	Pre-plant incorporation	3.53	34.07	48.76	9.78	668	26.27
Pendimethalin	1.00	Pre-emergence	3.67	30.43	45.71	8.83	721	36.29
Weedy check			2.73	28.63	40.02	9.55	529	-
CD (P=0.05)			0.90	8.70	8.15	0.62	109.5	

as pre-emergence produced 21.6 percent higher yield as compared to application as pre-plant incorporation (mean of respective 4 treatments). Similar trend was also recorded for weed index. However, the yield reduction due to weeds was to the tune of 56.9 percent. The observation gains support from the earlier report (Billore *et al.,* 1999). The pooled yield turns out to be low as year 2000 experienced drought.

Influence on monocot weeds

Application of herbicides significantly reduced the monocot weed count and their dry matter at 30 and 60 DAS (Table 2). At 30 DAS, the lowest weed count was recorded with oxyfluorfen @ 0.75 kg per ha and 1.0 kg per ha, both levels applied as pre-emergence. Pre-emergence application of oxyfluorfen at other two levels *viz.*, 0.25 and 0.50 kg per ha revealed lower count than pre-plant incorporations of this chemical. While the lowest dry matter of monocot weeds was recorded in pre-emergence application of oxyfluorfen @ 0.75 kg per ha followed by pendimethalin @ 1.0 kg per ha, but was at par with remaining treatments. The highest monocot weed control efficiency was computed with oxyfluorfen @ 0.75 kg per ha as pre-emergence followed by pendimethalin @ 1.0 kg per ha as pre-emergence. Weed control efficiency recorded was higher in case of application of oxyfluorfen as pre-emergence as compared to its application as pre-plant incorporation. However, at 60 DAS, application of oxyfluorfen @ 1.00 kg per ha followed by 0.75 kg per ha as pre-emergence showed the lowest weed count and their dry biomass and the maximum weed control efficiency was noted with pendimethalin applied @ 1.0 kg per ha followed by oxyfluorfen @1.00 and 0.75 kg per ha as pre-emergence.

Table 2. Effect of oxyfluorfen on monocot weed count, dry biomass and weed control efficiency (mean of 2 years)

Treatment	Dose (kg/ha)	Application mode	30 Days after sowing			60 Days after sowing		
			Count (no/m^2)	Dry biomass (g/m^2)	Weed control efficiency (%)	Count (no/m^2)	Dry Biomass (g/m^2)	Weed control efficiency (%)
Oxyfluorfen	0.25	Pre-emergence	12.84	17.00	60.77	8.32	53.50	55.42
Oxyfluorfen	0.25	Pre-plant incorporation	29.16	18.00	58.46	13.00	79.66	33.62
Oxyfluorfen	0.50	Pre-emergence	17.00	16.16	62.71	19.18	106.34	11.38
Oxyfluorfen	0.50	Pre-plant incorporation	48.00	22.66	47.72	15.84	163.00	-
Oxyfluorfen	0.75	Pre-emergence	7.00	4.16	90.40	8.00	32.00	73.33
Oxyfluorfen	0.75	Pre-plant incorporation	28.84	23.34	46.15	13.50	60.86	49.28
Oxyfluorfen	1.00	Pre-emergence	7.00	18.84	56.53	2.50	30.51	74.58
Oxyfluorfen	1.00	Pre-plant incorporation	28.66	24.50	43.47	14.84	127.50	-
Pendimethalin	1.00	Pre-emergence	21.66	6.84	84.22	1.84	15.84	86.80
Weedy check			72.84	43.34	-	529.50	120.00	-
CD (P=0.05)			**12.60**	**25.02**		**10.71**	**88.14**	

Influence on dicot weeds

The dicot weed density and dry biomass were significantly influenced by the treatments (Table 3). At 30 DAS, the lowest dicot weed count was recorded in oxyfluorfen @ 1.0 kg per ha as pre-emergence and remained at par with the application of oxyfluorfen @ 0.25, 0.50, 0.75 kg per ha as pre-emergence and 1.0 kg per ha as pre-plant incorporation. The dry matter accumulation and dicot weed control efficiency followed the similar trend for weed count. At 60 DAS, the lowest weed count and dry biomass and the highest weed control efficiency were found to be associated with oxyfluorfen @ 0.75 kg per ha as pre-emergence application.

Table 3. Dicot weed count, dry biomass and weed control efficiency as influenced by oxyfluorfen (mean of 2 years)

Treatment	Dose (kg/ha)	Application mode	30 Days after sowing			60 Days after sowing		
			Count (no/m²)	Dry biomass (g/m²)	Weed control efficiency (%)	Count (no/m²)	Dry biomass (g/m²)	Weed control efficiency (%)
Oxyfluorfen	0.25	Pre-emergence	26.18	20.50	49.48	33.48	137.16	35.18
Oxyfluorfen	0.25	Pre-plant incorporation	39.68	29.34	27.69	47.00	169.00	20.13
Oxyfluorfen	0.50	Pre-emergence	22.00	11.84	70.82	26.34	70.25	66.70
Oxyfluorfen	0.50	Pre-plant incorporation	39.00	26.16	35.53	33.32	133.16	37.07
Oxyfluorfen	0.75	Pre-emergence	19.68	10.00	75.35	17.18	53.59	74.67
Oxyfluorfen	0.75	Pre-plant incorporation	36.66	21.84	46.18	37.00	117.59	44.42
Oxyfluorfen	1.00	Pre-emergence	9.16	8.34	79.44	33.00	81.16	61.64
Oxyfluorfen	1.00	Pre-plant incorporation	31.84	17.00	58.10	22.34	83.66	60.46
Pendimethalin	1.00	Pre-emergence	53.34	28.00	31.00	37.16	203.50	3.82
Weedy check			26.16	40.58	-	54.66	211.59	-
CD (P=0.05)			**29.70**	**16.57**		**16.82**	**93.10**	

Influence on total weeds

Total weed count and their dry biomass were significantly reduced by the treatments (Table 4). The lowest weed density at 30 DAS was recorded with oxyfluorfen @ 1.0 kg per ha as pre-emergence and remained at par with its other levels @ 0.50 and 0.25 kg per ha, both applied as pre-emergence. The application of oxyfluorfen as pre-plant incorporation showed non-significant differences with control. The lowest dry biomass and highest weed control efficiency was with oxyfluorfen @ 0.75 kg per ha as pre-emergence. At 60 DAS, application of oxyfluorfen at 0.75 kg per ha as pre-emergence was found to be more effective amongst all the treatments as evidenced from the values of weed count, dry biomass and total weed control efficiency, and was followed by oxyfluorfen @ 1.0 kg per ha as pre-emergence. The application of oxyfluorfen as pre-emergence was found more effective to reduce the weed load in soybean as compared to pre-plant incorporation. Better efficacy of pre-emergence chemicals to manage weeds in soybean as compared to pre-plant incorporation has also been documented earlier (Porwal *et al.,* 1990; Tiwari and Kurchania, 1990; Joshi and Billore 1998).

Table 4. Total weed count, dry biomass and weed control efficiency as influenced by oxyfluorfen (mean of 2 years)

Treatment	Dose (kg/ha)	Application mode	30 Days after sowing			60 Days after sowing		
			Count (no/m²)	Dry biomass (g/m²)	Weed control efficiency (%)	Count (no/m²)	Dry biomass (g/m²)	Weed Control efficiency (%)
Oxyfluorfen	0.25	Pre-emergence	39.00	37.50	55.30	41.80	188.41	43.18
Oxyfluorfen	0.25	Pre-plant incorporation	68.84	47.34	43.58	65.00	248.66	25.00
Oxyfluorfen	0.50	Pre-emergence	39.00	28.00	66.63	45.52	176.59	46.74
Oxyfluorfen	0.50	Pre-plant incorporation	87.00	48.82	41.81	49.16	296.16	10.68
Oxyfluorfen	0.75	Pre-emergence	26.68	14.16	83.12	25.18	85.59	74.18
Oxyfluorfen	0.75	Pre-plant incorporation	65.50	45.18	46.15	50.50	178.45	46.18
Oxyfluorfen	1.00	Pre-emergence	16.16	27.18	67.60	35.50	111.67	66.32
Oxyfluorfen	1.00	Pre-plant incorporation	60.50	41.50	50.54	37.18	211.16	36.32
Pendimethalin	1.00	Pre-emergence	75.00	34.84	58.47	39.00	219.34	33.85
Weedy check			99.00	83.90	-	84.15	331.59	-
CD (P=0.05)			**30.27**	**27.64**		**17.56**	**118.56**	

On the basis of foregoing results, it is concluded that the application of oxyfluorfen @ 0.75 kg per ha as pre-emergence can be employed effectively to manage weeds in soybean to harness higher yields.

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Efficacy of Post- Emergence Herbicides for Weed Management in Soybean [*Glycine max* (L.) Merrill] in Vertisols

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ABSTRACT

A field experiment was conducted at research farm of College of Agriculture, Indore under All India Coordinated Research Project on Dry Land Agriculture during rainy season of 2000 and 2001 to assess the bio-efficacy of herbicides in comparison to farmer's practice and weed free conditions in soybean. The results revealed that the maximum weed control efficiency being with weed free treatment was followed by post-emergence herbicides, while, just the reverse trend was true in case of weed index. The weed control practices in soybean significantly enhanced the branches and pods per plant and seed index over control. The soybean yield increased with different treatments to the tune of 37 to 71 percent as compared to control. The application of post-emergence herbicides i.e. imazamox + imazethapyr @ 800 to 1000 ml per ha or imazethapyr @ 75 to 100 g a. i. per ha or imazamox @ 30g a. i. per ha at 25 days after sowing were found as effective as weed free or check herbicide trifluralin @ 1.2 kg a. i. per ha (combination product) to minimize the weed load in soybean which was reflected in higher weed control efficiency, lower weed index and enhanced seed yield.

Key words: Soybean, herbicides, post-emergence, Vertisols

Weed infestation is one of the serious problems in rainy season, which reduces yield 27 to 70 percent depending upon the type of weeds, intensity and time of occurrence (Muniyappa *et al*., 1986). Weeds, in general, cause competition stress on soybean growth, especially during the first 40 days after sowing (Tiwari *et al*., 1997). The incessant rains and consequent wet condition of Vertisols does not permit intercultural operations or manual weeding in the standing crop. Moreover, the scarcity of labour and high wages restricts their utilization in weeding and also their working efficiency remains a question. It is, therefore, necessary to evaluate alternative method for controlling weeds during critical crop growth period. Pre-planting and pre-emergence herbicides showed inconsistent weed control due to soil types, rainfall distribution and limited time available for operations during planting time in Vertisols. The present investigation was undertaken to find out the efficacy of post-emergence herbicides for weed management in soybean.

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MATERIAL AND METHODS

Studies were carried out under All India Coordinated Research Project on Dry Land Agriculture at College of Agriculture, Indore (Madhya Pradesh) during *kharif* 2000 and 2001 to evaluate the efficacy of post- and pre-emergence herbicide in soybean. The soils were medium deep black having clay 60 percent, pH 7.5, EC 0.22 dS per m, and organic carbon 0.25 per cent. The available nitrogen, phosphorus, potassium was 150, 13 and 422 kg per ha, respectively. The twelve weed management treatments (Table 1) were laid out in randomized block design in three replications. Soybean *cv*. JS 335 was sown at 30 cm row spacing. A basal dose of 30:27:16 kg NPK per ha through urea, di-ammonium phosphate and muriate of potash was applied at the time of sowing. Trifluralin 48 EC @ 1.2 kg a. i. per ha was sprayed and incorporated with blade harrow in soil before sowing. Pendimethalin 30 EC @ 1 kg a. i. /ha was applied as pre-emergence. All post-emergence herbicides, namely imazethapyr (10 SL) @ 75 and 100 g a. i. per ha, imazamox (12 EC) @ 30 and 40 g a. i. per ha and imazamox (2.5%) + imazethapyr (2.5%) formulated product (FP) @ 800 and 1000 ml/ha were applied as post-emergence spray at 25 days after sowing. Weed control efficiency and weed index were worked out as per standard formulae. The weed control efficiency was determined as – weed dry matter in control – weed dry matter in treatment / weed dry matter in control x 100, while weed index was calculated as- yield in weed free plot – yield in treatment / yield in weed free plot x 100.

RESULTS AND DISCUSSION

Effect on weeds

The dominant weeds in experimental area were *Echinochloa spp., Cynodon dactylon, Dinebra arabica, Cynotis auxillaris, Commelina benghalensis, Euphorbia geniculata, Acalypha indica, Corchorus acutangulis, Digera arvensis, Xanthium strumarium, Achyranthus aspera, Cyperus rotundus, Eleusine indica* and *Panicum repens.*

The maximum weed biomass was recorded in weedy check (355 kg/ha) followed by application of pendimethalin @ 1 kg a. i. per ha as PE (171 kg/ha) and farmer's practice (132 kg/ha). The lowest weed biomass was recorded in weed free treatment (22 kg/ha). However, one inter culture + imazethapyr @ 50 g a. i. per ha and both the levels of imazethapyr (75 and 100 g a. i. /ha) behaved more or less identically. The weed control efficiency was highest with weed free treatment (93.8%) followed by imazamox + imazethapyr @ 1000 ml per ha (84.8%) and imazethapyr 100 g a. i. per ha (79.7%). Among the two levels of herbicides, applications at higher levels of imazamox (40 g a. i. /ha), imazethapyr (100 g a. i./ha) and imazamox + imazethapyr (1000 ml/ ha) showed higher weed control efficiency as compared to their lower levels i. e 30 g, 75 g and 800 ml per ha, respectively. All the post-emergence herbicides proved their superiority over pre-emergence and pre-plant incorporation herbicides with reference to weed control efficiency. The reverse was the trend observed in case of weed index. These observations are in conformity with the findings reported by Nelson and Renner (1993) Dubey *et al*. (1996) and Kushwah and Vyas (2005).

Yield attributes

All the treatments significantly enhanced the branches, pods and seed index over control. The maximum branches per plant were recorded with imazamox @ 30g a. i. per ha followed by weed free and trifluralin @ 1.2 kg a. i. per ha treatments. The minimum pods per plant were associated with weedy check, while, the remaining treatments were on par. The higher seed index was recorded in weed free and one interculture + imazethapyr @ 50 g per ha (at 20 and 30 days after sowing, respectively), which was closely followed by trifluralin @ 1.2 kg a. i. per ha, imazamox @ 30 g a. i. per ha, one inter culture + imazethapyr @ 50 g a. i. per ha, imazamox @ 40g a. i. per ha and both the levels (800 and 1000 ml/ha) of imazamox + imazethapyr (Table 1). Similar findings were earlier reported by Tiwari *et al.* (1997) and Billore *et al.* (1999).

Table 1. Effect of weed control **treatments on soybean yield and yield attributes, weed control efficiency (WCE) and weed index (WI). (Pooled data of two years)**

Treatments	Branches/ plant (No)	Pods / Plant (No)	Seed index (g/ 100 seeds)	Dry weight of weeds at 60 DAS (kg /ha)	Weed Control Efficiency (%)	Weed index (%)	Seed yield (kg /ha)	Straw yield (kg /ha)
Control	1.8	21.4	8.4	355	-	42.0	792	1739
Weed free up to 60 DAS	3.3	31.6	10.5	22	93.8	-	1353	3128
Farmer's practice*	2.6	29.0	10.0	132	55.2	20.3	1083	2398
One interculture + Imazethapyr @ 50 g a. i. /ha as post-emergence	3.0	28.9	10.5	63	74.9	14.6	1166	2435
Pendimethalin @ 30 EC @ 1000 ml/ha as pre-emergence	3.1	30.7	10.2	171	57.6	13.6	1169	2468
Trifluralin 48 EC @ 1.2 kg a. i./ha as pre-plant incorporation	3.0	32.4	10.3	84	72.9	5.8	1274	2732
Imazamox 12 EC @ 30 g a. i./ha as post-emergence	3.4	32.0	10.0	63	75.6	5.2	1284	2871
Imazamox 12 EC @ 40 g a. i./ha as post-emergence	2.9	31.3	9.9	58	78.2	11.4	1196	2763
Imazamox (2.5 %) + Imazethapyr (2.5%) @ 800 ml/ha as post-emergence	2.9	30.7	10.4	70	79.0	8.3	1241	2602
Imazamox (2.5 %) + Imazethapyr (2.5 %) @ 1000 ml/ha as post-emergence	2.9	31.9	10.2	53	84.8	4.5	1362	3020
Imazethapyr 10 SL @ 75 g a. i./ha as post-emergence	2.9	28.8	9.7	75	78.1	5.6	1299	3007
Imazethapyr 10 SL@ 100 g a. i./ha as post-emergence	2.5	29.0	10.0	68	79.7	7.3	1301	2857
(P = 0.05)	**0.58**	**3.5**	**0.5**	**14.8**	**-**	**-**	**105**	**196**

** One inter culture 20 DAS + One hand weeding 30 DAS*

Seed and straw yield

Pooled data of two years (Table 1) revealed that the weed control practices increase the yield to the tune of 37 to 71 percent over control. The significantly higher grain yield was recorded with the application of imazamox + imazethapyr @ 1000 ml per ha (1362 kg/ha) over weedy check (792 kg/ha), farmer's practice (1083 kg/ha), one inter culture + imazethapyr @ 50 g a. i. per ha (1166 kg/ha), trifluralin @ 1.2 kg a. i. per ha (1169 kg/ha), imazamox @ 40 g a. i. per ha (1196 kg/ha) and Imazamox + Imazethapyr @ 800 ml per ha (1241 kg/ha). However, weed free and application of trifluralin 1.2 kg a. i. per ha, imazamox @ 30 g a. i. per ha, and both the levels of imazethapyr (75 and 100 g a. i. /ha) were found to be at par with imazamox + imazethapyr @ 1000 ml per ha. The lowest yield was noted in weedy check. These differences may be due to variation in corresponding weed control efficiency of the treatments imparted. These results were further confirmed by Kushwah and Vyas (2005). The highest straw yield was recorded with weed free treatment which closely followed by imazamox + imazethapyr @ 1000 ml per ha and imazethapyr @ 75 g a. i . per ha.

On the basis of two years results it could be concluded that the application of Imazamox + Imazethapyr @ 800 and 1000 ml /ha as well as Imazethapyr @ 75 and 100 g a. i. per ha were found equally effective as weed free up to 60 DAS. These herbicides, which can be applied as post-emergence, provides an opportunity to soybean growers to take advantage of appropriate weed management and harness higher yields.

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Soybean Research, 4: 24-27 (2006)

Efficacy of Chitin Inhibitors against Green Semilooper, *Chrysodeixis acuta* (Wlk.) and Tobacco Caterpillar, *Spodoptera litura* (Fab.) Larvae Infesting Soybean

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ABSTRACT

Field and laboratory experiments were conducted to test the efficacy of two chitin synthesis inhibiting insecticides viz., lufenuron 5 EC and diflubenzuron 25 WP against green semilooper, Chrysodeixis acuta *(Walker) under field conditions and against tobacco caterpillar,* Spodoptera litura *(Fab.) under controlled laboratory conditions. Results revealed that all the doses of lufenuron and diflubenzuron were effective in causing conspicuous larval mortality, hindering pupal development and adult emergence. Lufenuron 5 EC @ 500 ml/ha and diflubenzuron 25 WP @ 350 g/ha could not only serve as ideal alternative to chemical insecticides but also fit well in the IPM programmes for the management of lepidopterous pests infesting soybean.*

Key words: Soybean, defoliators, chitin inhibitors

Green semilooper *Chrysodeixis acuta* (Walker) and tobacco caterpillar *Spodoptera litura* (Fab.) are predominant defoliators infesting soybean [*Glycine max* (L.) Merrill]. Besides defoliation they also feed on buds, flowers and young pods resulting in substantial yield losses (Singh *et al.*, 1990). Chemical insecticides viz. chlorpyrifos, quinalphos, methomyl etc. have been observed to be effective against foliage feeders (Sharma, 2004). Extensive and non-judicious use of chemical insecticides leads to development of resistance against chemical insecticides. Chitin synthesis inhibiting insecticides provide better alternative for insect management (Chari *et al.*, 1985; Hoogewerff and Duphar, 1986; Liew *et al.*, 1994). In order to reduce the dependence on toxic chemical insecticides by using eco-friendly insecticides, two insecticides with chitin inhibitory mode of action, diflubenzuron 25 WP and lufenuron 5 EC were evaluated for their efficacy against *Chrysodeixis acuta* (Walker) and *Spodoptera litura* (Fab.) larvae infesting soybean crop.

MATERIAL AND METHODS

Field experiments were conducted at National Research Centre for Soybean, Indore during *kharif* 2001 and 2002 with 8 treatments and 4 replications (Table 1)

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with randomized block design. Soybean variety PK 472 was planted in 13.5 sq m plots at 45 cm row-to row spacing. Treatments were applied at peak incidence of green semilooper *Chrysodeixis acuta* (Walker). Observations on number of larvae per m row were recorded at 3 places per plot at 5 days after treatment (DAT) using 'Vertical Beat Sampling Tray' (Sharma, 1999). Grain yield was recorded at maturity from net plot. Data on insect population and yield were subjected to statistical analysis using MSTAT-C software. Besides, both chitin inhibitors were also tested for their efficacy against *Spodoptera litura* (Fab.) larvae during 2002 under controlled laboratory conditions (Table 2). Leaves of soybean variety PK 472 were sprayed with test chemicals; shade dried and kept in 500 ml glass jars. Each treatment was replicated four times. Twenty laboratory-reared, pre-starved larvae (III rd instar) were released in each jar and allowed to feed on treated leaves. Jars covered with muslin cloth were kept in the entomological chamber maintained at 26 $\pm$ 1 ^{0} C and 85 $\pm$ 5 % RH during the study period. Observations on larval mortality (5 DAT), pupal development and adult emergence were recorded. Data were subjected to statistical analysis after appropriate transformation.

RESULTS AND DISCUSSION

Results of field trials revealed that the population of green semilooper, *Chrysodeixis*

Table 1. Effect of chitin inhibitors on population of *Chrysodeixis acuta* (Walker) larvae and grain yield

Treatment / Dose	Larvae / m row *			Grain yield (kg/ha)			Addl. yield
	2001	2002	Mean	2001	2002	Mean	
Diflubenzuron 25 WP (Dimilin) @ 300 g/ha	4.17 (2.00)	0.45 (0.55)	2.31	2089	750	1420	376
Diflubenzuron 25 WP (Dimilin) @ 350 g/ha	4.60 (2.11)	0.78 (0.86)	2.70	2111	842	1477	433
Diflubenzuron 25 WP (Dimilin) @ 400 g/ha	3.90 (1.94)	0.33 (0.47)	2.11	2105	873	1489	445
Lufenuron 5 EC (Match) @ 400 ml/ha	10.42 (3.22)	2.33 (1.52)	6.37	2008	804	1406	362
Lufenuron 5 EC (Match) @ 500 ml/ha	8.67 (2.94)	2.22 (1.49)	5.44	2074	731	1403	350
Lufenuron 5 EC (Match) @ 600 ml/ha	6.92 (2.63)	2.11 (1.45)	4.51	2165	835	1500	456
Chlorpyrifos 20 EC (Radar) @ 1500 ml/ha	1.57 (1.19)	1.22 (1.09)	1.39	2220	1096	1658	614
Control	15.67 (3.95)	13.33 (3.65)	14.50	1525	563	1044	--
SEm ($\pm$)	(0.21)	(0.13)	--	64	76	--	--
(P= 0.05)	**(0.62)**	**(0.40)**	**--**	**189**	**232**	**--**	**--**

** Square root transformed values are given in parentheses* *acuta* (Walker) larvae recorded at 5 DAT was significantly lower in all the treatments than in control plots (Table 1). Chlorpyrifos 20 EC @ 1500 ml per ha was most effective with significantly less larval population. Among chitin inhibitors, all the doses of lufenuron recorded significantly less larval population than diflubenzuron. There was no significant difference between doses of lufenuron in both the years. However, diflubenzuron @ 400 g per ha recorded significantly less larval population than rest of the doses in 2001. But in 2002, all the doses of diflubenzuron were at par. This differential efficacy could be attributed to weather parameters. Liew *et al.* (1994) also found over 90 percent reduction in population of lepidopterous insects with lufenuron @ 5.0 g per 100 lit. Qu *et al.* (1987) found effective control of *Chrysodeixis acuata* infesting soybean with diflubenzuron. Chakraborti and Chatterjee (2000) found diflubenzuron to be most effective among five chitin inhibitors tested against chickpea pod borer, *Heliothis armigera*.

As *kharif* 2002 was a draught year, yields realized were lower than in *kharif* 2001. Nevertheless, the treatment responses were same in both years. On the basis of mean yields and additional yield realized over control, potential of chitin inhibitors is well established.

Table 2. Effect of chitin inhibitors on *Spodoptera litura* (Fab.) larvae

Treatment / Dose	Larval mortality (%) (n=20) *	Larvae completing larval growth (%) *	Pupa formation (%) *	Adult emergence (%) *
Diflubenzuron 25 WP (Dimilin) @ 300 g/ha	43.75 (41.38)	56.25 (48.65)	21.25 (27.34)	6.25 (12.45)
Diflubenzuron 25 WP (Dimilin) @ 350 g/ha	56.00 (48.46)	44.00 (37.75)	8.75 (17.06)	2.50 (6.46)
Diflubenzuron 25 WP (Dimilin) @ 400 g/ha	66.25 (54.52)	33.75 (35.48)	2.50 (6.46)	0.00 (0.00)
Lufenuron 5 EC (Match) @ 400 ml/ha	68.75 (56.06)	31.25 (33.94)	3.75 (7.84)	2.50 (6.46)
Lufenuron 5 EC (Match) @ 500 ml/ha	85.00 (67.36)	15.00 (22.64)	1.25 (3.23)	0.00 (0.00)
Lufenuron 5 EC (Match) @ 600 ml/ha	88.75 (70.77)	11.25 (19.23)	1.25 (3.23)	0.00 (0.00)
Chlorpyrifos 20 EC (Radar) @ 1500 ml/ha	91.25 (75.39)	8.75 (14.62)	0.00 (0.00)	0.00 (0.00)
Control	0.00 (0.00)	100.00 (90.00)	100.00 (90.00)	100.00 (90.00)
SEm (+)	(2.24)	(2.31)	(2.86)	(2.37)
(P=0.05)	**(6.58)**	**(6.79)**	**(8.41)**	**(6.98)**

* *Angular transformed values are given in parentheses*

In laboratory experiment, mortality of *S. litura* (Fab.) larvae with both chitin inhibitors increased with their doses (Table 2). Although, chlorpyrifos recorded maximum larval mortality (91.25%), but it was *at par* with lufenuron @ 600 ml per ha (88.75%), which was in-turn *at par* with lufenuron 500 ml per ha (85.00%). Among the doses of diflubenzuron, the most effective dose was 400 g per ha, which was *at par* with 350 g per ha. Pupal development and adult emergence were significantly reduced by all the treatments. Diflubenzuron @ 400 g per ha and all the doses of lufenuron were found to be equally effective with respect to pupal development. Mule and Patil (2000) reported 20 to 100 percent mortality in *S. litura* (Fab.) larvae with different concentrations of diflubenzuron. Foerster (1993) and Mule and Patil (2000) reported that application of diflubenzuron not only restricts defoliation but also provides protection for longer duration.

On the basis of field and laboratory experiments, it is concluded that chitin synthesis inhibiting insecticides viz. lufenuron 5 EC @ 500 ml per ha or diflubenzuron 25 WP @ 350 g/ha, not only serve as ideal alternative to chemical insecticides but could also fit well in the IPM programmes for the management of lepidopterous pests infesting soybean. Moreover, compatibility of chitin inhibitors with microbial insecticides (Visalakshmi *et al.*, 2000) could be an added advantage.

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Soybean Research 4: 28-32 (2006)

Developmental Behaviour of Pulse Beetle, *Callosobruchus Chinensis* (Linn.) on Some Soybean Varieties and Their Resistance Status[1]

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ABSTRACT

Fast growing tendency of soybean growers to store their produce till they get remunerative prices warrants information on the status of susceptibility of popularly grown soybean varieties to major storage insect-pests. The study was therefore conducted to generate information on varietal susceptibility / resistance of 10 popular soybean varieties against major storage insect, pulse beetle **Callosobruchus chinensis *(L)*** *and the losses caused. On the basis of developmental behaviour of pulse beetle studied by multiple-choice method and no-choice method varieties MAUS 47, Bragg and NRC 7 were found to be relatively resistant, while other varieties JS 335, JS 93-05, JS 95-60, Pusa 16, Samrat, NRC 37 and NRC 12 were susceptible to pulse beetle* C. chinensis.

Key words: *Callosobruchus chinensis* (L.), developmental behaviour, suceptibility, resistance status

Pulse beetle, *Callosobruchus chinensis* (L.) is a major storage insect of soybean (Pruthi and Singh, 1950). Losses caused by the pulse beetle are not only in terms of quality but also in terms of quantity. As market intervention by both public and private sectors farmers are now in a position to hold their soybean and sale whenever they get the remunerative price. But unfortunately, poor storage infrastructure at their disposal gives rise to post-harvest storage losses. Infestation due to insects causes contamination and thereby rapid deterioration of grain quality and reduced seed viability. Thus, the present study was conducted to study the response of popular soybean varieties to infestation by pulse beetle; to study developmental behaviour of pulse beetle on popular soybean varieties and to identify soybean varieties resistant /tolerant to pulse beetle.

MATERIAL AND METHODS

Two different experiments were conducted to evaluate the resistance and susceptibility of soybean varieties. "Multiple-choice method" (Fig. 1) was used to study the varietal preference for egg-laying by

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the pulse beetle. Twenty soybean seeds of each genotype were arranged in a circular tray and exposed to 50 adult pulse beetles. Three replicates were maintained. Observations on number of eggs, number of seeds with eggs, test weight (g/100 seeds) and seed coat texture were taken (Table 1).

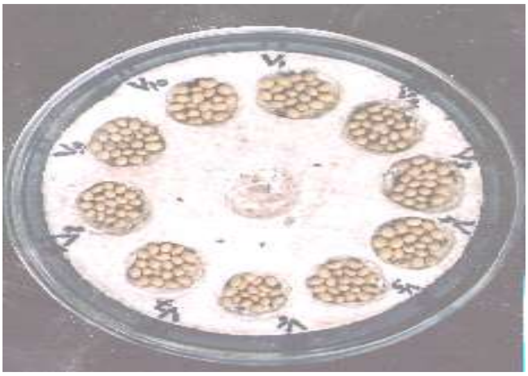

Fig. 1. Multiple-choice Method

"No-choice method" (Fig. 2) was used to assess the resistance or susceptibility of soybean varieties to pulse beetle. Approximately 20 g seed of ten soybean genotypes were taken and exposed to six pairs of adult beetles in individual glass tubes. Three replicates were maintained. Observations on number of eggs laid and adult emergence and developmental period were taken to calculate the growth index. The difference in initial and the final weight of seed was used to calculate percent loss in seed. Both the tests were conducted in an Entomological Chamber maintained at 26 $\pm$ 1^0 C temperature and 60 $\pm$ 5 percent relative humidity.

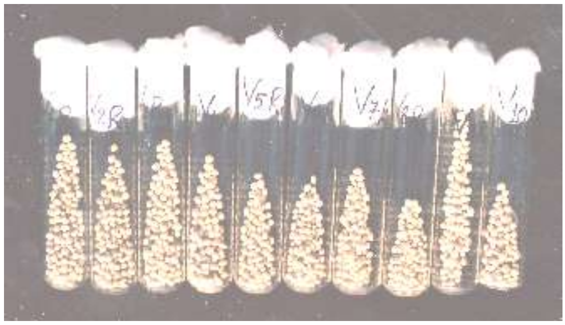

Fig. 2. No - choice Method

Besides above, seed coat thickness was also determined by cutting the sections and observing them under stereo zoom binocular microscope (Nikon SMZ 2T) fitted with suitable ocular micrometer. Oil content in all the 10 soybean genotypes was also estimated with Soxlet apparatus (Socsplus SCS-6).

RESULTS AND DISCUSSION

Results obtained in multiple-choice test indicated that Pusa 16 was most preferred variety for egg-laying (18.33 eggs; 65% seed infestation), while NRC 12 was least preferred (2.33 eggs; 10% seed infestation) (Table 1). It was also observed that the varieties with smooth seed coat texture (JS 93-05, Samrat, NRC 37, NRC 7 and NRC 12) were less preferred than those with rough texture (JS 335, JS 93-05, MAUS 47, Bragg and Pusa 16). Role of seed coat texture in providing better substrate for egg laying was also established by Nawanze and Horber (1976) in case of cowpea and Haque *et al.* (1992) in case of mung bean. However, no precise correlation could be established between seed size (as reflected by test weight) and infestation (egg-laying). Gupta and Kashyap (1995) observed that the thickness of seed coat in

Bengal gram (*Cicer arietinum*) appeared to influence preference by the pulse beetle, *Callosobruchus chinensis,* rather than the size of the seeds.

Table 1. Varietal preference of pulse beetle for egg laying (Multiple-choice method)

Variety	No. of eggs	No. of seeds with eggs (n=20)	Seed infestation (%)	No. of eggs / seed	Test weight (g)	Seed coat texture
JS 335	8.00 (2.79)	7.00 (2.60)	35.00 (35.95)	0.40 (0.62)	12.67	Rough
JS 93-05	10.33 (3.19)	10.00 (3.13)	52.66 (46.63)	0.51 (0.71)	13.62	Rough
MAUS 47	9.66 (3.09)	8.66 (2.93)	43.33 (41.13)	0.48 (0.69)	12.56	Rough
JS 95-60	7.00 (2.57)	6.33 (2.45)	31.66 (33.73)	0.35 (0.57)	15.65	Smooth
Bragg	9.66 (3.05)	8.66 (2.90)	43.33 (40.96)	0.48 (0.68)	13.66	Rough
Pusa 16	18.33 (4.23)	13.00 (3.59)	65.00 (53.93)	0.91 (0.94)	11.92	Rough
Samrat	6.66 (2.52)	6.33 (2.46)	31.66 (33.86)	0.33 (0.56)	12.58	Smooth
NRC 37	7.00 (1.53)	6.00 (1.41)	30.00 (23.86)	0.35 (0.34)	9.61	Smooth
NRC 7	6.66 (2.39)	5.66 (2.15)	28.33 (30.08)	0.33 (0.53)	13.72	Smooth
NRC 12	2.33 (1.52)	2.00 (1.41)	10.00 (18.43)	0.11 (0.34)	13.61	Smooth
(P= 0.05)	**(1.44)**	**(1.33)**	**(22.02)**	**(0.32)**	**--**	**--**

Soybean oil *per se* has been reported to be a good seed protectant against storage insects for many crops like pigeon pea (Singh and Singh, 1989), chickpea (Singal and Singh, 1990), black gram (Lakhanpal *et al.*, 1995) etc. However, in the present study, no relation between oil content and bruchid infestation could be observed.

Normally, pulse beetle take 2-3 weeks time to complete development from egg- laying to adult emergence on soybean under laboratory conditions (Singh *et al.*, 1989). Singhal (1998) reported this duration on cowpea to be 35.5 days under laboratory conditions. In present study with no-choice test, the varieties JS 335, JS 93-05, MAUS 47, NRC 7 and Samrat exhibited relatively shorter developmental period of *C. chinensis* ranging between 27.00 and 28.67 days as compared to other varieties (31 to 37 days) (Table 2). Presence of non-nutritional chemicals such as amylase, saponin (Applebaum *et al*., 1965; Dwivedi and Sharma, 1993), lectin (Ignacimuthu *et al*., 2000) and could also be responsible for shorter developmental period. The adult emergence was significantly less in MAUS 47 (30.31%), Bragg (33.14%) and NRC 7 (35.26%). However, in a separate study, Mannan and Bhuiyah (1994) reported no adult emergence of *C. maculatus* on kidney beans and soybean.

The growth indices of *C. chinensis* on varieties NRC 7 (1.03), MAUS 47 (1.05), Bragg (1.14) and NRC 12 (1.24) were significantly lower than the other varieties.

Table 2. Growth Indices of *C. chinensis* on soybean varieties loss in weight ("No-choice method")

Variety	No. of eggs laid	No. of adult emergence	Adult emergence (%)	Develop-ment period (days)	Growth Index	Loss in seed weight (%)	Seed-coat thickness (μ)
JS 335	73.33 (8.51)	41.33 (6.40)	56.52 (48.75)	28.00	2.01	39.95 (39.20)	195.9
JS 93-05	98.00 (9.89)	60.66 (7.78)	62.15 (52.06)	27.67	2.24	47.67 (43.67)	182.6
MAUS 47	106.00 (10.23)	32.00 (5.63)	30.31 (33.40)	28.67	1.05	19.80 (26.37)	235.9
JS 95-60	22.33 (4.70)	16.66 (3.85)	66.91 (54.89)	33.00	2.36	45.18 (42.23)	103.9
Bragg	84.00 (8.84)	28.00 (5.09)	33.14 (35.14)	29.00	1.14	22.77 (28.49)	273.9
Pusa 16	58.66 (7.62)	27.00 (5.17)	46.16 (42.80)	31.00	1.48	30.57 (33.57)	151.3
Samrat	82.33 (9.05)	52.00 (7.19)	63.24 (46.86)	27.00	2.34	45.94 (42.69)	164.6
NRC 37	63.33 (7.95)	42.00 (6.47)	66.34 (54.53)	28.00	2.36	47.00 (43.28)	119.9
NRC 7	65.33 (8.07)	23.00 (4.79)	35.26 (36.42)	28.00	1.03	25.90 (30.59)	213.9
NRC 12	61.00 (7.65)	28.00 (5.18)	45.98 (42.69)	37.00	1.24	28.29 (32.13)	189.9
(P = 0.05)	**(2.31)**	**(1.43)**	**(5.82)**	**0.69**	**0.13**	**(1.88)**	**1.68**

Seed coat thickness which plays a significant role in providing resistance against storage insects, was found to be maximum in variety Bragg (273.9 μ), followed by MAUS 47 (235.9 μ) and NRC 7 (213.9 μ). Minimum percent loss in seed weight due to *C. chinensis* infestation was observed in variety MAUS 47 (19.80%), followed by Bragg (22.77%) and NRC 7 (23.90%).

Thus, on the basis of adult emergence, growth indices and per cent loss in seed weight, varieties MAUS 47, Bragg and

NRC 7 appear to have resistant traits against *C. chinensis* under storage conditions. In present study, seed coat thickness was found to be directly associated with adult emergence. Irrespective of number of eggs laid on the seeds, thicker seed coat of these varieties offered resistance to hatched grubs for entering the seed. These varieties also recorded significantly less loss in seed weight and less adult emergence.

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In Vitro Evaluation of Cow Urine and Butter Milk against Three Major Soil-borne Pathogens of Soybean

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ABSTRACT

Cow urine and buttermilk reduced mycelial growth, number and size of sclerotia of Rhizoctonia bataticola. *The mycelial growth was completely inhibited by buttermilk at 500 and 1000 ppm whereas at 100 ppm it was minimum (3.31 mm). Cow urine and butter milk not only reduced the mycelial growth of* Sclerotium rolfsii *but also affected the viability of sclerotia formed and reduced number of sclerotia per plate. Smallest sclerotia were recorded in buttermilk followed by cow urine. Slight reduction of mycelia growth of* Fusarium solani *f. sp.* glycine *by cow urine and butter milk was recorded. Storage period had no effect on its fungi-toxicity. Conidial production decreased with increasing concentration of cow urine whereas at 500 ppm it induced chlamydospore production.*

Key words: Soybean, soil-borne pathogens, cow urine, buttermilk.

In Madhya Pradesh, the area under soybean is 4.44 m ha with a production of 3.47 million tonnes and the productivity is 780 kg per ha (Anonymous, 2005). The crop suffers badly with soil pathogens namely, *Rhizoctonia bataticola, Sclerotium rolfsii and Fusarium solani* f. sp. *glycine* causing charcoal rot, collar rot and root rot, respectively. On account of the inherent hazardous effects involved in conventional chemical management, the alternative plant protection measures like organic farming, use of FYM, green manuring neem oil, botanicals and animal by-products such as cow urine, butter milk as described in Vedas, Arthshastra, Aginpuran, Surapala's (Nene, 2003; Sadhale, 1996; Wojtilla, 1985) etc are gaining importance. Cow urine and butter milk are being used for the management of insect pest and diseases in many crops. Various preparations of cow urine are available in the market for the management of insect-pest and diseases. US Patent NO.6, 410, 059 (issued in June 25, 2002), as bio-enhancer, has been validated by the Council of Scientific and Industrial Research for its medicinal value and antibiotic properties. These products are often named as antifungal, organic gold, biodynamic, bio-pesticide, bio-organic manure, bio-growth promoters, and

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indigenous seed dressing. Scientific literature available on these aspects is very limited. Therefore, the present investigation was undertaken to generate information on the efficacy of cow urine and buttermilk in management of major soil-borne pathogens of soybean.

MATERIAL AND METHODS

Cow urine: Cow urine collected from dairy farm, Jawarharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur was filtered through Whatman filter paper No.1. The filtered cow urine was sterilized by using Seitz filter. The filtrate was collected in sterilized glass stopper bottle and stored at room temperature for further studies.

Buttermilk: Buttermilk was collected from Sanchi Dugdhashangh *Maryadit*, Jabalpur. After filtration through Sietz filter it was kept in a glass-stopper bottle and stored at room temperature.

In vitro *evaluation of cow urine and butter milk*: *In vitro* evaluation of cow urine and buttermilk was done by using poisoned food technique. Required dilutions were done to achieve concentration of 100, 500 and 1000 ppm of both the products and screened at three storage period i.e. fresh, 3 days old and 5 days old against three major soil-borne pathogens i.e. *Rhizoctonia bataticola , Sclerotium rolfsii and Fusarium solani* f. sp. *glycine* of soybean. Seven mm disc of the test fungus was used. Three replications of each treatment were maintained. Observations on radial growth on potato-dextrose medium and colony character were recorded after 5 and 10 days incubation at 25 ^{0}C. Measurements of sclerotia/ chlamydospores/conidia were made after 15 days with the help of colour image analyzer and for other two pathogens spore count per microscopic field (10 x 10 x) were recorded and compared with the population in control plates. Germination percentage of sclerotia was recorded 7 days after incubation at 25 ^{0}C over blotter paper soaked with Hoagland's solution.

RESULTS AND DISCUSSION

Rhizoctonia bataticola

No mycelial growth was observed on PDA amended with buttermilk at 500 and 1000 ppm (Table 1). Mycelial growth in cow urine amended PDA ranged from 58.7 to 85.5 mm after 10 days of inoculation. There was a decrease in mycelial growth with increase in concentration of cow urine. Reddish discoloration was observed in culture plates amended with cow urine. Slightly reduced growth was recorded in cow urine stored for 5 days as compared to fresh cow urine, whereas increase in growth was recorded in buttermilk (100 ppm) stored for 5 days as compared to fresh buttermilk.

The data (Table 1) showed that sclerotial number in control was 212 sclerotia per m.f. with mean size of 179.7 x 285.6 µm (max. 252 x 451 µm and min. 114 x 188 µm). In cow urine amended medium, number of sclerotia per m.f. ranged from 41 to 178 and in butter milk amended medium it was 3-31. No sclerotia formation was recorded in butter milk 500 and 1000 ppm under all the three storage conditions. Minimum number of sclerotia (41/m.f.) in cow urine amended medium was recorded with 3 days old urine at 100 ppm concentration followed by fresh (64/m.f.) and 5 days old (56/m.f.) cow urine, both at the concentration of 1000 ppm. Size of the sclerotia in all the treatment was found lower as compared to control. Minimum size of 90.32 x 130.12 μm and 96.77 x 134.77 were recorded in fresh and 5 days old cow urine, respectively.

Table 1. Mean radial growth and size of sclerotia of *Rhizoctonia bataticola* on potato dextrose agar medium amended with different concentration of cow urine and buttermilk

Treatment/ storage period (ppm)	**Mean colony growth (mm) after**		**No. of sclerotia/ m.f.***	**Maximum (LxW) (μm)**	**Minimum (LxW) (μm)**	**Mean (μm)**
	5th day	10th day				
Cow urine						
Fresh						
100	56.0	85.5	138	184 x 282	74 x 99	114.47 x 166.42
500	49.0	73.0	178	154 x 220	27 x 39	90.32 x 13012
1000	44.0	69.0	64	345 x 636	49 x 20	112.92 x 157.51
3 days old						
100	56.0	76.0	41	196 x 122	67.59 x 71	106.86 x 71.14
500	59.0	71.0	76	172 x 249	62 x 69	121.50 x 164
1000	52.0	64.0	88	184 x 264	82 x 102	123.42 x 161.71
5 days old						
100	38.0	69.0	104	179 x 214	69 x 108	144.37 x 18.25
500	48.0	63.0	155	171 x 266	49 x 62	96.77 x 134.77
1000	49.0	58.7	56	175 x 321	76 x 89	127.25 x 190.33
Buttermilk						
Fresh						
100	17.0	19.0	31	185 x 247	68 x 89	122.21 x 154.9
500	0.0	0.0	-	-	-	-
1000	0.0	0.0	-	-	-	-
3 days old						
100	21.0	27.0	9	223 x 420	26 x 41	105.6 x 205
500	0.0	0.0	-	-	-	-
1000	0.0	0.0	-	-	-	-
5 days old						
100	22.0	32,0	3	167x278	37x38	97.16x 97.35
500	0.0	0.0	-	-	-	-
1000	0.0	0.0	-	-	-	-
Control	74.0	90.0	212	252 x 451	114 x 188	179.7 x 285.6
S.Em±	1.60	1.68				
(P= 0.05)	**3.38**	**3.45**				

**mf – multiplication factor*

Studies indicated that cow urine and buttermilk reduced the mycelial growth of *Rhizoctonia bataticola.* Buttermilk at 500 and 1000 ppm completely inhibited the mycelial growth. Sundaraj *et al*. (1998) also found reduced mycelial growth and mycelia dry weight (50%) of *R. soalni* by hen urine. Similar finding was also reported by Raja and Kurucheve (1997) against *Macrophomina phaseolina*. Size and number of sclerotia was reduced in cow urine and buttermilk amended media. Reduction in growth, size and number by buttermilk was not reported before.

Sclerotium rolfsii

In cow urine and buttermilk amended media (Table 2) mycelial growth ranged from

Table 2. Mean radial growth, number and size of *Sclerotium rolfsii* on potatodextrose agar medium amended with difference concentration of cow urine and buttermilk

Treatment/ storage period (ppm)	Mean colony growth (mm) after		Number of sclerotia/ plate (90mm)	Size (mm)	Germination (%)
	5th day	10th day			
Cow urine					
Fresh					
100	57.0	78.0	334	2.16 x 2.27	50
500	52.0	67.0	259	1.63 x 1.66	76
1000	44.5	77.0	109	1.63 x 1.63	74
3 days old					
100	52.0	87.6	307	2.14 x 2.17	50
500	31.0	85.2	243	1.43 x 1.66	76
1000	46.0	77.5	171	1.66 x 1.67	74
5 days old					
100	52.8	88.6	354	2.26 x 2.25	50
500	52.9	87.9	294	1.66 x 1.63	76
1000	52.6	87.6	278	1.67 x 1.77	74
Buttermilk					
Fresh					
100	56.0	72.0	219	1.90 x1.97	82
500	73.0	84.0	137	1.77 x 1.81	78
1000	54.0	83.0	139	1.44 x 1.53	68
3 days old					
100	52.4	84.6	307	1.88 x1.97	82
500	52.7	88.2	296	1.77 x 1.86	78
1000	52.3	87.9	204	1.64 x 1.43	68
5 days old					
100	59.7	82.7	337	1.90 x1.97	82
500	57.2	85.6	317	1.77 x 1.81	78
1000	55.9	82.4	314	1.44 x 1.53	68
Control	59.0	90.0	399	2.08 x 2.28	100
S. Em. (±)	1.4	0.78			
CD at 5%	**2.94**	**1.60**			

67.0 to 88.6 mm as compared to 90.0 mm in control on 10th day. Mycelial growth in fresh cow urine and fresh buttermilk was 67.0 to 78.0 mm and 72.0 to 84.0 mm, respectively. Stored cow urine for 3 and 5 days had mycelial growth at par with the control. Storage period of cow urine and buttermilk had no significant effect on mycelial growth.

Number of sclerotia ranged 374-416 in control, 109 – 354 in cow urine and 137 to 337 in buttermilk. Minimum number of sclerotia was recorded in cow urine (fresh) 1000 ppm followed by in buttermilk (fresh) at 500 ppm. No significant difference among fresh, 3-days old and 5-days old was recorded as for as size and number of sclerotia was concerned.

Table 3. Mean radial growth, number of conida and chlamydospores of *Fusarium solani f.* sp. *glycine* on potato dextrose agar medium amended with different concentration of cow urine and butter milk

Treatment/ storage (ppm)	Mean colony growth (mm) after		No. of conidia/ microscopic field	No. of chlamydospores
	5th day	10th day		
Cow urine				
Fresh				
100	30.0	72.0	++	0
500	41.0	74.0	+	179
1000	33.0	68.0	-	40
3 days old				
100	42.0	72.0	++	0
500	45.0	73.0	-	181
1000	57.0	69.0	-	56
5 days old				
100	42.0	69.0	++	0
500	34.0	68.0	-	147
1000	27.0	68.0	-	29
Butter milk				
Fresh				
100	36.0	66.0	+++	7
500	38.5	65.0	++	0
1000	44.0	71.0	+	3
3 days old				
100	33.0	77.0	++	5
500	38.5	75.0	++	0
1000	30.0	77.5	+	0
5 days old				
100	37.0	64.3	++	1
500	35.0	78.0	++	2
1000	40.0	74.0	-	1
Control	43.0	80.0	+++	0
S.Em. (±)	1.21	2.42		
(P = 0.05)	**2.48**	**4.96**		

- = *Traces (<20); + = Few; ++ = Normal; +++ =Abundant.*

Data showed that slightly larger sclerotia measuring 2.16 x 2.27 mm were formed in cow urine 100 ppm as compared to control (2.08 x 2.28 mm). Smallest sclerotia (1.44 x 1.53 mm) were recorded in buttermilk 1000 ppm followed by 1.63 x 1.63 mm and 1.63 x 1.66 mm in cow urine at 1000 ppm and 500 ppm, respectively. Overall smaller sclerotia were formed in treatments as compared to control. Germination percentage of sclerotia in all the treatments ranged from 50 to 82% as compared to control (100%). Minimum germination percentage (50%) was recorded in cow urine (100 ppm) followed by buttermilk (1000 ppm) (68%).

Cow urine and buttermilk reduced the mycelial growth, number of sclerotia and viability of sclerotia formed. Literature pertinent to this fungus is lacking, therefore this finding is first report on this aspect. Similar finding was also reported by Raja and Kurucheve in (1998) in *Rhizoctonia solani*. Size of sclerotia was invariably reduced by cow urine and butter milk except in cow urine 100 ppm.

Fusarium solani* f. sp. *Glycine

Cow urine and buttermilk amended PDA mycelial growth varied from 64.3 to 78.0 mm as compared to growth of 80 mm in control plates (Table 3). Mostly increase in concentration or storage period had not any significant difference in reducing mycelial growth. Fluffy colony growth was recorded in all the treatments.

Data (Table 3) revealed that abundant conidia of *Fusarium solani* f. sp. *glycine* were formed on PDA medium after 12 day of inoculation and no chlamydospores were produced. Overall cow urine and buttermilk decreased the production of conidia except by buttermilk (fresh) at 100 ppm. It was also evident that with increase of concentration

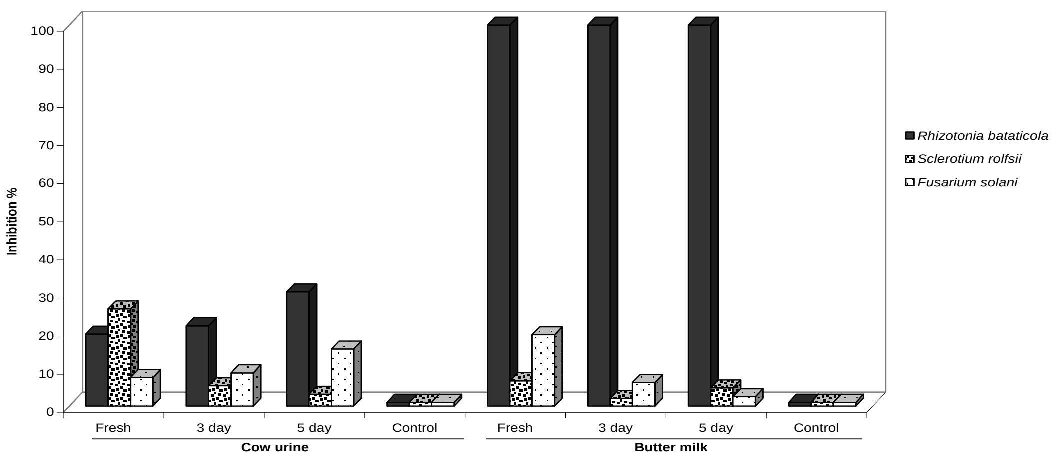

Fig. 1: Showing inhibition in mycelial growth of *Rhizoctonia bataticola* **,** *Sclerotium rolfsii* **and** *Fusarium soloni f.sp. glycine* **on PDA medium amended with 500 ppm cow urine and butter milk**

there was decrease in conidial production i.e. higher concentrations were more toxic. Maximum number of chlamydospores 181, 179 and 147 were observed in cow urine 500 ppm in 3 days old, fresh and 5 days old, respectively. In cow urine there was no formation of chlamydospores at 100 ppm in all the three storage conditions whereas few chlamydospores (40, 56, 29/microscopic field) were recorded at 1000 ppm. In case of buttermilk smaller number of chlamydospores was formed.

The present findings are in partial agreement with Alanso *et al*. (1994). Raja and Kurucheve (1999) and Basak and Lee (1998), who reported severe reduction and complete inhibition of *Fusarium subglutenes* and *Fusarium oxysporum* f.sp. *lycopersici,* respectively. This variation may be due to concentrations used or difference in test organism used. Production of macro-conidia and micro-conidia was reduced at higher concentration (1000 ppm) only. Similar finding was also reported by Gupta (1989) who reported adverse effect of cow urine on the production of ascospore by *Venturia inaqualis*. Cow urine and buttermilk stored in closed glass bottle for 3 day, 5 day did not affect its fungi-toxicity. The present finding is in full agreement with the finding of Wani and Kurucheve (2004) and Kurucheve (2003) who reported that urine retained their fungi-toxicity for one month in closed container.

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Optimization of Level of Ingredients for the Preparation of Soy-Fortified Fermented Beverage (*Lassi*) using Response Surface Methodology (RSM)

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ABSTRACT

Experiments were conducted to develop an acceptable combination of dairy milk and soy milk for the preparation and acceptability of lassi, *a fermented, milk based Indian beverage. Central Composite Rotatable Design (CCRD) with three independent variables (soy milk, sugar and flavour) at five levels was used to design the experiments. The level of soy milk ranged from 10 – 50, sugar 8 – 16, flavour 0.05 – 0.25 percent, respectively. Addition of soy milk resulted in decrease of scores of all sensory parameters (color, appearance, flavour and overall acceptability) except for consistency. Acidity of* lassi *decreased whereas, viscosity increased significantly ($P \leq 0.01$) with the increase in the level of soy milk. The addition of soy milk increased the overrun significantly ($P \leq 0.05$) in* lassi *samples. Based on individual and compromise optimization, optimum level of ingredients recommended were: soy milk level 32.70 percent, sugar 13.70 percent and vanilla flavour 0.22 percent. It was noted that addition of soy milk also supplemented the* lassi *samples in minerals content i.e., Cu, Fe, Mg and Zn, in which milk is deficient.*

Key words: Soy milk, dairy milk, sugar, flavour, *lassi*, minerals, RSM

Fermented milk products are known through out the world for their taste, nutritive value and therapeutic properties. The most commonly consumed fermented milk products in India are curd (*Dahi*) and *lassi*. *Lassi* is obtained by churning of whole milk curd or skimmed milk curd after the addition of ice, sugar or salt with or without addition of flavours. The composition of *lassi* varies considerably, depending upon the composition of curd, the extent of which curd is diluted while churning and the efficiency of fat removal. *Lassi* contains appreciable amount of milk proteins and phospholipids and is an excellent beverage for quenching the thirst by reason of its lactic acidity. Most nutritional beverages falls in to the category of functional food or nutraceuticals, among the functional drinks protein based beverages such as in sports drinks or health promoting drinks (Jayprakash and Bruenker, 1999) are becoming popular day by day.

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Soybean [*Glycine max* (L.) Merrill] can surely, today help to feed the people better and could do much to reduce nutritional deficiency in India at an affordable cost. Nutritive value of soybean appears to have no equals in supplying protein, fat, minerals salts like Ca, Mg, and P and to some extent vitamins A, D and B complex (Ali, 2005). A variety of acceptable food products can be prepared from soybean to fit in to Indian dietary pattern. Among that soymilk is one, which has drawn greater attention in the country because of short supply and high cost of regular milk (Yadav *et al*., 2003). Today, soy milk is not a specific product but could be a base for range of different drinks and beverages. Yadav and Chauhan (2005) reported that soy milk resembles bovine milk in physical appearance, consistency and contains less amount of fat and higher amount of iron and copper as compared to cow milk. Therefore, it can be blended with dairy milk and perhaps this blend will be more acceptable as compared to soy milk alone. They further reported that blending of soy milk to fluid milk for the preparation of dairy products will add to the balance sheet of benefits of soy protein consumption and reduce the gap of demand and supply of dairy milk at one hand and at other hand it will enhance popularization of soybean. Not much information is available on the development of products from the blends of soy milk with dairy milk. Although some researchers had developed some soy milk blended dairy milk based products i.e. *zabady* (El-Sayed and El-Sayed, 1988), *channa* (Katara and Bhargava, 1990), *paneer* (Changade and Tombat, 1992), mozzarella cheese (Kumar and Jha, 1997), cottage cheese (Gopal *et al*., 1998) and flavoured beverage (Yadav *et al*., 2005, Yadav and Chauhan, 2005). Karatzas *et al* (1999) reported that a combination can be established between soy milk and cow milk to produce a range of beverages and fermented products with improved flavour profile and health attributes. Therefore, an attempt was made to develop an acceptable combination of dairy milk and soy milk blend for the preparation of *lassi*, and to optimize the level of other ingredients i. e. sugar and flavour.

MATERIAL AND METHODS

The soybean *cv*. PS 1042 and standardized milk were procured from crop research centre and live stock research centre, respectively of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar. Soybean was manually cleaned and used for the preparation of soy milk. Food grade sugar and vanilla essence were purchased from the local market. All chemicals used in analysis are of analytical grade and procured from M/S E Merck India Ltd, Mumbai.

The Central Composite Rotatable Design (CCRD) was used to determine the combination of variables level in each experiment. The variables used were soy milk, sugar and flavour percentage. The levels of these variables along with experimental plan consisting of three variables at five levels have been given in table 2. Variables were standardized to simplify computation and to deduce the relative effect on the responses. The magnitude of the coefficients in second order polynomial shows the effect of that variable on the response.

Parameters	Levels (in %)
Soy milk, X_1	10, 20, 30, 40 and 50
Sugar, X_2	8, 10, 12, 14 and 16
Flavour concentration, X_3	0.05, 0.10, 0.15, 0.20 and 0.25

Experimental procedure

Preparation of soy milk: The soybean seeds were manually cleaned, soaked in water (8-10 h, 1:3 w/v), dehulled (removal of husk), ground with hot water (85 ^{0}C), filtered through muslin cloth and diluted (1: 8 v/v).

Preparation of starter culture: Mother culture of curd was used as a starter culture. Bulk starter culture was prepared using skimmed milk. The skimmed milk was autoclaved at 1.05 kg per cm^2 for 15 min, cooled to 25 ^{0}C and previous day curd culture were inoculated (@ 2.5 %) aseptically and incubated at 37$\pm$ 1 ^{0}C. After 6-7 h, the bulk culture flask was chilled and transferred to refrigerator till addition to the milk for the preparation of curd.

Preparation of curd: Milk and soy milk blends were mixed in blender mixer, preheated up to 60 ^{0}C, filtered, homogenized (175 kg/cm^2), boiled for 5 min, cooled to 37 ^{0}C, inoculated with culture (@ 2.7 %) and incubated at 37 ^{0}C for 6 h (on pre-trial basis).

***Preparation of* lassi**: Milk–soy milk blended curd, sugar, flavour and ice (small quantity) were mixed in a blender mixer and beating were done manually and after that some pieces of beaten ice were added and served to panelists for sensory evaluation.

Sensory evaluation: *Lassi* samples were evaluated for sensory attributes on 9-point hedonic scale by trained panel of 10 judges drawn from the university staff and students of the department. Colour, appearance, consistency, flavour and overall acceptability were the quality parameters.

Physical analysis: Viscosity of the *lassi* samples were determined by Brookfield Synchro-electric Rotary Viscometer (Model LVT) using spindle no. 2 at a speed of 30 rpm and at temperature of 20 ^{0} C. pH was determined using a microprocessor based pH meter (Century, CP 931) and acidity was determined by the method of AOAC (1995). Overrun in *lassi* was measured using following equation.

Per cent overrun = Final volume of lassi- Initial volume of curd taken/ Initial volume of curd taken x 100

Chemical analysis: Moisture, protein, fat and ash were determined by using AOAC (1995) methods. Carbohydrate was calculated by subtracting the sum of moisture, protein, fat and ash from 100. Trypsin inhibitor activity was determined by the method of Kakade *et al.* (1974).

Minerals analysis: Ca, P, Fe, Cu, Mg, Zn, Na and K were determined by atomic absorption spectrophotometer (EC Ltd. Model No. AAS 4141) following the digestion of samples in ternary acid mixture (HNO_3:H_2SO_4: HCl, 10:1:4 v/v).

Statistical analysis: Data analysis and response optimization were done using spread sheet lotus 123, Minitab statistical package and multiple response optimization package.

RESULTS AND DISCUSSION

The proximate composition, minerals content and trypsin inhibitor activity of standardized milk and soy milk are shown in table 1. The values for pH ranged from 4.30-4.55, acidity 0.77-0.92, viscosity 125-240 Cp, overrun 22.5-33.0 percent, colour 7.8-8.7, appearance 7.8-8.7, consistency 7.3-8.8, flavour 7.2-8.6 and for overall acceptability 7.1-8.6 among the *lassi* samples prepared using different 20 combinations of ingredients.

A second order polynomial of the following form was fitted to the data of all responses and the results are reported in table 3.

$$Y = \beta_0 + \sum_{i=1}^{3} \beta_i x_i + \sum_{i=1}^{3} \beta_{ii} x_i^2 + \sum_{i=1}^{2} \sum_{j=i+1}^{3} \beta_{ij} x_i x_j$$

$\beta_0, \beta_i, \beta_{ii}, \beta_{ij}$ = regression coefficients
x_i, x_j = independent variables
Y= dependent variable

The effect of soy milk, sugar and flavour concentration on the responses at linear, quadratic and interactive level has been presented in table 3. Negative sign of a coefficient at linear level indicated decrease in response value with an increase in level of the variable, whereas, at interactive level, level of one variable could be increased while that of other decreased to get the same response value.

Effect of variables on responses**:** Table 3 revealed that at linear level, level of soy milk significantly ($P \leq 0.05$) affected all physical as well as sensory properties of *lassi*. Acidity of *lassi* samples decreased with the increase of level of soy milk. Matsuyama *et al.* (1992) also reported that acid development in soy milk fermented with lactic acid bacteria was low. The variable soy milk had significant ($P \leq 0.01$) positive effect on pH and overrun. These responses increased as the level of soy milk increased with blend. This might be due to low level of fermentable sugars in soy milk and due to soy protein, which is known for its high whipping properties, respectively. The sugar level significantly ($P \leq 0.01$) affected overrun, consistency and overall acceptability. The concentration of vanilla flavour had no effect on physical properties of *lassi* samples as expected, whereas it had significant ($P \leq 0.01$) effect on sensory scores of colour, flavour and overall acceptability. The scores for colour, appearance, flavour and overall acceptability of *lassi* samples were negatively affected with the increased level of soy milk in blends. This might be due to dull colour and residual beany flavour of soy milk. At interactive level soy milk and sugar significantly ($P \leq 0.05$) affected the consistency of *lassi*. Interaction between soy milk and flavour concentration had significant ($P \leq 0.05$) effect on colour, appearance, flavour and overall acceptability. It was noted from the table that there was no interactive effect of sugar and flavour concentration on physical as well as sensory properties of *lassi*. At quadratic level, soy milk, significantly ($P \leq 0.05$) affected all the responses except

Table 1. Proximate composition, minerals content and trypsin inhibitor activity of standardized milk and soy milk

Chemical composition	Standardized milk	Soy milk
Moisture (%)	78.16	84.56
Protein (%)	3.17	2.98
Fat (%)	4.50	1.80
Ash (%)	0.79	0.53
Carbohydrate (%)	12.78	10.13
Trypsin inhibitor activity (TUI/ml)	-	1.74
Minerals (mg/100 ml)		
Ca	123.00	23.24
P	76.62	47.18
Fe	0.08	1.72
Na	53.40	3.71
Mg	9.80	20.40
K	153.70	131.12
Cu	-	0.26
Mn	1.12	1.42
Zn	0.72	0.82

Table 2. Experimental design matrix for *lassi* preparation and levels in coded and un-coded form

Exp. No.	Coded form			Un-code form		
	X_1	X_2	X_3	Soy milk	Sugar	Flavour
1	-1	-1	-1	20	10	0.1
2	+1	-1	-1	40	10	0.1
3	-1	+1	-1	20	14	0.1
4	+1	+1	-1	40	14	0.1
5	-1	-1	+1	20	10	0.2
6	+1	-1	+1	40	10	0.2
7	-1	+1	+1	20	14	0.2
8	+1	+1	+1	40	14	0.2
9	-1.682	0	0	13.18	12	0.15
10	+1.682	0	0	46.82	12	0.15
11	0	-1.682	0	30	8.636	0.15
12	0	+1.682	0	30	15.364	0.15
13	0	0	-1.682	30	12	0.0659
14	0	0	+1.682	30	12	0.2341
15	0	0	0	30	12	0.15
16	0	0	0	30	12	0.15
17	0	0	0	30	12	0.15
18	0	0	0	30	12	0.15
19	0	0	0	30	12	0.15
20	0	0	0	30	12	0.15

Table 3: Regression coefficient of full second order model for physical and sensory responses of *lassi* and their significance

Coefficients	pH	Acidity (% lactic acid)	Viscosity (Cp)	Overrun (%)	Colour	Appearance	Consistency	Flavour	Overall acceptability
β_0	4.4168	0.8564	159.5810	31.9016	8.4140	8.4630	8.2396	8.2829	8.1261
β_1	0.0335***	-0.0191***	24.7280***	2.3181***	-0.1395***	-0.1271**	0.0431**	-0.1927**	-0.0386**
β_2	-0.0228	0.0169	6.9240**	-0.9052***	-0.0023	-0.0169	0.4021***	0.0818	0.2381***
β_3	-0.0512	0.0348	0.9160	0.0116	0.1956***	0.1617	0.0206	0.3797***	0.0346***
β_{12}	-0.0123	0.0075	1.2500	0.3750	-0.0250	-0.0250	0.0463**	0.0037	0.0500
β_{13}	0.0012	-0.0025	0.0000	-0.1250	0.1500***	0.1750**	0.0012	0.1612***	0.0050***
β_{23}	-0.0038	0.0025	1.2500	0.2500	0.0000	0.0000	0.0362	0.0113	0.1050
β_{11}	0.0282***	-0.1848***	13.4850**	-1.3738***	-0.0063***	-0.0704	-0.0101**	-0.0699**	-0.0868***
β_{22}	-0.00013	-0.0025	9.9500**	-0.5785**	-0.0063	0.0179	-0.0791***	-0.0222	-0.1752**
β_{33}	0.0037	-0.0008	-10.3740	-0.1367	0.0593***	-0.1057	-0.0207	-0.1193***	0.0846***
R^2, %	93.2	91.4	82.5	92.6	86.4	78.7	98.0	81.8	73.6
F	15.20	11.87	5.23	13.87	7.06	4.11	53.26	5.01	3.10

****significant at 1%level, **significant at 5% level*

Table 4: Analysis of variance for the overall effect of process variables

Process variable	F value								
	pH	Acidity (% lactic acid)	Viscosity (Cp)	Overrun (%)	Colour	Appearance	Consistency	Flavour	Overall acceptability
Total individual effect									
Soy milk (%)	13.5213***	8.9116***	8.7328***	26.7711***	6.9923***	4.5963**	4.1600**	4.8352**	6.5704***
Sugar (%)	3.9377	3.8895	4.8124**	4.6845**	0.0786	0.1805	118.0478***	0.3499	5.9678**
Flavour (%)	1.2866	1.3688	1.2453	0.2403	11.6961***	6.6465	1.1473	8.8533***	8.9037***
Combined effect of all variables at									
Linear level	37.1672***	29.2709***	9.3532**	30.2528***	16.3190***	6.7549**	151.7846***	12.7176***	14.7012***
Quadratic level	7.7118**	5.6909**	6.3148**	10.7568***	5.0482**	2.6730	6.2784**	11.2623***	13.9657***
Interactive level	0.7242	0.6324	5.0263**	5.6258**	13.8278***	2.9015	4.8719**	11.0356***	10.6278***

****significant at 1%level, **significant at 5% level* appearance. The variable sugar level significantly ($P \leq 0.05$) affected viscosity, overrun, consistency and overall acceptability whereas; flavour concentration had significant ($P \leq 0.01$) effect on the scores of colour, flavour and overall acceptability at quadratic level.

Total effect of individual variable and combined effect of all variables at linear, quadratic and interactive level has been given in table 4. It is clear that soy milk level significantly ($P \leq 0.05$) affected all the physical as well as sensory characteristics of *lassi* samples. The variable sugar had a significant ($P \leq 0.05$) effect on viscosity, overrun, consistency and overall acceptability, whereas, flavour concentration had significant ($P \leq 0.05$) effect on only sensory responses i.e. colour, flavour and overall acceptability. The total individual effect of soy milk level was maximum followed by sugar and flavour concentration. At linear and quadratic level combined effect of all variables on responses were significant ($P \leq 0.05$) except on appearance at quadratic level. At interactive level the responses viscosity, overrun, colour, consistency, flavour and overall acceptability were significantly ($P \leq 0.05$) affected. Combined effect of all variables at linear level was maximum followed by quadratic and interactive level.

Optimization of independent variables: For the optimization of independent variables the responses i.e. consistency, flavour, overall acceptability and overrun were selected on the basis that these responses had direct effect on the acceptability and quality of the *lassi*. The responses were optimized individually and in combination using multiple response (MR) optimization software (Conlon and Khuri, 1988). The estimated individual optima of responses and corresponding levels of ingredients are given in table 5. It is clear that the optimum levels of independent variables i.e. soy milk, sugar and flavour percentage were different for the responses and no compromise optima could be obtained. Hence, it was difficult to recommend specific combinations of levels of independent variables. Therefore, the combinations with maximum soy milk level and maximum response values of various responses were considered for the selection of optimum product. Optimum levels of independent variables for flavour and overall acceptability were almost similar. Both the optimum conditions for flavour and overall acceptability were considered and triplicate samples were prepared and evaluated for all the selected responses. The corresponding values for consistency, flavour, overall acceptability and overrun were 8.5, 8.4, 8.5, 30.7 and 8.4, 8.7, 8.5 and 30.2 at optimum independent variables level of flavour and overall acceptability, respectively. The sensory responses and overrun of the products were comparable with the predicted values obtained by the software. Therefore, both the optimum levels are recommended for *lassi* preparation. The optimized *lassi* samples (soy milk, 32.70 %, sugar, 13.70 % and vanilla flavour, 0.22 %) were also analyzed for physico-chemical and minerals content. The physico-chemical analysis showed that it had pH 4.42, acidity 0.86 %, viscosity 160 Cp, overrun 31.50, moisture 76.50, protein 2.80, fat 3.00, ash 0.75, carbohydrate 16.85

Table 5. Estimated individual optima of responses and ingredients required for *lassi* preparation.

Responses	Predicted response values at individual optima				Individual optimum condition		
	Consistency*	Flavour*	Overall acceptability*	Overrun (%)	X_1	X_2	X_3
Consistency	8.7	8.5	8.1	28.1	-0.3309 (26.69)	1.5895 (15.18)	0.4585 (0.17)
Flavour	8.5	8.6	8.5	31.3	0.2773 (32.77)	0.8574 (13.71)	1.4120 (0.22)
Overall acceptability	8.5	8.6	8.5	30.9	0.02575 (30.26)	0.7167 (13.43)	1.5201 (0.23)
Overrun	7.8	7.1	7.3	33.1	0.7993 (37.99)	-0.8174 (10.37)	-1.2395 (0.09)

**On 9 point hedonic scale. * Values in parenthesis are un-coded values of independent variables*

per cent and trypsin inhibitor activity 0.20 TUI/ml. The optimized *lassi* samples were also analyzed for minerals content i.e. Ca, P, Fe, Na, Mg, K, Cu, Mn and Zn and corresponding values were 80.20, 55.38, 0.51, 32.51, 10.20, 123.47, 0.09, 1.03 and 0.63 mg/100g *lassi*.

It is concluded that an acceptable *lassi* can be prepared from curd containing 67.30 percent standardized dairy milk, 32.70 percent soy milk, 13.70 percent sugar and 0.22 percent vanilla flavour or 69.74 percent standardized dairy milk, 30.26 percent soy milk, 13.43 percent sugar and 0.23 percent vanilla flavour. Further it was found that addition of soy milk improved the overrun and consistency of *lassi* and also supplemented the *lassi* in minerals content i.e. Fe, Cu, Mg and Zn, in which milk is deficient.

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Growth and Supply Response of Soybean in *Malwa* Plateau of Madhya Pradesh

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ABSTRACT

The present paper addresses the issues concerning growth in area, production, productivity and supply response of soybean in different districts in Malwa *plateau of Madhya Pradesh. The secondary data related to area, production, productivity, prices of soybean, area and harvest prices of maize (competitive crop) and rainfall were collected for the period of 1990-91 to 2002-03. The results show that the growth of soybean productivity was positive in Dhar, Mandsaur, Ratlam, Dewas and Rajgarh districts but it was insignificant except for Dewas, while in case of area, growth was positive and significant for all the districts of Malwa plateau. The coefficient of lagged area under soybean was having positive and highly significant impact on current area under soybean in Indore, Ujjain, Dewas and Rajgarh districts as well as lagged yield of soybean was found to have positive and highly significant impact on the current area of soybean in Dhar, Mandsaur and Dewas districts.*

Key words: Supply response, soybean, *Malwa* plateau

Soybean is a major *kharif* crop of *Malwa* plateau of Madhya Pradesh, which contributes about 51.85 percent area, and 52.13 percent production of soybean in the State (2002-03). The economic reforms initiated in 1991 aim at accelerating agricultural production through improvement in terms of trade (Ahluwalia, 1996; Desai, 2002; Gulati, 1998; Mishra, 1998; Singh, 1995). Price related interventions to the relative exclusion of non-price intervention characterized the strategy for agricultural development in the nineties (Sen, 2001). The impact of economic reforms on rural employment also depends on the extent of supply response in agriculture (D'Souza, 2001). Keeping, this background, it is necessary to have an estimate of aggregate agricultural supply response to estimate the change in agricultural terms of trade. If the aggregate supply response is small than the current structural adjustment, programmes cannot rely exclusively on price instrument for bringing about structural change in agriculture (Palanivel, 1999). The index of terms of trade of the agricultural sector during the eighties generally remained adverse but stages

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a steady recovery and turned favourable in the nineties albeit with minor fluctuations (Anonymous, 2003). In the present paper attempt has been made to examine growth performance and supply response of soybean in *Malwa* plateau of Madhya Pradesh.

MATERIAL AND METHODS

The present study is mainly based on time series secondary data on area, production and productivity of soybean as well as area and harvest price of maize (competitive crop) in the zone. Besides, rainfall data were collected for the different districts of Malwa plateau (Indore, Dhar, Ujjain, Mandsaur, Ratlam, Dewas, Shajapur and Rajgarh) for the period of 1990-91 to 2002-03. The secondary data were collected from different sources like *Mandi* Board, and Directorate of Agriculture, Madhya Pradesh, Bhopal. The linear growth rates and acreage supply response were worked out. The following Nerlovian model was used for estimation of supply response as it is a dynamic model that explains area as a function of expected price of output, area adjustment and some exogenous variables. This type of model was also used by Venkatram and Subramanniam (2002).

$$A_t = f\,(A_{t-1}, P_{t-1}, Y_{t-1}, NA_t, R_{t-1}, PC_{t-1}, AC_{t-1})$$

Where:

A_t	=	Area under soybean in year 't'
A_{t-1}	=	Lagged area of soybean (one year lagged)
P_{t-1}	=	Lagged price of soybean (one year lagged)
Y_{t-1}	=	Lagged yield of soybean (one year lagged)
NA_t	=	Area under maize in year 't'
R_{t-1}	=	Lagged rainfall (one year lagged)
PC_{t-1}	=	Lagged price of competing crop (maize) (one year lagged)
AC_{t-1}	=	Lagged area of the maize (one year lagged)

RESULTS AND DISCUSSION

The linear growth rates and supply response of soybean for different districts of the zone as well as State were worked out.

Growth rates

The maximum growth rate of soybean area was found in Mandsaur district (8.03%) followed by Rajgarh (4.81%), Dewas (4.54%), Shajapur (3.69%), Ratlam (3.54%), Dhar (3.03%), Ujjain (2.56%) and Indore (2.16%) against moderate growth rate in *Malwa* plateau as a whole (3.99%) as compared to Madhya Pradesh (4.22%). In the case of production, the highest growth rate was recorded in Rajgarh (7.75%) followed by Dewas (6.24%), Mandsaur (7.03%), Ratlam (3.33%), Dhar (3.22%), Shajapur (3.16%), Indore (2.09%) and Ujjain (0.51%). The growth rate of production was higher in the *Malwa* plateau (4.00%) as compared to state (3.13%). The growth rate of productivity of soybean was negative in Indore, Ujjain and Shajapur districts, while it was positive and highly significant in Dewas district (Table 1).

Table 1. Growth rate of soybean area, production and productivity in *Malwa* plateau of Madhya Pradesh

Districts	Area (000′ ha)		Production (000′ tons)		Productivity (kg/ha)	
	b	LGR (%)	B	LGR%	b	LGR (%)
Indore	4.335** (0.595)	2.16	4.733 (3.134)	2.09	-0.344 (15.02)	-0.03
Dhar	6.530** (1.349)	3.03	6.698* (2.899)	3.22	1.500 (12.910)	0.16
Ujjain	9.601** (2.253)	2.56	1.905 (7.832)	0.51	-19.969 (18.355)	-1.99
Mandsaur	19.239** (2.730)	8.03	16.740* (7.379)	7.03	0.241 (21.341)	0.03
Ratlam	5.537** (1.311)	3.54	5.32 (5.092)	3.33	5.990 (25.149)	0.61
Dewas	10.109** (1.365)	4.54	15.561** (2.690)	6.24	21.632** (12.041)	1.98
Shajapur	10.089** (1.338)	3.69	7.807 (4.854)	3.16	-2.346 (14.495)	-0.26
Rajgarh	10.007** (0.490)	4.81	12.759** (3.697)	7.75	28.335 (16.490)	3.69
Malwa Plateau	75.446** (10.724)	3.99	74.380* (33.236)	4.00	3.313 (13.883)	0.34
Madhya Pradesh	150.618** (55.692)	4.22	113.847* (54.590)	3.13	-2.580 (59.797)	-0.22

*Parenthesis indicated standard error of coefficient of regression; * Significant at 5% level; ** Significant at 1% level*

Supply Response

The estimated supply response equation shows that the seven explanatory variables together explained variation in area under soybean between 77 percent in Ratlam to 99 percent in Dewas districts (Table 2). These variables explained 99 percent variation in area for the *Malwa* plateau as a whole (R^2). The coefficient for lagged acreage (A_{t-1}) was found to be significant and positive for Indore, Ujjain, Dewas and Rajgarh districts and for the *Malwa* plateau as a whole revealing that the acreage under soybean during current year is guided by acreage allocation under the crop during previous year. The coefficient for lagged acreage (A_{t-1}) was negative but insignificant for Dhar and Shajapur districts. Due to concurrent increasing trend in price of soybean the coefficient for lagged prices of soybean (p_{t-1}) did not exhibit any significant impact on acreage under soybean during current year, although lagged yield of soybean showed positive and significant impact on acreage under soybean in current year in Dhar, Mandsaur and Dewas districts where increasing trend in productivity of soybean was noted. The maize is emerging as the competing crop for soybean in *Malwa* plateau of Madhya Pradesh. However, due to meager acreage allocation under this crop did not show significant affect on the acreage under soybean in current year in most of the districts except for Mandsaur and Rajgarh districts. The lagged rainfall did not reveal any significant impact on current year acreage under soybean except for Dhar district where lagged rainfall adversely affected the soybean acreage during current year. Coefficient for lagged prices of competing crop (maize) was positive and significant affecting the current acreage under soybean and this may be due to the fact that the demand of maize as industrial raw material for starch and bird feed industry for export purpose is increasing in this area. This is also clear from the coefficient for lagged area under maize, which is positively and significantly affecting the acreage under soybean in the current year in these districts.

Table 2. Estimated supply response function for soybean in *Malwa* plateau agro-climatic region

District	Regression coefficient of								R^2 (%)
	Intercept value (a)	A_{t-1}	P_{t-1}	Y_{t-1}	NA_t	R_{t-1}	PC_{t-1}	AC_{t-1}	
Indore	0.588	0.748**	0.033	0.104	-0.115	-0.049	-0.061	-0.011	98
		(0.118)	(0.023)	(0.067)	(0.054)	(0.026)	(0.0461)	(0.082)	
Dhar	-1.534	-0.677	-0.175	0.00153**	0.0015	-0.324*	0.973*	1.589*	93
		(0.359)	(0.290)	(0.0003)	(0.0006)	(0.139)	(0.331)	(0.648)	
Ujjain	0.421	0.615**	0.170	0.062	0.002	0.019	-0.066	0.0173	94
		(0.134)	(0.209)	(0.096)	(0.065)	(0.081)	(0.118)	(0.082)	
Mandsaur	-0.002	0.234	-0.309	0.497**	-0.002**	0.192	0.628*	0.0017**	99
		(0.153)	(0.248)	(0.121)	(0.0005)	(0.129)	(0.271)	(0.00046)	
Ratlam	-0.020	0.252	0.394	0.188	-0.147	0.020	0.071	-0.029	77
		(0.44)	(1.116)	(0.459)	(0.421)	(0.251)	(0.594)	(0.382)	
Dewas	0.534	0.843**	-0.122	0.160**	-0.042	-0.064	0.002	-0.039	99
		(0.045)	(0.071)	(0.029)	(0.029)	(0.029)	(0.003)	(0.034)	
Shajapur	0.278	-0.189	0.295	0.160	-0.255	0.033	0.221	0.672	99
		(0.624)	(0.223)	(0.092)	(0.184)	(0.046)	(0.155)	(0.350)	
Rajgarh	0.361	0.904**	-0.043	0.039	-0.171*	-0.008	0.028	0.079	99
		(0.077)	(0.046)	(0.028)	(0.066)	(0.025)	(0.029)	(0.058)	
Malwa plateau	-0.351	0.773**	0.184	0.0002	0.143	0.097	-0.134	0.107	99
		(0.193)	(0.175)	(0.023)	(0.185)	(0.081)	(0.101)	(0.248)	

*Values in parenthesis indicates the standard error of regression coefficient; * Significant at 5% level; **Significant at 1% level*

The growth rate in area, production and productivity as well as supply response of soybean indicated that the highest growth rate of area was noted in Mandsaur and least in Indore district, Growth rate of production was recorded more in Rajgarh district and less in Ujjain district. The negative growth rate of soybean productivity was noted in Indore, Ujjain and Shajapur districts of the *Malwa* plateau. The growth rate of productivity was very low in *Malwa* plateau (0.34%) as a whole. The coefficient of lagged area under soybean had positive and highly significant impact on current area under soybean in Indore, Ujjain, Dewas and Rajgarh districts while lagged yield of soybean had positive and highly significant impact on current area of soybean in Dhar, Mandsaur and Dewas districts.

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Contribution of Area and Productivity towards Growth of Soybean Production in Madhya Pradesh

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ABSTRACT

The study has been conducted in Madhya Pradesh, to analyze the variability, growth, trends, and contribution of area, yield and their interaction on production of soybean. All the major soybean growing districts of Madhya Pradesh were considered for the collection of secondary data related to area, production, and productivity from 1984-85 to 2003-2004. The entire period of the study was divided into two sub- periods i.e. period I (1984-85 to 1993-94) and period II (1994-95 to 2003-04) for getting clear-cut temporal shift in contribution of area and productivity towards growth of soybean production in Madhya Pradesh. It was observed from the study that Ujjain, Indore, Ratlam, and Dewas being the most important soybean producing districts contributing more than 24.2 percent of area and 26.0 percent of production of soybean in the state, with an average productivity of 1207 kg per ha. Six districts, namely Indore, Dhar, Shajapur, Sehore, Sagar and Betul fall under the category of low risk prone districts. The growth in area, production, and productivity was positive and significant in all the major districts except Betul during the study period, and growth was higher during period I as compared to period II. The area, yield, as well as their interaction effect were also found positive in almost all districts of Madhya Pradesh. In the period II area effect was found to be negative in Betul district, while yield effect and interaction effect were found to be negative in Dhar, Ujjain and Sagar districts of Madhya Pradesh.

Key words: Soybean, area, production, productivity

Soybean is one of the important commercial oilseed crops of Madhya Pradesh. It ranked first (2003-04) in India by contributing 4.1 million ha area (70.7%) and 4.7 million tones of production (72.4%) with average productivity of 1130 kg per ha (Table 1). It is a prospective crop and ensures the highest profits among all commercial crops (Gautam and Nahatkar, 1993). The versatility of the crop and availability of varieties with varying maturity duration permits its successful inclusion as intercrop in sorghum, pigeon pea, cotton and maize.

The productivity of soybean in the state revealed an increase of 63.3 percent from 1984-85 (692 kg/ha) to 2003-04 (1130 kg/ha), while the increase in area exhibited was 747 percent (from 0.47 m ha to 4.17 m ha). During the same period,

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the production of soybean also increased by 1184 percent (from 0.32 mt to 4.11 mt). But, the information on its growth, relative change, and contribution of area, production, and productivity in major soybean production districts in Madhya Pradesh was lacking and hence this study was taken up as a guideline for policy initiative for sustaining soybean production in the state.

MATERIAL AND METHODS

Of the 48 districts of Madhya Pradesh, 12 districts namely Ujjain, Hoshangabad (Harda), Mandsaur (Nimach), Shajapur, Dewas, Sehore, Raigarh, Sagar, Indore, Ratlam, Dhar, and Betul were purposively selected for the study. These districts not only contributed about 70 percent of the area but also had share of 75 percent soybean production of the state (Table 1).

Table 1. Area, production and productivity of soybean in different districts of Madhya Pradesh (2003-04)

District	Area		Production		Yield (kg/ha)
	000′ ha	% to total	000′ tons	% to total	
Indore	220.0	5.3	236.4	5.0	1075
Dhar	225.2	5.4	249.4	5.3	1108
Shajapur	289.3	6.9	322.0	6.8	1113
Mandsaur	289.9	7.00	335.2	7.1	1156
Ratlam	177.4	4.3	195.4	4.2	1101
Ujjain	370.0	8.9	448.1	9.5	1211
Dewas	239.2	5.7	345.0	7.3	1442
Raigarh	256.1	6.2	288.6	6.1	1127
Sehore	248.8	6.0	319.9	6.8	1286
Sagar	156.4	3.8	156.5	3.3	1001
Hoshangabad	203.6	4.9	207.2	4.4	1018
Betul	158.3	3.8	151.8	3.2	959
Madhya Pradesh	**4165.6**	**100.0**	**4708.5**	**100.0**	1130

Source: Agriculture Statistics office, Madhya Pradesh, Bhopal and office of the Commissioner of Land Records, Madhya Pradesh

The entire study period i.e. period 1984-85 to 2003-04 was divided into two sub-periods i.e. Period I (1984-85 to 1993-94) and Period II (1994-95 to 2003-04) for getting clear cut picture of contribution of area and productivity towards growth of soybean production in the state. The data related to area, production, and productivity of soybean, were collected from the Office of Agriculture Statistics, Madhya Pradesh, Bhopal and the Office of the Commissioner of Land Records, Gwalior, Madhya Pradesh from published records. To minimize the irregular fluctuation in time series secondary data, the three-year moving averages were worked out. The relative change, variability in area, production and productivity and contribution of area, yield and their interaction towards production of soybean in different periods and in different districts were analyzed with the help of percentage change over the base year, coefficient of variance, and decomposition model (Nahatkar and Sharma, 1998). The compound growth rates of area, production and productivity in different period of the study were also worked out (Sharma and Nahatkar, 2004).

RESULTS AND DISCUSSION

Relative change and variability

The area of soybean in Madhya Pradesh showed 848.5 percent change during the entire period under study with co-efficient of variation of 60.2 percent. The relative change in area was more in period I than period II. Maximum relative change of area was observed in Mandsaur (8903.9%), followed by Ratlam (2568.5%), Sagar (1980.8%), Rajgarh (1114.8%), Ujjain (1023.9%), Shajapur (829.0%), Sehore (688.1%), Dewas (493.8%), Hoshangabad (486.8%), Indore (312.0%), Betul (255.0%), and Dhar (76.3%) districts, during the period under study. During period I the maximum relative change was observed in Mandsaur (1002.9%), followed by Sagar (745.9%), Ratlam (680.6%), Rajgarh (523.2%), Ujjain (421.1%), Shajapur (345.2%), Sehore (323.8%), Dhar (293.9%), Betul (191.8%), Dewas (156.9%), Indore (150.6%), and Hoshangabad (132.6%) districts. During period II, the maximum relative change in area was observed in Mandsaur (135.6%) followed by Sagar (72.0%), Dewas (50.1%), Rajgarh (48.3%), Hoshangabad (47.6%), Shajapur (40.8%), Ujjain (39.4%), Ratlam (39.3%), Dhar (35.3%), Sehore (28.0%), Indore (15.6%) and Betul (7.0%) districts (Table 2).

Analysis of data revealed that the area of soybean in these districts were fluctuated in the range of 41.0 (Indore) to 98.8 percent (Mandsaur) during the entire period of study. The fluctuation area was found more in period I (34.2 to 100.9%) as compared to period II (6.4 to 33.3%).

The production of soybean in the state also exhibited 1198.9 percent relative change with fluctuation of 71.0 percent in the entire period, as compared to period I (407.6% and 67.7%, respectively) and period II (52.5% and 25.7%, respectively). Amongst different districts, the maximum relative change in production observed was in Ujjain (1762.4%) followed by Sagar (1701.1%), Rajgarh (1499.3%), Mandsaur (1461.1%), Shajapur (1288.7%), Dhar (1095.4%), Sehore (1029.8%), Dewas (897.3%), Hoshangabad (616.2%), Indore (606.7%), Ratlam (487.5%), and Betul (239.1%), districts during the entire period. The relative change in production was observed to be more in period I as compared to period II. During period I, the maximum relative change in production was observed in Mandsaur district (1175.7%), followed by Ratlam (952.8%), Sagar (759.8%), Ujjain (691.9%), Sehore (481.7%), Dhar (415.8%), Shajapur (413.1%), Rajgarh (392.5%), Indore (274.5%), Dewas (260.7%), Betul (248.2%) and Hoshangabad (151.9%). During the period II, all these districts showed positive relative change in production except Betul (-27.26%). The maximum relative change in production during this period was observed in Mandsaur (160.7%) followed by Rajgarh (156.2%), Ratlam (105.4%), Dewas (84.6%),

Table 2. Relative changes and variability in area, production and productivity of soybean in major soybean growing districts of Madhya Pradesh

Districts	Period I (1984-85 to 1993-94)						Period II (1994-95 to 2003-04)						Entire period (1984-85 to 2003-2004)					
	Area		Production		Productivity		Area		Production		Productivity		Area		Production		Productivity	
	Relative contri-bution	CV (%)	Relative contri-bution	CV (%)	Relative contri-bution	CV (%)	Relative contri-bution	CV (%)	Relative contri-bution	CV (%)	Relative contri-bution	CV (%)	Relative contri-bution	CV (%)	Relative contri-bution	CV (%)	Relative contri-bution	CV (%)
Indore	150.6	36.4	274.5	59.4	45.5	24.4	15.6	6.4	30.7	20.2	13.5	16.3	312.0	41.0	606.7	56.6	69.9	24.6
Dhar	293.9	50.4	415.8	67.8	29.7	23.4	35.3	13.2	24.0	24.3	-6.8	20.0	76.3	56.4	1095.4	66.4	33.8	23.2
Shajapur	345.2	54.2	413.1	64.3	14.5	18.2	40.8	14.3	80.2	28.2	29.1	17.8	829.0	55.9	1288.7	70.2	48.3	22.5
Mandsaur	1002.9	100.9	1175.7	122.0	16.3	29.2	135.6	33.3	160.7	52.3	16.7	30.0	8903.9	98.8	1461.4	116.0	66.5	38.5
Ratlam	680.6	85.7	952.8	114.9	31.4	31.9	39.3	14.0	105.4	40.1	49.5	31.0	2568.5	77.8	4875	97.0	88.0	38.8
Ujjain	421.1	59.4	696.0	86.2	49.1	28.4	39.4	15.7	37.3	27.0	-1.8	21.2	1023.9	60.0	1762.4	73.9	65.0	30.0
Dewas	156.9	35.9	260.7	56.3	38.6	26.3	50.1	17.2	84.6	31.2	23.2	18.6	493.8	50.1	897.3	68.8	68.2	27.6
Rajgarh	523.2	63.8	392.5	62.6	-21.1	22.3	48.3	16.5	156.2	48.1	75.3	37.1	1114.8	57.3	1499.3	82.3	13.4	32.9
Sehore	323.8	53.0	481.7	74.4	29.9	22.6	28.0	12.0	45.9	22.5	14.0	13.8	688.1	51.8	1029.8	63.2	38.5	20.7
Sagar	745.9	67.2	759.8	77.6	49.0	17.6	72.0	30.6	53.8	36.2	-9.7	18.2	1980.8	68.3	1701.1	73.7	-13.1	17.7
Hoshangabad	132.6	34.2	151.9	45.5	20.7	25.7	47.6	26.5	48.6	36.6	2.5	19.0	486.8	56.1	616.2	74.0	21.1	27.2
Betul	191.8	52.9	248.2	64.2	17.1	18.1	7.0	10.6	-27.3	29.4	-13.8	23.9	255.0	42.5	239.1	56.6	-3.4	23.7
Madhya Pradesh	**296.0**	**51.8**	**407.6**	**67.7**	**27.6**	**18.0**	**47.4**	**18.1**	**52.5**	**25.7**	**4.4**	**12.0**	**848.5**	**60.2**	**1198.9**	**71.0**	**36.9**	**19.6**

Table 3. Relative contribution of area and yield in increasing / decreasing production of soybean in major soybean growing districts of Madhya Pradesh

Districts	Period I (1984-85 to 1993-94)				Period II (1994-95 to 2003-04)				Entire period (1984-85 to 2003-2004)			
	Absolute change (th tons)	Area effect	Yield effect	Inter-action effect	Absolute change (th tons)	Area effect	Yield effect	Inter-action effect	Absolute change (th tons)	Area effect	Yield effect	Interaction effect
Indore	102.4	56.2	19.2	26.8	62.1	31.0	21.8	4.0	226.7	117.5	26.8	82.3
		(56.3)	(18.7)	(25.2)		(51.2)	(43.6)	(6.4)		(51.9)	(11.8)	(36.3)
Dhar	86.8	61.1	7.0	18.1	48.3	67.8	-14.4	-5.1	228.6	165.7	7.0	55.9
		(70.5)	(8.1)	(20.2)		(140.3)	(-29.7)	(-10.5)		(72.5)	(3.1)	(24.5)
Shajapur	99.6	83.9	3.5	12.1	148.9	73.4	53.9	21.7	310.6	201.6	11.7	97.2
		(84.3)	(3.5)	(12.2)		(49.3)	(36.2)	(14.6)		(64.9)	(3.8)	(31.3)
Mandsaur	27.4	22.9	0.4	3.7	214.1	168.7	20.8	24.8	341.0	142.6	1.8	95.0
		(83.4)	(1.4)	(13.6)		(78.8)	(9.7)	(11.4)		(59.6)	(0.7)	(39.7)
Ratlam	45.7	33.2	1.5	10.9	125.3	46.2	57.7	21.5	239.0	228.9	7.4	201.4
		(72.5)	(3.4)	(23.78)		(36.8)	(46.0)	(17.2)		(52.3)	(1.7)	(46.0)
Ujjain	171.8	105.0	15.7	51.6	125.7	133.1	-6.1	-1.3	437.7	255.2	16.2	165.8
		(61.1)	(9.1)	(30.0)		(105.9)	(-4.9)	(-1.1)		(58.3)	(3.7)	(37.9)
Dewas	77.2	46.4	11.4	17.9	135.3	79.8	36.9	18.5	265.6	145.9	20.1	99.6
		(60.1)	(14.8)	(23.2)		(59.0)	(27.0)	(13.7)		(54.9)	(7.6)	(37.5)
Rajgarh	54.0	72.6	-2.9	15.5	134.2	5.0	7.6	3.6	206.4	153.5	4.3	48.5
		(134.4)	(-5.4)	(-28.3)		(30.7)	(47.2)	(22.1)		(74.4)	(2.1)	(23.5)
Sehore	105.2	73.2	6.8	21.9	77.6	12.3	6.2	1.7	224.8	118.7	22.1	84.0
		(69.6)	(6.4)	(20.8)		(61.10)	(30.4)	(8.5)		(52.8)	(9.8)	(37.4)
Sagar	45.3	44.7	0.2	0.9	37.6	133.9	-18.2	-13.1	101.5	81.0	3.5	16.3
		(98.7)	(0.4)	(1.9)		(131.7)	(-17.9)	(-12.9)		(79.8)	(3.4)	(16.0)
Hoshangabad	66.0	58.2	3.61	4.2	101.7	31.6	1.7	0.8	267.6	149.6	9.0	107.0
		(88.2)	(5.5)	(6.4)		(92.5)	(5.0)	(2.4)		(55.9)	(3.4)	(40.0)
Betul	65.1	49.6	5.4	10.1	-33.3	-8.4	38.8	2.9	62.7	65.9	-0.9	-2.2
		(76.2)	(8.3)	(15.5)		(-25.3)	(116.5)	(8.8)		(105.0)	(-1.4)	(-3.6)
Madhya Pradesh	**1316.1**	**960.8**	**92.1**	**263.2**	**1443.4**	**1284.6**	**115.5**	**43.3**	**3870.8**	**2748.3**	**116.1**	**1006.4**
		(73.0)	**(7.0)**	**(20.0)**		**(89.0)**	**(8.0)**	**(3.0)**		**(71.0)**	**(3.0)**	**(26.0)**

Figures in parentheses show percentage

Shajapur (80.2%), Sagar (53.8%), Hoshangabad (48.6%), Sehore (45.9%), Ujjain (37.3%), Indore (30.7%), Dhar (24.0%) and Raisen (20.6%) districts.

The production of soybean fluctuated in the range of 56.6 percent (Indore) to 116.0 percent (Mandsaur) during the entire period of study. This fluctuation in production was more in period I as compared to period II. In period I, maximum fluctuation was observed in Mandsaur district (122.0%) followed by Ratlam (114.9%), Ujjain (86.2%), Sagar (77.6%), Sehore (74.4%), Dhar (67.8%), Betul (64.2%), Shajapur (64.3%), Rajgarh (62.6%), Indore (59.4%), Dewas (56.3%) and Hoshangabad (45.5%) while during period II fluctuation in the production was observed in the range of 20.2 percent (Indore) to 52.32 percent (Mandsaur).

The productivity of soybean showed a positive relative change (13.4 to 88.0%) in the districts of Madhya Pradesh except Sagar (-13.1%), and Betul (-3.4%) during the entire period under study. The relative change in productivity of soybean was also observed more in period I (27.6%) as compared to period II (4.4%). All the districts showed a positive relative change except Rajgarh (21.1%) in period I and Betul (-13.8%), Sagar (-9.7%), Dhar (-6.8%), and Ujjain (-1.8%) in period II. The productivity of soybean fluctuated with the range of 17.7 percent (Sagar) to 38.8 percent (Ratlam) during the entire period.

Relative contribution of area and yield

In Madhya Pradesh, the production of soybean increased by 1316.1 thousand tonnes, of which 960.8 (73%) thousand tonnes was brought through increased acreage during period I. Only 92.1 thousand tons (7.00%) of increased production was the result of increased productivity. The interaction effect of area and productivity lead to increased production to the tune of 263.2 thousand tonnes (20%). This analysis brings out that the major break-through in soybean production took place during period I and it was due to horizontal expansion (increase in area) in the state. Among the different districts, maximum increase in production of soybean was observed in Ujjain district (171.8 thousand tones), in which contribution of area was 61.1 per cent and that of productivity 9.12 per cent. The combined contribution of area and yield was 51.6 thousand tones (30.0%) in this district. In general, the contribution of area has been much higher than that of productivity during the entire period (Table 3).

During period II, the production of soybean in Madhya Pradesh increased by 1443.4 thousand tonnes. The increased area under soybean during this period contributed 89 percent towards total increase in production of soybean, while contribution of increased productivity was only 8 percent. The districts having maximum increase in production of soybean included Mandsaur (241.1 thousand tonnes), out of this 168.7 thousand tones (78.8 %) of production increase was due to area expansion, 9.7 per cent due to increase in productivity and 24.6 tonnes (11.4%) due to interaction effect. In Dhar, Ujjain and Sagar districts increase in production of soybean during period II was noted, but in these districts the increase in production was solely due to increased area. The reduction in production by 33.3 thousand tones in Betul district was noted. This was mainly due to reduction in yield (116.5%) and reduction due to interaction effect, on account of biotic stresses (Sharma and Nahatkar, 2004). The Betul district is known as potential area for soybean rust which causes substantial yield losses (Gupta and Chauhan, 2005, Sharma and Gupta, 2006).

In entire period, there was an increase in production of soybean by 3870.8 thousand tons in Madhya Pradesh, in which the contribution of area was 71.0 percent and of productivity only 3.0 percent. The increase in production due to interaction effect of area and productivity was 26.0 percent. Amongst all the districts, maximum increase in production was noted for Ujjain (437.7 thousand tones). This was on account of 58.3 percent increase in area and 38.0 percent due to increased area along with productivity. Only 3.7 percent change in production was due to increase in productivity. The contribution of productivity was positive for all the districts except Betul (-0.9), but its percentage share was lower as compared to percentage share of acreage.

Growth trend in area, production and productivity

The growth in soybean area as well as production was positive and significant during period I (21.7 and 28.1%), period II (6.0 and 6.9%) and entire period (18.5 and 22.4%) of study whereas the growth of productivity was positive but non-significant during period I (2.8%) and II (0.9%) in Madhya Pradesh. The highest percentage growth in production of soybean during period I was noted for Mandsaur district (40.5%). This growth in production was due to acreage enhancement (39.1%). In all the soybean growing districts of Madhya Pradesh, positive and significant growth was found in production during this period. The significant and positive growth in productivity was depicted only in Indore district. In all other districts growth in productivity was positive but was non-insignificant (Table 4).

During period II, none of the district showed significant growth in productivity of soybean, although it was positive in all the districts except for Ujjain, Sagar, and Betul districts. The production during this period increased significantly in Indore, Shajapur, Mandsaur, Dewas, Rajgarh, and Sehore districts of the state. The significant increase in area of soybean during period II was observed in most of the districts of the state except in Betul, revealing that this crop is still replacing non-remunerative crops and *kharif* fallow lands. Similar trend has been reported by Singh *et al.* (1993)

Risk prone districts

Risk prone district were identified on the basis of productivity variability during the entire period. The districts Indore, Dhar, Shajapur, Sehore, Sagar and Betul fall in the category of low risk prone districts, where as Dewas, Ujjain, Hoshangabad and Rajgarh districts are moderately risk prone (variability between 25 to 35%). The Mandsaur, and Ratlam

Table 4. Compound growth rates (%) of area, production and productivity of soybean in major soybean growing districts of Madhya Pradesh

Districts	Period I (1984-85 to 1993-94)			Period II (1994-95 to 2003-04)			Entire period (1984-85 to 2003-2004)		
	Area	Production	Yield	Area	Production	Yield	Area	Production	Yield
Indore	14.11** (14.63)	19.55**	4.77*	2.06**	4.40*	2.29	11.17**	15.93**	4.28**
		(5.75)	(2.44)	(8.37)	(2.32)	(1.31)	(17.81)	(11.59)	(4.85)
Dhar	21.55**	25.17**	2.98	4.38**	4.80	0.41	17.51**	20.53**	2.57
	(12.81)	(5.59)	(1.19)	(9.86)	(1.67)	(0.01)	(24.71)	(9.87)	(2.19)
Shajapur	24.08**	24.79**	0.58	4.85**	8.09**	3.19	17.84**	21.73**	3.31**
	(24.84)	(6.69)	(0.42)	(14.61)	(3.70)	(1.75)	(34.99)	(13.32)	(3.90)
Mandsaur	39.12**	40.48**	0.97	13.06**	15.07*	1.77	44.04**	51.81**	6.40**
	(4.78)	(3.61)	(0.27)	(9.57)	(2.73)	(0.78)	(13.39)	(7.14)	(3.39)
Ratlam	32.69**	36.26**	2.69	4.69**	8.51	3.64	30.04**	37.47**	5.72**
	(6.12)	(4.03)	(0.91)	(8.28)	(2.08)	(1.25)	(15.75)	(8.09)	(3.72)
Ujjain	26.11**	31.94**	4.62	4.79**	2.51	-2.17	19.63**	24.65**	4.19
	(10.69)	(4.95)	(1.85)	(4.26)	(1.06)	(0.50)	(18.94)	(8.29)	(3.25)
Dewas	13.93**	17.37**	3.02	5.89**	9.74**	3.36	13.71**	19.10**	4.74**
	(7.15)	(4.05)	(1.41)	(11.29)	(4.25)	(1.90)	(25.22)	(11.75)	(4.77)
Rajgarh	29.35**	24.27**	-3.92	5.69**	12.91*	6.83	19.38**	21.84**	2.06
	(19.88)	(5.76)	(1.57)	(24.65)	(2.74)	(1.84)	(44.12)	(7.29)	(1.63)
Sehore	23.10**	26.72**	2.94	3.92**	6.27**	2.26	16.18**	19.84**	3.15**
	(22.74)	(6.01)	(1.45)	(9.20)	(3.60)	(1.60)	(26.18)	(14.00)	(3.78)
Sagar	38.47**	38.49**	0.01	9.43**	8.75	-0.62	24.40**	25.04**	0.52
	(10.92)	(11.43)	(0.08)	(4.16)	(2.18)	(0.21)	(4.13)	(8.94)	(0.69)
Hoshangabad	12.75**	12.86**	0.10	7.46**	9.34	1.75	14.11**	18.49**	3.84*
	(6.76)	(3.72)	(0.15)	(3.40)	(2.23)	(0.76)	(11.58)	(7.85)	(3.20)
Betul	16.66**	18.75**	1.80	1.02	-2.80	-3.78	10.77**	12.51**	1.57
	(5.40)	(4.39)	(1.00)	(0.84)	(0.73)	(1.38)	(7.94)	(4.48)	(1.41)
Madhya	**21.71****	**25.07****	**2.76**	**6.01****	**6.92***	**0.85**	**18.53****	**22.43****	**3.28****
Pradesh	**(15.72)**	**(6.54)**	**(1.70)**	**(7.00)**	**(2.91)**	**(0.65)**	**(25.21)**	**(12.49)**	**(4.56)**

*Figures in parentheses show t values, * Significant at 5 %, ** Significant at 1 %*

districts were found to be highly risk prone due to high percentage of productivity fluctuations (Table 5). In Mandsaur district productivity ranged between 700 kg per ha (1984-85) to 1200 kg per ha (2003-04). Similarly in Ratlam district it ranged between 500 kg per ha (1984-85) to about 1200 kg per ha (2003-04). This risk may be accouted for the prevailing biotic and abiotic stresses.

Table 5. Risk prone districts for soybean production of Madhya Pradesh (Based on 1984-85 to 2003-2004 time series data)

Productivity Coefficient of Variation	Districts
Low (15-25 %)	Indore, Dhar, Shajapur, Sehore, Sagar and, Betul
Moderate (25-35 %)	Dewas, Ujjain, Hoshangabad and Rajgarh
High (35-45 %)	Mandsaur, and Ratlam

It is concluded from the study that the productivity of soybean in the state has been hovering around 1000 kg per ha with insignificant growth during the period of 1994-95 to 2003-04. The relative change in area and production of soybean was observed more in period I as compared to period II. The period coincides with the duration in which soybean revolution in the state was experienced with the simultaneous growth of processing industry, especially in Ujjain, Mandsaur, Indore, Dhar, Shajapur, Ratlam, Dewas and Rajgarh districts. During this period, soybean occupied vast *kharif* fallows available in the state (Williams *et al*., 1974) and re-establishing the commodity balance in the state by marginal replacement of less remunerative crops. During the period II (1994-95 to 2003-04) the soybean crop had established in the cropping pattern and therefore pace of growth of soybean area was slowed-down. Another reason of slowed down growth was prevalence of unfavorable monsoon during some of years during the period under study.

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Impact of Training Intervention on Knowledge and Domestic Utilization of Soy-Based Food Preparations for Health Benefits and Nutritional Security

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ABSTRACT

Efforts were made at the institutional level to disseminate the knowledge on processing techniques to popularize soy-based food preparations with the overall objective of promoting its food uses. Through externally aided project under TMOP&M, 35 one-day training-cum-demonstration programmes were organized during 2004-2006 in different villages of Madhya Pradesh involving 1248 rural women. Out of four preparations demonstrated, being a simple technique to prepare and excellent taste, soy-nut was most liked by the trained women participants which they prepare once a month and also on special occasions like festival season or on arrival of guests. Other three products viz. soy-pakora, soy-milk and soy-paneer (tofu) were prepared by few participants. The impact assessment of the project revealed cases of some of the most enthusiastic women participants who further disseminated the knowledge gained to other women relatives, peer groups and neighbors. Few trained participants shown keen interest by applying innovative ideas in practice to prepare new products other than demonstrated to them.

Key words: Soybean, processing, utilization, training, women, knowledge

Soybean, though a recent introduction to India has successfully established itself as an integral part of the cropping systems of Madhya Pradesh, Maharashtra and Rajasthan states which are leading in area and production of this golden crop. The wonder crop of soybean is able to provide solution to the protein-calorie malnutrition of the millions. Over the past decades, researchers have documented the health benefits of soy protein, especially for those who take soy-protein daily. Soy-protein's benefit relate to reduction in cholesterol level and menopause symptoms and the reduction of risk for several dreaded diseases like cancer, heart disease and osteoporosis (Riaz, 1999). Use of soybean in the form of food preparations even after thirty-five years of its introduction as commercial crop in India is non-significant leaving aside that of soy-oil for culinary purpose (Dupare *et al.* 2005). Sporadic attempts made earlier have not brought desired results so far in order to make its entry in to the kitchen of rural households. National Research Centre for Soybean

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through its Technology Mission on Oilseeds, Pulses and Maize (TMOP&M) funded project entitled, 'Soybean: Processing and Utilization for Nutritional Security' conducted regular one-day off-campus training programmes for the rural women of Indore, Dhar, Dewas, Khargone and Shajapur districts of Madhya Pradesh with the major objective of promoting the food uses of soybean at the kitchen level thereby reaping the health benefits and providing nutritional security, especially in rural area.

MATERIAL AND METHODS

The trainings were imparted to the rural women by lecture and demonstration method. Before the start of programme, the knowledge level of participants was assessed using an interview schedule, followed by a lecture on health benefits of soybean and processing techniques to prepare different soy based food preparations. Demonstration on preparation of soy-milk, soy-*paneer* (*tofu*), soy-nuts and soy-*pakora* was also conducted inviting active participation of the respondents. During the project period (April 2004 -June 2006), a total of 35 off-campus training programmes each of one day duration were organized in different villages, thereby imparting knowledge and skill to 1248 rural women. The same interview schedule was administered immediately after the training programme for the participants to assess knowledge gain through training intervention. Out of 1248 trained women respondents, the data were again collected (after a gap of two years) from randomly selected 77 participants belonging to 12 villages to assess the overall impact of the training programme using semi-structured interview schedule. The collected data was compiled and analyzed using simple statistical tools *viz*, frequency and percentage.

RESULTS AND DISCUSSION

Respondents status of using soy food: pre-training phase

Before attending the training programme, only 4 out of 1248 participants had very less experience of preparing soy products with exception to use soy oil for culinary purpose. These products included soy-nuggets, soy-*papad* and curry prepared from soybean grains. The remaining participants were either least aware or ignorant about the enormous health and nutraceutical properties of soybean and different soy-based food preparations.

Knowledge gain of respondents: Pre- and post-training phase

There was significant improvement reported in the knowledge level of participants after attending the training programme (Table 1). About all the participants got aware that soybean is the richest and cheapest source of protein as well as full of nutritional properties. They also gained the knowledge that soybean is good for lactose-intolerant kids, diabetic patients, prevention of cardiac and cancerous ailments, avoiding menopausal syndrome, osteoporosis, anemia etc. Majority of them accepted that consumption of 25-30 g of soybean in any preferred form is essential so as to reap the medicinal and nutritional properties of soybean. They further promised to prepare soy products at their domestic level on regular basis.

Table 1. Knowledge gain of women respondents through the training programme (N=1248)

Item	Before training	After training
Knowledge about the soybean products being cheapest and richest source of quality protein	5(0.40)*	1247(99.99)
Knowledge about the utility of soybean to avoid the risk of diabetics, osteoporosis, anemia, cardiac and cancerous diseases	150(12.00)	1211(97.03)
Knowledge regarding utility of soybean to prepare different soybean based food preparations	200(16.02)	1248(100.00)
Knowledge on daily intake of 25-30 g soybean to get health benefits of soybean	00.00	1239 (99.27)

**Figures in parentheses indicate percentage*

Respondents' liking of soy preparations *vis a vis* their taste and ease in preparations

As has been stated earlier, 4 soy based food preparations were demonstrated to the trainees through learning by doing principle. Out of these, taste-wise it was found that soy-nuts (83.89%) and soy-*pakora* (54.88%) were most preferred by the trained participants followed by soy-*paneer* (8.25%) and soy-milk (3.20%) (Table 2). However, in case of method of preparations of above 4 soy-products, only soy-nuts were found to be most preferred by the trainees (about 99.0%). A negligible number of respondents gave preference to soy-*paneer (tofu)*, soy-*pakora and soy-milk* as these products which need more time and labor (soaking, grinding, sewing etc). Since they are accustomed to normal dairy milk and associated products, they found the taste of soy-milk and soy *paneer (tofu)* are slightly different hence the preference for these products was less. Further, some of the respondents were residing in interior area and they have not been exposed to *paneer*, so the product was new for them; hence they give little preference for soy *paneer (tofu)*.

Table 2. Respondents' liking of soy preparations vis-a-vis on taste and method of preparations (N=1248)

Item	Liking based on taste	Liking based on process/method
Soy-nuts	1047 (83.89)*	1235 (98.95)
Soy-milk	40 (3.20)	2 (0.16)
Soy-*pakora*	685 (54.88)	2 (0.16)
Soy-*paneer*	103 (8.25)	9 (0.72)

**Figures in parentheses indicate percentage*

Respondents status of using soy food: Post-training phase (n=77)

The data collected from 77 respondents under the impact study revealed that more than 90 per cent of the trained participants were reported to have prepared soy- products at their household level after attending the training programme. The trained participants continued preparation of soy-products at their domestic level till date but their frequency of preparation varies. About one third of the respondents (31%) reported that they prepare soy-products weekly and during the special occasions like festival or on arrival of guests. About 29 percent respondents are preparing soy-products once a month whereas 9 percent never prepared any soy products after attending training programme (Table 3).

Table 3. Respondents' frequency of preparing soy products at domestic level after attending training programme (n=77)

Status of respondents	Frequency of preparation of soy-products				
	Daily	Weekly	Monthly	On special occasions	Never
Pre-training phase	0	0	0	1 (1.29)*	76 (98.70)
Post-training phase	0	24 (31.16)	22 (28.57)	24 (31.16)	7 (9.09)

Figures in parentheses indicate percentage

Respondents' status of preparing soy-products at domestic level: Impact of training (n=70)

The data collected from 70 respondents who continued preparation of soybean based food products after attending training programme were further analyzed to explore their choice of most likely soy product (Table 4). Having asked about the soy- product, soy-nuts are being prepared and consumed by 61 percent, *Pakora* by 56 percent, soy-milk by 20 per cent, soy-*paneer (tofu)* by 13 percent and soy flour mixed with wheat flour for preparation of *roti* by 5 percent respondents, respectively. Enquiry on any problem subsequent to the consumption of soy-product, only one of the 77 participants responded affirmative. Lack of time to prepare soy products with routine diet in their kitchens was the major constraint for the women participants. This is justified as they are having farming background and has to spent considerable time in farm activities apart from managing home.

Table 4. Respondents' status of different soy products prepared at domestic level after attending training programme (n=70)

Name of soy preparation	No. of respondents (n=70)
Soy-*paneer*	18 (12.98)*
Soy-*pakora*	43 (55.84)
Soy-flour for *roti* making	4 (5.19)
Soy-milk	16 (20.07)
Soy-nuts	61 (79.22)
Other	22 (31.42)

Figures in parentheses indicate percentage

Case studies of enthusiastic and innovative participants who further integrated and transmitted the technologies to others

After attending the training, majority of the participants further transmitted knowledge gained through training programme to other women, particularly their neighbors, relatives etc. Few of the trained women are found to be very innovative and are preparing soy-*papad*, soy-*chakli* etc. Ms Annapurna Prakash, trained women from Machal village prepared soy-toffee and soy-biscuit at her home. Ms Nisha Thakur from same village also prepared soy-*dhokla*, soy-*halwa* and soy-*papad*. Being an *Anganwadi* teacher, she further transmitted this knowledge by calling other *Anganwadi* workers and demonstrating the soy-products.

Trained women from Neu Guradia Ms. Draupadibai prepared tea out of soy milk and offered to guests. She proudly puts her experience that none of the guest could make out difference with this tea. Ms Rani, a young participant from Datoda village prepared *gulab jamun* from soy-okara and enjoyed with the family and friends.

Ms Aasha Parmar, trained women from Badipura village prepares 1 kg soy-nuts every month for her family members and guests. Few participants like Ms Rani Sanwalia, Premlata, Nirmala and Sushila from Ghatabillod village which is situated on national highway are preparing soy-*paneer (tofu)* once a fortnight and making curry out of it.

Ms Bhuribai, Ms Saraswati Shinde, Ms Radha Kharadi, Ms Gangabai, Ms. Sushila Kohali and Ms Sagarbai from Joshi Guradia village are using soybean grains for preparation of curry.

It is worthwhile to note here that rural women from Borkhedi displayed 19 soy products viz. *Pedha, Dahiwara, Laddoo, Gulab Jamun,* soy-nuts, soy-*pakora, Paneer, Shrikhand, Pohe, Halwa, Milk, Chai, Dahi, Murmure, Burphy, Papad, Papdi* during the Field Day "Soybean *Diwas*" observed by National Research Centre for Soybean in this village on 10th September 2004. Honorable Assistant Director General (Oilseed & Pulses) Dr. N. B. Singh visited the exhibition stall and appreciated the efforts made by the centre to popularize soy-products among the masses.

The real impact of the project was visualized in the *Kisan Mela* organized by the centre during 21-22 April, 2006 when a trained group from Pithampur bagged first prize in the Best Soy -Product Competition organized on the occasion. This group comprising 7 women displayed 15 soy-products *viz*. soy-biscuits, soy-nuts, soy-cake, soy-*sev*, soy-*bari* (nuggets), soy-*shakkarpare*, soy-*khaman*, soy-*papad*, soy-*pakora*, soy-*chakli*, soy-*shrikhand*, soy-*rasgulla*, soy-*dahibara* and soy-yoghurt. Another trained women Ms Lalita Zaria from Chikhali village bagged second prize in the same competition for her preparation of soy-*pakora* and soy-nuts while Ms Rajkumari Joshi received third prize for the same products.

On the eve of Women Awareness Campaign, trained participants from Chikhali village also participated in the Soy-Product Competition organized by Women and Child Welfare Department of Madhya Pradesh and received first, second and third prizes.

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Comparative Efficacy of New Insecticides, Botanicals and Insect Growth Regulators against the Pod Borer Complex of Soybean

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Key words: Pod borer management, soil application, *neem* extract, *Vitex negundo* L.

Soybean [*Glycine max* (L.) Merrill] is an important pulse as well as oilseed crop. Even though the area under soybean in India had shown an appreciable increase, the productivity remains only 1 tonne per ha as against world average of 2.2 tonnes per ha. This lower productivity can be attributed to many biotic as well as abiotic factors. Among the biotic factors, the ravages caused by insect pests are of paramount importance in reducing the soybean yield. At present 270 insect pests, one mite, two millipedes, ten vertebrate pests and one snail are associated with soybean in India (Singh, 2001). Among the insect pests, those that attack during flowering and post-flowering stages are causing huge yield losses. The major post-flowering pests are the pod borers that cause considerable yield loss to soybean. In this context the present investigation was carried out assess the efficacy of new generation insecticides as well as some eco-friendly components against the pod borers of soybean viz. *Cydia ptychora* and *Etiella zinckenella*.

A field trial was laid out during the *kharif* season of 2004 at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad in a randomised block design with 13 treatments and 3 replications (Table 1). The crop was sown at a spacing of 30 cm x 10 cm in a plot size of 15 m^2 using the cultivar JS 335. The treatments were applied during the morning hours. Three sprays were given at 45 DAS, 60 DAS and 75 days after sowing (DAS).

For preparing the extracts, fresh plant material was collected from the campus of Main Agricultural Research Station, Dharwad. *Neem* (*Azadirachta indica* A Juss) seed kernel extract (NSKE) 5 percent is prepared by smashing 50 g of *neem* seeds soaked overnight in one liter of water. The extract was then collected, by squeezing through a muslin cloth.

Fresh leaves of the vitex (*Vitex nugundo* L.) and pongamia [*Pongamia*

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pinnata (L.) Pierre] were collected and washed thoroughly 3-4 times in tap water. After that, they were chopped into small pieces with knife. To get one liter extract, 50 g of the chopped material was soaked overnight in enough water, squeezed through muslin cloth and residue was smashed in mortar and pestle, again extracted and filtered through muslin cloth and the volume was made up to one litre to get 5 percent leaf extract for spraying.

For the preparation of garlic (*Allium sativum* L.)-chilli (*Capsicum annuum* L.)-kerosene extract (GCKE), 20 g each of dried garlic and green chilli were crushed using mortar and pestle separately, soaked in 10 ml kerosene and kept overnight, separately. Next day, the contents were squeezed through a muslin cloth. The extracts of garlic and chilli obtained were mixed and the volume was made up to 100 ml to get 2 per cent GCKE. Later the required concentration was obtained by diluting with water.

After the pod maturity stage, per cent pod damage, on each plot was calculated. For that ten soybean plants were selected at random from each plot. Total number of pods and number of damaged pods were counted from each plant and mean was calculated. Per cent pod damage was calculated as follows.

Percent Pod Damage =No. of damaged pods/Total no. of pods x100

Yield data was converted to kg per ha. Per cent pod damage data was subjected to arcsine transformation before the analysis. Finally, the yield data and the transformed data were analysed using ANOVA technique and subjected to DMRT (Duncan's Multiple Range Test).

The effect of new generation chemicals and eco-friendly components on the per cent pod damage of soybean (Table 1) revealed that all the treatments recorded significantly less pod damage as compared to control. Among the different treatments, lowest pod damage was shown by lambdacyhalothrin 0.3 liter per ha (13.22%) which was on par with spinosad 0.1 liter per ha (13.58%) and indoxacarb 0.25 liter per ha (14.47%). This was followed by diafenthiuron 0.5 kg per ha (18.68%), emamectin benzoate 0.18 kg per ha (15.82%), quinalphos 1.5 liter per ha (23.95%) and chlorpyriphos 1.5 liter per ha (27.21%). Among the eco-friendly treatments, nimbecidine @ 3 liter per ha recorded significantly less pod damage (26.05%) followed by NSKE 5 percent (29.79%) and GCKE 0.5 percent (32.17%). Vitex leaf extract 5 percent recorded 37.64 percent pod damage, which was on par with pongamia leaf extract 5 percent (38.28%). Thus, percent reduction in pod damage over control was highest in lambdacyhalothrin, spinosad and indoxacarb, which were on par with each other recording 36.28, 35.92 and 35.03 percent reduction in pod damage over control, respectively.

The grain yield ranged from 669.7 kg per ha in the untreated check to 1426.6 kg per ha in spinosad @ 0.1 liter per ha. The grain yield recorded in spinosad was on par with lambdacyhalothrin (1412.0 kg/ha),

Table 1. Efficacy of new chemicals and eco-friendly components in the management of pod borer complex of soybean (% pod damage and yield)

Treatments	Dose/ conc. (per ha)	Per cent pod damage	Per cent reduction over control	Grain yield (kg/ha)	Additional yield over control (kg/ha)
Spinosad 45 SC	0.1 l	13.58 j (21.63)	35.92	1426.6 a	756.9
Lamdacyhalothrin 5 EC	0.30 l	13.22 j (21.33)	36.28	1412.0 a	742.3
Emamectin benzoate 5 SG	0.18 kg	15.82 i (23.45)	33.68	1360.7 ab	691.0
Indoxacarb 14.5 SC	0.25 l	14.47 j (22.37)	35.03	1358.9 ab	689.2
Diafenthiuron 50 WP	0.50 kg	18.68 h (25.62)	30.82	1317.5 abc	647.8
Nimbecidine	1.5 l	26.05 f (30.71)	23.45	1231.5 bcd	561.8
Chlorpyriphos 20 EC	1.5 l	27.21 e (31.46)	22.29	1187.6 bcd	517.9
Neem seed kernel extract (NSKE)	5%	29.79 d (33.10)	19.71	1187.5 bcd	517.8
Garlic-chilli-kerosine (GCKE)	0.5%	32.17 c (34.57)	17.33	1175.8 cd	506.1
Vitex negundo leaf extract	5%	37.64 b (37.86)	11.86	1141.1 cd	471.4
Pongamia leaf extract	5%	38.28 b (38.24)	11.22	1130.6 d	460.9
Quinalphos 25 EC	1.5 l	23.95 g (29.32)	25.55	1231.6 bcd	561.9
Untreated check	-	49.50 a (44.74)	0.00	669.7 e	0.00

Means followed by same letters in the column are not statistically different by DMRT; Figures in parentheses are arcsine-transformed values emamectin benzoate (1360.7 kg/ha), indoxacarb (1358.9 kg/ha) and diafenthiuron (1317.5 kg/ha). This was followed by quinalphos 25 EC (1231.6 kg/ha), nimbicidine (1231.5 kg/ha), chlorpyriphos 20 EC (1187.6 kg/ha) and NSKE 5 percent (1187.5 kg/ha). Next best treatments were GCKE 0.5 percent (1175.8 kg/ha) and *Vitex negundo* leaf extract (1141.1 kg/ha). It was interesting to note that eco-friendly treatments - nimbicidine and NSKE registered grain yield on par with all chemical insecticides except spinosad and lambdacyhalothrin. Thus, an additional yield of 756.9, 742.3, 691.0 and 689.2 kg/ha over untreated control was recorded in spinosad, lamdacyhalothrin, emamectin benzoate and indoxacarb, respectively.

Present findings are in conformity with Knight *et al*. (2000), who reported that indoxacarb, methoxy fenozide and spinosad had good potential to control soybean looper (*Thysanoplusia orichalcea* Fabricius). Lakshmi *et al*. (2002) reported that the application of spinosad 0.005 percent was most effective and recorded highest mean percent reduction of *Maruca vitrata* Fabricius larval population (63.99%) over untreated check in urdbean. Giraddi *et al*. (2002) revealed that indoxacarb 15SC and thiodicarb 75 WP were highly efficient in reducing *Helicoverpa armigera* Hubner population, lowering the pod damage and increase the seed yield in pigeon pea. Mohapatra and Srivastava (2002) observed that spraying of lamdacyhalothrin 5 EC @ 25 g ai/ha and thiodicarb 75 WP @ 750 g ai/ha provided higher yield and less larval incidence of legume pod borer *M. vitrata* in pigeon pea. Bhoyar *et al*. (2004) reported that spinosad 2.5 SC (25 g ai/ha) recorded least percent pod damage (11.85%) by *H. armigera* in pigeonpea.

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Effect of Sowing Date and Row Spacing on Incidence of Major Insect-Pests of Soybean, *Glycine max* (L.) Merrill

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Key words: Sowing date, row spacing

Soybean, *Glycine max* (L.) Merrill, is a major oil seed crop of the world. The production of soybean crop is affected by variety of limiting factors. Insect pests and diseases are responsible for reduction in average yield to the tune of 27 percent (Sharma and Shukla, 1997).

Since introduction of soybean crop in the zone/state of Rajasthan, farmers have depended only on chemical insecticides for insect control. Over-dependence and indiscriminate use of insecticides has resulted into manifold problems like application hazard, health hazard, development of resistance in insect to insecticides, destruction of natural enemies, insecticidal residue and environmental pollution. The epidemic out-breaks of *Spodoptera litura* (Fab.) in Kota division of Rajasthan during *kharif* 2000 in soybean ecosystem is an important example when all the insecticides failed to control insect population.

Cultural management is the easiest, economical and eco-friendly method of managing the insect-pest population without or with nominal use of chemical insecticides. Cultural practices viz. adjustment of planting time and row spacing has significant influence on insect-pest incidence. Studies conducted in Himachal Pradesh (Chandel and Gupta, 1995) brought out that delay in sowing date of soybean decreases the yield; soybean planted on 28th May yielded 3.69 tonnes/hectare as compared to planted on 25th May (1.45 t/ha). Insect-pests were more abundant when soybean was planted earlier during that year.

In order to study the effect of sowing date and row spacing on incidence of major insect-pests of soybean var. JS-335, the experiment was carried out in split plot design for two consecutive year i. e. 2002 and 2003. The sowing dates (25th June, 10th July and 25th July) constituted the main plot whereas the row spacing (22.5 cm, 30 cm and 45 cm) as sub-plots. The area for main plot was 54.0 m^2. These treatments were replicated four times. The observations

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on pest infestation/ population were recorded at weekly intervals.

Non significant differences for the interaction between sowing date and row spacing on the incidence of insect-pests was recorded. But in this respect seasonal means within different date of sowing differed significantly. Much alike the seasonal means within row spacing also showed a significant difference.

Incidences of stem fly under different sowing dates and row spacing

The early sown crop (25th June) had significantly lower infestation (0.50%) of stem fly while the crop sown on 10th July (mid) and 25th July 2002 (late) had more infestation of stem fly (19.70 and 22.40%), respectively. The infestation recorded on 25th June (Early), 10th July (mid) and 25th July (late) sowing dates were statistically different for each dates of sowing.

The sowing of crop at different row spacing clearly indicated the impact over insect population. The maximum infestation of stem fly was observed at 22.5 cm row spacing (19.90%) followed by that in plots with 30 cm row spacing (17.40%). The minimum infestation 15.30 percent was recorded at 45 cm row spacing.

Incidence of girdle beetle under different sowing dates and row spacing

The incidence of girdle beetle clearly indicated the significant difference in infestation levels at different sowing dates. The maximum infestation was recorded in early sowing (25.9%), while significantly less infestation was recorded in mid and late sowing (22.8 and 16.4%, respectively).

A significant difference in infestation levels of girdle beetle was recorded in plots having 22.5 cm, 30 cm and 45 cm row spacing. The maximum infestation was recorded in 22.5 cm row spacing (23.8%) followed by in 30 cm (21.5%) and in 45 cm row spacing (19.8%). However, the infestation level in plots at 30 cm and 45 cm row spacing was at par.

Incidence of semilooper under different sowing dates and row spacing

There was a significant difference in the population of semilooper at different sowing dates. The minimum larval population of 1.42 larvae per mrl was recorded in early sowing (25th June) followed by 1.67 larvae per mrl and 1.87 larvae/mrl in mid (10th July) and late (25th July) sowing dates, respectively.

Incidence of semilooper on soybean at different row spacing showed varied larval population. The plots having 22.5 cm row spacing had significantly higher population (1.82 larvae/mrl) followed by plots having 30 cm row spacing (1.62 larvae/ mrl) and the minimum population (1.52 larvae/mrl) was recorded at 45 cm row spacing. All these three treatments were significantly different from each other.

Table 1. Effect of sowing date and row spacing on incidence of major insect-pests of soybean (Pooled data of 2002 and 2003)

Date of sowing	Stem fly (% infestation)* Row spacing (cm)				Girdle beetle (% infestation)* Row spacing (cm)				Semilooper (Laevae /mrl)** Row spacing (cm)			
	22.5	30.0	45.0	Mean	22.5	30.0	45.0	Mean	22.5	30.0	45.0	Mean
25th June	14.0	10.1	7.3	10.5	28.1	26.0	23.7	25.9	1.57	1.38	1.30	1.42
	(5.85)	(3.08)	(1.61)	(3.30)	(22.19)	(19.21)	(16.09)	(19.10)	(1.97)	(1.42)	(1.180)	(1.52)
10th July	21.2	19.8	18.1	19.7	24.8	22.3	21.3	22.8	1.81	1.65	1.56	1.68
	(13.14)	(11.51)	(9.61)	(11.38)	(17.16)	(14.35)	(13.18)	(14.99)	(2.75)	(2.02)	(1.92)	(2.31)
25th July	24.4	22.2	20.7	22.4	18.6	16.1	14.3	16.4	2.08	1.82	1.71	1.88
	(17.05)	(14.33)	(12.46)	(14.56)	(10.21)	(7.73)	(6.12)	(7.94)	(3.84)	(2.85)	(2.43)	(3.01)
Mean	19.9	17.4	15.3	17.5	23.8	21.5	19.8	21.7	1.82	1.62	1..52	1.66
	(11.56)	(8.94)	(7.0)	(9.08)	(16.35)	(13.39)	(11.42)	(13.66)	(2.8)	(2.14)	(1.81)	(2.24)
(P= 0.05)												
Date of sowing		1.94				1.17				0.036		
Row spacing		1.94				1.17				0.036		
Interaction		NS				NS				NS		

** Angular transformed values; ** Square root transformed values; Figure in parenthesis are retransformed values*

The present findings are in agreement with those of Rai and Patel (1990) who reported lower infestation of girdle beetle (9.86 to 12.09%) in late planted soybean. Further, Kundu and Srivastva (1991) reported that sowing of the crop immediately after the monsoon break, attracted lower agromyzid, *Melanagromyza sojae* (Zehnt) than in case of delayed sowing. The maximum damage to soybean by girdle beetle, *Oberiopsis brevis* Swed in crop sown on 8th June and minimum damage in those sown on Ist July was recorded by Parsai and Shrivastava (1993). Buschman *et al.* (1981) also reported that soybean planted in last week of June had least stem fly, *M. sojae* infestation in the plains of northern India. But the soybean planted during this period is prone to attack by girdle beetle, *O. brevis*. Low population of semilooper, *C. acuta* in early sown (22nd June and 2nd July) soybean was also reported by Mandal *et al.* (1998). The present findings are comparable with the work of McPherson and Bondari (1991) who observed more number of *N. viridula* in narrow row planting than in wide row planting.

The study brings out that the early sown soybean crop had lower infestation of stem fly (10.50%) and semilooper (1.42 Larvae/mrl) but more infestation of girdle beetle (25.90%) than mid and late sown crop. Further, the infestation of major insect pests was more in 22.5 cm row spacing than 30 cm and 45 cm row spacing.

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A Preliminary Study on Pre-harvest Sprouting in Soybean [*Glycine max* (L.) Merrill]

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Although Assam is a non-traditional area for soybean cultivation, the crop offers great potentiality as an oilseed crop that can reduce dependence on presently cultivated single *rabi* oilseed crop of rape and mustard in the state. In addition, it will provide quality protein for food and feed. Suitable soybean varieties have been identified for Assam as well as for other North Eastern states (Singh and Singh, 2002). However, the region being located in the high rainfall zone, the crop encounters a major field problem of pre-harvest sprouting due to occurrence of post-monsoon rainfall during the month of October and November resulting in reduced economic return. Efforts are needed to identify genetic resistance to this serious field problem.

The present study was conducted to screen 62 soybean genotypes for resistance to pre-harvest sprouting under field condition at Biswanath Chariali. Each of these genotypes were grown in 2 rows of 3 m length during *kharif* 2005 (Date of sowing: 16th July) with all recommended package of practices. The crop received post monsoon rainfall of 175 mm during October and only 2.8 mm in November. The matured pods of the genotypes which received rainfall during the maturity stage were thoroughly observed for sprouting of seed prior to harvesting.

During the 3rd and 4th weeks of October, 2005 nearly 150 mm rainfall was recorded (Table 1). This time period coincided with grain maturity of 37 test entries. Out of these, 9 entries viz., JS 95-60, NRC 59, RKS 9, JS (SH) 96-16, RKS 15, RAUS 5, JS 97-52, JS 335 and BAUS 31 did not show any pre-harvest sprouting while 3 displayed only 2-5 percent sprout damage. All these genotypes except JS 97-52 were characterized by absence of pubescence on the pods. In contrast except JS 97-52, all the pubescent varieties exhibited varying degrees of sprouting damage ranging from 7.0 – 32.0 per cent. This indicates relationship between pubescence and pre-harvest sprouting under rainy condition. The presence of hairs on the pod surface might help in

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Table 1. Degree of pre-harvest sprouting in soybean genotypes during maturity period

Genotype	Pubescence	Date of maturity	Days to maturity	Rainfall (mm) in October	Degree of sprouting (%)	Grain yield (g/plant)
TS 17	Present	18.10.05	94	1st week=23.4	14.0	7.25
JS 95-60	Absent	20.10.05	96	2nd week= 0.2	0.0	12.37
NRC 59	Absent	21.10.05	97	3rd week=61.6	0.0	12.05
DSb 6	Present	21.10.05	97	4th week=88.0	27.0	7.00
BNS(Sk) 1	Absent	22.10.05	98	5th week= 1.8	5.0	12.33
VLS 55	Present	22.10.05	98	Total = 175.0	20.0	6.77
KB 261	Present	23.10.05	99		32.0	6.22
JS 96-31	Present	23.10.05	99		12.0	7.66
RKS 9	Absent	24.10.05	100		0.0	14.25
VLS 58	Present	24.10.05	100		17.0	5.89
SL 637	Present	24.10.05	100		30.0	8.02
JS(SH) 96-16	Absent	25.10,05	101		0.0	10.89
BNS(Sk) 2	Absent	25.10.05	101		4.0	9.77
NRC 2	Present	25.10.05	101		20.0	5.23
PK 1314	Present	25.10.05	101		12.0	7.70
SL 633	Present	26.10.05	102		10.0	7.25
TNAUS 7	Present	27.10.05	103		25.0	6.00
RKS 15	Absent	28.10.05	104		0.0	17.25
RAUS 5	Absent	28.10.05	104		0.0	15.35
JS 97-52	**Present**	28.10.05	104		**0.0**	**14.82**
JS(SH) 98-22	Absent	28.10.05	104		2.0	13.03
AMS 2001-1	Present	28.10.05	104		13.0	7.00
RKS 7	Present	28.10.05	104		15.0	7.12
NRC 56	Present	28.10.05	104		12.0	8.13
JS 335	Absent	29.10.05	105		0.0	12.00
SL 688	Present	29.10.05	105		22.0	5.85
TS 148-22	Present	29.10.05	105		26.0	6.05
BAUS 31	Absent	30.10.05	106		0.0	8.32
PS 1368	Present	30.10.05	106		11.0	7.86
RSC 5	Present	30.10.05	106		7.0	8.23
PK 1347	Present	30.10.05	106		10.0	8.26
DS 228	Present	30.10.05	106		17.0	7.45
HIMSO 1597	Present	30.10.05	106		15.0	6.66
VLS 56	Present	30.10.05	106		13.0	5.89
MACS 708	Present	31.10.05	107		16.0	8.33
TS 29	Present	31.10.05	107		12.0	6.97
DSb 3	Present	31.10.05	107		23.0	4.45

retention of rain water for considerable period of time thereby accelerating the germination process of the physiologically matured seed. Hence, non-pubescence could be used as a marker for selection of plants resistant to this problem. The resistance exhibited by pubescent genotype, JS 97-52 to pre-harvest sprouting is interesting and needs to be looked into critically. The problem of pre-harvest sprouting is also encountered in other pulse crops like urdbean and mungbean (Sheikh and Hazarika, 2001) and cereals (Derera, 1989; Schwarz and Henson, 2004). In the current study grain yield reduction due to pre-harvest sprouting is evident as all the sprouted varieties exhibited much lower grain yield per plant as compared to the resistant types (Table 1). The present preliminary investigation reveals that resistance is available for this field problem in the existing soybean germplasm, however, a thorough and systematic study on this aspect is necessary.

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SOYBEAN RESEARCH

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Abstract: This should not exceed 150 words and should indicate main findings of the paper, without presenting experimental details.

Key words: There should be 4-5 key words indicating the contents of the MS and should follow the abstract. Invariably the name of host and pest should be included in key words.

Results: Data should be presented in text, tables or figures. Repetition of data in two or three forms should be avoided. All quantitative data should be in standard/ metric units. Each table, figure or illustration must have a self-contained legend. Use prefixes to avoid citing units as decimals or as large numbers, thus, 14 mg, not 0.014 g or 14000 μg. The following abbreviations should be used: yr, wk, h, min, sec., RH, g, ml, g/l, temp., kg/ha, a.i., 2:1(v/v), 1:2 (w/w), 0:20: 10 (N:P:K), mm, cm, nm, cv. (cvs., for plural), % etc.

References: References should be cited by authors and year: Ansari (2000) or Ansari and Sharma (2000) in the text. References should be arranged in alphabetical order and listed at the end of the paper as follows:

Ansari M M and Sharma A N. 2000. Compatibility of *Bacillus thuringiensis* with chemical insecticides used for insect control in soybean (*Glycine max*). *Indian Journal of Agricultural Sciences* **70**: 48-9. **(Journal)**

Joshi O P, Billore S D, Ramesh A and Bhardwaj Ch . 2002. Soybean-A remunerative crop for rainfed forming. (*in*) Agro technology for dry land forming, pp 543-68. Dhopte AM (Eds.). Scientific Publishers (India), Jodhpur. **(Book chapter)**

Ansari M M and Gupta G K. 1999. Epidemiological studies of foliar diseases of soybean in Malwa plateau of India. Proceedings, World Soybean Research Conference VI, Aug 4-7, 1999, Chicago, Illinois, USA, 611p. **(Symposium/ Conf./Workshop)**

Pansae V G and Sukhatme P V. 1978. Statistical Methods for agricultural workers. Indian Council of Agricultural Research, New Delhi. pp.186. **(Book)**

Table: Each table should be typed on separate page and numbered sequentially. Tables should have descriptive heading. Authors are advised to avoid large table with complex columns. Data are restricted to only one or two decimal figures only. Transformed values should be included if these are discussed in the text.

Illustrations: Number all illustrations consecutively in the text. Line drawing should be made in undiluted black ink on smooth white card or tracing paper. Original and two Photostat copies should be drawn approximately twice the size of reproduction. Original should not be labeled and should also not be numbered. Line diagrams of plants, fungi etc. should indicate the scale.

Photographs: Photographs should be on glossy paper and have good contrast. Trim unnecessary areas. Three copies of the photographs should be provided. On the back of the photographs write names of authors, figures numbers and indicate top of the photographs with an arrow using a soft pencil. Show magnification with a bar scale. **Coloured photographs can be printed on payment of full printing cost by the authors**. Legends for figures should be typed separately and numbered consequently.

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They should not exceed more than 1300 words (total 5 typed pages, which deal with (i) research results that are complete but do not warrant comprehensive treatment, (ii) description of new material or improved techniques or equipment, with supporting data and (iii) a part of thesis or study. Such notes require no heading of sections. It should include key words. Figures and tables should be kept to a minimum.

Review articles

Authors with in-depth knowledge of the subject are welcome to submit review articles. It is expected that such articles should consist of a critical synthesis of work done in a field of research both in India and/or abroad, and should not merely be a compilation.

Proofs

Authors should correct the proof very critically by ink in the margin. All queries marked in the article should be answered. Proofs are supplied for a check-up of the correctness of the type settings and facts. Excessive alterations will be charged from the author, Proof must be returned immediately to shorten the reproduction time.

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