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Induced Mutations in Soybean [*Glycine max* (L.) Merr.] Cv. MACS 450

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ABSTRACT

Soybean variety MACS 450 was subjected to combination treatments of gamma rays and ethyl methane sulphonate (EMS) with an objective to induce variability for quantitative traits. The treatments of different combinations of gamma rays and EMS included 50Gy + 0.2 % EMS, 50Gy + 0.4 percent EMS, 100Gy + EMS (0.2 %) and 100Gy + EMS (0.4 %). The combination treatments of 50 and 100 Gy gamma rays doses with 0.4 percent EMS showed higher percentage of lethality as compared to their combinations with 0.2 percent EMS. Highest frequency of chlorophyll mutations was observed in combination treatment of 100 Gy gamma rays and 0.4 percent EMS. In M_2 generation, a large number of morphological mutants with altered plant height, flower colour, sterility, leaf shape, pod number, seed size and colour and also the mutants with early or late maturity were isolated. The results indicated that 100 Gy gamma rays treatment in combination with 0.4 percent EMS was the most effective dose to induce a wide range of genetic variability in soybean.

Key words: Soybean, gamma rays, EMS, mutant

Soybean that occupies a coveted place among the oilseed crops, being cultivated all over the world, is an economically important leguminous crop for oil, feed and food products. In India, soybean attributes above 10 percent to the domestic edible oil pool, and the country earns substantial foreign exchange through export of soy-meal (Joshi, 2003). It has become a major oilseed crop of India, covering an area of about 6.46 million hectares with 6.93 million tonnes as annual production (Agrawal, 2005). Though the area and production has increased, the national productivity is less than half as compared to the world average. The major constraints for low productivity of soybean are its poor seed viability and non-availability of early maturing, photo-insensitive, high yielding cultivars with resistance to biotic and abiotic stresses (Bhatnagar and Karmakar, 1995). Secondly the present day soybean cultivars are derived from narrow genetic base. The genetic variability present in any crop is of vital importance in the formulation of effective breed-

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ing programme. Thus, the genetic variability generated by induced mutations can certainly help to recover the alleles for higher productivity and also for better plant type. However, mutation-breeding studies in soybean have lagged behind other economically important crops (Singh and Hymowitz, 1999). In India, so far only four varieties have been released through mutation breeding (Tara Satyavathi *et al.,* 2003). In view of this background, the present studies were undertaken to induce mutations for earliness, improved plant architecture, moderate seed size, high number of pods and seed yield in the cultivar MACS 450 by combination treatments of gamma rays and EMS.

MATERIAL AND METHODS

Dry seeds of soybean variety MACS 450 were subjected to combination treatments of gamma rays and EMS (50Gy + 0.2 % EMS, 50Gy + 0.4 % EMS, 100Gy + 0.2 % EMS and 100Gy + 0.4 % EMS). For each treatment, 800 seeds were exposed to gamma rays in gamma cell 200 with ^{60}Co source installed at BARC and followed by the treatment with EMS prepared in phosphate buffer (pH 7.0) for 4 h. The treated seeds along with the control were sown in the experimental field at Department of Botany, University of Pune, Pune to raise the M_1 generation. The data on germination were recorded at three to twelve days after sowing. The M_1 plants were harvested individually and the seeds obtained were used to raise the M_2 generation as plant-to-row progenies. The M_2 population was carefully screened for morphological mutations. Since, lethal chlorophyll mutants do not grow beyond the cotyledonary stage, chlorophyll mutations were scored immediately after the emergence of cotyledons. Plants appearing different from the control for one or more morphological traits were harvested separately.

RESULTS AND DISCUSSION

Studies on M_1 generation

Studies on various parameters have been carried out extensively in soybean to understand the biological effects of mutagen. Constantin *et al.* (1976) observed reduction in survival, plant height and seed yield with increase in dose/rate of mutagen. Germination and plant survival in M_1 generation have been extensively used in soybean to measure the mutagenic effect (Mehetre *et al.*, 1994). The effects of physical and chemical mutagens on gene/ chromosomal mutations in the biological method could be measured quantitatively by degree of reduction in germination percentage, seedling survival, growth and fertility (Gaul, 1970). The treatments with 50 and 100 Gy gamma ray doses in combination with 0.4 percent EMS showed higher values for percent lethality as compared to the combination treatment with 0.2 percent EMS (Table 1). Perez (2000) has also observed differential response of the soybean varieties to the same dose of gamma rays for germination. In our studies high lethality was observed and may be attributed to the injuries caused by combined mutagenic treatments of gamma rays and EMS.

Chlorophyll mutations

In the M_2 population, four different types of chlorophyll mutations namely albina, xantha, chlorina and viridis were observed (Table 2). Highest frequency of chlorophyll mutations was observed in the combined treatment of 100 Gy gamma rays and 0.4 percent EMS. The frequency of albina mutants that survived only 3-4 days after emergence was higher in the treatment with 0.4 percent EMS combined with 50 Gy or 100 Gy gamma rays. Chlorophyll mutations occur in high frequency following mutagenic treatments of seeds. Many researchers regard them as test mutations assuming that their frequency is proportional to the rate of viable mutations. Naskida and Koduata (1980) reported high frequency of chlorophyll mutations after irradiation with 5 and 20 Kr gamma ray doses. They observed high frequency of mutations, somatic mosaicism and mitotic crossing over. Various chlorophyll mutations like albina, xantha, chlorina, virescent, maculata and striata were observed in soybean earlier also (Harb, 1990; Geetha and Vaidyanathan, 2000).

Table 1. Germination and survival percentage in M_1 generation

Treatments	Seed sown (No.)	Plants survived (No.)	Germination (%)	Lethality (%)
Control (MACS-450)	200	191	95.50	4.50
50 Gy gamma rays+ EMS (0.2 %)	800	514	64.25	35.75
50 Gy gamma rays +EMS (0.4 %)	800	425	53.13	46.87
100 Gy gamma rays+ EMS (0.2%)	800	490	61.25	38.75
100 Gy gamma rays+ EMS (0.4%)	800	466	58.25	41.75

Table 2. Frequency and spectrum of induced chlorophyll mutations in the M_2 generation in soybean

Treatments	Plants in M2 (No.)	Chlorophyll mutants (No.)	Frequency and spectrum of chlorophyll mutants			
			Albina	Xantha	Chlorina	Viridis
50 Gy gamma rays + EMS (0.2 %)	11,168	86	-	13 (15.1)	17 (19.8)	56 (65.1)
50 Gy gamma rays + EMS (0.4 %)	5,948	120	2 (1.66)	14 (11.7)	45 (37.5)	49 (49.2)
100 Gy gamma rays + EMS (0.2 %)	12,039	56	-	9 (16)	16 (28.6)	31 (55.4)
100 Gy gamma rays + EMS (0.4%)	7,890	227	17 (7.48)	16 (15.9)	68 (29.6)	106 (46.6)
Total	37,045	489	19 (3.88)	52 (10.63)	126 (25.76)	242 (49.48)

(.) – Percent frequency

Viable mutations

A number of viable mutations were observed in the M_2 generation in all the four treatments (Table 3). The spectrum of viable mutations ranged from flower colour mutants to those with agronomically important traits. Frequency of morphological mutants ranged from 3.46 to 9.68 percent and was highest in combined treatment of 100Gy gamma rays with 0.4 percent EMS. The frequency of viable mutations increased with increase in concentration of EMS. The frequency of viable mutations is reported to be dose dependent (Caroll *et al.*, 1986). Mutations affecting gross morphological changes according to system suggested by Swaminathan (1965) were broadly classified as mutants for height, growth habit, foliage, flower colour, maturity, pod colour, seed characters and sterility (Table 3).

Table 3. Spectrum of induced viable mutants in the M_2 generation

Character of the mutant	Plants selected in M_2 (No.)			
	50 Gy gamma rays + EMS (0.2%)	50 Gy gamma rays + EMS (0.4%)	100 Gy gamma rays + EMS (0.2%)	100 Gy gamma rays + EMS (0.4%)
M2 plant screened	11,168	5,948	12,039	7,890
Growth habit				
Stunted	3	20	2	30
Dwarf	89	71	36	30
Semi dwarf	30	23	16	91
Tall	1	-	4	45
Very tall	-	2	-	2
Giant	-	-	1	6
Compactoid	9	28	4	29
Dwarf bushy	-	8	1	4
Coloured branches	2	-	-	13
Branched	7	6	2	11
Unbranched	31	39	39	7
Erect	12	20	9	6
Bolted	3	13	5	4
Dark green	19	48	11	18
High yielding	5	9	4	17
Flower colour				
White	2	42	63	-
Pink	-	3	-	1
Violet	1	1	1	7

Table 3 contd.

Sterile	55	80	44	138
Maturity				
Early flowering	15	8	3	39
Late flowering	-	1	6	3
Early maturity	-	3	1	-
Late maturity	-	-	3	33
Pod mutants				
Pale yellow	2	-	-	17
Dark yellow	2	-	-	-
Pinkish yellow	-	-	-	6
Ash	-	6	-	-
Leaf mutants				
Lanceolate	25	22	9	6
Elliptical	6	9	-	7
Oblong	-	-	-	6
Linear	-	5	-	-
Small leaflets	24	30	14	29
Broad leaflets	3	16	5	13
Round	8	12	1	9
Crinkled	17	26	27	50
Smooth leaf	3	-	-	-
Feathery leaf	7	14	5	18
Tetrafoliate	-	-	-	3
Pentafoliate	3	1	-	1
Total	**386 (3.46)**	**583 (9.80)**	**318 (2.64)**	**764 (9.68)**

( ) Percent frequency

Growth habit mutations

The mutations affecting height of plants were identified and classified as dwarf, semi dwarf, very tall and giant. The mutants showed remarkable variation in height as compared to that of the parent MACS 450. Mutations for other plant characteristics included bushy, compact, pigmented-branched, unbranched and erect. Similar mutants have been reported earlier for altered plant architecture in soybean (Alexieva, 1991; Mehetre *et al.*, 1994; Wakode *et al.*, 2000). In the present studies high yielding mutants bearing more number of pods were also observed. Ram *et al.* (1982) observed high variability for plant height and pods per plant in M_3 generation of soybean varieties when treated with gamma rays and EMS. High yielding mutants were also isolated by Rajput and Sarwar (1998) following gamma ray irradiation.

Leaf mutations

Several leaf mutants were isolated in the present studies. These included mutations with alterations in the leaflet number, size, shape and structure. Many mutants with different types of leaves like curly, thick, linear (sword shape), lanceolate, wavy, obtuse apices, small, broad, wrinkled, tetrafoliate and pentafoliate were observed. Commonly, soybeans have trifoliate leaves, rarely with five leaflets or multifoliate leaves. Wakode *et al*. (2000) also observed crinkle leaf mutant in the gamma ray irradiated population. Leaf mutants like narrow and dark green leaves (Naskida and Koduata, 1980), two opposite trifoliate leaves per node (Laiquing, 1986) have also been reported in soybean.

Flower mutations

Different flower colour mutants including pink and white were obtained from the purple flower coloured MACS 450 in the present studies. Pink coloured soybean flower was earlier identified by Stephens and Nickell (1991). The genetic analysis revealed the unique color was due to homozygous recessive *wp* alleles in the presence of *W1*. Pink flowered lines averaged 22 percent higher in seed weight, and 4 percent higher in protein content compared to purple flower lines from same background (Stephens *et al*., 1993). Bhatnagar *et al.* (1990) obtained white flower mutants in the M_2 population. Pink flower mutant was also isolated in soybean by Smutkupt (1996).

Mutations affecting maturity

The parent MACS 450 flowered in 40-45 days after sowing and crop matured in 90-95 days. Based on the days to flowering and days to maturity four distinct category of mutants were isolated. These included early flowering mutants blooming 7-10 days earlier than control. Late flowering mutants flowered 30-60 days later than control. This type of mutant was mostly found in the combination treatment of 100Gy and 0.2 percent EMS. Early maturity was found in the treatment of 50Gy and 0.4 percent EMS. But one mutant of 58 days late maturity was found in treatment of 100 Gy and 0.2 percent EMS. Early maturing mutants have been isolated obtained by Tulman and Pieixoto (1990) in the cultivar Parana following treatment with 220 Gy gamma rays. Xue Bai *et al*. (2000) induced early maturity in soybean variety by gamma ray treatment and late maturity was obtained with combination treatment of gamma rays and EMS.

Mutations affecting pod and seed characters

Different pod colour mutants like pale yellow; dark yellow and ash were observed as compared to brown pods of the parent. Non-shattering pod mutants were also obtained. The seeds in parent variety are medium in size with pale yellow seed coat and black hilum. Remarkable variations in size, shape, and colour of seed coat and hilum were observed. The prominent seed coat colour mutants like white, dark yellow, black and yellow (black saddle) were identified. Pods of control plant were brown in colour but due to mutations different pod colour mutants like pale yellow, dark yellow and ash coloured were observed in M_2 population. Many reports of induced mutations for seed colour (Kerketta and

Haque, 1986; Mehta *et al.*, 1994), hilum colour (Bhatnagar *et al.*, 1990) and seed size (Bhatnagar *et al.*, 1989; Husain *et al.*, 1998) are available in the literature.

In breeding programmes, hybridization provides unlimited possibilities of generating new combinations of characters, which can be selected in the segregating population. In contrast, by induced mutations it is possible to improve a single trait without causing extensive disruption in the genome. The use of induced mutation techniques for crop improvement over the past few decades has shown that it is an effective plant breeding method to improve yield, quality and resistance to biotic and abiotic stresses (Nichterlein *et al.*, 2000). In the present studies significant variations for morphological characters indicated the effectiveness of the combined treatments of physical (gamma ray) and chemical (EMS) mutagens. The results also indicated that a dose of 100Gy gamma rays in combination with 0.4 percent EMS was more effective in inducing broad genetic variability in soybean. The selected mutants could be further exploited by large-scale cultivation or breeding to combine the desirable traits in high yielding soybean genotypes. In addition, these can be used as source material for cloning of mutant genes for their further utilization in crop improvement programme.

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Genetic Divergence in Indian Varieties of Soybean [*Glycine max* (L.) Merrill]

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ABSTRACT

Genetic divergence using Mahalanobis D^2 analysis among 62 varieties of soybean based on seventeen characters led to their grouping into fifteen clusters out of which nine were monogenotypic. PK 472 and SL 295 have been identified as the most potential parents for hybridization programme. Among the seventeen characters, protein percentage contributed maximum to the genetic divergence, followed by number of pods per plant and seed yield per plant. This indicated that these characters were mainly responsible for genetic divergence in the parent material. The highest divergence was observed between cluster XV and IX followed by cluster XV and XIV, which may serve as potential parents for hybridization programme. Based on the cluster mean values of different characters, donors for use in breeding programme for carrying out improvement in respective character were suggested.

Key words : *Glycine max, genetic divergence, cluster*

Soybean [*Glycine max* (L.) Merrill] tops the list of oilseed crops at the global level. Soybean, a major oilseed crop of India, is contributing to the extent of one tenth of domestic edible oil pool and the country earns substantial foreign exchange through the export of soy-meal. However, overall improvement in yield, oil and protein content in soybean remains a perpetual task to be accomplished by the plant breeders. This can be achieved through selection, efficiency of which mainly depends on the extent of variability existing in the available gene pool. However, in the case of Indian soybean varieties, a narrow genetic base has been observed, whereas now-a-days in soybean breeding, maximum involvement of improved soybean cultivars is being observed in hybridization programmes to create genetic variability. The use of related wild species is at minimum bringing about a very low impact on broadening of genetic base in soybean. Hence, knowledge on genetic divergence in the available cultivars of soybean has an immense importance and in tune with immediate need in the selection of parents to be used in hybridization

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programme for obtaining desirable genetic recombination. The present studies were therefore, undertaken to ascertain the genetic divergence in 62 soybean cultivars, available in India.

MATERIAL AND METHODS

Genetic divergence measured by Mahalanobis D^2 statistics (Mahalanobis, 1936) was studied in 62 Indian varieties of soybean (Table 1) for seventeen characters namely, days to initiation of flowering, days to fifty per cent flowering, days to maturity, flowering span, reproductive phase, basal node height, basal pod height, plant height, number of primary branches per plant, number of nodes per plant, number of pods per plant, number of seeds per pod, number of seeds per plant, grain yield per plant, hundred seed weight, total oil and protein contents. They were planted in a single row plot of three metre length with spacing of 60 cm × 10 cm in a Completely Randomized Block Design with two replications, at the Crop Research Centre of G. B. Pant University of Agriculture and Technology, Pantnagar during *kharif* season of 2002. The observations were recorded on five randomly selected competitive plants. The mean values of each character were subjected to analysis of variance. The criterion used by Tocher (Rao, 1952) was followed for making group constellation.

Table 1. Pedigree of Indian varieties of soybean

Variety	Pedigree	Developed / released
Alankar	D 63-6094 × D 61-4249	Pantnagar
Ankur	Composite of 22 crosses	Pantnagar
Bragg	Jackson × D 49-2491	Pantnagar
Birsa Soya 1	Mutant of Sepaya black	Ranchi
Co 1	Selection from EC 39821	Coimbatore
Co 2	UGM 21 × JS 335	Coimbatore
GS 1	Selection from Punjab 1	Gujarat
Hardee	Introduction from U.S.A.	Karnataka
HIMSO 1563	(Ankur × HIMSO 330) × Bragg	Palampur
Improved Pelican	Introduction from U.S.A.	Karnataka
Indira Soya 9	Selection from JS 80-21	Raipur
JS 2	Indigenous selection	Jabalpur
JS 335	JS 78-77 × JS 71-05	Jabalpur
JS 71-05	Selection from exotic material	Jabalpur
JS 72-280	EC 14437 × Bragg	Jabalpur
JS 72-44	D 60-9647 × EC 7034	Jabalpur
JS 75-46	Improved pelican × Seemes	Jabalpur
JS 76-205	Kalitur × Bragg	Jabalpur
JS 79-81	Bragg × Hara Soya	Jabalpur
JS 80-21	JS 71-1 × PK 73-94	Jabalpur
JS 90-41	PS 73-7 × Hark	Jabalpur

Table 1 Contd.

Kalitur	Land race	Bangalore
KB 79	Hardee × Monetta	Bangalore
KHSb 2	Manloxi × EC 39821	Karnataka
Lee	S_{100} × CMS	Pune
MACS 124	JS 2 × Improved Pelican	Pune
MACS 13	Hampton × EC 7034	Pune
MACS 330	Monetta × EC 95937	Pune
MACS 450	Bragg × MACS 111	Pune
MACS 57	JS 2 × Improved Pelican	Pune
MACS 754	Bragg × JS 335	Pune
MACS 58	JS 2 × Improved Pelican	Pune
MAUS 2	Selection from SH 81-14	Prabhani
MAUS 32		Prabhani
MAUS 47	Selection from MACS 308	Prabhani
Monetta	EC 2587	Prabhani
NRC 2	Mutant of Bragg	Indore
NRC 12	Mutant 95-10 (parent Bragg)	Indore
NRC 37	Gaurav × Punjab 1	Indore
NRC 7	Selection from S 69-96	Indore
PS 1024	PK 308 × PK 317	Pantnagar
PK 1029	PK 262 × PK 317	Pantnagar
PK 262	UPSM 97 × Hardee	Pantnagar
PK 308	T 31 × Hardee	Pantnagar
PK 327	UPSM 82 × Seemes	Pantnagar
PK 416	UPSM 534 × S 38	Pantnagar
PK 471	Hardee × Punjab 1	Pantnagar
PK 472	Hardee × Punjab 1	Pantnagar
PK 564	(UPSM 534 × S 38) × Bragg	Pantnagar
Punjab 1	Selection from Nanking variety	Pantnagar
PUSA 16	CMS × Lee	Pusa, New Delhi
PUSA 20	Bragg × Lee	Pusa, New Delhi
PUSA 22	Punjab × Clark 63	Pusa, New Delhi
PUSA 24	Shelby × Bragg	Pusa, New Delhi
PUSA 37	Bragg × Java 16	Pusa, New Delhi
PUSA 40	8-3 × Lee	Pusa, New Delhi
Samrat	Local cultivar	Jabalpur
Shilajeet	Selection from EC 9309	Pantnagar
Shivalik	Selection from PK 73-55	Palampur
SL 295	PK 416 × PK 564	Ludhiana
T 49	From local germplasm selection	Kanpur
VLS 47	Selection from KHSb 3-1-1	Almora

RESULTS AND DISCUSSION

The analysis of variance exhibited significant differences among the soybean genotypes for all the characters studied. This indicated the existence of significant amount of variability among the varieties. On the basis of D^2 analysis, the 62 varieties were grouped into fifteen clusters (Table 2). The maximum numbers of varieties (32) were included in cluster I. Cluster II and III had nine and six varieties, respectively. Clusters IV, V and VI had two varieties each, and remaining clusters had only one variety each. The pattern of group constellation proved that geographical diversity need not necessarily be related to the genetic diversity (Das *et al.,* 2000; Ganesamurty and Seshdari, 2002).

The generalized intra-cluster distance range was from 3.13 (Cluster IV) to 4.43 (Cluster VI) (Table 3). The maximum inter-cluster distance was recorded between cluster IX and XV (8.49). Whereas, the minimum inter-cluster distance (4.09) was observed between cluster pair I and II, suggesting that the genetic constitution of

Table 2. Clustering pattern of varieties of soybean on the basis of genetic divergence

Cluster's Number	Variety			Number
I	2 (Ankur)	3 (Bragg)	8 (Hardee)	32
	9 (Hara Soya)	10 (Improved pelican)	13 (JS 335)	
	15 (JS 72-280)	17 (JS 75-46)	18 (JS 76-205)	
	19 (JS 79-81)	22 (Kalitur)	23 (KB-79)	
	25 (Lee)	26 MACS 124)	27 (MACS 13)	
	30 (MACS 57)	31 (MACS 754)	32 (MACS 58)	
	33 (MAUS 2)	34 (MAUS 32)	37 (NRC 2)	
	40 (NRC 7)	41 (PS 1024)	42 (PK 1029)	
	44 (PK 308)	45 (PK 327)	49 (PK 564)	
	52 (PUSA 20)	53 (PUSA 22)	55 (PUSA 37)	
	58 (Shilajeet)	59 (Shivalik)		
II	4 (Birsa Soya 1)	6 (Co 2)	7 (GS 1)	9
	11 (Indira Soya 9)	12 (JS 2)	20 (JS 80-21)	
	43 (PK 262)	51 (PUSA 16)	54 (PUSA 24)	
III	35 (MAUS 47)	36 (Monetta)	38 (NRC 12)	6
	16 (JS 72-44)	29 (MACS 450)	46 (PK 416)	
IV	1 (Alankar)	47 (PK 471)		2
V	21 (JS 90-41)	57 (Samrat)		2
VI	56 (PUSA 40)	60 (SL 295)		2
VII	5 (Co 1)			1
VIII	50 (Punjab 1)			1
IX	48 (PK 472)			1
X	62 (VLS 47)			1
XI	14 (JS 71-05)			1
XII	24 (KHSb 2)			1
XIII	39 (NRC 37)			1
XIV	61 (T 49)			1
XV	28 (MACS 330)			1
Total				**62**

Table 3. Average inter and intra-cluster D values

Cluster	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
I	3.80	4.09	4.32	4.94	5.04	4.80	4.76	4.71	4.99	4.93	5.49	4.81	4.89	5.80	7.52
II		3.85	4.55	5.04	5.35	4.95	4.90	5.23	5.35	4.81	6.18	4.34	4.76	5.90	7.46
III			3.99	5.44	5.47	5.32	5.13	4.99	5.33	5.28	6.36	5.07	5.60	6.24	7.80
IV				3.13	6.41	4.77	5.91	5.65	5.33	6.26	5.79	5.97	6.48	6.45	7.80
V					3.81	5.36	5.90	6.01	6.69	6.67	6.67	5.72	6.21	6.87	7.68
VI						4.43	5.43	5.25	5.50	5.13	6.92	5.85	5.75	6.53	8.11
VII							0.00	4.66	4.89	5.12	5.59	5.15	4.84	5.96	7.22
VIII								0.00	4.80	6.23	6.97	6.31	4.91	5.70	7.89
IX									0.00	4.72	4.92	6.45	5.72	7.31	8.49
X										0.00	6.22	6.22	5.92	6.72	8.12
XI											0.00	5.43	7.65	6.78	8.12
XII												0.00	5.72	6.40	7.55
XIII													0.00	6.97	8.30
XIV														0.00	8.40
XV															0.00

these genotypes in one cluster is in close proximity with the genotypes in other cluster of the pair. Hybridization between genotypes from highly divergent groups should result in maximum hybrid vigour and highest number of useful segregants (Shwe *et al.*, 1972). Hybridization between genotypes from highly divergent groups could even produce new and heterotic unknown gene combinations. Hybridization between genetically distant genotypes promising breeding material has been suggested frequently (Sichkar *et al*., 1998).

The average cluster means for different characters (Table 4) show that varieties included in clusters XV, V, XII, XI, VI and X were early flowering. The variety PK 472 forming a separate cluster (IX) had maximum mean values for number of primary branches, number of pods and oil percentage. Thus, PK 472 holds great promise as a parent to obtain promising hybrids and create further variability for these characters.

Based on the genetic divergence analysis, it would be possible to point out some potential combinations, subject to the condition that environment maintain the relative expression of characters with regard to the genotypes. The potential combinations based on the D^2 statistics were found to be PK 472 × T 49, VLS 47 × T 49, KHSb 2 × PK 472, MACS 330 × PK 472, PUSA 40 × PK 472, SL 295 × PK 472, JS 90-41 × PK 472, JS 90-41 × T 49, Samrat × PK 472 and Samrat × T 49. These combinations should result in maximum hybrid vigour and highest number of useful segregants during the process of selection in the genotypes of soybean.

The various donors identified for different characters through this study are,

Table 4. Cluster mean values and contribution of different characters

Character	% Contri-bution	Cluster mean values in different clusters														
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
Days to flower initiation	5.13	51.02	51.06	49.08	54.00	38.75	47.75	54.00	58.00	49.50	48.00	45.00	44.00	53.50	61.50	21.00
Days to 50% flowering	0.00	56.03	56.00	54.50	58.75	42.25	53.00	59.00	65.50	58.00	53.00	50.00	48.50	59.00	67.00	25.00
Days to maturity	0.00	123.34	122.56	122.42	120.25	123.25	125.25	117.50	121.50	124.00	123.50	121.00	122.00	122.50	124.00	79.00
Flowering span	6.24	11.16	11.06	11.00	10.25	9.75	11.25	12.00	16.00	15.00	12.00	11.00	10.00	12.50	12.50	9.00
Reproductive phase	2.12	72.36	71.44	73.33	66.25	84.50	77.50	63.50	63.50	74.50	75.50	76.00	78.00	69.00	62.50	58.00
Basal node height (cm)	5.45	1.70	1.67	1.55	4.54	1.39	1.60	1.75	1.93	1.66	1.35	1.28	1.80	2.60	1.75	1.00
Basal pod height (cm)	6.45	13.68	14.42	11.51	9.00	11.65	16.30	14.70	15.15	10.30	18.40	3.55	8.60	16.60	9.85	5.85
Plant height (cm)	5.98	68.73	66.01	72.87	60.00	81.00	89.00	73.90	87.40	70.30	78.20	42.60	50.00	74.70	89.90	34.00
Primary branches/plant (No.)	8.46	3.54	2.57	4.93	4.20	2.10	3.05	4.00	4.90	5.60	3.20	4.00	2.00	2.90	2.80	1.40
Nodes/plant (No.)	6.08	15.04	13.91	14.80	15.50	17.15	17.15	15.60	17.10	15.20	13.70	10.00	10.60	15.30	12.10	10.50
Pods/plant (No.)	9.78	48.42	40.89	92.88	78.20	17.20	79.40	56.00	48.20	101.30	92.50	52.70	5.00	41.60	41.80	1.40
Seeds/pod (No.)	7.30	1.87	1.86	1.89	1.90	1.51	1.87	1.18	1.90	1.88	2.04	1.39	1.42	1.89	1.88	1.00
Seeds/plant (No.)	4.87	78.81	67.43	74.90	150.95	24.90	144.60	61.00	90.00	105.90	121.00	61.20	7.90	53.60	79.40	1.40
Grain yield/plant (g)	8.51	8.09	6.95	9.30	19.03	2.11	28.64	5.24	9.98	17.25	13.95	6.67	1.00	4.77	6.14	0.10
100-seed weight (g)	4.71	10.37	11.24	12.27	12.46	8.97	13.08	8.79	9.74	11.62	12.18	10.37	13.75	9.17	7.78	10.17
Oil (%)	7.67	20.49	20.88	19.86	20.83	19.74	21.16	20.55	20.45	22.86	21.58	21.41	20.75	21.54	17.63	18.62
Protein (%)	11.26	39.90	38.66	38.61	39.23	40.52	39.16	38.59	39.02	39.20	39.03	43.23	40.41	37.28	40.89	40.69

MACS 330 (early maturity and dwarfness), PK 472 (number of primary branches, number of pods/plant and oil content), VLS 47 (pods/plant). Improved Pelican (seeds/pod), Alankar (number of seeds/plant), PUSA 40 (pods/plant and seeds/plant), SL 295 (grain yield/plant and hundred seed weight), NRC 7 (hundred seed weight), and JS 71-05 (protein content) (Table 5). These donors were found to be useful to get better segregants for yield and its component on the basis of genetic divergence analysis.

The relative contribution of different characters towards the expression of genetic divergence (Table 4) was calculated. The main important trait causing maximum genetic divergence was protein percentage (11.26 %) followed by number of pods per plant, grain yield per plant, number of primary branches per plant

Table 5. Promising genotypes identified as donors for important characters

Character	Donor		
	I	II	III
Days to Maturity	MACS-330 (79.00)	Co-1 (117.50)	JS-2 (118.00)
Reproductive phase	Samrat (87.50)	PUSA 24 (82.00)	NRC 12 (80.00), PUSA 22 (80.00)
Plant height (cm)			
Dwarf	MACS 330 (34.00)	JS 71-05 (42.60)	JS 2 (47.80)
Tall	T 49 (89.90)	SL 295 (89.40)	Punjab 1 (87.40)
Primary branches/plant (No.)	PK 472 (5.60)	MAUS 57 (5.50)	MACS 57 (5.20) PK 416 (5.20)
Nodes/ plant (No.)	MACS 450 (19.40)	MACS 57 (19.30)	PUSA 40 (18.70)
Pods/plant (No.)	PK 472 (101.30)	VLS 47 (92.50)	PUSA 40 (88.20)
Seeds/pod (No.)	Improved pelican (2.17)	PUSA 24 (2.06)	PK 416 (2.05)
Seeds/plant (No.)	Alankar (159.90)	PUSA 40 (156.00)	PUSA 20 (141.90)
Grain yield/plant (g)	SL 295 (20.46)	PK 471 (19.14)	PK 472 (17.25)
100-seed weight (g)	SL 295 (15.23)	NRC 7 (15.02)	KHSb 2 (13.75)
Oil (%)	PK 472 (22.86)	PUSA 24 (22.58)	NRC 7 (21.88)
Protein (%)	JS 71-05 (43.23)	Shivalik (42.79)	T 49 (40.89)

and number of seeds per plant. The contribution of protein percentage may be realized probably due to inclusion of soybean varieties from different geographical areas of India and more differences in protein content are present among the varieties. So, it is concluded that while selecting parents for hybridization programme protein content, number of pods, grain yield, number of primary branches and number of seeds per pod should be considered to achieve wider variability in segregating generations. Earlier soybean breeders (Kumar and Nadarajan, 1994; Ganesamurty and Seshdari, 2002), have found the 100-seed weight as an important trait contributing to divergence, whereas the contribution of this trait was low (4.17%), because here the study in released varieties (selected genotypes) of soybean in which the aim is enhancing the seed weight.

The genotypes with high mean values of characters in any cluster as well as high D^2 values between clusters can be used either for direct adaptation or for hybridization in order to breed for better genotypes of soybean.

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Influence of Tillage Operations on Sustainable Production of Soybean Based Cropping Systems

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ABSTRACT

A field experiment at a fixed site on vertisols was conducted for six years to study the tillage requirement of soybean based cropping systems. Results accrued over the years (1995-2001) revealed that the soybean yield was not influenced by the extent of tillage operations. The highest yield of rabi crops was recorded with minimum tillage and remained at par with conventional tillage. The sustainability of rabi crops was higher than soybean. The sustainability index indicated that the minimum tillage was found more sustainable in case of total productivity. Economic evaluation of tillage operations revealed that the minimum tillage produced significantly higher net returns and B: C ratio and also showed higher sustainable value index. The minimum tillage was found energy efficient. The highest soybean yield and sustainable yield index were recorded when soybean was grown after mustard. While the lowest soybean yield was noted when grown after linseed. The maximum soybean equivalent yield, sustainable yield index and energy efficiency was associated with soybean – wheat cropping system. Soybean – safflower as well as soybean – wheat was the most profitable systems. The sustainability of soybean was the maximum when grown after mustard.

Key words: Soybean, tillage, cropping system, energy, sustainability

Tillage is a basic component of the agricultural production technology. It plays a major role in agricultural sustainability through its effects on soil processes, properties and crop growth. The exact nature on appropriate tillage operations is said to be governed by soil and crops (Lal, 1985). Tillage contributes major portion of cost of cultivation and energy input. Tsatsarelis (1993) identified fertilizer and tillage as the most important energy concerns in crop production. Moreover, the decreased soil organic carbon content with cultivation has been documented (Cook *et al*., 1992). Soybean [*Glycine max* (L.) Merrill] is a dominant and versatile rainy season crop that fits well in most of the traditional cropping sequences (Bhatnagar *et al*., 1996). In view of meager information on the subject, an attempt has been made in the present investigation to study the effect of tillage operations on productivity; sustainability and energy budgeting of soybean based cropping systems.

MATERIALS AND METHODS

A field experiment at a fixed site was conducted from 1995 to 2001 at research

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farm of National Research Centre for Soybean, Indore. The experimental soil belonged to Typic Haplusterts, which had pH 7.86, EC 0.14 dS/m, organic carbon 0.30%, available P 4.80 kg/ha and available K 299 kg/ha. Accordingly the soil was normal with low available nitrogen, phosphorus and potassium. The treatments followed in *kharif* as well as *rabi* comprised of three tillage operations viz., zero, minimum (2 cross harrowing) and conventional (one deep ploughing, 2 harrowing and planking) as main plots and 5 cropping systems i.e. soybean (JS 71 05) – followed by wheat (*Triticum aestivum* L. emend. Fiori & Paol.) cv. Sujata, chickpea (*Cicer arietinum* L.) cv. JG 218, mustard (*Brassica Juncea* L.) cv. Pusa bold, safflower (*Carthamus tinctorus* L.) cv. JSF 1 and linseed (*Linum usitatissimum* L.) cv. R 17 as sub-plots arranged in strip plot design with three replications. The weed load in zero tillage was kept under limit using herbicides. The *rabi* crops were sown with pre-sowing irrigation. Wheat received two additional irrigations. The crops in the sequence were raised with the recommended package of practices 100:60:40 (wheat), 60:30:20 (mustard), 30:15:10 (linseed), 30:20:0 (safflower), 25:60:0 (chickpea) and 20:60:20 (soybean) of $N:P_2O_5:K_2O$ kg/ ha, respectively. The plot size for each treatment was 6 m x 3.6 m.

The economics of each treatment was calculated as per the prevailing prices of inputs and outputs. The energy budget of the treatments were determined by using the conversion factors for each and every inputs, outputs and cultural activities as suggested by Mittal and Dhawan (1988). Energy intensiveness (EI) and energy productivity (EP) were worked out as per Burnett (1982) and Fluck (1979). Sustainability index was calculated as per Singh *et al*. (1990).

The total rainfall during the experimentation was 946.2, 1331.4, 1166.6, 969.5, 902.0 and 486.1 mm in 1995-96, 1996-97, 1997-98, 1998-99, 1999-2000 and 2000-01, respectively.

RESULTS AND DISCUSSION

Tillage

Tillage operations of varying intensities did not influence the yield of soybean (Table 1and 2). The observation is in conformity with the findings of Duseja (1998) who reported that the soybean yield in no till plots were either equal or better than those of conventional tillage. The yields of *rabi* crops were found to vary significantly due to tillage treatments. Minimum tillage produced highest yield, which remained at par with conventional tillage. A similar trend was noted with respect to soybean equivalent yield, sustainability index of soybean and yield of *rabi* crops. Similar, were the observations of Edwards *et al.* (1988) and Singh *et al.* (1996). Accounting for the yield responses due to tillage, Stibbe and Ariel (1970) further elaborated that it depended on the quantum and distribution of rainfall; under well-distributed rains yield depressed by 40% under no till whereas just reverse was true with low and ill distributed rainfall.

Table 1. Mean yield (1995-96 to 2000-01) of different cropping systems under various tillage operations

Cropping system	Tillage operations							
	Zero		Minimum		Conventional		Mean	
	Kharif	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*	*Kharif*	*Rabi*
Soybean-wheat	1359	2530	1297	2806	1239	2725	1298	2687
Soybean- chickpea	1273	705	1156	924	1261	795	1230	808
Soybean-linseed	1047	875	1121	1035	1249	1049	1139	986
Soybean-mustard	1252	766	1384	1086	1371	900	1336	917
Soybean-safflower	1217	1125	1113	1163	1081	1165	1137	1151
Mean	1230	1200	1214	1403	1240	1327	1226	1310
CD (P=0.05)								
Tillage	**NS**	**206**						
Cropping system	**30**	**260**						
Tillage x cropping system	**59**	**517**						

Table 2. Effect of tillage operations on productivity, sustainable yield index and economic traits of soybean based cropping systems (Pooled data)

Treatment	Yield (kg/ha)		Soybean equi-valent yield (kg/ha)	Sustainable yield index			Net returns (Rs/ha)	B: C ratio	Sustainable value index	
	Kharif	*Rabi*		*Kharif*	*Rabi*	Soybean equivalent yield			Net returns	B: C ratio
Tillage										
Zero	1145	1107	2394	0.27	0.54	0.48	12497	2.04	0.23	0.45
Minimum	1127	1325	2629	0.39	0.60	0.62	14672	2.40	0.42	0.62
Conventional	1123	1254	2558	0.39	0.62	0.60	12805	2.11	0.30	0.60
CD (P=0.05)	NS	206	110	0.03	0.03	0.03	1069	0.11	0.04	0.03
Cropping system										
Soybean – wheat	1195	2552	3012	0.33	0.54	0.58	16651	2.08	0.34	0.58
Soybean – chickpea	1126	785	2135	0.28	0.52	0.45	8659	1.75	0.09	0.44
Soybean – linseed	1053	923	2510	0.35	0.45	0.47	14473	2.40	0.27	0.47
Soybean – mustard	1213	828	2258	0.52	0.63	0.56	10865	2.03	0.31	0.57
Soybean – Safflower	1137	1152	2833	0.30	0.68	0.48	16879	2.69	0.29	0.49
CD (0.05)	**30**	**260**	**138**	**0.04**	**0.04**	**0.04**	**1346**	**0.14**	**0.05**	**0.04**

The sustainability yield index indicated that the minimum tillage was found more sustainable in case of total productivity and remained at par with conventional tillage. The sustainability of *rabi* crops had a clear edge over soybean. The sustainability index value of soybean remained identical due to minimum and conventional tillage. Whereas in case of *rabi* crops, the sustainability yield index value for the conventional tillage was marginally higher than minimum tillage.

Economic evaluation revealed that the minimum tillage produced significantly higher net returns, B: C ratio and higher sustainable value index. The differences in aforesaid economical parameters may be due to the variation in cost of cultivation and yield levels in respective treatments.

On energy analysis basis, the conventional tillage consumed the maximum energy input (22225 MJ/ha) and that was remarkably higher than minimum (16988 MJ/ha) and zero tillage (14283 MJ/ha). The highest gross energy output was with minimum tillage (38646 MJ/ha) and remained at par with conventional tillage (37603 MJ/ha), while net energy output was the maximum with minimum tillage (21658 MJ/ha) and showed non-significant differences with zero tillage (20907 MJ/ha). Similar trend was noticed in energy use efficiency. However, significantly higher energy productivity (168 g/MJ) and energy use efficiency (2.46) was associated with zero tillage followed by minimum tillage (155 g/MJ and 2.27, respectively) and conventional tillage (115 g/MJ and 1.69, respectively). The differences in energy indices might be due to variations in energy input and output.

Cropping system

The preceding *rabi* crops significantly influenced soybean productivity in the sequence. The highest soybean yield was recorded when soybean followed mustard whereas it remained at par with prior cultivation of wheat or safflower (Table 1 and 2). The soybean yield was lowest when grown after linseed. Among the *rabi* crops, wheat out yielded rest of the crops. The maximum soybean equivalent yield was associated with soybean – wheat followed by soybean – safflower and soybean – linseed. The better yields of these *rabi* crops and higher prevailing market prices of these commodities led to higher soybean equivalent yield. The lowest soybean equivalent yield was noted in soybean – chickpea cropping system. These results are in agreement with the findings of Billore *et al*. (1996). The sustainability yield index of soybean was the maximum when grown after mustard followed by linseed. While the highest sustainable yield index was with safflower followed by mustard among the *rabi* crops. The sustainability index for wheat and chickpea was found more or less identical. Among the cropping systems, soybean – wheat was found to be the most sustainable which remained on par with soybean – mustard and remaining cropping systems showed non-significant differences among them selves.

The highest net returns were recorded with soybean – safflower that remained at par with soybean – wheat (Table 2). As far as the B: C ratio is concerned, significantly higher value was with soybean – safflower. The B: C ratio of soybean – wheat and soybean- mustard differed non-significantly, whereas the lowest B: C ratio was associated with soybean – chickpea. The sustainable value index indicated that the soybean –wheat was more sustainable followed by soybean – mustard.

Energy budgeting (Table 3) of different cropping systems indicated that the highest energy input was with soybean – wheat (20302 MJ/ha) followed by soybean

Table 3. Effect of tillage operations on energy budgeting of soybean based cropping systems

Treatment	Energy input (MJ/ha)	Energy output (MJ/ha)		Energy use efficiency	Energy productivity (g/MJ)
		Gross	Net		
Tillage					
Zero	14283	35192	20907	2.46	168
Minimum	16988	38646	21658	2.27	155
Conventional	22225	37603	15378	1.69	115
CD (P=0.05)		**1613**	**1718**	**0.14**	**10**
Cropping system					
Soybean - wheat	20302	44281	23979	2.18	148
Soybean – chickpea	17660	31389	13729	1.78	121
Soybean – linseed	16390	36897	20307	2.22	151
Soybean – mustard	18034	33192	15158	1.84	125
Soybean - Safflower	16579	41650	25071	2.51	171
CD (P=0.05)		**2030**	**2163**	**0.18**	**12**

– mustard (18034 MJ/ha). The lowest energy input was required by soybean – linseed (16390 MJ/ha) cropping system. These results are in accordance with Billore *et al*. (1994, 1996) and Vyas *et al*. (1995). The maximum gross energy output was recorded in soybean – wheat (44281 MJ/ha) followed by soybean – safflower (41650 MJ/ha), whereas net energy out put was just reverse trend. Soybean – safflower was found to be the most energy efficient cropping system (2.51). The energy use efficiency of soybean – wheat (2.18) and soybean – linseed (2.22) was almost identical. The lowest energy indices were associated with soybean – chickpea (energy use efficiency –1.78 and energy productivity – 121g/MJ) cropping system. However, the maximum energy productivity was noted in soybean – safflower (171 g/MJ) followed by soybean – linseed (151 g/MJ) and soybean – wheat (148 g/MJ) cropping systems.

The study paves the way for crop diversification thorough alternative cropping systems than the prevalent soybean followed by wheat and chickpea in the vertisols of Madhya Pradesh. Although soybean followed by safflower and mustard are feasible in this region also, the possibility of extending the experience of introducing soybean as early crop before rapeseed - mustard in the Gird/Bundelkhand region and as preceding crop to safflower which dominates in vertisols of Maharashtra. These cropping systems as have been evaluated in the presented work will generate more profit at lesser cost of cultivation but shall also strengthen sustainable production under rainfed agriculture. Reducing the extent of tillage is likely to contribute considerably in minimizing the cost of production.

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Effect of Integrated Weed Management, Varieties and Crop Geometries on Weed Dynamics in Soybean

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ABSTRACT

The result of a field experiment conducted during kharif 2001 and 2002 at Instructional Farm, Rajasthan College of Agriculture, MPUA and T, Udaipur indicated that soybean variety JS 335 produced significantly higher seed yield (1609 kg/ha) than JS 71 05 and NRC 37, though there were non-significant differences in density and dry matter of weeds encountered in these varieties. Crop geometries (30cm x 10cm and 20cm x 15cm) also revealed non-significant effect either on intensity of weeds and on crop performance. Echinochloa colonum and Cynodon dactylon were effectively controlled by pre-emergence application of clomazone @ 1.0 kg/ha and post-emergence application of fenoxaprop-p-ethyl @ 75 g/ha at 20 DAS. However, both the herbicides failed to control Amaranthus spinosus and Digera arvensis. Clomazone @ 1.0 kg/ha as PE did reduce the population of Cyperus rotundus, Trianthema portulacastrum, Parthenium hysterophorus and Commelina benghalensis. The highest weed control efficiency observed was under clomazone+ hand weeding at 40DAS (88.58%), which was on par with two hand weeding at 20 and 40 DAS (88.45%). Two hand weeding and clomazone @ 1.0 kg/ha as PE + hand weeding were at par, but both were superior over weedy check in respect of seed yield of soybean.

Key words: Clomazone, crop geometry, fenoxaprop-p-ethyl, hand weeding, soybean and weed management

Soybean [*Glycine max* (L) Merrill] being a potential oilseed crop can play a vital role on boosting up oilseed production in the country. It occupies a parallel place to groundnut and rapeseed/mustard among the nine-oilseed crops of India. Inadequate weed management in soybean has been reported to cause 40-70% reduction in the seed yield of soybean (Dubey *et al*., 1984; Singh and Singh, 1987) depending upon the nature of weed flora and intensity of infestation. Scarcity of farm-labour for manual weeding operation at the time of need and incessant rains impose impediments in weed management and warrants adoption of an integrated approach capitalizing appropriate herbicides and competing varieties at an early growth stage (Bussan *et al*., 1997). In addition, different crop geometry is also known to impart competing ability of crop plants with weeds (Singh and Bhan, 2002). The present investigation therefore, was carried out to study the influence of inte-

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grated weed management approach including varieties and crop geometries on weed dynamics in soybean.

MATERIAL AND METHODS

The experiment was conducted at Udaipur, zone IV A (region, Sub-humid Southern Plain and *Aravali* Hills) of Rajasthan during *kharif* seasons of 2001 and 2002. The experimental soil belonged to fine, montmorollinitic, isohyperthermic, typic Haplustert. It analysed clay loam in texture and alkaline (pH 7.9), medium in available nitrogen (288.9 kg N/ha), phosphorus (24.1 kg P_2O_5/ha) and potassium (310.7 kg K_2O/ha). The experiment consisted of three soybean varieties (NRC 37, JS 335 and JS 71 05) and two crop geometries (30cm x 10cm and 20cm x 15 cm) in main plots and six weed management practices viz. weedy cheek, two hand weeding (HW) at 20 and 40 days after sowing (DAS), clomazone @ 1.0 kg per ha as pre-emergence (PE), clomazone @ 1.0 kg per ha as PE + HW at 40 DAS, fenoxaprop–p-ethyl @ 75 g per ha as post-emergence (POE) and fenoxaprop–p-ethyl @ 75 g per ha as POE + HW at 40 DAS in sub-plots. The experiment was laid out in split plot design with three replications. A uniform dose of 20 kg N and 40 kg P_2O_5 per ha was applied through urea and di-ammonium phosphate as a basal in crop rows below 5 cm of the seed. The crop was sown in second week of July and harvested in first week of November during both the years. Total rainfall received during the crop growth period was 362.7 and 253.2 mm in 2001 and 2002, respectively. Due to long dry spell at critical growth stages, two life-saving irrigations were applied at flowering and pod initiation stages in 2001 and 2002, respectively. Clomazone was applied on the next day of sowing while fenoxaprop-p-ethyl at 20 days after sowing. The data on weed density and dry matter (total and species-wise) were recorded at 40 DAS and harvest. The seed yield was recorded at harvest. The data was processed statistically (Fisher, 1950)

RESULTS AND DISCUSSION

Weed management

Major weed species (at 40 DAS and harvest) infesting soybean crop included *Trianthema portulacastrum* (28.4 and 0.0%), *Commelina benghalensis* (11.8 and 18.2%), *Parthenium hysterophorus* (8.4 and 20.1%), *Amaranthus spinosus* (5.4 and 6.8%), *Digera arvensis* (4.1 and 5.2%), *Echinochloa colonum* (25.5 and 32.5%), *Cynodon dactylon* (11.5 and 11.1%) and *Cyperus rotundus* (4.5 and 5.5%). Population of *T. portulacastrum* at the harvesting stage was missing on account of shorter life span (Sharma *et al.,* 1988) than that of soybean crop.

Varieties as well as crop geometries exerted non-significant effect on weed density and total weed dry matter (Table 1). At 40 DAS and at harvest, both the herbicides clomazone @ 1.0 kg per ha as PE and fenoxaprop-p-ethyl @ 75g per ha as POE effectively limited the density of *Echinochloa colonum* and *Cynodon dactylon* as compared to weedy check (Table 1). Similar were the findings of Kondhare *et al.* (1999). At 40 DAS of crop-growth, clomazone @ 1.0 kg per ha PE was found as effective as two hand weeding, when judged in terms of reduced density of total

Table 1. Effect of varieties, crop geometries and weed management practices on density of prominent weed flora, total weed density and total dry matter at 40 DAS (Pooled for 2001 and 2002)

Treatments	Weed density (No./ m²)								Total weed density (No/m²)	Total weed dry matter (kg/ha)
	E. colonum	*C. dactylon*	*C. rotundus*	*T. portul acastrum*	*C. bengha-lensis*	*A. spinosus*	*D. arvensis*	*P.hystero-phorus*		
Varieties										
NRC 37	3.22* (9.88)**	3.26 (10.14)	2.74 (7.13)	5.14 (26.07)	3.75 (13.65)	3.32 (10.66)	2.89 (7.89)	3.38 (10.95)	10.13(102.24)	745
JS 335	3.16 (9.57)	3.15 (9.46)	2.65 (6.62)	5.04 (25.02)	3.63 (12.80)	3.22 (9.98)	2.82 (7.53)	3.28 (10.29)	9.87 (97.20)	717
JS 71 05	3.18 (9.66)	3.21 (9.88)	2.70 (6.85)	5.07 (25.33)	3.70 (13.31)	3.26 (10.22)	2.80 (4.03)	3.33 (10.66)	9.97 (99.05)	728
C.D. (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Crop geometries										
30 cm x 10 cm	3.15 (9.48)	3.17 (9.60)	2.66 (6.66)	5.07 (25.29)	3.66 (12.99)	3.23 (10.05)	2.83 (7.56)	3.29 (10.34)	9.91 (97.93)	722
20 cm x 15 cm	3.22 (9.93)	3.24 (10.05)	2.74 (7.07)	5.10 (25.66)	3.73 (13.52)	3.30 (10.52)	2.85 (7.66)	3.37 (10.93)	10.07 (101.05)	738
C.D. (0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Weed management										
Weedy check	7.67 (58.36)	5.16 (26.34)	3.27 (10.36)	8.08 (65.04)	5.20 (26.89)	3.56 (12.28)	3.14 (9.39)	4.43 (19.32)	15.13 (228.79)	1541
Two HW at 20 and 40 DAS	2.29 (4.79)	2.49 (5.75)	2.08 (3.87)	2.34 (65.04)	5.20 (26.89)	3.56 (12.28)	3.14 (9.39)	4.43 (19.32)	15.13 (228.79)	86
Clomazone @1.0 kg/ ha (PE)	2.19 (4.31)	2.32 (4.92)	2.24 (4.56)	2.12 (4.02)	2.26 (4.64)	3.38 (11.00)	3.01 (8.63)	2.20 (4.39)	6.90 (47.22)	180
Clomazone @1.0 kg/ ha (PE)+ HW at 40 DAS	2.25 (4.61)	2.35 (5.03)	2.25 (4.63)	2.17 (4.25)	2.29 (4.75)	3.40 (11.16)	2.99 (8.37)	2.24 (4.57)	6.96 (48.05)	179
Fenoxaprop-p-ethyl @75 g/ ha(POE)	2.37 (5.13)	3.46 (11.52)	3.19 (9.77)	7.92 (62.55)	5.03 (25.04)	3.54 (12.20)	3.03 (8.74)	4.36 (18.69)	12.43 (154.38)	1195
Fenoxaprop-p-ethyl @75 g/ha(POE) + HW at 40 DAS	2.36 (5.10)	3.45 (11.48)	3.16 (9.64)	7.87 (61.83)	4.99 (24.31)	3.55 (12.24)	3.10 (9.16)	4.34 (18.49)	12.36 (152.84)	1200
C.D. (0.05)	**0.16**	**0.18**	**0.17**	**0.26**	**0.21**	**0.18**	**0.15**	**0.18**	**0.32**	**34**

** Transformed values; ** Actual values* weed-flora studied, except *Amaranthus spinosus* and *Digera arvensis*. Weed density of *Cyperus rotundus*, *Trianthema portulacastrum*, *Commelina benghalensis* and *Parthenium hysterophorus* reduced significantly by two HW, clomazone @ 1.0 kg per ha as PE and clomazone + HW in comparison to weedy check. However, fenoxaprop-p-ethyl @ 75 g per ha (POE) had no effect on the population of these weeds. The results are in close conformity with the findings reported by Bhalla *et al*. (1998).

At harvest, it was clomazone integrated with one HW was found more useful than integration with fenoxaprop-p-ethyl. It was also found equally effective to two HW.

Total weed density and their dry matter were reduced significantly by all the evaluated weed management practices as compared to weedy check. Among treatments, two hand weeding reduced total weed density and total dry matter significantly compared to rest of the treatments at 40 DAS of crop growth. However, at harvest, only clomazone + HW was found comparable to two HW and both of these treatments reduced the total weed density and dry matter significantly as compared to the remaining treatments. Maximum weed control efficiency was recorded with clomazone + HW (88.6%) closely followed by two HW (88.5%). This superiority in weed management over remaining treatments can be explained by the fact that in pre-emergence application of clomazone + HW inhibited the emergence and early growth of weeds coupled with management of late emerging weeds by HW at 40 DAS. Similarly, by imparting two HW at 20 and 40 DAS, the early as well as late flushes of weeds could be eradicated. These results are in agreement to those reported earlier (Veeramani *et al*., 2001).

Effect on performance of soybean

All the three varieties differed significantly from each other in seed yield (Table 2). JS 335 recorded significantly highest seed yield (1609kg /ha) followed by JS 71 05 (1292 kg/ha) and NRC 37 (1229 kg/ha). Among these varieties NRC 37 is with longer maturity duration of 103-105 days as compared to later two (95-100 days) and likely to suffer most on account of its luxuriant plant type and water stress conditions. The water requirement of soybean varies between 500-600 mm depending on the maturity duration of the variety (Bhatnagar and Joshi, 1999). During both the years, the rainfall during crop growth period had been on lower side and imparted supplemental irrigations could extend benefit to JS 335. On the contrary, the variety JS 71 05 is with lower genetic yield potentials. The performance of evaluated varieties was the combined expression of their genetic potential and prevailing climate during crop-growth period. Variable performance based on these parameters has been reported by Billore *et al*. (2000). Crop geometries could not record any significant influence on seed yield of soybean. All the weed management treatments could significantly increase the seed yield of soybean over weedy cheek. Among different weed control practices, two hand weeding at 20 and 40 DAS and clomazone @ 1.0 kg per ha + HW were equally effect-

Table 2. Effect of varieties, crop geometries and weed management practices on density of prominent weed flora, total weed density and dry matter, WCE and soybean seed yield at harvest (Pooled for 2001 and 2002)

Treatments	Weed density (No./ m^2)							Total weed density **(No/m^2)**	Total weed dry matter **(kg/ha)**	Weed Control Efficie-ncy **(%)**	Soybean seed yield **(kg/ha)**
	E. colonum	***C. dactylon***	***C. rotundus***	***C. benghalensis***	***A. spinosus***	***D. arvensis***	***P. hysterophorus***				
Varieties											
NRC 37	4.74* (22.04)**	3.67 (13.06)	3.07 (8.99)	4.04 (15.92)	3.57 (12.35)	3.19 (9.77)	4.27 (17.76)	10.20 (103.61)	1236	-	1229
JS 335	4.66 (21.32)	3.57 (12.39)	2.94 (8.24)	3.90 (14.79)	3.47 (11.63)	3.12 (9.25)	4.20 (17.17)	9.92 (98.00)	1186	-	1609
JS 71 05	4.71 (21.76)	3.61 (12.67)	3.00 (8.63)	3.97 (15.36)	3.53 (12.01)	3.18 (9.64)	4.25 (17.61)	10.08 (101.25)	1211	-	1292
C.D. (0.05)	NS	NS	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**		**61**
Crop geometries											
30cm x 10 cm	4.67 (21.40)	3.59 (12.51)	2.96 (8.36)	3.93 (15.00)	3.48 (11.73)	3.11 (9.26)	4.19 (17.12)	9.98 (99.12)	1193	-	1402
20cm x 15 cm	6.93 (22.01)	3.65 (12.91)	3.05 (8.89)	4.02 (15.71)	3.56 (12.27)	3.21 (9.85)	4.28 (17.91)	10.16 (102.78)	1230	-	1351
C.D. (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	-	**NS**
Weed management											
Weedy check	9.12 (82.86)	5.34 (28.17)	3.81 (14.10)	6.83 (46.33)	4.19 (17.25)	3.71 (13.32)	7.18 (51.16)	15.97 (254.85)	3046	-	848
Two HW at 20 & 40 DAS	2.86 (7.76)	2.78 (7.29)	2.48 (5.72)	2.34 (4.99)	2.68 (6.70)	2.43 (5.41)	2.60 (6.31)	6.73 (44.89)	351	88.45	1718
Clomazone @ 1.0 kg /ha (PE)	2.94 (8.19)	2.71 (6.90)	2.61 (6.40)	2.43 (5.45)	4.02 (15.89)	3.51 (11.85)	2.61 (6.35)	7.90 (61.99)	561	81.48	1718
Clomazone @ 1.0 kg /ha(PE) + HW at 40 DAS	2.88 (7.89)	2.77 (7.24)	2.56 (6.15)	2.50 (5.76)	2.84 (7.59)	2.55 (6.01)	2.62 (6.39)	6.93 (47.61)	347	88.58	1520
Fenoxaprop-p-ethyl 75@ g/ha (POE)	6.05 (36.30)	4.67 (21.50)	3.62 (12.71)	6.60 (43.36)	4.14 (16.80)	3.64 (12.79)	7.01 (48.76)	13.93 (193.65)	2297	24.57	1091
Fenoxaprop-p-ethyl @ 75 g/ha (POE) + HW at 40 DAS	4.35 (18.53)	3.46 (11.51)	2.95 (8.30)	3.13 (9.39)	3.27 (10.21)	3.16 (9.53)	3.41 (11.22)	8.93 (79.45)	665	78.07	1393
C.D. (0.05)	**0.27**	**0.22**	**0.19**	**0.26**	**0.22**	**0.20**	**0.23**	**0.29**	**51**	**-**	**66**

** Transformed values; ** Actual values* tive in enhancing seed yield of soybean and were significantly superior to remaining treatments. The increase is seed yield under these treatments may be attributed to efficient weed management leading to minimized crop-weed competition during critical crop growth period. The result affirmed the findings of Pandya *et al*. (2005).

On the basis of two years results, it may be concluded that *Echinochloa colonum* and *Cynodon dactylon* were effectively controlled by pre-emergence application of clomazone @ 1.0 kg per ha and post-emergence application of fenoxaprop-p-ethyl @ 75 g per ha at 20 DAS. However, both the herbicides failed to control *Amaranthus spinosus* and *Digera arvensis.* Clomazone @ 1.0 kg per ha as PE did reduce the population of *Cyperus rotundus, Trianthema portulacastrum, Parthenium hysterophorus* and *Commelina benghalensis.*

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Effect of Nutrients, pH and Temperature on the Growth and Sclerotium Formation in *Sclerotium rolfsii* and Amendments on Collar Rot in Soybean [*Glycine max* (L) Merrill]

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ABSTRACT

A study was conducted to know the influence of nutrients, pH and temperature on the growth and sclerotium formation in Sclerotium rolfsii and amendments on collar rot incidence in soybean. The growth of Sclerotium rolfsii in the medium containing sulphur, zinc, copper, iron, manganese and calcium was better. A pH of 6.5 and 35⁰C temperature were most favourable for the growth. Formation of sclerotia was earliest and higher in number at this temperature as compared to rest of the temperatures. Overall, seed treatment with thiram + carbendazim (2:1) @ 3 g per kg and soil amendments like cotton oil cake, farmyard manure, biogas slurry and soya de-oiled cake were promising in reducing pre-and post-emergence mortality caused by Sclerotium rolfsii

Key words: Amendments, collar rot, nutrients, pH, *Sclerotium rolfsii,* soybean, temperature

Collar rot caused by *Sclerotium rolfsii* (Sacc.) is one of the important diseases of soybean [*Glycine max* (L) Merrill] responsible for yield losses ranging from 30 to 40 percent under congenial climate (Gupta and Chauhan, 2005). Seedling mortality ranging from 1.6 to 65 percent has been reported under Indian condition (Agrawal and Kotasthane, 1971). *Sclerotium rolfsii* survives from one season to another by producing sclerotia. Survival of sclerotia is influenced by factors such as temperature, moisture, proximity to a susceptible host and depth in soil. In India, meager information is available on this aspect and therefore the present investigation was undertaken to ascertain the influence of temperature, pH and nutrients on the growth and sclerotium formation in *Sclerotium rolfsii* and soil amendments on the incidence of collar rot.

MATERIAL AND METHODS

Four days old culture of *Sclerotium rolfsii* grown on PDA was cut in to 9 mm discs and used as inoculum in all the laboratory experiments. Observations were recorded on the radial growth (in mm) and on the initiation of sclerotial formation in *S. rolfsii* at different time intervals.

Effect of nutrients: Different nutrients (Table 1) were utilized for the study. 100 ml stock solution of 1000 ug per ml concentration of each nutrient was pre-

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pared and required volume was mixed with 250 ml of PDA to achieve targeted concentration of each nutrient. After sterilization, the media was poured in 6 petriplates for each nutrient and inoculated with disc of fungal culture before incubating in BOD incubator at 27 ^{0}C.

Effect of pH: The pH levels of molten and sterilized PDA were adjusted to 5.5, 6.5, 7.0, 7.5, 8.5 and 9.5 using 0.01 M solution of HCl or KOH. For each pH level 250 ml media is used and poured in to 6 petriplates. After inoculation with disc of fungal culture, plates were incubated at 27^{0} C.

Effect of temperature: A set of five PDA plates after inoculating with disc of *S. rolfsii* were incubated each at 10, 20, 25, 30, 35, 40 and 45^{0} C temperatures maintained in BOD incubators.

Effect of organic amendments on collar rot incidence: About 10 days old 50,000 sclerotia and mycelium of *S. rolfsii* were mixed properly in 360 kg soil collected from the field of National Research Centre for Soybean, Indore to make it sick. The soil was then divided in nine equal parts to accommodate nine treatments comprised of amendments namely, (i.) FYM, (ii.) soy de-oiled cake (DOC), (iii.) mustard oil cake, (iv.) cotton oil cake, (v.) neem cake, (vi.) biogas slurry and (vii.) poultry manure @ 2.25 g per kg soil (to make it equivalent to @ 5 tones/ha) and two parts untreated (nonamended soil). The soil of each part was filled in five earthen pots of 45 cm diameter, representing five replications for each treatment and thus each pot received about 1100 sclerotia @ 139 sclerotia per kg soil. Twenty-five seeds of the variety JS 335 were sown in each pot. Out of the 10 pots containing no amended soil, in five, seeds treated with thiram + carbendazim 2:1@ 3 g per kg were sown (treated check). In other five pots, normal seeds were sown (control check) for the comparison. After sowing, each pot was irrigated daily with equal amount of water. Seedling emergence was counted up to 5 days of germination. Seedling mortality was counted from the day of emergence till one month. Percent pre- and post-emergence mortality were calculated.

RESULTS AND DISCUSSION

Influence of nutrients

Initially at 24 h, Cu, Mn, Mo, S, B and Zn marginally (3 to 10 %) improved the rate of growth, but K and N retarded the growth significantly (Table 1). After this period, presence of Ca, Fe, Mg, Cu boosted the growth significantly up to 48 h as compared to control. After 72 h, the growth picked up with S, Zn, Cu, Fe, Mn and Ca. The fastest growth (76 mm) was with S. However, growth was minimum and significantly low (13 %) with N followed by Mo and B (10 %) as compared to control. However, growth of the fungus after 96 h was at par (90 mm) with all the treatments. Sclerotial formation was the earliest (after 80 h) and maximum (at 96 h) in the presence of Ca and Cu. The sclerotial formation was initiated in all other treatments in between 90 to 96 h.

Table 1. Effect of nutrients on the growth and sclerotial development of *Sclerotium rolfsii* on PDA

Nutrient source (Nutrient)	Nutrient concentration (ppm)	Mean radial growth of *S. rolfsii* (mm) after				Initiation time of sclerotia (h)
		24 h	48 h	72 h	96 h	
Urea (N)	10	20.5	51.3	63.0	90.0	96
Potassium di-hydrogen phosphate (P)	15	25.3	47.5	68.0	90.0	96
Potassium chloride (K)	15	21.6	46.3	68.0	90.0	90
Calcium sulphate (S)	20	27.8	52.2	76.0	90.0	90
Sodium chloride (Na)	5	24.1	47.5	70.0	90.0	96
Calcium carbonate (Ca)	10	24.0	60.4	73.0	90.0	80*
Ferrous sulphate (Fe)	5	25.8	60.0	74.0	90.0	90
Zinc sulphate (Zn)	5	27.6	49.3	75.0	90.0	96
Manganese sulphate (Mn)	5	28.8	49.0	73.0	90.0	96
Magnesium sulphate (Mg)	10	25.0	58. 6	71.0	90.0	90
Copper sulphate (Cu)	5	29.5	56.8	74.0	90.0	80*
Sodium molybdate (Mo)	0.2	28.2	51.5	65.0	90.0	90
Boric acid (B)	2	27.6	46.8	65.0	90.0	96
Control	-	26.8	52.2	72.5	90.0	96
CD at 5%	**-**	**3.7**	**4.5**	**4.7**	**NS**	**-**

** Sclerotia were maximum in number*

The results of this study have clearly shown the requirement of S, Zn, Cu, Fe, Mn and Ca for the mycelial growth of *S. rolfsii*. Ca is known to facilitate sclerotial germination and promote mycelium of *S. rolfsii* in soil (Fang *et al*., 1988). The reduction in growth under nitrogen may be due to the fact that it is reported to reduce the synthesized oxalic acid and production of polygalocturonase in the media (Upadhyay and Mukhopadhyay, 1985). Oxalic acid plays an essential role in pathogenicity of *S. rolfsii* (Kritzmen *et al*., 1977). Nitrogen through different sources is also known to inhibit the germination of sclerotia (Fang *et al*., 1988) and growth of *S. rolfsii* in culture (Messiaun, 1976). Results also indicated the possible role of Ca and Cu in inducing early sclerotial formation as also reported by Fang *et al*. (1988).

Influence of pH

The response of pH was not consistent with time period (Table 2). After 24 h, the growth was maximum at pH 5.5 and reduced gradually with the increase in pH, differences being significant mostly. Subsequently, at 48 h, it was maximum (86.24 mm) at pH 6.5 and again reduced with increasing pH. After 72 h the growth was equal (90 mm) under all the treatments. However, it reached to 90 mm earliest at the pH level of 6.5 in 52 h while at all pH levels the fungus reached 90 mm growth in 72 h. Sclerotial formation was also earliest (96 h) at the pH level of 6.5 while at all pH levels sclerotial formation was recorded after 120 h. Thus, pH level of 6.5 was most favourable for fungus growth and sclerotial production.

Table 2. Effect of pH on the growth and of sclerotial development of *Sclerotium rolfsii* on PDA

PH of the medium	Mean radial growth of *S. rolfsii* (mm) after			Initiation time of sclerotia (h)
	24 h	48 h	72 h	
5.5	46.84	83.98	90.00	120
6.5	43.90	86.24[1]	90.00	96
7.0	42.14	85.00	90.00	120
7.5	41.80	84.38	90.00	120
8.5	41.24	83.94	90.00	120
9.5	40.68	81.60	90.00	120
CD 5%	**0.93**	**1.52**	**NS**	**NS**

**Fungus culture attained 90 mm growth after 52 h of incubation.*

The results clearly indicated that pH 6.5 is the best for the growth of the fungus though neutral (7.0) or slightly alkaline (7.5) medium also supported good growth. A pH level of 6.4 and 6 was reported to be the as best for the growth of *S. rolfsii* (Chowdhury, 1946; Kanzaria and Patel, 1994), which has been attributed to the optimum production of oxalic acid (Kanzaria and Patel, 1994). Present finding of earliest sclerotial formation at pH 6.5 is in agreement with that of Chowdhury (1946).

Effect of temperature

Influence of temperature on the growth of test fungus was distinct (Table 3.). At all the stages of observations, maximum growth was recorded at 35^{0}C. The growth initiated after 72 h, 48 h and 24 h at 10^0, 15^0 and 20^{0}C, respectively. While at 40^{0}C, growth initiated at 24 h but ceased afterwards. At 45^{0}C, the culture became non-viable. Maximum growth of 90 mm was achieved in 72 h at 35^{0}C, while it reached to this level in 96 h, 120 h, 120 h, 168 h and 192 h at 30, 25, 20, 15 and 10^{0}C, respectively. However, sclerotial formation took 336 and 384 h at the temperature of 15 and 10^{0}C, respectively. The interesting observation was that the pattern of sclerotial formation varied with the temperature range. At the temperature range of 25 to 35^{0}C, the sclerotia were found scattered all around the plate. At 15 to 20^{0}C sclerotial formation was at the periphery of the plate, while at 10^{0}C the sclerotia formation was in between the centre and periphery.

Table 3. Effect of temperature on the growth and sclerotial development of *Sclerotium rolfsii* on PDA

Temperature (^{0}C)	Mean radial growth of *S. rolfsii* (mm) after								Initiation of sclerotia (h)
	After 24 h	After 48 h	After 72 h	After 96 h	After 120 h	After 144 h	After 168 h	After 192 h.	
10	9.0	9.0	10.0	23.0	41.0	67.4	84.2	90.0	384
15	9.0	12.6	18.6	30.9	45.1	75.0	90.0	----	336
20	12.5	20.5	45.0	72.5	90.0	----	----	----	120
25	16.5	38.3	63.7	89.4	90.0	----	----	----	120
30	23.6	49.2	84.8	90.0	----	----	----	----	96
35	23.7	63.6	90.0	----	----	----	----	----	72
40	20.8	----	----	----	----	----	----	----	-
45	9.0	----	----	----	----	----	----	----	-

Moderately higher temperature of 35^{0}C favoured the growth of the fungus, while at 40^{0}C and 45^{0}C growth of the fungus is checked. Yu *et al.* (1996) reported 28-32^{o}C as optimum temperature for mycelial growth of *S. rolfsii.* while Anil Kumar *et al.* (1990) observed that at the temperature range of 42 to 63^{0}C *S. rolfsii* was killed. Gupta *et al*. (2002) observed higher incidence of *S. rolfsii* on French bean at soil temperature of 25-30^{o}C as compared to 20^{o}C. Probably, very fast growth at 35^{0}C and in turn quick depletion of the nutrients in the medium might have triggered the early formation of sclerotia (Rawn, 1991).

Effect of organic amendments on collar rot incidence

All the soil amendments (except cotton and mustard oil cake) and fungicidal seed dressing could significantly improve the germination over 17.2 % of untreated control (Table 4). Farmyard manure with 48.8 % germination was most effective being followed by biogas slurry (36.8 %), fungicidal seed treatment (28.4 %), soy de-oiled cake (24.8 %), neem oil cake (22.4 %) and poultry manure 22.4 %). Post-emergence mortality was minimum (0.5 %) and significantly lower under seed treatment of thiram + carbendazim in comparison to control check (63.6 %). Other treatments could also reduce the mortality significantly but cotton oil cake with 8.3 percent was most effective amendment followed by farmyard manure (12.2 %), soy DOC (12.9 %), poultry manure (17.2 %), biogas slurry (17.4 %) and neem oil cake (27.4 %).

The effect of farmyard manure and other oilcake amendments on germination, pre- and post-emergence mortality might be on account of increased activities of antagonistic microorganisms in the rhizosphere. Highest reduction in pre- and post-emergence death of groundnut seedlings by *S. rolfsii* was achieved by amendments of safflower oil cakes and sun hemp (Kulkarni *et al.*, 1995). The negative effect of FYM and amendments on disease may also be attributed to inhibitory effect on hyphal germination (Bhoraniya *et al.*, 2002), chemical gradients (Bowen and Rovira, 1976), and an altered nutrient balance in soil, host and pathogen (Saxena, 1980) or by altering soil structure (Tsunio, 1991), and cation exchange capacity of the soil (Barber, 1984).

Table 4. Effect of organic amendments on germination, pre- and post- emergence mortality of soybean seedlings caused by *Sclerotium rolfsii*

Treatment	Rate (g/ kg soil)	Germination at 5 DAG* (%)	Post-emergence mortality (%)
FYM	2.25	48.8 (44.31)**	12.2 (20.85)
Soy de-oiled cake	2.25	24.8 (29.85)	12.9 (21.45)
Mustard oil cake	2.25	18.6 (25.52)	47.8 (44.02)
Cotton oil cake	2.25	19.2 (25.96)	8.3 (17.24)
Neem oil cake	2.25	22.4 (28.23)	27.4 (31.88)
Bio-gas slurry	2.25	36.8 (37.33)	17.4 (25.01)
Poultry manure	2.25	22.4 (28.20)	17.2 (24.86)
Treated check***	-	28.4 (32.17)	0.5 (4.05)
Untreated check	-	17.2 (24.48)	63.6 (52.91)
CD %	**-**	**(2.25)**	**(1.29)**

DAG = Days after germination; **Figures in parentheses are arc sine angular values; * Seeds were treated with thiram + carbendazim (2:1) @ 3 g/kg seed*

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Effect of Pre-storage Treatments on Soybean Seed Quality

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ABSTRACT

Seeds of six varieties of soybean viz., Pusa 16, Pusa 20, Pusa 22, JS 335, JS 75-46, JS 80-21 with 8 percent moisture content were given pre-storage seed treatment with thiram (tetramethylthiuram disulphide), carbendazim, a combination of thiram thiram + carbendazim (1:1) and a new systemic molecule hexaconazole separately and stored in cloth bags and 700-gauge polythene bags under ambient conditions of Delhi for 5 months. The findings revealed that seeds stored in polythene bags could maintain the germinability above the certification standards, irrespective of the chemical treatments. Statistically, there was no significant difference among the treatments, however seeds treated with thiram were found to have a better germination. Seed treatment with thiram could eliminate the associated mycoflora considerably. Nevertheless, there was no significant reduction in vigour of the seeds treated with thiram. Hexaconazole was not found suitable for pre-storage seed treatment, as there was a reduction in vigour in all the varieties during storage; though the germination was satisfactory except that in Pusa 16 where it fell below the minimum seed certification standards.

Key words: Certification standard, seed treatment, soybean, seed quality parameters, seed storage

Soybean [*Glycine max* (L.) Merrill], a miracle crop of the 20th century occupies an important place, next only to cereals in the country, providing the base for a wide range of fermented foods and industrial products. It is an excellent source of both protein (40%) and oil (20%) and holds a great promise in solving the malnutrition problems. In India, the crop has gained popularity as a cash crop that earns more than any of the competing crops in specified time. Soybean seeds are normally stored for a period of six months before they are sown in the next season. They show orthodox seed characteristics meaning that an increase in moisture content and temperature results in rapid loss of viability (Justice and Bass, 1979). Delouche *et al.* (1973) classified soybean as a 'poor storer' species as it loses viability very rapidly under warm and humid conditions of storage. The loss of viability in storage differs amongst the varieties within a species (Agrawal, 1977; 1978).

Seed moisture content and storage temperature are the two major factors which influence the rate of loss of viability in storage (Owen, 1956, Barton, 1961, Justice and Bass, 1979). Also, the packaging material as well as the kind and level of mycoflora associated with the seeds play a vital role in ascertaining the health

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status of the seeds (Goodman *et al.,* 1981). Chemical treatments are applied to control internally or externally borne pathogens associated with seeds which enhances not only the germination potential of the seed but also increases longevity of the seeds. Pertinent literature to date reveals that there is paucity of information about the effects of fungicides on germination, viability and associated mycoflora of seeds during storage.

Keeping these aspects in view, it was considered worthwhile to study the effect of fungicides on germination, vigour and viability of soybean seeds and the efficacy of these fungicides during storage.

MATERIAL AND METHODS

Freshly harvested seeds of six cultivars of soybean viz. Pusa 16, Pusa 20, Pusa 22, JS 335, JS 75-46, JS 80-21 obtained from the seed production unit, Jawaharlal Nehru Krishi Vishwavidyalaya, Jabalpur were utilized for the study. The seeds were dried in sun for 2-3 days to bring down their moisture content below 8 percent. The initial observations for germination, moisture content, vigour, viability and associated mycoflora of different varieties were taken. Each of the seed lot was divided into five sub-lots. The required quantity of each fungicides viz., thiram, carbendazim and a combination of thiram and carbendazim in the ratio of 1:1 (mixed mechanically) were applied to the seeds @ 3g/kg of seed to get uniform coverage on their surface. However, in the case of hexaconazole, seeds were sprayed with 0.3 percent solution using an atomizer followed by the drying of seeds. Proper controls were also maintained in each case. Each treatment was further divided in two sub-lots; one lot was kept in cloth bag and the other in 700-gauge polythene bag. These polythene bags containing equal amount of seeds were sealed with an electric sealer. Both the cloth bags and polythene bags were stored in the seed cabinets under ambient conditions of Delhi from December to May (Fig. 1) and the samples were drawn at 45 days interval for taking observations on germination percentage, seedling drying weight, seed viability and seed health. The data were subjected to analysis of variance in completely randomized design.

Germination test was conducted by between the paper method at 25°C in four replicates of fifty seeds each, following ISTA method (Anonymous, 1993). Ten random normal seedlings from each replicate were dried overnight in the oven at 90°C and final dry weight was taken. For seed health, standard blotter method was followed to determine the percent incidence of the various fungi associated with the seed lot using hundred seeds per treatment. After incubation, the plates were observed under stereobinocular microscope.

RESULTS AND DISCUSSION

Initial germination for all the six cultivars was found to be in the range of 87 to 97 percent (Table 1). Germination for all the cultivars was recorded at an interval of 45 days up to 135 days. A gradual decline in germination percentage was observed in all the cultivars at the end of 135 days storage in the untreated seeds. Gradual loss of seed viability was observed under ambient conditions of storage in earlier investigations (Agrawal, 1975).

Fig. 1: Temperature and Relative humidty during December 1995 to May 1996 at IARI, New Delhi

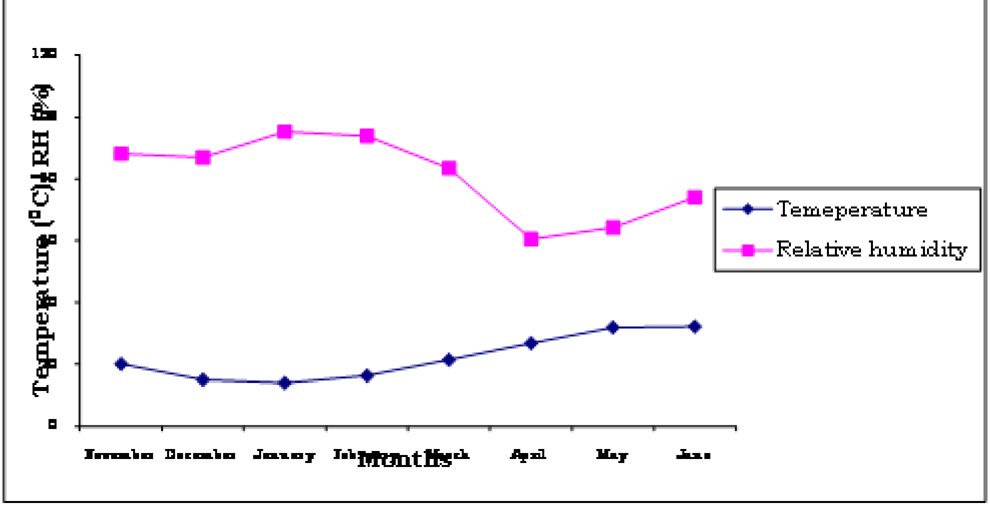
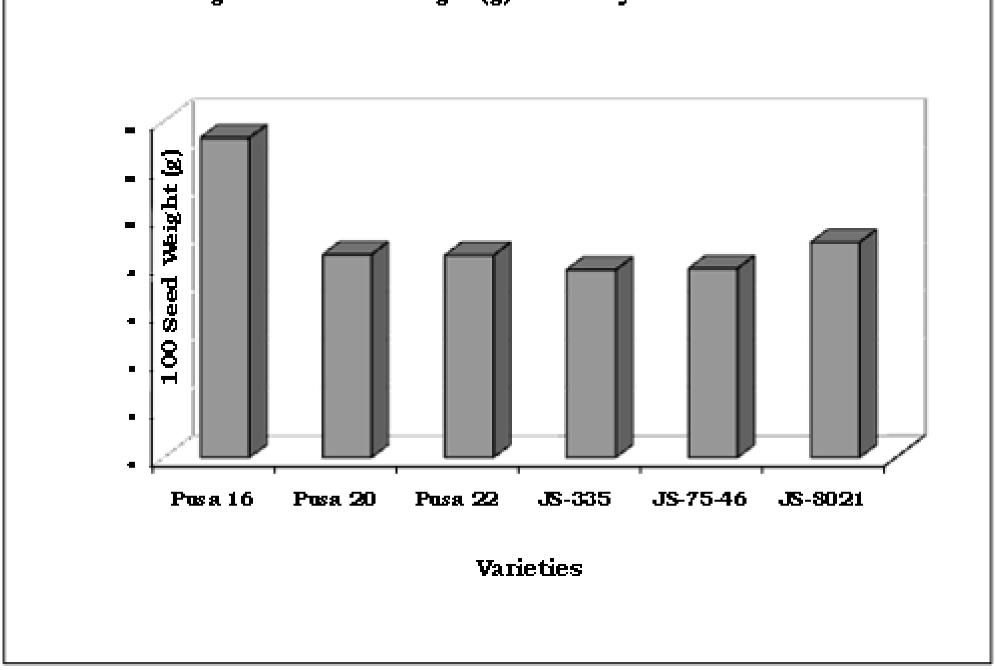


Fig. 2 : 100 Seed weight (g) of six soybean cultivars



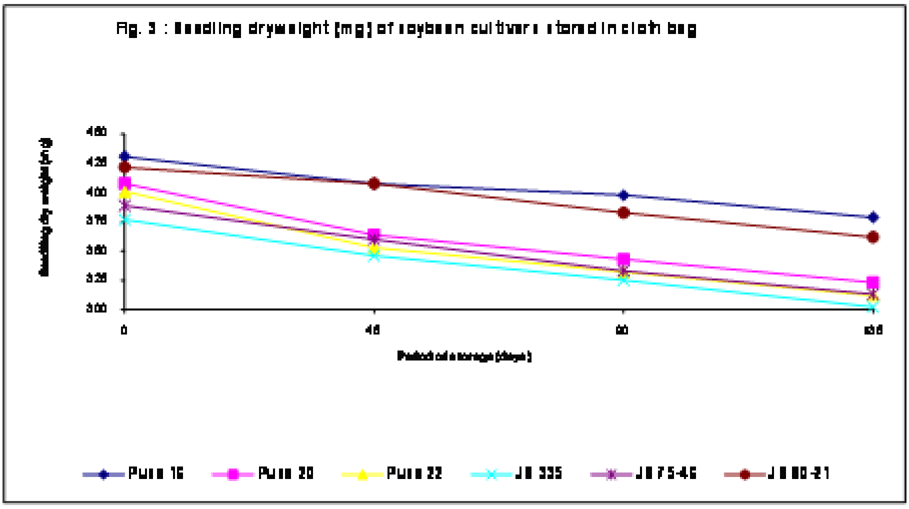


Fig. 3 : Seedling dryweight (mg) of soybean cultivars stored in cloth bag
Period of storage (days)
Pusa 16
Pusa 20
Pusa 22
JS 335
JS 75-46
JS 80-21

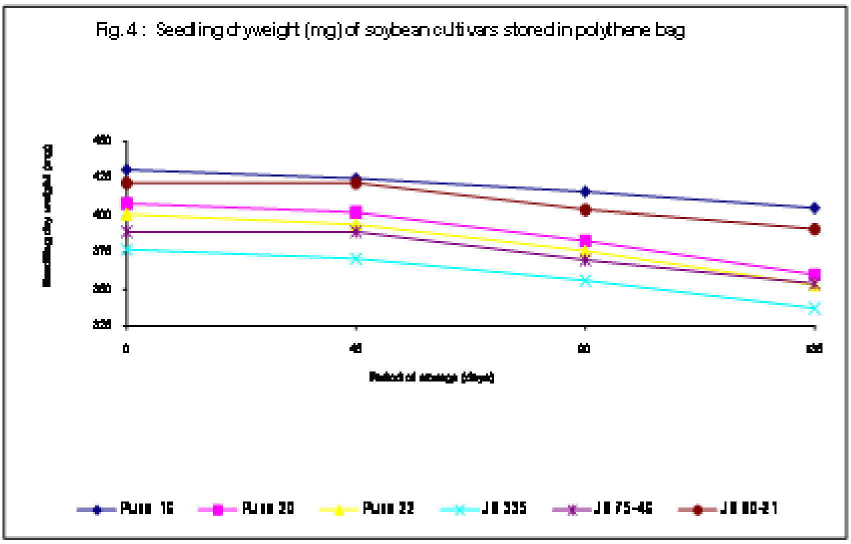


Fig. 4 : Seedling dryweight (mg) of soybean cultivars stored in polythene bag
Period of storage (days)
Pusa 16
Pusa 20
Pusa 22
JS 335
JS 75-46
JS 80-21

Table 1. Germination percentage of soybean seeds during storage

Cultivars/ Treatment	Pusa 16		Pusa 20		Pusa 22		JS 335		JS 75-46		JS 80-21	
	0	135	0	135	0	135	0	135	0	135	0	135
Cloth bags												
Control	87	62	89	78	92	79	91	78	97	76	96	75
Thiram		63		84		82		83		83		81
Carbendazim		69		83		80		84		80		81
Thiram+Carbendazim		65		81		81		84		81		82
Hexaconazole		64		79		80		81		80		78
Polythene bags												
Control	87	67	89	79	92	82	91	81	97	79	96	79
Thiram		72		87		85		88		84		86
Carbendazim		71		88		83		83		82		82
Thiram+Carbendazim		71		85		84		86		83		84
Hexaconazole		67		79		82		80		80		80

C.D. (P = 0.05) A = 1.0006; B = 1.74; A x B = NS; C = 1.59; A x C = NS; B x C = NS; A x B x C = NS where, A – Storage container; B – Varieties; C – Treatments; NS – Non-significant

Germination of seeds stored in cloth bag and polythene bag

The initial germination of soybean seeds before storage in Pusa 16 was 87 percent that came down to 62 percent, a loss of 28 percent within a span of 135 days. However, seed treatment with different contact and systemic fungicides gave some boost to the germination percentage. Thiram, a di-thiocarbamate is known to improve germination, but the germination percentage was only 63 percent, even in thiram treated seeds after 135 days of storage (since Pusa 16 is a poor storer). The difference between control (62 %) and thiram treated seeds (63 %) was almost non-significant. The seed treatment with carbendazim resulted in 69 percent germination and a combination of thiram + carbendazim resulted in 65 percent germination at the end of 135 days when stored in cloth bags. In general, Pusa 16 was found to have the lowest germination percentage among all the cultivars taken in these studies. Gaur and Sharma (1994) also reported the poor performance of Pusa 16 when stored in cloth bags.

The seeds treated with carbendazim and thiram + carbendazim when stored in 700-gauge polythene bags, the germination was at par (71 %) after 135 days of storage. Even the untreated seeds stored in polythene bags gave a better germination (67 %) as compared to treated seeds when stored in cloth bags (except in thiram + carbendazim treatment). In all the other varieties, even in case of untreated seeds stored in polythene bags, loss in germination was gradual, among the various treatments recorded after 135 days of storage. Basu (1976) also preferred sealed containers (moisture impervious) to the unsealed ones (moisture pervious) for storage.

Seedling vigour of the soybean seeds stored in cloth bag and polythene bag

Seedling vigour was measured as seedling dry weight of 10 normal seedlings (mg/10 seedlings), after the final count of germination was taken. Initial seedling vigour appeared to be inversely related to the seed size of different genotypes evaluated. The seedlings produced by seeds of Pusa 16 were most vigorous on account of the fact that its seeds were the boldest among all the cultivars evaluated. The range of 100 seed weight among different cultivars is presented in Fig. 2. Irrespective of the seed treatment, seeds of all the cultivars when stored in cloth bags showed gradual decline in their seedling dry weight (Fig. 3). The seedling dry weight of treated and untreated seeds stored in polythene bags did show a gradual decline as the storage period progressed (Fig. 4), but the decline was rather slow as compared to when the seeds were stored in cloth bag e.g. in Pusa 20, a decline from 408 to 309 mg and from 408 to 334 mg when stored in cloth bag and polythene bag respectively, was observed after 135 days of storage. Similar differences were observed in other cultivars as well.

Loss in seedling vigour is reported to precede the loss of seed viability in a number of crops (Harrington, 1972; Yadav *et al.*, 1987; Dharamalingam and Basu, 1990). In the present study also, decline in seedling dry weight was preceded with the reduction in germination. Shanmugavel (1993) established a direct relationship between decline in seedling vigour and loss in germination in soybean.

Table 2. Percent viability of soybean seeds during storage

Cultivars/ Treatment	Pusa 16		Pusa 20		Pusa 22		JS 335		JS 75-46		JS 80-21	
	0	135	0	135	0	135	0	135	0	135	0	135
Cloth bags												
Control	86	67	88	73	93	78	92	78	96	77	95	74
Thiram		72		78		84		83		82		81
Carbendazim		73		78		82		80		80		80
Thiram+Carbendazim		69		78		83		80		81		79
Hexaconazole		68		73		78		78		77		74
Polythene bags												
Control	86	69	88	78	93	82	92	80	96	80	95	80
Thiram		72		83		87		86		86		86
Carbendazim		74		82		84		84		84		86
Thiram+Carbendazim		70		84		84		84		84		87
Hexaconazole		70		79		82		79		80		83

C.D. (p = 0.05) **A =0.80; B = 1.39; A x B = 1.96; C = 1.27; A x C = NS; B x C = NS; A x B x C = NS where, A – Storage container; B – Varieties; C – Treatments; NS – Non-significant.**

Viability of the seed stored in cloth bag and polythene bag

Viability of both treated and untreated seeds of all the cultivars were determined by the tetrazolium test (Anonymous, 1993). The maximum seed viability was observed in case of cv. JS 75-46 (96 %) and lowest (86 %) in case of cv. Pusa 16. During the course of storage, all the cultivars showed a reduction in viability from the initial level (Table 2). The rapid loss in viability was observed when the untreated seeds were stored in cloth bags. The loss of viability was not that high when the untreated seeds were stored in polythene bags.

In general, it was possible to slow down the process of losing seed viability during storage with the help of fungicidal seed treatment. However, there appears to be genotypic differences with respect to seed viability and therefore, different seed treatments respond differently in case of different genotypes.

In the present studies, thiram treated seeds stored in polythene bags appear to be the best as it improved seed viability from 93 to 95 percent (Pusa 20), 92 to 95 percent (JS 335). This was followed by seed treatment with a combination of thiram + carbendazim (1:1) in case of Pusa 20, Pusa 22, JS 335 and JS 80-21.

Seed Health

A large number of storage fungi are associated with the soybean seeds resulting in seed rot and spoilage during storage. Mc Gee and Nyvall (1981) reported the association of fungi like *Cercospora, Fusarium, Alternaria, Cladosporium* and *Penicillium* with soybean seeds.

In the present study, seeds of all the six cultivars were found to be associated with fungi like *Alternaria alternata* (Fr.) Keissler, *Cladosporium spp, Penicillium spp.* and *Fusarium moniliforme* Sheldon. Since the atmospheric conditions at the time of harvest play an important role in the association of fungi with seeds, same mycoflora was found associated with all the cultivars as the seeds were collected from the same place and at the same time (Table 3a and 3b).

The initial incidence of *Cladosporium spp*. was more than 50 percent in all the cultivars except Pusa 20 and Pusa 22 where its incidence was only 26 percent. The incidence of *Alternaria alternata* was below 10 percent in all the cultivars except Pusa 22 where it was 16 percent. The incidence of *Fusarium moniliforme* was only 2 percent in Pusa 16 and nil in remaining cultivars. The incidence of *Penicillium* was not observed initially during the storage period but made its debut after 45 days of storage in all the cultivars except in Pusa 20 where it was observed only after 90 days of storage.

When the seeds were treated with different fungicides and stored in cloth bags and polythene bags, the percentage incidence of these fungi declined amongst the cultivars. However, different fungicidal treatments responded differently as the storage period progressed. Further, it was observed that the same seed treatment is more effective in reducing/ eliminating the different fungi when the seeds were stored in polythene bags instead of cloth bags. It is possible that some quantity of fungicidal dust is lost in handling during the storage

Table 3a. Percent incidence of field fungi associated with seeds of soybean cultivars after storage

Cultivars/	Pusa 16				Pusa 20				Pusa 22				JS 335				JS 75-46				JS 80-21			
Treatment	*A.a.*		*C. sp.*		*A. a.*		*C. sp.*		*A. a.*		*C. sp.*		*A. a.*		*C. sp.*		*A. a.*		*C. sp.*		*A. a.*		*C. sp.*	
	0	135	0	135	0	135	0	135	0	135	0	135	0	135	0	135	0	135	0	135	0	135	0	135
Cloth bags																								
Control	2	4	68	16	10	18	26	2	16	-	26	-	2	5	54	14	2	4	58	28	4	14	54	24
Thiram		-		-		-		-		-		-		-		-		-		-		-		-
Carbendazim		4		10		-		-		-		-		-		-		-		4		-		-
Thiram+ Carbendazim		-		6		-		-		-		-		-		-		-		-		-		-
Hexaconazole				6		6		-		-		-		-		-		-		20		10		4
Polythene bags																								
Control	2	2	68	2	10	4	26	1	16	-	26	-	2	3	54	32	2	6	58	12	4	1	54	9
Thiram		-		-		-		-		-		-		-		-		-		-		-		-
Carbendazim		-		6		-		-		-		-		-		10		-		-		-		-
Thiram+ Carbendazim		-		-				-		-		-		-		-		-		-		-		
Hexaconazole		-		2		-		-		-		-		-		6		1		2		-		-

Note: A.a..- Alternaria alternata; C.. sp.-: Cladosporium spp.

Table 3b. Percent incidence of storage fungi associated with seeds of soybean cultivars after storage

Cultivars /Treatment	Pusa 16				Pusa 20				Pusa 22				JS 335				JS 75-46				JS 80-21			
	F.m.		*P.sp.*		*F.m.*		*P.sp.*		*F.m.*		*P.sp.*		*F.m.*		*P.sp.*		*F.m.*		*P.sp.*		*F.m.*		*P.sp.*	
	0	**135**	**0**	**135**	**0**	**135**	**0**	**135**	**0**	**135**	**0**	**135**	**0**	**135**	**0**	**135**	**0**	**135**	**0**	**135**	**0**	**135**	**0**	**135**
Cloth bags																								
Control	2	10	-	40	-	2	-	64	-	14	-	12	-	32	-	5	-	60	-	8	-	28	-	2
Thiram		10		6		-		-		-		-		-		-		22		-		-		-
Carbendazim		4		14		-		28		12		-		24		-		24		-		-		-
Thiram+Carbendazim		-		12		-		6		-		-		-		-		6		-		-		-
Hexaconazole		4		24		2		28		12		-		30		2		44		4		16		-
Polythene bags																								
Control	2	2	-	16	-	1	-	-	-	-	-	4	-	4	-	3	-	6	-	4	-	-	-	2
Thiram		-		20		-		-		-		-		-		-		-		-		-		-
Carbendazim		6		2		-		2		-		-		4		-		16		-		-		-
Thiram+Carbendazim		-		4		-		-		-		-		-		-		4		-		-		-
Hexaconazole		2		4		1		-		2		-		-		-		-		-		-		-

Note: *F.m. Fusarium moniliforme; P.sp.: Penicillium spp.*

when the seeds are kept in cloth bags. Secondly, the seeds were loosely packed in cloth bags while they were tightly packed and sealed in polythene bags and obviously there is no loss of fungicidal dust because of the impervious nature of the polythene bags. The combination of thiram + carbendazim was found to be the best in eliminating/ reducing the fungal mycoflora when the treated seeds were stored in polythene bags. This combination was followed by seed treatment with thiram and Carbendazim individually. However, hexaconazole was not very effective in controlling the associated mycoflora.

On the basis of present studies, it can be concluded that storage of soybean seeds is a problem in warm and humid conditions prevailing in our country. Genotypic differences were observed in the storage behavior of the cultivars taken in these studies. However, irrespective of the genotypic differences, the germination, vigour and viability could be maintained/improved by giving a pre-storage seed treatment with a fungicide like thiram and storing the seeds in moisture impervious containers like 700-guage polythene bags, provided the moisture content of the seed is around 8%.

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Quality Characteristics of Beverage Prepared from Milk-Soy extract Blends

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ABSTRACT

Effect of blending of soy extract with milk on physical, chemical and sensory attributes of flavoured beverage was studied. For this, soy extract was prepared from seeds of soybean. Milk-soy extract blends were prepared in the ratio of 100: 0, 90: 10, 80: 20, 70: 30, 60: 40, 50: 50 and 0: 100 using skimmed milk, toned milk, standardized milk and soy extract. For the preparation of flavoured beverage, sugar (6.5%) and sodium alginate (0.2%) were added in blends, boiled, cooled and flavoured with vanilla essence. On the basis of results of physical and sensory properties, it was found that the soy extract could be blended up to 30 per cent with toned milk without affecting its acceptability.

Key words: Antinutrients, flavoured beverage, milk, minerals, proximate composition, sensory evaluation, soy-extract

Beverages are an integral part of human diet. The cycle starts with the infants' formulas-highly complex drink, rich in many key-nutrients. As human age and their nutritional requirements change, product designer keeps pace by developing new and innovative beverages to meet these needs. In India traditional cuisine includes drinks, which were developed primarily to provide aesthetic appeal, though they also contain certain components having nutritional and therapeutic values. In the course of time, these traditional health drinks vanished as for a long period the Indian beverage industry was dominated by aerated synthetic drinks. To improve the flavor of the product and also to enhance the acceptability of the beverage, soymilk was blended with cow's milk to develop an acceptable beverage. Entrepreneurial products, where the beneficial factors of two or more ingredients can be combined to produce healthier functional foods, are gaining more interest and one such combination can be established of soymilk and cow milk to produce a range of beverages and fermented products with improved flavour profile and health attributes. Blended products may posses the nutritional and health benefits of both soybean and cow's milk (Karatzas *et al.*, 1999; Sherkat *et al.*, 1999).

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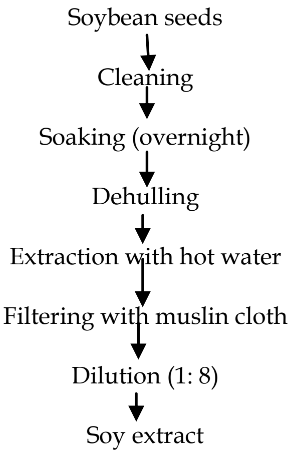

Fig. 1. Process flow diagram for soy extracts preparation

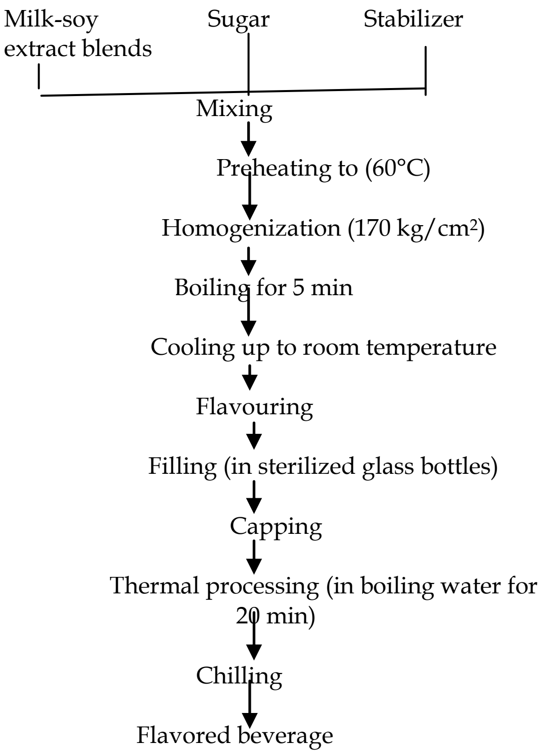

Fig.2. Process flow diagram for the preparation of flavored beverage from milk-soy extract blends

MATERIAL AND METHODS

Manually cleaned seeds of soybean, variety PS 1042 were used for the preparation of soy extract by traditional process (Fig. 1). Milk-soy extract blends were prepared in the ratio of 100: 0, 90: 10, 80: 20, 70: 30, 60: 40, 50: 50 and 0: 100 using skimmed milk, toned milk, standardized milk and soy extract. For the preparation of flavoured beverage, sugar (6.5%) and sodium alginate (0.2%) were added in each blends, boiled, cooled and flavoured with vanilla essence (Fig. 2) and evaluated for sensory attributes after chilling.

The proximate composition (moisture, protein, fat and ash content) was determined (AOAC, 1984). The percent carbohydrate was calculated by subtracting the sum of moisture, protein, fat and ash from 100. The minerals as calcium, phosphorus and iron were estimated by the method described by Ranganna (1999); Cu, Mn, Mg, Zn, Co and Pb were determined on an Atomic Absorption Spectrophotometer (EC Ltd. Model No. AAS 4141) following the digestion of sample in ternary acid mixture (HNO_3: H_2SO_4: $HClO_4$; 10:1:4 v/v) and Na and K were analysed by Flame Photometry. The viscosity was determined using Brookfield Synchro- electric Rotary Viscometer (Model LVT) using spindle No.1 at a speed of 60 rpm. The pH was determined using a microprocessor based pH meter (Century, CP 931) and acidity as per AOAC (1984). Trypsin inhibitor activity (Kakade *et al.*, 1974), phytic phosphorus (Hauge and Lantzsch, 1983) and oligosaccharides employing paper chromatography (Tanaka *et al.* 1975) were assayed using standard methods. Method described by Larmond (1977) was employed for sensory evaluation. The data generated was statistically analysed (Snedecor and Chochran, 1968) and presented.

RESULTS AND DISCUSSION

Nutrients and anti-nutrients content of soybean, soy extract, cow milk and beverages prepared from soy extract and different type of milk revealed that soy extract contains very similar amount of protein as in cow milk. Soy extract contains low amount of Ca, P, Na and Pb and higher amount of Fe, Mg, Cu, Mn, Zn and Co as compared to cow milk (Table 1). Therefore, blending of soy extract supplements the milk in Fe, Cu, Mg and Zn content as these minerals are essential for human body.

Table 1. Nutrients and antinutrients content of soybean (dry basis), soy extract, cow milk and beverages prepared from soy extract and different type of milk

Constituents	Soybean	Soy extract	Cow milk	Beverages			
				Soy extract beverage (0:100)	Skimmed milk beverage (100:0)	Tonned milk beverage (100:0)	Standard milk beverage (100:0)
Moisture (%)	-	92.40	86.80	84.36	81.92	80.11	78.76
Protein (%)	43.68	3.12	3.18	3.10	3.29	3.22	3.17
Fat (%)	21.63	1.92	4.00	1.92	0.50	3.00	4.50
Ash (%)	5.04	0.52	0.79	0.54	0.83	0.81	0.79
Carbohydrate (%)	29.65	2.04	5.23	10.08	13.46	12.86	12.78
Total Solids (%)	-	7.60	13.20	15.64	18.08	19.89	21.24
Trupsin Units Inhibited (TUI/ml[1])	31.25	2.33	-	2.33	-	-	-
Raffinose (%)	1.182	0.103	-	0.103	-	-	-
Stachyose (%)	3.564	0.296	-	0.296	-	-	-
Phytic phosphorus (%)	0.226	0.024	-	0.024	-	-	-
Ca (mg/100g)	236.82	21.20	122.20	23.24	127.30	125.40	123.00
P (mg/100g)	509.43	44.23	76.30	47.18	81.20	78.18	76.62
Fe (mg/100g)	20.12	1.68	0.08	1.72	0.09	0.09	0.08
Na (mg/100g)	43.02	3.50	52.12	3.71	56.72	55.71	53.40
Mg (mg/100g)	219.12	18.35	9.70	20.40	10.10	9.85	9.80
K (mg/100g)	1519.00	127.21	151.80	131.12	158.30	155.10	153.70
Cu (mg/100g)	2.90	0.24	-	0.26	-	-	-
Mn (mg/100g)	15.90	1.33	1.10	1.42	1.15	1.13	1.12
Zn (mg/100g)	9.00	0.75	0.72	0.82	0.74	0.73	0.72
Co (mg/100g)	5.60	0.47	0.28	0.51	0.31	0.31	0.29
Pb (mg/100g)	2.99	0.25	0.92	0.28	0.95	0.93	0.93

[1] 1 gm sample extracted with 50 ml 0.01 N NaOH, 1 ml of extract diluted to 50 ml, 1ml of dilution taken for assay; All values are average of three determinations

Table 2. Mean sensory scores for colour, appearance, consistency, flavour and overall acceptability of flavored beverage prepared from soy extract, milk and their blends

Quality parameters	Milk-soy extract blend							SEM (±)		
	100:0	90:10	80:20	70:30	60:40	50:50	0:100	a	b	a × b
Colour								0.133	0.204	0.353
Skimmed milk	7.6	7.8	8.0	8.0	7.9	7.6	7.0		CD (≤0.05)	
Toned milk	8.4	8.5	8.5	8.3	8.0	7.8	7.0	0.382	0.583	1.010
Standardized milk	8.2	8.2	7.9	7.8	7.7	7.4	7.0			
Appearance									SEM ±	
Skimmed milk	7.4	7.5	7.9	7.9	7.6	7.4	7.2	0.142	0.217	0.376
Toned milk	8.4	8.4	8.5	8.3	7.9	7.7	7.2		CD (≤0.05)	
Standardized milk	8.0	8.2	8.2	8.1	7.8	7.6	7.2	0.406	0.621	1.076
Consistency									SEM±	
Skimmed milk	7.5	7.4	7.4	7.4	7.5	7.5	7.1	0.133	0.204	0.353
Toned milk	7.9	7.9	7.8	7.8	7.7	7.4	7.1		CD (≤0.05)	
Standardized milk	8.0	7.9	7.9	7.7	7.6	7.4	7.1	0.382	0.583	1.010
Flavour									SEM±	
Skimmed milk	8.0	8.0	7.9	7.9	7.8	7.5	7.0	0.131	0.200	0.347
Toned milk	8.4	8.4	8.4	8.3	8.0	7.8	7.0		CD (≤0.05)	
Standardized milk	8.3	8.3	8.2	8.2	8.0	7.7	7.0	0.375	0.573	0.993
Overall acceptability									SEM±	
Skimmed milk	7.7	7.7	7.8	7.8	7.6	7.5	7.1	0.132	0.202	0.350
Toned milk	8.3	8.3	8.3	8.2	7.7	7.7	7.1		CD (≤0.05)	
Standardized milk	8.1	8.2	8.0	8.0	7.8	7.5	7.1	0.378	0.578	1.000

a: type of milk; b: milk-soy extract blend; all values are average of ten replicates

The sensory score for colour was highest (8.5) for beverage of toned milk and soy extract blend (80: 20) and lowest for beverage from soy extract (0: 100). The differences were not significant among type of milk, but differed significantly ($P \leq 0.05$) with increase in soy extract level (Table 2). However, toned milk- soy extract blend (60: 40) did not differ significantly with control (100:0). The differences due to their interaction were also non-significant. The sensory score for appearance was highest (8.5) for beverage of toned milk and soy extract blend (80: 20) and lowest (7.2) for beverage from soy extract (0: 100). The differences were non-significant among type of milk used but differed significantly ($P \leq 0.05$) with increase in soy extract level. However, toned milk – soy extract (60: 40) blend did not differ significantly with control (100:0). The differences due to their interaction were also non-significant. Flavored beverage prepared from standardized milk (100: 0) had highest (8.0) and beverage from soy extract (0: 100) had lowest (7.0) score for consistency. Differences were not significant for type of milk, level of soy extract and due to their interactions.

Flavored beverage prepared from skimmed milk (100: 0) had highest (8.4) score and beverage from soy extract (0: 100) had lowest (7.0) score for flavour. From the results it was noted that sensory scores for flavour decreased significantly ($P \leq 0.05$) with the increase of soy extract level but the reduction was not significant among type of milk and due to its interaction with soy extract level. Beverage from toned milk-soy extract (70: 30) blend had score (8.3) for flavour and did not differ significantly with control (100:0). The sensory score for overall acceptability was highest (8.3) for beverage from toned milk (100: 0) and lowest (7.1) for soy extract (0: 100). The scores were significantly ($P \leq 0.05$) decreased with the increase in soy extract level, but the differences were not significant among type of milk and due to their interactions. The sensory score for overall acceptability (8.2) of toned milk-soy extract (70: 30) beverage did not differ significantly with control (100:0), hence recommended.

Physico-chemical as well as nutritional analysis of optimized flavoured beverage showed that it contained pH, 6.65; acidity, 0.125 percent; viscosity, 9.5 CP; total solids, 18.62 percent; protein, 3.18 percent; fat, 2.67 percent; ash, 0.72 percent; carbohydrate, 12.05 percent; stachyose, 0.075 percent; raffinose, 0.020 percent; phytic phosphorus, 0.005 percent; trypsin units inhibited, 0.48 TUI/ml and minerals i.e. Ca, P, Fe, Na, Mg, K, Cu, Mn, Zn, Co, Pb content were 94.60, 68.90, 0.55, 41.12, 12.97, 147.12, 0.08, 1.20, 0.75, 0.38 and 0.75 mg per 100 ml, respectively.

From the results it can be concluded that soy extract can be blended up to 30 per cent with toned milk without affecting its sensory characteristics. Blending may also supplement the milk in minerals content i.e. Cu, Fe, Mg and Zn, in which the milk is deficient.

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Soy-Products and Their Relevance to India

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ABSTRACT

Soybean is one of the nature's wonderful nutritional gift of plant origin. It provides a high quality protein and other nutrients along with health promoting phytochenmicals. Using soy-products in daily diet help people feel better and live longer with an enhanced quality of life. The present need is to create awareness about soy-products and its health and economic benefits. For all these to happen, there must be a commitment and missionary zeal by all those involved in soybean production and value chain.

Key words: Soybean, health benefits, phytochemicals

There are more than 1000 million people in India and majority of them (65-70%) are vegetarian and derive their proteins from pulses, cereals, milk and to some extent from oilseeds like groundnut, sesame and soybean. In general, the quality of protein eaten by such population is poor. Better quality proteins from egg, meat and aqua products are costly and only a select group of rich population has access to it. 25-30 percent of Indian population are below poverty line (BPL) and do not have enough purchasing power for good quality dietary proteins. This calls for providing them an alternative source of dietary protein, which could be financially affordable. Soybean meets such requirements (Table 1). Hence for India, one of the options is to make use of soybean as protein source to augment its conventional protein supply at a cost/price affordable to all especially the lower income group of population. India produces about 06 million tonnes of soybean annually.

Table 1. Comparative analysis for protein content and its cost in some selected protein food sources in India (Ali, 2000)

Protein source	Cost of food items (Rs./kg)	Protein content (%)	Cost of protein (Rs/kg)
Soybean (Fullfat soyflour)	20.0	40.0	50.0
Groundnut (kernel)	25.0	25.0	100.0
Pulses (splits/dal)	30.0	25.0	130.0
Egg	30.0	16.0	180.0
Milk	12.0	4.0	300.0
Fish	60.0	16.0	360.0
Meat	90.0	16.0	540.0

[1]*Deputy Director General (Agricultural Engineering)*

Soybean is a grain legume rich in good quality nutrients and health promoting phyto-chemicals. Soybean grain quality is of fundamental importance and plays a major role in its utilization. Various grain quality parameters of soybean can be divided into two groups - information related and quality related (Table 2). Information factors help in deciding the soybean price and whether it is at proper moisture for storage or processing. It may not be directly responsible for soybean quality but useful to farmers, traders and processors. The quality factors have a direct bearing on nutritional value of the beans and on the quality of food products prepared using these beans. Soybean processors are interested in high oil content beans, to get a higher yield of oil in the extraction process. Since the price of oil per tonne is generally 5-7 times higher than that of meal, a higher oil content means a high product value per tonne of soybean crushed and naturally a better margin for the processors. Soy-food manufacturers prefer soybean of clear yellow colour, uniform size and high protein content with no foreign materials. Soybean containing high protein may get a premium.

Table 2. Soybean grain quality parameters

Information related	Quality related
• Moisture content • Test weight • Foreign matters • Splits • Damage • Breakage • Colour	• Protein content • Oil content • Trypsin inhibitor • Free fatty acids • Germination • Hardness • Phyto-chemicals

Soybean has a long and respected history and it is one of the most important world agricultural commodities. It has a wide range of geographical adoption, unique chemical composition, good nutritional value, functional health benefits, and versatile end uses. Yet, at present, only a small portion of annual soybean production is used for direct food consumption, and a majority of soy meal rich in protein (45-50%) still goes to live-stock feed. There are many constraints associated with food use of soybean in the non-traditional soybean growing countries like India. These are beany flavour of soybean products, oxidative instability of soy oil, sulphur-containing amino acid deficiency, poor protein digestibility, lack of certain functional properties, flatulence, and low consumer acceptance. To overcome some of these constraints, both innovative industrial processing and advanced plant breeding have been used. This has resulted in quality improvement of both soybeans and resulting soy products. Coupled with these efforts is the current medical research to reveal health benefits of soy. Consequently, the image and the acceptance of soy as food have been significantly improved these days. However, to further increase soy consumption as food and to improve soy acceptance among mainstream consumers, we still have a long way to go, not only in continuing our efforts to overcome these constraints, but also in emphasizing marketing and consumer awareness educational efforts and a shift towards soy-based dietary habits.

Nutritional importance and soy fortified diet

Soybean can today, help feed the people better and could do much to reduce nutritional deficiencies in India at an affordable cost. Nutritive value of soybean appears to have no equal in supplying protein, fat, mineral salts like calcium, magnesium, phosphorus and to some extent vitamins A, D and B complex (Table 3).

The presence of abundant phosphorus and protein in soybean is made use of in curing nervous disorders, rickets, pulmonary diseases and anaemia. Since soybean contains less carbohydrate and more proteins, it forms one of the best foods for diabetic patients. Soybeans are alkaline in nature and their use in diet reduces the acidity in blood. Indians use varieties of *dals*, grams and oilseeds. All these have characteristics aroma and flavour by mouth. For these traditionally used pulses Indian have become habituated but not for the flavour of soybean. As taste is an acquired habit, with proper education and change of attitude of the people, soybean can become a pulse in demand like any other pulse we are accustomed to.

Table 3. Approximate food value of 100 g edible soybeans

Constituents/Nutrients	Value (g)	Remarks
• Protein	43	• Soybean is a rich source of best quality plant protein, PUFA rich oil, omega-3 fatty acids, fibre, minerals, carotene and health promoting phyto-chemicals.
• Carbohydrates	21	
• Fats	19	
• Moisture	8	
• Mineral	5	• Dietary energy of soybean is about 430 K cal/100g.
• Fibre	4	

Food habits die-hard and the change has to be brought about gradually. Therefore, soybean, and its *dal* and flour should be used in smaller percentages in place of the existing popular pulses, *dals* and flours and later on the quantity can be increased for complete replacement wherever acceptable. The quantity of protein and fat present in soybean is so high that even a substitution of 10-15 percent in place of any cereals and 25 percent in place of any pulse will considerably enhance protein content and quality. The kind of fat, soybean has is most welcome. It is made up of essential fatty acid required by human beings and is free from cholesterol.

Soy products and human health

Soybean has a long and respected history as a versatile plant food that provides high-quality protein but only minimal saturated fat (Holt, 1998). It should earn soy foods a bigger place in diets. Recently, it has been observed that soy foods are rich and unique dietary source of isoflavones/ phytoestrogens, which lower serum cholesterol levels. The hypocholesterolemic effect of soy protein have been demonstrated in clinical studies for more than 30 years although until recently, few health professionals were aware of this literature (Messina, 2002). The health professionals have gradually begun to appreciate the hypocholesterolemic effect of soy protein and now the official recognition has come in October 1999, with an authorization by the US Food and Drug Administration (FDA) to grant a health claim for soy protein. Initial interest in isoflavones focused on their possible anti-cancer effects but it is clear that this view of isoflavones is far too limiting. Isoflavones are now thought to reduce risk of a wide array of diseases including osteroporosis and coronary heart disease (CHD). They may also help to alleviate menopause symptom. Soybean contains two primary isoflavones called genistein and diadzein, and a minor one called glycitein. Whole soybeans and non-fermented soy foods contain primarily isoflavones in the glycoside form, which means they are attached to a molecule of sugar. In contract, fermented soy-foods like *miso* contain mostly *aglycones*, isoflavones without the sugar. Isoflavones have a very limited distribution in nature. Soybeans and soy foods contain approximately 1-3 mg of isoflavones per gram.

Processing of soybean originally was done to improve/extend the shelf life, inactivate/remove anti-nutritional factors, improve safety, make desirable sensory changes, more convenient products and value addition to soybean. However, now-a-days, some of the above reasons have changed to maintain/save some of the components of soybean that have health benefits (Liu, 1999). For example, instead of removing oligosaccharides that cause flatulence in some people, these are now looked upon favourably because they increase the population of bifidobacteria in colon, giving a protective effect against pathogenic organisms. Isoflavones and TI (BBI) are believed to provide protection from cancer (Wilson, 1999). With increasing interest in the use of soybean in foods, due to its health benefits, the demand of soybean for direct food uses would increase in the future.

Economic value of soybean and some of its products

Taking an average market price of soybean during 2004-05 as Rs. 12,000/tonne and the total quantity of soybean available for direct food uses as 5 million tonnes, the commercial/market value of soybean is about Rs. 6000 crores (one crore = 10 million). When it is processed into oil and protein (as soy-meal for live-stock feed/edible grade defatted soy-flour), the marketable value of such products would be Rs. 7600 crores @ Rs. 40,000/tonne for 0.9 million tonne of soybean oil and @Rs. 10000/tonne for 4 million tonne of soy-meal based live-stock feed and/or defatted soy-flour). If all the 5 million tonne of soybean is processed into full fat soy-flour (FFSF) and used to fortify wheat and/or chickpea flour for better quality proteins and higher contents, the retail market cost of processed soy-product as FFSF and byproducts (consisting of hull, germ/embryo and brokens) as live-stock feed would be Rs. 8500 crores @ Rs. 20,000/t for 4 million tonne of FFSF and @ Rs. 5000/t for one million tonne of byproducts). 42 percent monetary value is added to soybean through primary processing by transforming it into FFSF (Rs. 8500 – Rs.6000 = Rs. 2500 crores). Similarly, if one kg soybean costing Rs. 12 is transformed into soymilk (5 litres/kg of soybean) and soy-*paneer* (1.5 kg/kg of soybean) and assuming the retail price of these soy-products at 50 percent of animal milk (Rs. 12/litre) and animal milk *paneer* (Rs. 80/kg), the monetary value addition to soybean in the form of soymilk and soy-*paneer* would be 150 and 400 percent, respectively.

Direct food uses of soybean in the form of soy-fortified cereal/legume flour, soymilk, soy-*paneer* (Tofu), soy-based *sattu,* roasted/fried/fermented soy-snacks, soy-millet based extruded/baked food products, etc. are more nutritious and healthful and also economically affordable by majority of the Indian population. Soy protein is the best among all plant proteins and at the same time, soybean is most economical source of protein in the world. Cost of one kg of Soy protein in the form FFSF is Rs. 50 only whereas it is Rs. 100 from groundnut kernel, Rs. 130 from pulses, Rs. 180 from egg, Rs. 300 from milk, Rs. 360 from fish and Rs. 540 from goat/sheep meat (Table 1). Moreover, the ab-

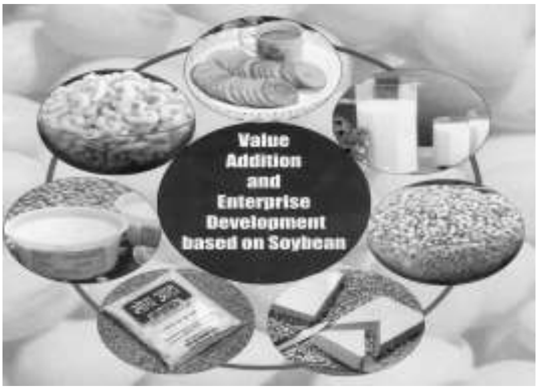

Fig.1. Some of the value added products from soybean

Fig. 2. Training of rural/urban women in domestic utilization of soybean

Fig. 3. Potential entrepreneurs in soymilk, soy-*paneer* and soy based other dairy analogs

sorption/assimilation of health promoting soybean phyto-chemicals by human beings may be better when taken/eaten along with foods prepared from whole soybean than when these chemicals are extracted and isolated from soybean and then later used as medicine/micro-nutrients as and when required. Examples are soy-based isoflavones, lecithin, dietary fibre, fatty acids, etc. It, therefore, suggests that direct food use of soybean is in human interest on account of health and economic benefits and needs to be encouraged and promoted.

Soy-product promotion and entrepreneurship development

Soybean is generally processed in the form of whole beans or partially/fully defatted cake/meal for making various soy-based food items (Fig. 1). Whole beans are used for making full-fat soy-flour, dairy analogs, fermented and snack foods. Soy-flour can also be made from partially/fully defatted beans (cake/meal) and used in making baked products, texturized soy-proteins (TSP), protein isolates and concentrates, extruded snack foods, and so on. A range of technologies - physical, chemical, biological or a combination of these is used in making various soy-based fermented and non-fermented foods. However, the option of technology depends on the type of product and its use. There is a need for concerted efforts to popularize and promote soy based food products through training and entrepreneurship development (Fig. 2 & 3). Some of the suggested approaches are as follows.

- Creation of awareness among the masses about the economic, nutritional and health benefits of soybean and its products through awareness programme, exposure training, exhibition and print and electronic media
- Training of individuals, groups and entrepreneurs in manufacture and marketing of machinery and soy-based food products
- Technical support to the potential upcoming entrepreneurs through training project report, consultancy and services
- Development of policies to encourage processing and utilization of soybean through fiscal incentives like soft-loan and concessions
- Strengthening of Research and Industry Linkage/Interface
- Development of strong and continued linkage with different Government. and non-government development and R and D organizations involved in soybean value chain.

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Knowledge of Women Respondents About the Health Benefits and Utility of Soybean for Food Uses

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ABSTRACT

The use of soybean as food even thirty-five years after its introduction in late seventies as commercial crop in India is non-significant leaving aside that of soy-oil for culinary purpose. In view of rampant energy-protein mal-nutrition in the Indian populace and enlightenment on health benefits of soybean in the recent past, it is considered that awareness on this aspect will not only mitigate the problem but will also ensure good health. The efforts made by National Research Centre for Soybean, Indore while working with the rural/tribal and urban women brings out that though the people hesitant initially to give entry to soybean in their kitchen, are convinced on its value as food/functional food and are revealing their acceptance for soy-processed products; soy-pakora, soy-nuts, soy-milk and tofu (soy-paneer) in order of preference. The sustained efforts in this direction may help to mitigate mal-nutrition problem at one hand and extending health benefits on the other.

Key words: Food uses, health benefits, knowledge, soybean, women

Soybean shares nearly 32 percent of the total oilseeds produced in India. Besides contributing substantially (above 13%) to the edible oil production of the country, it fetches average export earnings worth Rs. 20, 000 million each year by way of export of soy-meal. Though soybean has established itself as an integral part of traditional cropping systems, particularly in the *Malwa* plateau of Central India, its food uses have been meager except that in the form of edible oil for culinary purpose. The research during recent past has surfaced the beneficial effect of soybean intake as food on providing total health and nutritional security to human beings (Riaz, 1999; Ali, 2001). Considering the significance of the neutraceutical values of soybean and its emerging status as a functional food, National Research Centre for Soybean, Indore has successfully completed a project on "Popularization of soybean at household levels for nutritional security" with the financial support from TMOP&M. The efforts were made therein to take various soy-preparations to the kitchens of housewives by imparting training on their preparations along with knowledge on possible health benefits. The outcome from these training programmes organized in the *Malwa* and adjoining regions of Madhya Pradesh are stated in the following text.

[1] Scientist Senior Scale, [2,3]Senior Scientist, [4]Principal Scientist

MATERIAL AND METHODS

The present study undertaken by the National Research Centre for Soybean), Indore with a view to create awareness among the women on health benefits accruing by daily intake of soybean and on processing of soybean at home level through 34 one-day training programmes during 2000-02 was utilized to assess the impact. The sample size for the present study has been 603 respondents, comprising 164 urban women, 305 rural women and 134 tribal women from Indore, Dhar, Jhabua, Ratlam and Dewas districts of Madhya Pradesh and Chittaurgarh and Banswara districts of Rajasthan. To collect the post-training information, a pre-designed interview schedule was utilized. The data so collected was subjected to frequency, percentage and CV.

RESULTS AND DISCUSSION

Status of awareness on food uses among the respondents

The feed back (Table 1) brought out that around 43 % of the respondents were aware of utility of consumption of soybean in different forms (soy-oil, soy-flour and baked soy-pods). Among different categories, majority of urban women (about 71 %) had awareness of the usage in popular form like soy-flour and soy-oil. Interestingly, the rural women (37 %) and tribal women (23 %) stated that they have been consuming soybean mainly as backed soy-pods at green pod maturity stage and in the form of soy-oil. The tribal category of respondents had very little awareness on soy-flour utility for human consumption, but knew about use of soybean straw as animal feed. The major chunk of urban respondent had recognition on the efforts being made by the National Research Centre of soybean to create awareness on health benefits of consuming soy-products, whereas the rural/tribal respondent had no or little idea about it.

Table 1. Awareness of respondents about the food uses of soybean

Aspects of awareness	Category of women				CV (%)
	Urban n=164	Rural n=305	Tribal n=134	Total N=603	
Status of soybean consumption as food in any form prior to attending training	116 (70.73)	113 (37.05)	31 (23.13)	260 (43.11)	56.09
Efforts of NRC for Soybean on popularization of soybean for food uses	108 (65.85)	59 (19.34)	5 (3.73)	172 (28.52)	109.02

Figures in parentheses indicate percentages

Knowledge gained by the respondents

Most of respondents irrespective of the categories developed an extremely positive attitude after training about the food and nutraceutical value of soybean, and its status as a functional food (Table 2). Almost all of them agreed that soybean being a cheapest source of high quality protein has potentials to abridge the gap of calorie-protein malnutrition along with minimizing the chances ailing from dreaded diseases like cancer, diabetes, osteoporosis and cardiac arrest. The phyto-hormone, isoflavone, contained in the soybean is also reported to protect women from breast cancer and relives from menopausal blues. Documented literature (Khan, 2001; Wang, 1999, Messina, 1997; Browning and Niebrugge, 1999) amply supports the statements made above.

Table 2. Distribution of respondents according to their knowledge gained regarding nutritional aspects of soybean

Nutritional aspects of soybean	Category of women				CV (%)
	Urban n=164	Rural n=305	Tribal n=134	Total N=603	
Highest protein content	149 (90.85)	291 (95.41)	134 (100)	574 (95.19)	4.79
Cheapest protein source	160 (97.56)	295 (96.74)	130 (97.01)	585 (97.01)	0.43
Beneficial in reducing the risk of cancer, diabetics, and heart diseases etc	154 (93.90)	294 (96.39)	129 (96.27)	577 (95.69)	1.47
Relief from menopausal problems in women.	162 (98.78)	295 (96.72)	134 (100)	591 (98.01)	1.68
Soybean as a Functional food	164 (100)	305 (100)	134 (100)	603 (100)	0.0

Figures in parentheses indicate percentages

Feed back on soy-preparations

An attempt was made to ascertain the preference of respondents about different soy dishes prepared by themselves as per the directions given during the course of trainings. Among the five different ways of processing soybean for food usage, soy-*pakora* and soy-nuts were most preferred items on account of ease in preparation and taste-wise liked by majority (around 50 %) of the respondents (Table 3). Soymilk and green pods boiled in salt water followed this. There has been luke-warm preference (about 17%) for *tofu* (soy-*paneer*) on the reasoning that it requires special skill and hard work in processing. All the categories of respondents reported that preparation of soy-*pakora*

Table 3. Distribution of respondents according to their preference of various soy products along with suitable soybean varieties

Soy- preparation/ variety	Category of women				CV (%)
	Urban n=164	Rural n=305	Tribal n=134	Total N=603	
Easiest soy preparations					
Tofu	26 (15.85)	63 (20.66)	13 (9.7)	102 (16.92)	**35.66**
Green pods	37 (22.56)	95 (31.15)	42 (31.34)	174 (28.86)	**17.69**
Soy-Pakora	101 (61.59)	135 (44.26)	71 (52.99)	307 (50.91)	**16.37**
Soy-nuts	78 (47.56)	173 (56.72)	74 (55.22)	325 (53.90)	**9.24**
Soy-milk	76 (46.34)	90 (29.51)	14 (10.45)	180 (29.85)	**62.42**
Preferred variety for green pod consumption					
JS 335	95 (57.92)	165 (90.81)	23 (17.16)	283 (46.93)	**66.72**
NRC 7	69 (42.07)	140 (45.90)	111(82.83)	320 (53.06)	**39.53**
Preferred varieties for tofu and milk preparation					
Punjab 1	144 (87.80)	277 (90.81)	130 (97.01)	551 (91.37)	**5.11**
JS 335	20 (12.19)	21 (6.88)	4 (2.98)	45 (7.46)	**62.89**
Samrat*	0 (0.00)	7 (2.29)	0 (0.00)	7 (1.16)	**17.21**

*Figures in parentheses indicate percentages; * a variety of common knowledge*

was the easiest one followed by soy-nuts. The crispy nature of these items suiting to taste and food habits of *Malwa* people appears to be the reason for this preference. They are akin to the snacks and *namkeens* normally consumed in this region. As far as the suitable variety for consumption at green pods stage after boiling in water with a pinch of salt is concerned, 'NRC 7' (Ahilya 3) leads. Better taste in addition to bold seededness of this variety in comparison to JS 335 justifies the preference. The respondents expressed that the variety 'Punjab 1' was good for tofu making and processing for soymilk.

The study suggests that there is a need to create awareness in the general masses, particularly dwelling in rural areas, on the utility of soybean in food to meet the calorie-protein deficiency and on health benefits of soybean. A bright possibility lies in the introduction of simple soy-products, akin to their food habits and taste, in regular intake of people. This will canalize the soybean as food, thereby extending health benefits to the Indian masses and reduce the huge protein drain from the country. Concerted efforts are also needed to promote the soy- preparations at the level of cottage industry and create employment in rural areas.

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Effect of Enriched Compost in Combination with Fertilizers on Nodulation, Growth and Yield of Soybean [*Glycine max* (L.) Merrill]

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Key words: *Glycine max,* enriched compost, fertility levels

Soybean is generally grown without taking much care on balanced nutrition leading to sub-optimal performance. In India, the productivity is much lower than the potentials of popular varieties (2500 to 3000 kg/ha) and performance of crop under available production technology (above 1800 kg/ha) under real farm conditions. Therefore, there is a need to increase yield, oil and protein content of soybean with integrated approach involving judicious use of fertilizers along with other organic sources taking care of soil health. The lacunae in use of organic components, particularly slow decomposition can be over come by employing fast decomposing cellulolytic fungi (Bhardawaj and Gaur, 1985) and that of low nutrient content by enrichment with fertilizer N, rock phosphate, bone meal, feldspar, pyrite, N_2 fixing bacteria and phosphate solubilizing microorganisms (Manna *et al*., 1997). Phosphorus enriched compost owing to addition of low-grade rock phosphates, available abundantly in various parts of India, in association with phosphate-solubilizing fungi (*Aspergillus awamori*) to accelerate the process of composting as well as its quality (Singh *et al*., 1992 and Singh, 2000). The present study was conducted to see the impact of enriched compost alone and in combination with the levels of fertilizer NPK on nodulation, growth, yield and nutrient content of soybean crop.

The field experiment was conducted at Crop Research Centre, Pantnagar during *Kharif* 2004 using soybean *var.* PK 1042 in randomized block design involving seven treatments *viz*. control, recommended level of NPK, enriched compost (EC) + 75 percent NPK, EC +50 per cent NPK, EC + 25 per cent NPK, EC and farmyard manure (FYM) alone, replicated thrice in Typic Hapludoll soil having pH (7.2), EC (0.41dS/m), organic carbon (0.39 %), mineralisable N (195.62 kg /ha), Olsen's available P (18.16 kg/ha) and normal ammonium acetate extractable K (125.12 kg/ha). The crop was sown on 22nd July 2004 in 4 × 3 m^2 plots and harvested

[1]*Research Scholar;* [2,3]*Senior Research Office;* [4]*Assocoate Professor*

on 28th November 2004. The EC and FYM were applied @ 10 t /ha. The recommended level of fertilizer consisted of 20-60-40 kg/ha N, P_2O_5 and K_2O, respectively, which were applied through urea, single super phosphate and muriate of potash. The enriched compost was prepared utilizing organic wastes viz press mud, sugarcane trash, paper mill bagasse and pine needle by pit method. To hasten the decomposition rate of organic wastes, liquid inoculants of fungi (*Humicola sp.* and *Trichoderma viride*) were used. The C:N ratio of the composting materials was maintained at 30:1 by adding urea. One per cent single super phosphate and 5 percent lime (calcium carbonate) were also added at the time of filling the pits for fast decomposition and enrichment of nutrients. The prepared EC had pH (7.28), organic carbon (33.64 %), C:N ratio (17.93), total N (1.87 %), total P (1.09 %), total K (0.924 %) and total S (0.816 %). FYM utilized for experimentation had pH (7.21), organic carbon (35.84 %), C:N ratio (42.16), total N (0.85 %), total P (0.40 %), total K (0.77 %) and total S (0.296 %). The observations on symbiotic traits and shoot dry weight were recorded at 30, 60 and 90 days after sowing (DAS). The nitrogen content in soybean seed was determined by micro Kjeldahl method (Bhargava and Raghupathi, 1998). The contents of potassium and phosphorus in seeds after digestion in tri-acid mixture were determined by flame photometer and phospho-vandomolybdate yellow colour methods, respectively (Bhargava and Raghupathi, 1998).

The nodule number per plant of soybean increased significantly by applying 100 percent NPK and EC along with 75 and 50 percent NPK at 30 DAS, while all the treatments gave significantly more nodule number than the control at 60 DAS. The maximum number of nodules per plant at 30 and 60 DAS was recorded with treatment having EC + 75 percent NPK by giving 18.2 percent more nodule number than 100 percent NPK at 60 DAS. Significantly higher nodule dry weights were received from all the treatments at all intervals, except FYM, in comparison to control. Maximum nodule dry weight (122.50 mg/plant) at 30 and 60 DAS were observed with EC + 75 per cent NPK. The performance of enriched compost + 75 percent NPK was numerically better than 100 percent NPK (Table 1). Significant increases in shoot dry weight were found with application of 100 percent NPK and EC in combinations of NPK at 30 and 60 DAS (Table 1). The highest shoot dry weights of 18.83, 26.26, and 38.15 g per plant were recorded with EC + 75 percent NPK, at 30, 60 and 90 DAS, respectively, which were significantly higher than control, EC and FYM treatments. The addition of EC + 75 percent NPK also performed numerically better than 100 percent NPK by giving 8.65 and 18.12 percent respectively, more shoot dry weight at 30 and 60 DAS. The application of EC has earlier been reported to improve physical, chemical and biological properties of soil which in turn induce the survival of rhizobia in soil and improve the nodulation resulting increased shoot dry weight in soybean

(Singh, 2000) and Namdeo *et al.,* 2003). All treatments, except FYM, gave significantly higher grain yield over control (Table 2). Application of EC + 75 percent NPK showed maximum grain yield (2835 kg/ha) followed by 100 percent NPK. An increase of 17.4 percent in grain yield was noticed by addition of EC + 75 percent NPK over the EC alone. EC also proved as better organic component than FYM and yielded 8 percent higher. The results obtained can be substantiated by the fact that incorporation of EC with NPK fertilizer in soil leads to enhance availability of nutrients by limiting their fixation and improved nutrient use efficiency in soil (Bhriguvanshi, 1988). Similarly, Saha and Hajra (2001) observed that application of phospho-compost along with recommended NPK significantly increased grain yield of groundnut crop. The effect of given treatments on straw yield was not significant. The highest straw yield (5693 kg/ha) was obtained with 75 percent NPK + EC which was 7.0 percent more than 100 percent NPK. The total uptake of nitrogen and phosphorus by soybean significantly increased with addition of 100 percent NPK and EC along with different levels of NPK. The maximum N and P uptake was recorded with application of EC+ 75 percent NPK, which was 10.0 and 16.0 percent, respectively more than 100 percent NPK. Similarly, Bhriguvanshi (1988) and Dikshit and Khatik (2002) reported that addition of organic manures along with fertilizers significantly improved NPK uptake by crop.

Table 1. Effect of integration of enriched compost with inorganic fertilizers on nodule number, nodule dry weight and shoot dry weight of soybean

Treatments	**Nodule number**			**Nodule dry weight (mg/plant)**			**Shoot dry weight (G/plant)**		
				Days after sowing					
	30	**60**	**90**	**30**	**60**	**90**	**30**	**60**	**90**
Control	15.33	21.33	16.55	62.35	135.55	117.11	11.66	14.55	25.82
100 % NPK	24.00	29.33	18.89	71.95	222.22	125.66	17.33	22.23	32.39
Enrich Compost* + 75 % NPK	26.83	34.66	25.88	122.50	223.00	127.11	18.83	26.26	38.15
Enrich Compost* +50% NPK	23.16	33.33	25.00	82.66	206.56	126.99	16.16	21.04	34.29
Enrich Compost* + 25 % NPK	19.83	34.22	24.00	86.83	227.44	128.66	16.33	20.54	32.95
Enrich Compost*	18.3	30.00	26.25	89.66	216.44	124.55	14.66	19.45	34.31
Farmyard Manure*	18.0	30.44	20.33	66.16	151.55	120.11	13.66	16.01	27.72
SEm (±)	2.26	1.20	5.75	2.96	13.63	60.54	0.99	1.84	6.55
CD at 5 %	**6.96**	**3.72**	**NS**	**9.12**	**41.99**	**NS**	**3.07**	**5.66**	**NS**

**@ 10t/ha*

Table 2. Effect of integration of enriched compost with inorganic fertilizers on seed yield, straw yield, total nutrient uptake and B:C ratio of soybean

Treatments	Seed yield (kg/ha)	Straw yield (kg/ha)	Total nutrient uptake (kg /ha)			B:C ratio
			N	P	K	
Control	2090	4133	118.02	11.17	32.81	3.31
100 % NPK	2819	5323	188.48	22.92	69.53	3.52
Enrich Compost* + 75 % NPK	2835	5693	207.34	26.58	68.73	3.29
Enrich Compost* + 50% NPK	2754	5200	189.36	21.53	70.16	3.30
Enrich Compost* + 25 % NPK	2512	4652	164.76	18.57	59.11	3.24
Enrich Compost*	2414	4468	148.95	17.23	49.34	3.29
Farmyard Manure*	2235	4420	140.88	15.57	46.43	3.11
SEM ±	101	418	10.93	2.23	16.33	-
CD at 5 %	**312**	**NS**	**33.70**	**6.89**	**NS**	**-**

**@ 10t/ha*

The maximum B:C ratio (3.52:1) was found with 100 percent NPK followed by 75 percent NPK + EC and minimum (3.11:1) with application of FYM alone (Table 2). Though it is apparent from the data that the use of chemical fertilizer is slightly economical than integrated of use of chemical fertilizer and EC, but this was the initial effect of one year only, in long term the combined application of chemical fertilizer and EC is likely to be more beneficial due to increase in soil fertility status and in turn more soybean yield. The application of EC was relatively more economical in comparison to FYM.

Application of EC in combination with 75 or 50 percent recommended NPK was found equally good as 100 percent NPK. The treatment EC + 75 percent NPK performed better than all other treatments. The EC had an edge over FYM for all the parameters studied. Therefore, it appears that application of EC @ 10 t /ha could save chemical fertilizers to the extent of 25 to 50 percent of recommended dose in cultivation of soybean.

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Soybean Research, 3: 68-72 (2005)

Effect of Integrated Nutrient Management and Spatial Arrangement on Growth and Yield of Hybrid Cotton and Soybean under Intercropping System

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Cotton is a long duration crop, cultivated in widely spaced rows. Its growth habit allows enough time and space for better utilization of natural resources and inputs leading to increased production by introduction of intercrop like soybean. Balanced nutrition is one of the major ingredients to achieve higher yields in cotton + soybean intercropping system. Considering the abundance of resource-poor farmers in the country, integrated use of organic and inorganic fertilizers is a better option to achieve enhanced fertilizer use efficiency and productivity. Therefore, a field experiment to evaluate the effect of integrated nutrient management and spatial arrangement on intercropping soybean (JS 335) in hybrid cotton (NSC 145, Bunny) was conducted during *kharif* 2004 at Instructional Farm, Indira Gandhi Agricultural University, Raipur. The soil of the experimental site belonged to *Vertisols* and neutral in reaction (pH 7.24) with low available nitrogen (217 kg/ha), medium available phosphorus (12.86 kg/ha) and high available potassium (364 kg/ha). The experiment was laid out in a randomized block design with three replications and 14 treatments combinations (Table 1). In integrated nutrient treatments, required quantity of urea, single super phosphate and muriate of potash were thoroughly mixed with exact quantity of air dried FYM (containing 0.58, 0.19, 0.50 and 19.0 percent N, P, K and moisture, respectively) with sprinkling of light water followed by incubation for 48 hours prior to its application. For top dressing, blended urea was applied. The crops were and sown on June 27.

Results showed that the plant height, number of branches per plant and dry matter accumulation at harvest recorded were highest under both the sole crops with 100 percent recommended dose of fertilizers (RDF) which was statistically at par with cotton + soybean (2:2) + 100 percent RDF and cotton + soybean (2:4) + 100 percent RDF (Table 1). The reduction in growth parameters of crops under intercropping system as compared to respective sole crops may be due to increased

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competition. The results were in agreement with the findings of Pujari *et al*. (2001).

Sole cotton with 100 percent RDF recorded significantly higher number of bolls per plant as compared to other intercropping treatment. The maximum yield of seed and stalk was noted in sole cotton with 100 percent RDF followed by cotton + soybean in 2:2 and 2:4 row combination with 100 percent RDF and in 2:2 row combination with 75 percent RDF + 1 t FYM per hectare. Considerable reduction in cotton yield due to intercropping could be accounted to luxuriant growth of soybean as compared to cotton, which caused higher degree of competition for natural resources. These results are in agreement with the findings of Wankhede and Saraf (1997) and Padhi *et al.* (1998). Seed cotton and stalk yield increased with successive increase in the levels of nutrients reaching maximum with 100 percent RDF under sole cotton (Table 2).

Significantly highest number of pods per plant were noted under the treatment sole soybean with 100 percent RDF, which was statistically at par with cotton + soybean (1:4) with 100 percent RDF. The number of seeds per pod recorded was highest under sole soybean with 100 percent RDF. No significant differences were noticed in 100-seed weight due to various treatments. These results are in line with those reported by Panneerselvum and Lourduraj (1998). The maximum seed and straw yield of soybean was recorded under sole soybean with 100 percent RDF followed by cotton + soybean in 1:4 and 2:4 row ratio with 100 percent RDF and in 1:4 row ratio with 75 percent RDF + 1 t FYM per hectare. These treatments were at par among each other but significantly superior to others. Under sole soybean there was less competition effect for nutrient, light and space, which could have led to higher yield. Use of 100 percent RDF in sole soybean produced significantly highest yield (Table 2). Greater nutrient availability and dry matter production might also have facilitated the enhancement in yield. These results reaffirm the findings of Mishra *et al*. (1996) and Tiwari *et al*. (1998).

The highest system productivity (4998 kg/ha) was recorded under cotton + soybean (2:4) + 100 percent RDF, which was at par with the 2:4 row combination + 1 t FYM /ha + 75 percent RDF (4842 kg/ha). The comparatively higher yield due to less competition among the crops under this treatment increased the total productivity. Giri *et al*. (2003) also reported similar yield advantage in cotton based intercropping system. The land equivalent ratio was the highest (1.64) under the treatment cotton + soybean (2:4) + 100 percent RDF which was significantly superior to all other treatments, except cotton + soybean (2:4) + 1 t FYM /ha + 75 percent RDF, which was found to be at par with cotton + soybean (2:4) + 100 percent RDF. The maximum monetary advantage (Rs. 12, 525 /ha) was noted under cotton + soybean (2:4) + 100 percent RDF due to higher yield of component crops and also due to less competition among component crops (Table 2).

The intercropping of cotton + soybean (2:4) + 100 percent RDF performed the best in term of yield, land equivalent ratio and monetary advantage. The comparable performance of cotton + soybean (2:4) + 1 t FYM /ha +75 percent RDF provides next suitable options to get maximum yield from cotton + soybean intercropping system.

Table 1. Growth of hybrid cotton and soybean as affected by different treatments

Treatment	Plant height at harvest (cm)		Branches/plant at harvest (No.)		Dry matter accumulation at harvest (g/plant)	
	Cotton	Soybean	Cotton	Soybean	Cotton	Soybean
Sole cotton + 100% RDF*	80.7	-	17.6	-	98.7	-
Sole soybean + 100% RDF**	-	42.5	-	4.9	-	27.7
Cotton + soybean (2:2) + 100 % RDF	78.4	36.3	14.9	3.5	96.7	21.6
Cotton + soybean (2:2) + FYM @ 1 t / ha + 75% RDF	77.6	35.8	13.8	3.4	94.4	21.4
Cotton + soybean (2:2) + FYM @ 2 t / ha + 50% RDF	76.2	34.4	13.2	3.3	92.5	20.3
Cotton + soybean (2:2) + FYM @ 2 t /ha + 50% RDF + FYM @ 0.5 t / ha with urea (top dressing)	76.8	34.9	13.7	3.3	92.6	20.8
Cotton + soybean (2:4) + 100 % RDF	77.6	39.3	14.1	4.1	95.2	24.0
Cotton + soybean (2:4) + FYM @ 1 t /ha + 75% RDF	76.9	38.3	13.1	3.9	93.2	22.8
Cotton + soybean (2:4) + FYM @ 2 t /ha + 50% RDF	75.2	36.3	12.7	3.5	91.6	21.6
Cotton + soybean (2:4) + FYM @ 2 t /ha + 50% RDF+ FYM @ 0.5 t /ha with urea (top dressing)	75.4	36.9	12.8	3.7	91.7	21.7
Cotton + soybean (1:4) + 100 % RDF	75.0	40.3	12.3	4.3	91.5	26.0
Cotton + soybean (1:4) + FYM @ 2 t /ha + 75% RDF	74.3	39.1	12.2	3.9	89.6	24.6
Cotton + soybean (1:4) + FYM @ 2 t /ha + 50% RDF	73.6	37.3	11.1	3.7	88.5	24.0
Cotton + soybean (1:4) + FYM @ 2 t /ha + 50% RDF + FYM @ 0.5 t /ha with urea (top dressing)	73.7	37.5	11.5	3.8	88.5	24.2
SEm$\pm$	1.13	0.40	0.25	0.09	0.38	0.26
CD (P=0.05)	3.31	1.19	0.74	0.27	1.13	0.77

**(100:60:40 kg N: P_2O_5: K_2O /ha); **(30:60:40 kg N:P_2O_5: K_2O /ha)*

Table 2. Yield attributes, yield, total productivity of hybrid cotton and soybean and LER as affected by different treatments

Treatment	Cotton			Soybean					Total Productivity *** (kg/ha)	LER	Monetary advantage (Rs/ha)
	Bolls/ plant at harvest (No.)	Seed cotton yield (kg/ha)	Stalk yield (kg/ha)	Pods/ plant (No.)	Seeds/ pod (No.)	100-seed weight (g)	Seed yield (kg/ha)	Stover yield (kg/ha)			
Sole cotton + 100% RDF*	29.7	1007	1563	-	-	-	-	-	1772	1.00	-
Sole soybean + 100% RDF**	-	-	-	32.2	2.54	12.97	2094	2627	4188	1.00	-
Cotton + soybean (2:2) + 100 % RDF	27.9	814	1356	25.2	203	12.21	1530	2121	4493	1.54	10363
Cotton + soybean (2:2) + FYM @ 1 t / ha + 75% RDF	26.9	780	1312	24.2	2.01	12.13	1487	2080	4346	1.48	9327
Cotton + soybean (2:2) + FYM @ 2 t / ha + 50% RDF	25.3	687	1219	23.4	1.82	12.07	1376	1972	3961	1.34	6544
Cotton + soybean (2:2) + FYM @ 2 t /ha + 50% RDF + FYM @ 0.5 t / ha with urea (top dressing)	25.9	708	1222	23.8	1.95	12.11	1398	1988	4043	1.37	7140
Cotton + soybean (2:4) + 100 % RDF	26.9	790	1326	28.6	2.35	12.51	1804	2415	4998	1.65	12525
Cotton + soybean (2:4) + FYM @ 1 t /ha + 75% RDF	25.9	762	1299	27.2	2.23	12.31	1750	2388	4842	1.59	11482
Cotton + soybean (2:4) + FYM @ 2 t /ha + 50% RDF	24.3	668	1198	25.5	2.06	12.23	1614	2238	4404	1.43	8429
Cotton + soybean (2:4) + FYM @ 2 t /ha + 50% RDF+ FYM @ 0.5 t /ha with urea (top dressing)	24.4	692	1210	25.6	2.10	12.27	1638	2260	4394	1.47	9117
Cotton + soybean (1:4) + 100 % RDF	24.1	508	1050	30.9	2.43	12.57	1834	2435	4562	1.38	7497
Cotton + soybean (1:4) + FYM @ 2 t /ha + 75% RDF	23.6	484	1014	28.3	2.30	12.35	1783	1391	4418	1.33	6552
Cotton + soybean (1:4) + FYM @ 2 t /ha + 50% RDF	22.2	397	946	26.1	2.08	12.31	1653	2266	4004	1.18	3637
Cotton + soybean (1:4) + FYM @ 2 t /ha + 50% RDF + FYM @ 0.5 t /ha with urea (top dressing)	22.5	416	969	26.8	2.15	12.33	1680	2285	4090	1.22	4268
SEm±	**2.0**	**1.5**	**06.3**	**0.53**	**0.28**	**0.18**	**02.5**	**2.7**	**6.4**	**0.02**	
CD (P=0.05)	**5.9**	**4.5**	**18.5**	**1.57**	**NS**	**NS**	**07.3**	**7.9**	**18.8**	**0.06**	

*Price of produce - Cotton Seed @ Rs. 17.60/kg,;Cotton stalk @ Rs. 0.50/kg; Soybean seed @ Rs. 10.0/kg; Soybean stalk @ Rs. 0.50/kg; *(100:60:40 kg N: P_2O_5: K_2O /ha); **(30:60:40 kg N:P_2O_5: K_2O /ha; ***Total Productivity (cotton yield + cotton equivalent yield of soybean)*

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Evaluation of Compatible Combinations of *Bacillus Thuringiensis*, Insecticide and Fungicides for Green Semilooper and Pod Blight of Soybean (*Glycine max*)

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Soybean [*Glycine max* (L.) Merrill] is infested by many defoliators as well as foliar diseases during 30 to 40 days after sowing (DAS). Infestation of stem boring, girdle beetle also occurs during this period. Green semilooper and pod blight have also become perpetual problems in some areas of humid south eastern plain zone V of Rajasthan at post-flowering stage, which requires proper control measures so that loss can be minimized. However, sole dependence on chemical pesticides leads to numerous problems related to agriculture and human health. As an alternative microbial pesticide, *Bacillus thuringiensis* (Bt) has been tested and found to be highly effective against various insect-pests (Ansari and Sharma, 2000).

Present practice of insect and disease control is to spray insecticides and fungicides separately, which is not only time consuming and expensive but also labour intensive. To overcome these problems and to reduce the number of sprays and cost of application, experiments were conducted to find out the compatibility between microbial insecticides, synthetic insecticide and fungicides, so that tank mixture of either of these can be sprayed for effective management of insect pests and diseases.

The field experiments were conducted in a randomized block design with 3 replications during *kharif* 2001 and 2003 at Agricultural Research Station, Kota to evaluate the effect of compatible combination of *Bacillus thuringiensis,* insecticide and fungicides for the management of major defoliator (*Chrysodeixis acuta*) and anthracnose and pod blight disease caused by *Colletotrichum truncatum.* The plot size consisted of seven rows of 5-meter length with row-to-row distance of 30 cm. All the agronomical practices were followed as per the zonal recommendations. The first spraying was done at 30-35 DAS and second after 15 days. The population of *Chrysodeixis acuta* was recorded one day before and 7 days after spraying. Observation on anthracnose and pod blight was taken on 10 plants per plot after 7 days of spraying. The data

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Table 1.Evaluation of compatible combinations of *Bacillus thuringiensis*, insecticide and fungicides for insect pests and disease management in soybean

Treatment	Dose /ha	Green semilooper (pmrl) 7 DAT			Pod blight incidence (PDI)			ICBR	Seed Yield (kg/ha)		
		2001	**2003**	**Pooled**	**2001**	**2003**	**Pooled**		**2001**	**2003**	**Pooled**
Bt.	1.0 l	0.95	0.89	0.91	43.58	40.30	41.94	-	1467	1857	1657
Monocrotophos	0.8 l	0.83	0.60	0.71	45.58	43.02	44.30	-	1428	1936	1681
Carbendazim	@ 0.05 %	3.33	2.38	2.85	25.38	26.49	25.93	-	1269	1302	1285
Thiophanate methyle	@ 0.05 %	3.33	2.38	2.85	32.32	31.77	32.04	-	1309	1396	1300
Triadimefon	@ 0.05 %	3.22	2.50	2.86	43.03	43.01	43.02	-	1209	1301	1237
Bt + monocrotophos.	@ 1.0 l + 0.8 l	0.44	0.55	0.49	46.15	44.76	45.45	4.48	1785	1968	1896
Bt + carbendazim	@ 1.0 l + 0.05 %	1.22	1.27	1.24	26.49	29.51	28.00	2.63	1348	1556	1612
Bt + thiophanate methyle	@ 1.0 l + 0.05 %	1.11	1.22	1.16	31.40	30.84	31.12	1.91	1388	1714	1614
Bt + triadimefon	@ 1.0 l + 0.05 %	1.06	1.25	1.16	35.40	39.60	37.50	1.13	1388	1612	1601
Bt + monocrotophos. + carbendazim	@ 1.0 l + 0.8 l + 0.05 %	0.44	1.16	0.86	27.52	28.56	28.04	2.83	1586	1936	1760
Bt + monocrotophos + thiophanate methyle	@ 1.0 l + 0.8 l + 0.05 %	0.44	0.72	0.58	33.40	35.40	34.40	2.37	1467	1936	1719
Untreated control	-	3.39	3.66	3.52	59.37	48.10	53.76		1011	1174	1098
SEm ±		0.08	0.14	0.23	3.40	2.19	2.67		61	195	90
CD (P=0.05)		**0.23**	**0.42**	**0.67**	**9.99**	**6.44**	**7.62**		**181**	**490**	**267**

pmrl – Population per meter row length; DAT – Days after treatment; PDI – Percent disease index; ICBR = Incremental cost benefit ratio thus obtained of both the sprays were averaged and subjected to statistical analysis. The pest disease index PDI was calculated by using the method described by Mayee and Datar (1986) and categorized on 0-9 scale. The yield data were taken plot--wise at harvest and expressed on per hectare basis. The incremental cost benefit ratio due to particular combination was also worked out

The data presented in table 1 revealed that the minimum population of green semilooper, *Chrysodeixis acuta* was observed in combination of Bt (@ 1.0 l/ha) + monocrotophos (@ 0.8 l/ha) after 7 days of spraying which gave the highest seed yield (1896 kg/ha) with maximum ICBR (4.48) followed by combination of Bt (@ 1.0 l/ha) + monocrotophos (0.8 l/ha) + carbendazim (0.05 %) per ha, and Bt (@ 1.0 lit/ha) + monocrotophos (@ 0.8 l/ha) + thiophanate methyle (0.05 %) with 1760 and 1719 kg per ha seed yield and 2.83 and 2.37 (ICBR) respectively. However, in seed yield and controlling the major defoliator *Chrysideixis acuta,* these three combinations were statistically *at par*, while in controlling the anthracnose and pod blight, combination of Bt (@ 1.0 l/ha) + monocrotophos (0.8 l/ha) + carbendazim (0.05 %) per ha, and Bt (@ 1.0 l/ha) + monocrotophos (0.8 l/ha) + thiophanate methyle (0.05 %) were also statistically at par. Similar results were also obtained by Ansari and Sharma (1999 and 2000), who reported that monocrotophos was found compatible with Bt and carbendazim .

The increase in the efficiency of biological component (Bt) in the tank-mix formulations with chemical pesticides has earlier been reported by Jaques (1988) This practice not only helps to reduce usage of synthetic chemical with proven hazardous consequences but also saves the time and energy.

The study suggests that for the management of insect pests and diseases of soybean Bt (1.0 l/ha) + monocrotophos (0.8 l/ha) was found most remunerative with higher seed yield (1896 kg/ha) and ICBR (4.48) followed by Bt (1.0 l/ha) + monocrotophos (0.8 l./ha) + carbendazim (0.05 %) and Bt. (1.0 l/ha) + monocrotophos (0.8 l/ha) + thiophanate methyle (0.05 %). Both the combinations are statistically at par with combinations of Bt. (1.0 l./ha) + monocrotophos (0.8 l/ha). These compatible combinations are equally good in controlling the green semilooper (*Chrysodeixis acuta*) population and incidence of anthracnose and pod blight caused by *Colletotrichum truncatum.*

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Influence of Organic Amendments and Biorationals on Pod Borer Damage in Soybean (*Glycine max* (L.) Merrill)

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Soybean [*Glycine max* (L.) Merrill] is an important oilseed crop, containing about 40-43 per cent protein and about 20 per cent oil. Soybean protein is rich in amino acids like lysine, methionine and cystine. The area under this crop in India has spectacularly increased from merely 0.03 million ha in 1970-71 to 7.2 million in 2004-05 (Anonymous, 2005). In spite of this spectacular increase in area, the national productivity in India (1 tonne/ha) is only about half of the world average productivity (2.2 tonnes/ha). Among other constraints, biotic as well as abiotic factors are considered to be responsible for this lower productivity. 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 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 (Singh, 2001).

As in any other crop, to tackle the pest problem, indiscriminate use of synthetic chemical insecticides was undertaken in soybean also. This led to many serious problems like environmental contamination by way of pesticide residues, development of resistance in pests to pesticides, pest resurgence, etc. In this context present investigation was carried out to evaluate the eco-friendly and environmentally safe components like organic amendments, biorationals, *etc*.

A field experiment was laid out during the *kharif* 2004 at Main Agricultural Research Station, Dharwad, using the soybean cultivar JS 335. Split plot design was adopted with 5 treatments in the main plots (recommended dose of fertilizers + organic amendments) and 4 treatments (biorationals) in the sub-plots, along with two checks (Table 1) replicated thrice. The crop was sown at a spacing of 30 cm x 10 cm in a plot size of 12 m^2. The organic amendments were applied in the respective plots as basal application, *i.e.* at the time of sowing itself. Three sprays of biorationals were given during the morning hours at 45, 60 and 75 days after sowing (DAS).

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For preparing the extracts, fresh plant material was collected from the campus of Main Agricultural Research Station, Dharwad. To prepare neem seed kernel extract (NSKE) 5 percent, 50 g of smashed seeds of neem were soaked overnight in one litre of water, squeezed through muslin cloth and the extract was collected and used for spraying.

Fresh leaves of the respective plants (*Vitex negundo* and *Pongamia pinnata*) were collected, washed thoroughly 3-4 times with tap water and chopped into small pieces. Fifty g of the chopped material was soaked over-night 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 per cent leaf extract for spraying. Vermiwash collected from the vermicompost trays, was diluted with water in the ratio 1:2 and used for spraying.

Observations were made on pod damage and seed yield at harvest. For percent pod damage, 10 plants were selected at random from each plot and total number of pods and damaged pods from each plant was counted and mean was calculated. The percent pod damage was calculated (Percent pods damaged = number of damaged pods/total number of pods x 100) and the data was transformed to arcsine values for reliable analysis. On maturity, the yield data from each plot was recorded and expressed as kg per ha. Yield data and percent pod damage data were statistically analysed using ANOVA technique and the mean values were subjected to Duncan's Multiple Range Test (DMRT).

Efficacy of organic amendments and biorationals on pod damage

Among the organic amendments, the percent pod damage ranged from 25.80 percent in recommended dose of fertilizer (RDF) + FYM @ 5 t per ha + neem cake @ 500 kg per ha to 38.48 per cent in RDF + vermicompost @ 2.5 t per ha (Table 1). Least percent pod damage (25.80%) was on par with RDF + FYM + neem cake @ 250 kg per ha (26.77 %). Highest percent pod damage (38.48%) was observed to be on par with RDF + vermicompost + neem cake @ 250 kg per ha (34.10%). Among the biorationals, NSKE (5 %) recorded least percent pod damage (29.74 %) followed by 5 percent *Vitex negundo* leaf extract (31.65 %), 5 percent *Pongamia pinnata* leaf extract (32.40 %) and vermiwash (at par31.65 %), all later being.

The interaction effect between organic amendments and biorationals (23.67 to 40.14 % damaged pods) was significantly superior over untreated control (47.59 %). The recommended insecticide (quinalphos 25 EC @ 2 ml/l) employed for treated control recorded the least percent pod damage (21.21%), which was significantly superior over all other treatments. Among other interactions, lower percent pod damage was noticed in RDF + FYM @ 5 t/ha) + neem cake @ 250 kg per ha x NSKE (5%), RDF + FYM @ 5 t per ha + neem cake @ 500 kg per ha x NSKE (5 %), RDF + FYM @ 5 t per ha+ neem cake @ 500 kg per ha x *Vitex negundo* leaf extract (5 %), RDF + FYM @ 5 t per ha + neem cake @ 500 kg per ha x *Pongamia pinnata* leaf extract (5 %), RDF + FYM @ 5 t per ha + neem cake @ 500 kg per ha x vermiwash and RDF + FYM @ 5 t per ha + neem cake @ 250 kg per ha x vermiwash recording a per cent pod damage of 23.67, 25.51, 25.51, 26.77, 25.51 and 26.00 percent, respectively. All these treatments did not differ significantly among themselves.

Effect of organic amendments and biorationals on the grain yield of soybean

Among the organic amendments, RDF + vermicompost @ 2.5 t per ha + neem cake @ 500 kg per ha and RDF + FYM @ 5 t per ha + neem cake @ 500 kg per ha recorded the highest yield of 1308.4 kg per ha and 1302.3 kg per ha, respectively (Table 2). These treatments were on par with RDF + vermicompost @ 2.5 t per ha + neem cake @ 250 kg per ha (1244.5 kg/ha) and RDF + FYM @ 5 t per ha + neem cake @ 250 kg per ha (1205.5 kg/ha). Lowest seed yield (1104.9 kg/ha) was associated with RDF + vermicompost @ 2.5 t per ha, which was on par with above two treatments. In case of the biorationals, highest yield (1300.3 kg/ha) was recorded in NSKE (5 %), which was on par with *Vitex negundo* leaf extract (5%) and *Pongamia pinnata* leaf extract (5 %) which recorded, 1225.5 and 1225.2 kg/ha respectively. Lowest yield was recorded in vermiwash (1181.4 kg/ha), which was at par with above two treatments.

The interaction effect between organic amendments and biorationals (1055.5 to 1405.8 kg/ha) was significantly superior over untreated control (613.8 kg/ha), but were significantly lower than standard check (1541.5 kg/ha). RDF + vermicompost @ 2.5 t per ha + neem cake @ 500 kg per ha x NSKE recorded highest seed yield of 1405.8 kg per ha, which was on par with RDF + vermicompost @ 2.5 t per ha + neem cake @ 250 kg per ha x NSKE (5 %), RDF + FYM @ 5 t per ha + neem cake @ 250 kg per ha x NSKE (5 %), RDF + FYM @ 5 t per ha + neem cake @ 500 kg per ha x NSKE (5 %), RDF + FYM @ 5 t per ha + neem cake @ 500 kg per ha x *Vitex negundo* leaf extract (5%,) RDF + vermicompost @ 2.5 t per ha + neem cake @ 500 kg per ha x *Vitex negundo* leaf extract (5 %), RDF + FYM @ 5 t per ha + neem cake @ 500 kg per ha x *Pongamia pinnata* leaf extract (5 %) and RDF + vermicompost @ 2.5 t per ha + neem cake @ 500 kg per ha x *Pongamia pinnata* leaf extract (5 %), which recorded seed yield of 1347.8, 1299.1, 1329.4, 1317.2, 1306.6, 1310.5 and 1274.4 kg per ha, respectively. In general, RDF + vermicompost x vermiwash sprays recorded relatively lesser yield.

The results of this investigation gains support from earlier work on utility of integrating nutrition with insecticide in managing pod borers (*Maruca testulalis* Geyer and *Lampides boeticus* Linn.) in green gram (Gatoria and Singh, 1988), of integrating nutrient supplementation with cultural and plant protection measures for management of pod borer complex of pigeonpea (Badaya *et al.*, 1990) and of integrated use of fertilizers, manures and biorationals for managing the *Spodoptera litura* Fabricius and *Helicoverpa armigera* Hubner in groundnut (Rao, 2003). The present findings are in conformity with the report of Bhat *et al.* (1988) who reported that neem seed extract (5 %) was the next best treatment to monocrotophos against *M. testulalis* and *Cydia ptychora* (Meyrick)

Table 1. Influence of organic amendments and biorationals on pod borers damage and productivity of soybean

Treatments	Pod damage (%)	Per cent reduction over control	Seed yield (kg/ha)	Additional yield over control (kg/ha)
Organic amendments				
RDF* + vermicompost @ 2.5 t//ha	38.48 a	9.11	1104.9b	145.1
RDF + vermicompost @ 2.5 t//ha + neem cake @ 250 kg/ha	34.10 ab	13.49	1244.5ab	284.7
RDF + vermicompost @ 2.5 t//ha + neem cake @ 500 kg/ha	31.46 bc	16.13	1308.4a	348.6
RDF + FYM @ 5 t/ha + + neem cake @ 250 kg/ha	26.77 cd	20.82	1205.5ab	245.7
RDF + FYM @ 5 t/ha + neem cake @ 500 kg/ha	25.80 d	21.79	1302.3a	342.5
Biorationals				
NSKE (5 %)	29.74 b	17.85	1300.3a	340.5
Vitex negundo leaf extract (5 %)	31.65 a	15.94	1225.5ab	265.5
Pongamia pinnata leaf extract (5 %)	32.40 a	15.19	1225.2ab	265.4
Vermiwash (1:2)	31.65 a	15.94	1181.4b	221.6
Interaction				
RDF + vermicompost @ 2.5 t/ha x NSKE (5 %)	28.30 gh	19.29	1119.4ghi	159.6
RDF + vermicompost @ 2.5 t/ha + neem cake @ 250 kg/ha x neem seed kernel extract (5 %)	32.69 e	14.90	1347.8bc	388.0
RDF + vermicompost @ 2.5 t/ha + neem cake @ 500 kg/ha x neem seed kernel extract (5 %)	28.12 gh	19.47	1405.8b	446.0
RDF + FYM @ 5 t/ha + neem cake @ 250 kg/ha x neem seed kernel extract (5 %)	23.67 i	23.92	1299.1bcde	339.3
RDF + FYM @ 5 t/ha + neem cake @ 500 kg/ha x neem seed kernel extract (5 %)	25.51 i	22.08	1329.4bcd	369.6
RDF + FYM @ 5 t/ha + neem cake @ 500 kg/ha x *Vitex negundo* leaf extract (5 %)	25.51 i	22.08	1317.2bcd	357.4
RDF + FYM @ 5 t/ha + neem cake @ 250 kg/ha x *Vitex negundo* leaf extract (5 %)	28.60 g	18.99	1178.3d-i	218.5
RDF + vermicompost @ 2.5 t/ha + neem cake @ 500 kg/ha x *Vitex negundo* leaf extract (5 %)	30.89 f	16.70	1306.6b-e	346.8
RDF + vermicompost @ 2.5 t/ha + neem cake @ 250 kg/ha x *Vitex negundo* leaf extract (5 %)	35.32 d	12.27	1228.1c-h	268.3
RDF + vermicompost @ 2.5 t/ha + neem cake @ 500 kg/ha x *Vitex negundo* leaf extract (5 %)	37.74 c	9.85	1097.5hi	137.7
RDF + FYM @ 5 t/ha + neem cake @ 250 kg/ha x *Pongamia pinnata* leaf extract (5 %)	28.60 g	18.99	1186.1d-i	226.3
RDF + vermicompost @ 2.5 t/ha + neem cake @ 250 kg/ha x *Pongamia pinnata* leaf extract (5 %)	32.59 e	15.00	1207.7c-h	247.9
RDF + FYM @ 5 t/ha + neem cake @ 500 kg/ha x *Pongamia pinnata* leaf extract (5 %)	26.77 hi	20.82	1310.5bcd	350.7
RDF + vermicompost @ 2.5 t/ha + neem cake @ 500 kg/ha x *Pongamia pinnata* leaf extract (5 %)	33.73 e	13.86	1274.4b-f	314.6
RDF + vermicompost @ 2.5 t/ha x *Pongamia pinnata* leaf extract (5 %)	40.14 b	7.45	1147.2f-i	187.4
RDF + FYM @ 5 t/ha + neem cake @ 500 kg/ha x vermiwash (1:2)	25.51 i	22.08	1252.2c-g	292.4
RDF + vermicompost @ 2.5 t/ha + neem cake @ 500 kg/ha x vermiwash (1:2)	33.07 e	14.52	1246.6c-h	286.8
RDF + FYM @ 5 t/ha + neem cake @ 250 kg/ha x vermiwash (1:2)	26.00 i	21.59	1158.3e-i	198.5
RDF + vermicompost @ 2.5 t/ha x vermiwash (1:2)	37.74 c	9.85	1055.5i	95.7
RDF + vermiwash @ 2.5 t/ha + neem cake @ 250 kg/ha x vermiwash (1:2)	35.79 d	11.80	1194.4d-i	234.6
RDF + FYM @ 5 t/ha + recommended plant protection (Check)	21.21 j	25.38	1541.5a	581.7
RDF + No Plant Protection (Untreated Check)	47.59 a	-	613.8j	0.00

*Means followed by same letters in the column in each section are not statistically different by DMRT; *Recommended dose of fertilizers: 40:80:30 kg NPK/ha* in cowpea. Rabindra *et al*. (1991) reported that combined use of NPV and *V. negundo* leaf extract can reduce the pod damage in chickpea by *H. armigera*. Sharanabasappa (2002) observed that pod damage by *C. ptychora* in greengram was lowest in NSKE 5 percent treated plots. Ladaji (2004) observed pongamia leaf extract + NSKE 5 percent + aloe + cowurine recorded highest percent mortality of *H. armigera* in chickpea.

The study brings out that although the use of recommended dose of fertilizers in combination with farm yard manure and neem cake along with biorationals are not comparable to that of chemical control in reducing pod borer damage and increasing the seed yield of soybean, their integrated use can moderate damage by the pest and enhances productivity and emeritus adoption on account of eco-friendly nature which can lead to safer environment.

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