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Evaluation of G x E Interaction in Food Grade Soybean Genotypes

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ABSTRACT

Twelve green seeded and determinate vegetable type soybean strains, developed from five different crosses, were evaluated in four environments (kharif 2004, 2005, 2006 and 2007) for stability parameters using Eberhart and Russell (1966) model. Three strains, [P5-1 (H-1520 x H-330), P69-8-1-1-1 (H-330 x Hardee) and H-1520 (Ankur x H-330)], showed average response to change in environmental conditions for number of branches per plant. Other three strains [P6-1 (Hardee x H-330), P69-8-1-1 (H-330 x Hardee) and P69-8-4-4 (H-330x Hardee)] indicated their adaptation to specific favorable environments for this trait. The strain P169-3 (H-1520 x H-330), which had higher number of branches (3.35 each) as compared to the 'Hara Soya' (3.28), also showed promise as a stable genotype with average response to change in environments for this trait. One genotype [P6-1 (Hardee x H-330)] had 100-seed weight (17.90 g) equivalent to the population mean (17.91 g) but higher than the food grade check 'Hara Soya' (14.90 g) with non-significant deviation from regression and regression value > 1 indicating the stability of the strain and its adaptation to specific favorable environments. The strain P169-3 (H-1520 x H-330) showed higher 100-seed weight (14.98 g) than the check 'Hara Soya' (14.90 g) with very low non-significant deviation from regression and regression value < 1 indicating thereby the stability of the strain and its responsiveness to specific poor environments. The study was able to identify potential food grade soybean strains for cultivation in the mid-hills of Himachal Pradesh.

Key words: Food grade soybean, G x E interaction, stability analysis

Soybean (*Glycine max* L. Merrill) is an important leguminous crop valued for high protein as well as for oil content. It has emerged as the main oil seed crop in India since 2005 (Anonymous, 2008). In Himachal Pradesh, this crop is grown mainly in the mid-hills under rainfed conditions and primarily is being used as

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pulse as well as vegetable by the resource poor hill farmers. The crop can be raised in all parts of the state except areas above 2,200 m amsl. Moreover, the seed produced in the Himachal Pradesh has better quality and is superior in germinability. The early maturing soybean genotypes with bold (high test weight) and green seeds (green cotyledons with transparent seed coat) having characters like grey pubescence, large pod size (2-3 seeds/pod), sweeter in taste, easy to cook (10-12 minutes) with low content of lipoxygenase enzyme (negligible beany flavour) along with low content of flatulence causing raffinose and stachyose sugars, etc. are considered as 'food grade' traits and such genotypes are preferred by the farmers for culinary purpose. The green pods of food grade soybeans, i. e., vegetable type soybeans, can be used just like green peas and dried beans like dried peas. The green seeded soybeans are rich in protein, isoflavones, calcium, potassium, phosphorous, vitamin A, C and E, and dietary fibers (Basavaraja *et al*., 2005). The first-ever green seeded vegetable type soybean variety 'Hara Soya' was developed by our centre and was released for general cultivation in the northern hill zone of the country during 2000-2001. Soaring prices of pulses during past few years have led to the intensification of breeding efforts for the development of more varieties of vegetable type soybeans. Keeping these things in view, the present study was conducted to identify potential soybean genotypes with food grade traits having stable performance over years.

MATERIAL AND METHODS

The experimental material comprised 12 green seeded and determinate vegetable type soybean strains [P5-1 (H-1520 x H-330), P5-2 (H-1520 x H-330), P6-1 (Hardee x H-330), P8-1 (H-1520 x H-330), P69-8-1-1 (H-330 x Hardee), P8-2 (H-1520 x H-330), P69-8-1-1-1 (H-330 x Hardee), P69-8-3-1 (H-330 x Hardee), P69-8-3-3 (H-330x Hardee), P69-8-4-4 (H-330x Hardee), P169-3 (H-1520 x Bragg) and H-1520 (Ankur x H-330)], developed from five different crosses at Palampur. These genotypes, along with two checks ('Bragg' – yellow seeded check and 'Hara Soya' – a food grade green seeded check), were evaluated during *kharif* 2004, 2005, 2006 and 2007 (using four environments) at Palampur in a randomized block design (RBD) with three replications. The sowing was done during the first fortnight of June in all the years. The crop was raised using recommended package of practices and observations were recorded on days to flowering, days to maturity, plant height (cm), number of branches per plant, seeds per pod, 100-seed weight (g) and seed yield (q/ha). The data were analyzed for stability parameters using Eberhart and Russell (1966) model.

RESULTS AND DISCUSSION

Analysis of variance for pooled data over the years revealed significant differences among genotypes for all the traits studied (Table 1). Highly significant differences were observed for environments for all the traits except number of branches per plant. The genotype x environment (G x E) interaction was found to be significant for all the traits except seeds per pod and grain yield. The environment + G x E interactions were significant for days to flowering, days to maturity, plant height and seed yield when tested against pooled error which indicated that genotypes interacted considerably with environments in the expression of these traits. Significant mean sum of squares due to environments (linear) against pooled deviation for all the traits were indicative of considerable differences among the environments and their pre-dominant effects on these characters. This could be due to varied environmental conditions over years. The G x E interaction (linear) was non-significant against pooled deviation for all the traits except days to maturity. Non-significant and lower magnitude of pooled deviation for number of branches, seeds per pod and seed yield indicated linear response of genotypes for these characters due to change in environment. Mebrahtu and Elmi (1997) and Pan *et al*., (2007) have also reported significant environmental variations over years in soybean genotypes for food grade traits. Significant pooled deviation for days to flowering, days to maturity, plant height and 100-seed weight indicated non-linear response of the genotypes due to environmental changes and role of unpredictable components of G x E interaction towards differences in stability of genotypes. However, even for unpredictable traits, prediction can still be made on considering stability parameters of individual genotypes (Singh *et al*., 1991; Pan *et al*., 2007

As per Eberhart and Russell (1966), an ideal stable genotype would be the one, which has high mean (greater than the population mean), regression coefficient equivalent to unity (bi=1) and non-significant deviation from regression ($s^2di=0$). Accordingly, the stability parameters were worked out for days to flowering, days to maturity, plant height, number of branches per plant and 100-seed weight as G x E interactions were significant for these characters only. Although, five strains [P5-1 (H-1520 x H-330), P8-1 (H-1520 x H-330), P8-2 (H-1520 x H-330), P169-3 (H-1520 x Bragg) and H-1520 (Ankur x H-330)] exhibited earliness over population mean for days to flowering and maturity, none was found to be stable over environments as all the strains showed significant deviation from regression for these traits (Table 2). For plant height, five strains [P5-2 (H-1520 x

Table 1. Pooled analysis of variance (mean sum of squares) for different characters in food grade soybeans

Source of variation	d. f.	Days to flowering	Days to maturity	Number of branches per plant	Plant height (cm)	Seeds per pod	100-seed weight (g)	Grain yield (kg/ha)
Genotype (G)	13	54.31*	101.18*	0.61*	169.69*	0.02*	12.14*	681*
Environment (E)	3	666.46*	1539.08*	0.79	2137.00*	0.34*	10.72*	3385*
Genotype x Environment (G x E)	39	30.49*	26.36*	0.95*	176.12*	0.03	3.29*	844
Environment + (G x E)	42	57.04*	118.09*	0.35	207.18*	0.03	1.79	503*
Environments (linear)	1	1999.37+	4617.29+	2.38+	6411.03+	1.02+	32.15+	10156+
G x E (linear)	13	12.39	16.46+	0.44	7.74	0.008	0.43	402
Pooled deviation	28	8.41*	4.59*	0.24	78.20*	0.008	1.33*	205
Pooled error	104	0.079	0.06	0.16	15.10	0.007	0.14	161

**Significant against pooled error ms at P≤0.05; + significant against pooled deviation ms at P≤0.05*

H-330), P6-1 (Hardee x H-330), P69-8-3-1 (H-330 x Hardee), P69-8-4-4 (H-330x Hardee) and H-1520 (Ankur x H-330)] recorded higher plant height over grand mean, non-significant s^2di values and unit regression (b=1), which indicated their stability and general adaptability over environments.

Six strains [P5-1 (H-1520 x H-330), P6-1 (Hardee x H-330), P69-8-1-1 (H-330 x Hardee), P69-8-1-1-1 (H-330 x Hardee), P69-8-4-4 (H-330x Hardee) and H-1520 (Ankur x H-330)] exhibited higher number of branches per plant over population mean (3.64) and non-significant deviation from regression (Table 2) indicating thereby stable performance of these lines across the environments for this trait. Out of these, three strains [P5-1 (H-1520 x H-330), P69-8-1-1-1 (H-330 x Hardee) and H-1520 (Ankur x H-330)] with unit regression showed average response to change in environmental conditions. Other three strains [P6-1 (Hardee x H-330), P69-8-1-1 (H-330 x Hardee) and P69-8-4-4 (H-330x Hardee)], with bi values > 1, indicated their adaptation to specific favorable environments. The strain P169-3 (H-1520 x H-330), which had higher number of branches (3.35 each) as compared to the food grade check 'Hara Soya' (3.28), with bi = 1 and s^2di = 0, also showed promise as a stable genotype with average response to change in environments for this trait.

One genotype [P6-1 (Hardee x H-330)] had 100-seed weight (17.90 g) equivalent to the population mean (17.91 g) but higher than the check 'Hara Soya' (14.90 g) with non-significant deviation from regression and regression value > 1 (Table 2) indicating thereby the stability of the strain and its adaptation to specific favorable environments. The strain P169-3 (H-1520 x H-330) showed higher 100-seed weight (14.98 g) than the food grade check 'Hara Soya' (14.90 g) with very low non-significant deviation from regression and regression value < 1 indicating thereby the stability of the strain and its responsiveness to specific poor environments. Earlier workers (Sood *et al*., 1999; Jai Dev *et al*., 2009) have also identified stable soybean strains for cultivation under mid-hills of Himachal Pradesh.

It may be summarized that the present study has been able to identify potential food grade soybean strains for cultivation in the mid-hills of Himachal Pradesh. The genotypes P5-1 (H-1520 x H-330), P6-1 (Hardee x H-330), P69-8-3-1 (H-330 x Hardee), P169-3 (H-1520 x Bragg) and H-1520 (Ankur x H-330) were found to be promising for different traits. These genotypes may be considered for cultivation as vegetable type soybeans in mid-hills of the state.

Table 2. Stability parameters for different characters in food grade soybeans

Genotypes	Days to flowering			Days to maturity			Plant height (cm)			Number of branches per plant			100-seed weight (g)		
	Mean	bi	S²di	Mean	bi	S²di	Mean	bi	S²di	Mean	bi	S²di	Mean	bi	S²di
P5-1 (H-1520 x H-330)	61.42	0.85*	0.34*	125.67	1.01	0.09*	77.92	0.76*	5.38	3.77	-1.08	0.19	17.44	0.31	0.65*
P5-2 (H-1520 x H-330)	63.25	0.62*	3.94*	129.33	1.24*	0.05*	90.50	0.96	11.01	3.35	0.57	0.31	19.03	0.90	1.01*
P6-1 (Hardee x H-330)	65.33	1.21	11.10*	130.33	1.23*	0.07*	96.08	1.03	12.78	4.08	3.05*	0.16	17.90	1.69*	0.21
P8-1 (H-1520 x H-330)	60.25	1.00	8.81*	126.50	1.05	0.13*	89.58	1.20	46.10*	3.02	2.18	0.84*	18.97	0.64	0.64*
P69-8-1-1 (H-330 x Hardee)	65.83	1.24	9.68*	131.33	1.20	0.12*	87.42	1.05	4.98	3.72	3.78*	0.29	19.18	1.37	0.53*
P8-2 (H-1520 x H-330)	61.25	0.92	20.13*	122.75	0.78	0.16*	83.17	0.94	13.31	3.05	1.13	0.02	17.71	1.33	0.44*
P69-8-1-1-1 (H-330 x Hardee)	66.33	1.28	16.18*	130.50	1.20*	0.05*	90.42	1.07	37.46*	3.65	0.09	0.09	19.43	1.54	0.45*
P69-8-3-1 (H-330 x Hardee)	66.50	1.18	8.82*	130.92	1.12	0.06*	89.83	1.01	42.17	4.18	0.13	0.48*	19.84	1.23	1.37*
P69-8-3-3 (H-330x Hardee)	65.33	1.39*	00.45*	131.33	1.13	0.08*	75.42	0.92	863.54*	3.97	-1.38	0.57*	18.84	0.56	1.91*
P69-8-4-4 (H-330x Hardee)	65.83	1.37*	1.48*	132.17	1.11	0.08*	94.25	1.16	0.30	4.13	3.17*	0.003	19.80	1.39	0.47*
P169-3 (H-1520 x Bragg)	58.33	0.82	12.13*	120.33	0.64	0.22*	82.17	0.96*	1.92	3.35	-0.95	0.07	14.88	0.61*	0.0007
H-1520 (Ankur x H-330)	60.17	0.91	5.93*	127.58	0.98	0.10*	97.75	0.76	7.57	3.93	0.58	0.11	17.37	1.10	0.53*
Bragg (Check)	54.67	0.38*	10.95*	118.00	0.61*	0.16*	86.08	1.06	89.20*	3.50	0.26	0.11	15.43	0.74	9.30*
Hara Soya (Check)	58.58	0.82	7.77*	118.33	0.72*	0.13*	83.92	1.11*	0.89	3.28	1.19	0.09	14.90	0.59	1.11*
Population mean	**62.36**	-	-	**126.79**	-	-		**87.46**	-	-	**3.64**	-	-	-	-

**Significant at P≤0.05*

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Direct Organogenesis and Plantlet Regeneration from Cotyledonary Node of Indian Soybean [*Glycine max* (L.) Merrill] Cultivars

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ABSTRACT

An efficient system for direct shoot regeneration from cotyledonary node explant of soybean was established in Indian cultivars and factors affecting shoot regeneration efficiency were evaluated. Different combinations of N6-benzyladenine (BAP) and indole-3-butyric acid (IBA) were studied. MSB5 medium supplemented with 5 µM BAP and 1 µM IBA, resulted in the highest efficiency (96%) of shoot regeneration from cultures of cotyledonary node explant from 5-days old seedling after germination. The regenerated shoots were transferred to MSB5 medium fortified with 1µM BAP and 1µM IBA, for shoot elongation, and successfully rooted on half-strength B5 medium supplemented with 5 µM IBA. The rooted plantlets were transplanted in plastic pots containing a mixture of soil, pot mix and sand and transferred to greenhouse for further growth. No phenotypic abnormalities were observed among regenerated plants. This is the first report on direct regeneration of plantlet from cotyledonary node explant of Indian soybean cultivars.

Key words: Soybean, Cotyledonary node, Direct organogenesis, Indian cultivars.

Exogenous genes can be introduced in plant by genetic transformation techniques. However, an efficient regeneration system with high rate of plant recovery is necessary for gene introduction. While transgenic soybeans have been already produced using several transformation techniques that are either *Agrobacterium*- mediated (Hinchee *et al.*, 1988) or involves particle bombardment (MaCabe *et al.*, 1988, Christou et al. 1989, Falco *et al.*, 1995). Many workers have reported soybean shoot organogenesis (Barwale *et al.*, 1986; Wright *et al.*, 1986, Wright *et al.*, 1987a, b, Shetty *et al.*, 1992, Yoshida *et al.,* 2002, Liu *et al.*, 2004) and regeneration *via* somatic embryogenesis (Finer and Nagasawa, 1988, Parrott *et al.,* 1988, Komatsuda *et al.,* 1992). However, there are few reports on soybean regeneration in Indian soybean cultivars. Kumari *et al.* (2006) reported protocol for the induction of somatic embryogenesis and plant regeneration from embryonic

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axes explants collected from 7 days old in vitro seedlings. Tripathi and Tiwari (2003) reported callus induction and plant regeneration from mature seed derived explant. Somatic embryogenesis and plant regeneration via callus phase is genotype specific and accompanied with a high level of somaclonal variation in the regenerated plants (Parrot et al. 1989; Finer and McMullen 1991). Moreover, plant regeneration via somatic embryogenesis and callus phase is a time consuming process as compared to direct organogenesis.

There is no report on direct organogenesis and regeneration of plantlets in Indian soybean cultivars. Moreover, the frequency of plant regeneration reported in Indian soybean cultivars is not high enough for development of transgenic soybean. Here we report simple and reproducible direct regeneration protocol for Indian soybean cultivars using cotyledonary node explant.

MATERIALS AND METHODS

Plant material and preparation of explants

Mature seeds of soybean cultivars JS-335, Co1, Ankur, LSb1 and NRC 2 were used in the experiments. Soybean seeds were sterilized by placing seeds into a tightly sealed chamber filled with chlorine gas produced by mixing 3.5ml of 12 N HCL and 100ml bleach (4.0 % approx Sodium hypochlorite) for 6 hours (Liu and Wei 2002). Soybean seeds sterilized as above were germinated for 5 days on half-strength B5 medium (Gamborg et al. 1968) (pH 5.8) with 3% sucrose and 0.6% agar. A horizontal slice was cut through the hypocotyl regions of germinated seeds, approximately 3–5 mm below each cotyledon. A subsequent vertical slice was made between the cotyledons, and the primary leaves were removed.

Culture of cotyledonary node

The cotyledonary node (Cot-node) explants of cultivar JS335 were placed with its abaxial side contacting the medium. MSB5 medium [MS basal medium (Murashige and Skoog 1962) and B5 vitamins (Gamborg et al. 1968)] supplemented with 1.25, 2.5, 5.0, 7.5 or 10 µM BAP alone or in combination with 0, 0.25, 0.5, 1.0 or 2.0 µM IBA was used in the experiments. Finally, in order to test the selected regeneration systems for different genotypes, cotyledons excised from 5-day-old seedlings of four soybean cultivars, LSb1, Co1, Ankur, and NRC 2 were cultured on MSB5 medium supplemented with 5 µM BAP and 1 µM IBA.

Plantlet formation and hardening

After culture for 4 weeks, the multiple shoots regenerated from cot-node explants were transferred to MSB5 medium fortified with 1 µM BAP and 1 µM IBA for shoot elongation. The elongated shoots were cut from the cot-node explants and placed on the root induction medium consisting of half strength B5 medium with different concentrations IBA (0.0,2.5, 5.0 and 10 µM), and 0.6% agar (pH 5.8). Rooted plantlets were thoroughly washed with sterile distilled water and transplanted in plastic pots, in which soil, pot mix and sand (2:2:1) were blended, before they were moved to the greenhouse for further growth.

Culture conditions

All the experiments except for rooting and plantlets acclimatization were conducted in 250 ml conical flask containing 50 ml medium. All of the media were supplemented with 30 g/l sucrose, solidified with 6 g/l agar, with pH adjusted to 5.8 prior to autoclaving at 121°C for 20 min. The culture was maintained in culture room at 24 ± 2°C under 18 h/6h light/dark regime, at a photon flux density (PFD) of approx. 150µmol s^{-1} m^{-2}. Explants were sub cultured at 12 days intervals.

RESULT AND DISCUSSION

Cot-node explants were cultured on MSB5 medium supplemented with varying concentration of BAP (1.25µM-10µM). The results of effect of BAP concentration on shoot formation have been expressed as regeneration frequency. Regeneration frequency has been defined as number of explants forming shoots /Total number explants x 100. We observed a linear increase in regeneration frequency with increase in BAP concentration upto 5µM (73 %) and thereafter regeneration declined with further increase in BAP concentration upto 10µM (Table 1). In order to test the effect of BAP in

Table 1. Effect of BAP and IBA concentration on percentage of shoot formation and average number of shoots per explants (mean no. shoots ± SD) from cot-node of JS335 4 weeks after culture.

BAP (µM)	IBA (µM)	Percentage response (%)[a]	Mean no. shoots ±SD
Control	0	10	1.2±0.3
1.25	0	32	1.5±0.4
2.5	0	45	1.8±0.4
5	0	73	2.5±0.5
7.5	0	56	2.9±0.7
10	0	46	2.3±0.4
5	0.25	82	3.0±0.6
5	0.5	84	3.2±0.8
5	1	96	4.5±1.0
5	2	70	2.3±0.8

Control without growth regulators, B5 medium
a (Number of explants forming shoots/Total number of explants X100)

combination with IBA on shoot induction, 5µM BAP in combination with four varying concentrations of IBA were studied. Percentage of shoot formation of soybean cultivar JS 335 increased with increase in IBA upto 1µM (Table 1). The highest percentage of shoot formation (96%) and the largest number of shoots per explant (4.5±1.0) were obtained when 5 µM BAP and 1 µM IBA were used in combination. Similar observation were reported by Dan and Reichert (1988) and Saka *et al*. (1980) where use of 5µM BAP improved regeneration of hypocotyl explants and stem node segments of soybean, respectively Wright *et al* (1986), Hinchee et al. (1988) and Paz *et al.* (2006) obtained efficient shoot regeneration on cotyledonary explants on 5µM BAP alone while. Ma and Wu 2008 reported 1µM of IBA in combination with 5 µM BAP significantly enhanced multiple shoot formation. Regeneration frequency of this system was significantly higher than previously reported regeneration systems by Kaneda et al.1997, Franklin et al. 2004 and Liu et al. 2004.

Cot-node explants were cultured on MSB5 medium supplemented with 5 µM BAP and 1 µM IBA (Figure 1. A). Explants swelled, and the multiple shoot formation was observed after 12 days interval (Figure 1. B). The regenerated

Table 2. Effect of different IBA levels on rooting of the shoots of soybean (cv JS 335)

IBA (µM)	Number of shoots evaluated for rooting	Rooting rate (%)[a]
Control	58	15.5
2.5	56	48.2
5.0	60	95
10.0	60	90

Control without growth regulators, 1/2B5 medium
a (Number of explants forming shoots/Total number of explants X100)

Table 3. Effect of cultivars on percentage response of shoot formation, 4 weeks after culture using cot-node explants

Cultivars	Percentage response (%)[a]	Mean no. shoots ±SD
JS335	96	4.5±1.0
NRC 2	94	2.6±0.4
Ankur	92	1.8±0.4
Co1	90	2.5±0.5
Lsb1	95	3.9±0.7

[a] *(Number of explants forming shoots/Total number of explants X100)*

shoots were cut from cot-node explants 4 weeks after culture and were cultured on shoot elongation medium MSB5 medium fortified with 1 µM BAP and 1 µM IBA for shoot elongation and 0.6 per cent agar (pH 5.8). The shoots grew quickly on medium and reached 2 cm in height within 15 days (Figure 1. C), which were then transferred to half-strength B5 medium added with 5 µM IBA to induce root (Figure 1 D). All the IBA concentrations had significant effect on the rooting percentage. The

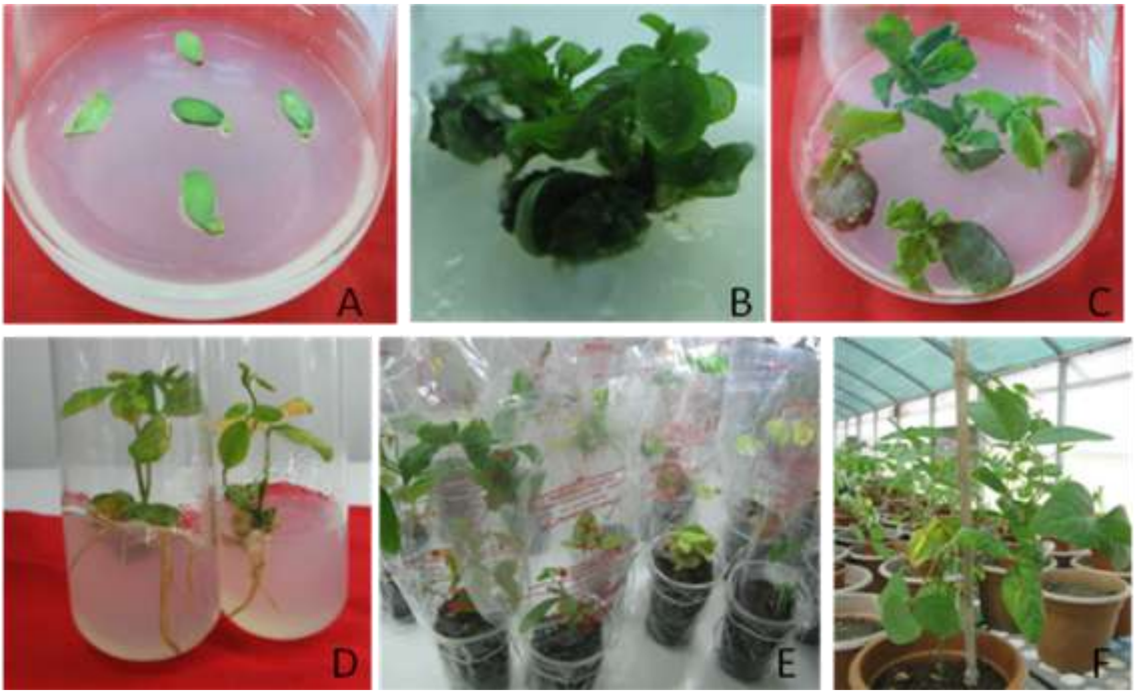

Figure 1. Plant regeneration from the cotyledonary node of soybean (cv. JS335). (A) Cot-node explant at the time of culture (B) Regeneration of adventitious shoots from the cotyledons cultured for 2 weeks on MSB5 medium with 5 µM BAP and 1 µM IBA.(C) Elongated shoots on shoot elongation medium after 3 weeks, (D) Root induction of elongated shoots on medium containing 5 µM IBA. (E) A well-rooted plantlets transferred to soil. (F) Plants established in the green house after hardening.

maximum rooting (95 %) was observed with 5 µM of IBA and followed by 10 µM of IBA (Table 2). The rooted plantlets were transplanted in plastic pots (Figure 1 E) containing soil, potmix and sand (2:2:1) and almost all of the plantlets survived in the greenhouse (Figure 1. F). Regenerated plants were healthy with normal leaf, flower shape and colour. No morphological variations were observed.

Cot-node of five cultivars was cultured on MSB5 medium containing 5 µM BAP and

1 μM IBA to investigate the genotypic response (Table 2.). Regeneration of shoots occurred in all of the genotypes with regeneration rate higher than 90% in all cases. However most responsive genotypes were JS335, followed by Lsb1, NRC 2, Ankur and Co1. Similar observations were reported by Sairam et al. 2003 and Franklin et al. 2004. They reported that shoot-formation frequency did not differ significantly using cotyledonary node of different genotypes. Somatic embryogenesis from immature cotyledons has been consistently reported to be genotype dependent by a number of authors (Parrott et al. 1989, Komatsuda and Ko 1990, Shoemaker et al. 1991). Graybosch et al. (1987) reported cotyledonary node regeneration system, three different soybean genotypes (Colland, Funman and Wayne) and found significant differences in their morphogenetic responses.

In conclusion, we report herein for the first time a protocol for highly efficient direct regeneration of plantlets from cot-node of Indian soybean cultivars. The established regeneration system holds great potential for *Agrobacterium tumefacien*s mediated transformation.

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Integrated Nutrient Management in Soybean [*Glycine max* (L.) Merrill]

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ABSTRACT

A field experiment was conducted for consecutive three years (2006 - 2008) during kharif *season on black clay soils classified as typic Ustochrept of Madhya Pradesh to study the effect of integrated nutrient management on yield attributes, seed and straw yield, economics, and total nutrient uptake of soybean. The values of different attributes associated with 75 per cent recommended dose of fertilizers coupled with application of phospho-compost @ 3 t/ha were maximum and differed significantly from the rest of the treatments. The next better combination turned out was recommended dose of fertilizers coupled with farmyard manure @ 4 t per ha.*

Key words: Phospo-compost, poultry manure, recommended dose of fertilizers, soybean, vermi-compost

Soybean [*Glycine max* (L.) Merrill] is one of the major *kharif* oilseed crops in India, mainly in semi-arid tropics of Central India. The limited area of 0.03 m ha in 1970 has increased 317 fold during year 2008 (9.5 m ha) (Anonymous, 2008). However, the gap between achievable seed yield (>2.5 t/ha) and current yield level of about 1.0 t per ha remains to be very wide (Gupta and Rajput, 2001). Low productivity of the crop is primarily considered on account of inappropriate soil, water and crop management practices. There exists a considerable potential to abridge this yield gap between farm realized and achievable yields through the adoption of appropriate resource management strategies. Soybean, if not fertilized properly, draws its nutrient need from soil, which adversely affects soil fertility. One such strategy is to maintain soil fertile for sustainable production of soybean is through judicious use of fertilizers (Bobde *et al.*, 1998) coupled with organic resources

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(Joshi and Billore, 2004). It has been realized from long-term fertilizer experiments that to achieve sustainability in production, the use of organic manures alone is not sufficient (Prasad, 1996). It has also been brought out that use of organic manures in integration with fertilizers meets the need of micronutrients of soybean (Joshi *et al.*, 2000).

Hence, the present investigation was undertaken to study the effects of judicious and integrated use of inorganic fertilizers (NPK) and organic manures (FYM, phospo-compost, vermi-compost, and poultry manure) on growth and yield of soybean.

MATERIAL AND METHODS

A field experiment was conducted during *kharif* seasons of 2006 to 2008 at fixed site of College of Agriculture, Indore Research Farm. The experimental soil belonged to order Vertisols with low ECe 0.22 dSm^{-1} and nearly neutral pH of 7.5. The available nitrogen, phosphorus and potassium content of the soil were 150 N, 13 P_2O_5 and 422 K_2O kg per ha, respectively. Soil is clayey in texture (clay 60 %, silt 30.7% and sand 9.3 %). The bulk density of plough layer (0-15 cm) soil was in the range of 1.352 to 1.650 ($Mg\ m^{-3}$). The steady state infiltration rate (terminal rate) was 10 mm per h. The $CaCO_3$ content of the soil was between 4.0 to 8.0 per cent. The experiment was laid out in a randomized block design with four replications and comprising of six treatments namely, recommended dose of fertilizers, RDF plus farmyard manure (FYM) @ 4 t per ha, RDF plus phospho-compost @ 2 t per ha, 75 per cent recommended dose of fertilizers plus phospho-compost @ 3 t per ha, 50 per cent recommended dose of fertilizers plus phospho-compost @ 5 t per ha and 50 per cent recommended dose of fertilizers plus poultry manure @ 2 t per ha. The recommended dose of N: P_2O_5: K_2O (100% RDF) used for soybean were 20:60:20 kg per ha applied as basal. The FYM ($N:P_2O_5:K_2O$ = 0.5%:1.0%:0.5%), vermi-compost (2% :1.5% :1.5%), phospo-compost (1.04%:5.5%:1.5%) and poultry manure (3.6 %:1.8%:2.0%) were applied at the time of field preparation in specified plots. Soybean (JS 335) at row-to-row spacing of 30 cm and plant-to-plant spacing of 10 cm was sown in last week of July during all *kharif* seasons. Statistical analysis was carried out using standard analysis of variance (Gomez and Gomez, 1984).

The observations on plant height, dry matter per plant and pods per plant were recorded at harvest on five randomly selected plants from each treatment. Seed index (g/100 seed) was recorded for each treatment and harvest index was worked out utilizing the total biological produce and the seed yield of soybean.

The processed seed and straw samples were analyzed for total nitrogen (Kjeldhal, 1983), and phosphorus and potassium (Prasad *et al.*, 2006). The uptake of these nutrients was worked out utilizing the data collected for seed and straw yield.

RESULTS AND DISCUSSION

Growth and yield attributes

Among growth parameters, only pods per plant recorded significant variations on account of different treatments (Table 1). Maximum number of pods per plant (45.8) was associated with integrated application of 75 per cent recommended dose of fertilizers coupled with phospho-compost @ 3 t per ha, which was at par with application of recommended dose of fertilizers plus farmyard manure @ 4 t/ha. Application of recommended dose of fertilizer with phospho-compost @ 2 t per ha also recorded significantly higher values (39.0) for this character as compared to 50 per cent recommended fertilizer dose either with phospho-compost @ 5 t per ha or poultry manure @ 2 t per hectare. Although, the application of 75 per cent recommended dose of fertilizers coupled with phospho-compost @ 3 t per ha did record the maximum values for plant height (53.5 cm) and dry matter per plant (19.57 g), the differences among treatments were non-significant. Similarly, this treatment recorded numerically higher values for seed index (10.88 g/100 seeds) and harvest index (41.37) than other treatments and differences were non-significant.

Table 1. Effect of integrated nutrient management on growth, yield attributes, yield and economics of soybean (pooled data - 2006 to 2008)

Treatment	Plant height (cm)	Dry matter/ plant (g) 80 DAS	Pods/ plant (No)	Seed index (g/100 seeds)	Harvest Index (%)	Seed yield (kg/ha)	Straw yield (kg/ha)	Net returns (Rs/ha)	B:C Ratio
RDF	50.2	16.51	36.5	10.46	39.65	1652	2523	14984	1.58
RDF+ FYM @ 4 t/ha	51.8	18.59	41.5	10.80	40.76	1786	2596	15203	1.53
RDF+ phospho-compost @ 2 t/ha	50.5	17.49	39.0	10.76	40.78	1742	2530	15182	1.62
75% RDF+ phospho-compost @ 3 t/ha	53.5	19.57	45.8	10.88	41.37	1970	2799	17633	1.71
50% RDF+ phospho-compost @ 5 t/ha	49.3	16.31	32.4	10.47	39.91	1599	2408	12281	1.21
50% RDF+ poultry manure @ 2 t/ha	49.4	15.91	32.0	10.37	39.16	1609	2512	13738	1.50
SEm (±)	1.4	0.88	1.69	0.179	0.9	51	91	745	-
CD (P = 0.05)	**NS**	**NS**	**5.09**	**NS**	**NS**	**154**	**273**	**2245**	**-**

RDF – recommended dose of fertilizers; FYM – farmyard manure

Productivity

Different nutrient management treatments could influence the seed and straw yield of soybean (Table 1). Application of 75 per cent recommended dose of fertilizers coupled with phospho-compost @ 3 t per ha yielded maximum (1970 kg/ha) and was significantly superior over rest of the treatments (1599-1786 kg/ha). Among remaining treatments, the seed yield (1786 kg/ha) recorded with recommended dose of fertilizer plus farmyard manure @ 4 t per ha was significantly superior over 50 per cent recommended dose of fertilizers either with either phospho-compost @ 5 t per ha or poultry manure @ 2 t per ha and was at par with recommended dose of fertilizers and recommended dose of fertilizer coupled with phospho-compost @ 2 t per ha. Similarly, the maximum straw yield (2799 kg/ha) recorded by application of 75 per cent recommended dose of fertilizers coupled with phospho-compost @ 3 t per ha was at par with recommended dose of fertilizers with farmyard manure @ 4 t per ha and recommended dose of fertilizer with phospho-compost @ 2 t per ha. Remaining treatments (2408-2512 kg/ha) were at par with recommended dose of fertilizers (2523 kg/ha). The yield achieved in different treatments was the reflection of growth parameters observed in the experiment. The positive impact of integrated nutrient management in increasing the yield attributing characters, and seed and straw yield has been reported by Mishra *et al*. (1990) and Ghosh *et al*. (2005).

Economic evaluation

The economic evaluation revealed that maximum net returns (Rs. 17, 633/ha) and C:B ratio (1.71) were associated with application of 75 per cent recommended dose of fertilizers coupled with phospho-compost @ 3 t per ha as compared to recommended dose of fertilizers (Rs. 14, 984/ha and 1.58, respectively). Application of recommended dose of fertilizer either with phospho-compost @ 5 t per ha (Rs 12, 281/ha and 1.21) or poultry manure @ 2 t per ha (Rs 13, 738/ha and 1.50) were not economically viable. Thus, it can be seen that the enhancement of growth and yield attributed have reflected in seed and straw yield of soybean (Table 1).

Nutrient uptake

Significant differences were noticed in nutrient uptake values for grain of soybean and total uptake by soybean crop by imparting different integrated management treatments (Table 2). The uptake of nitrogen (113.64 kg/ha), phosphorus (9.38 kg/ha) and potassium (36.66 kg/ha) in seed as well as total uptake (140.82 kg/ha, 13.28 kg/ha and 86.61 kg/ha, respectively) was maximum in treatment wherein 75 per cent of recommended dose of fertilizer coupled with phospho-compost @ 3 t per ha and the values were significantly superior over all other treatments, which were at par.

The cumulative results for three years suggested that at least 25 per cent of recommended level of nitrogen, phosphorus and potassium can be curtailed

Table 2. Effect of integrated nutrient management on nutrient uptake (pooled data - 2006 to 2008)

Treatment	N uptake (kg/ha)		P_2O_5 uptake (kg/ha)		K_2O uptake (kg/ha)		Total uptake (kg/ha)		
	Seed	**Straw**	**Seed**	**Straw**	**Seed**	**Straw**	**N**	**P_2O_5**	**K_2O**
RDF	90.47	23.72	7.37	3.28	25.43	38.85	114.18	10.65	64.28
RDF+ FYM @ 4 t/ha	102.66	25.05	7.99	3.55	31.17	41.94	127.72	11.54	73.12
RDF+ phospho-compost @ 2 t/ha	99.26	24.00	7.72	3.39	28.93	40.21	123.26	11.11	69.15
75% RDF+ phospho-compost @ 3 t/ha	113.64	27.18	9.38	3.90	36.66	49.95	140.82	13.28	86.61
50% RDF+ phospho-compost @ 5 t/ha	89.53	23.28	7.09	3.18	25.38	37.15	112.80	10.28	62.53
50% RDF+ poultry manure @ 2 t/ha	91.96	24.15	6.94	3.41	26.55	39.41	116.11	10.35	65.97
SEm (±)	3.50	0.89	0.30	0.16	1.057	2.373	4.04	0.39	2.674
CD (P = 0.05)	**10.56**	**NS**	**0.92**	**NS**	**3.19**	**NS**	**12.18**	**1.17**	**8.06**

RDF – recommended dose of fertilizers; FYM – farmyard manure

by integrating with phospho-compost @ 3 t per ha to optimize soybean yield with economic viability.

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Effect of Wellgro-soil application on Nodulation, Yield and Soil Biological Health in Soybean Grown in Vertisols of *Malwa* Region of Madhya Pradesh

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ABSTRACT

Field experiments were conducted during the kharif *seasons of 2006, 2007 and 2008 on Vertisols in* Malwa *region of Madhya Pradesh to study the response of Wellgro-soil (an organic product) application in combination with inorganic fertilizers on soybean (variety 'JS 93-05') for assessing its influence on soybean rhizobial and its mycorrhizal population, soil enzyme activities, organic carbon content and agronomic attributes of soybean. The experiment was laid out in a randomized block design consisted of 3 blocks. Eight treatment combinations comprising Wellgro-soil @ 100 and 200 kg per ha; NPK fertilizers @ 50, 75 and 100 per cent of recommended dose of fertilizers (RDF- @ N 20 kg/ ha; P_2O_5 60 kg/ ha; K_20 40 kg/ ha and S 20 kg/ ha) and in combination with Wellgro-soil was applied. An absolute control was also maintained. Application of Wellgro-soil continuously for three consecutive years enhanced the soybean growth, yield, organic carbon, rhizobial population and other biological parameters in soil. Wellgro-soil application @ 200 kg per ha along with 50 or 75 per cent RDF produced comparable yield with 100 per cent RDF, supporting higher nodulation; significantly higher than rest of the treatments. Besides yield, Wellgro-soil applied plots (alone or with fertilizers) maintained higher organic carbon, mycorrhizal and rhizobial population, FDA and dehydrogenases activity than the control plots. The protein and oil contents in seeds were not influenced by the application of Wellgro-soil.*

Key words: Mycorrhizal fungi, organic manure, soybean, Wellgro-soil

Soybean [*Glycine max* (L.) Merrill] is the most widely grown legume worldwide and is a potential source of protein and oil, and it also enhances soil fertility for other crops by modifying the soil nitrogen budget (Meghvansa *et al.*, 2008). India is the fifth largest producer of soybean after the United States, Brazil,

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China and Argentina (Joshi, 2003). Soybean has made an unprecedented expansion in India for the past ten years. *Malwa* region of central India comprised of Vertisols occupied a special niche for cultivation of soybean in the country with regards to production and area. In spite of high potentials (2-3.5 t/ha) of indigenously bred varieties, the yield potentials could not be harnessed to the extent needed and thereby the productivity hovers around 1 t per ha. Low productivity in Vertisols in this region is primarily due to erratic rainfall distribution and low soil organic matter status (Manna *et al.*, 2006). The influence of organic matter on soil biological and physical fertility is well known. Organic matter affects crop growth and yields either directly by supplying nutrients or indirectly by modifying soil physical properties and enhance P availability in P-fixing soils (Reddy *et al.*, 1999). Incorporation of organic matter either in the form of crop residues or farmyard manures has been shown to improve soil structure and water retention capacity (Bhagat and Verma, 1991). Recently Behera *et al.* (2007) reported from a long-term study that the effect of combined use of farmyard manure (FYM), poultry manure, vermicompost and biofertilizers (*Azotobacter* + phosphate solubilizing bacteria) with recommended dose of NPK fertilizers to wheat and residual effect on following soybean was found highly remunerative and sustainable. Therefore, integration of inorganic and organic nutrient sources is widely being advocated as a rational strategy for efficient use of natural resources to maintain soil health and to augment the efficiency of nutrients (Reddy *et al.*, 1999).

The present study was aimed to evaluate the response of Wellgro-soil, an organic manure rich in macro- and micro-nutrients developed from plant products/parts of different species in combination with inorganic fertilizers, on soybean nodulation, growth, yield and soil microbial health.

MATERIAL AND METHODS

Experimental Site

The field trial site was in semi-arid tropical climate with a mean annual air temperature of 25^{o}C and means annual rainfall of 985 mm and located at Research farm of Directorate of Soybean Research, Indore, India. The annual mean precipitation is 1,000-1,200 mm. The site situated at 485 m above mean sea level was continuously under soybean-wheat rotation for more than a decade. The soil type was Typic Haphustert under Sarol series of order Vertisols. The chemical and nutrient characteristics of the soil (0-20cm depth) were: pH 7.62 (1: 2.5 soil to water ratio); organic carbon 0.46 per cent and available P (Olsen's P) 4.42 mg/kg soil); exchangeable K 240 mg per kg and available S 4.5 mg per kg.

Procurement of seeds, fertilizers and organic manure

Seeds of soybean cultivar 'JS-93-05' were procured from Crop Improvement Discipline, Directorate of Soybean Research, Indore. The Wellgro-soil was procured from ITC Ltd, Guntur, Andra Pradesh having nutrient and chemical properties (organic carbon content 20 per cent; N 1.6 per cent; P 0.25 per cent; K 0.89 per cent; zinc 20 ppm; sulphur 80 ppm). Inorganic fertilizers, urea, single super phosphate (SSP) and muriate of potash to supply N, P, sulphur and K, respectively, were procured from MP State Agro-industries Corporation, Indore.

Experimental set up

The field trial was conducted during *kharif* season of 2006, 2007 and 2008 on the fixed site. The soybean cultivar, 'JS 93-05' was grown in a completely randomized block design taking following eight treatement combinations and 3 replications.

1. Absolute control,
2. Wellgro-soil @100 kg per ha as soil application before sowing,
3. Wellgro-soil @200 kg per ha as soil application before sowing,
4. Recommended dose of fertilizers (RDF @ N 20 kg/ha; P_2O_5 60 kg/ha; K_20 40 kg/ha and S 20 kg/ha),
5. 75 % of RDF + Wellgro-soil @100 kg per ha,
6. 75 % of RDF + Wellgro-soil @200 kg per ha,
7. 50 % of RDF + Wellgro@100 kg per ha, and
8. 50 % of RDF + Wellgro-soil @200 kg per ha.

Commercially available soybean *Rhizobium* was also applied as seed inoculation as a recommended practice to all the treatments except absolute control. The Wellgro-soil and recommended dose of NPK fertilizers were applied as a basal application.

Sampling and analysis for soil chemical and microbial health parameters

Soil sampling was done before the allocation of treatments with the soil auger at the depth of 0-20 cm. A total of nine samples (three samples per block) were taken randomly and then were pooled to three for assessment of rhizobial population and organic carbon content. Soil sampling was again carried out at 30 days after sowing from all the treatment plots. There were 24 composite samples, which were also analyzed for rhizobial population and organic carbon content. The organic carbon in soil was determined by standard potassium dichromate and back titration with iron solution (Walkley, 1935). Available phosphorus in the soil was determined by extraction with sodium bicarbonate for 30 minutes (Olsen *et al.*, 1954).

The rhizobial count (colony forming units, CFU) in soil samples were carried out in Petri plates containing yeast extract mannitol agar medium supplemented with congo red dye (CRYEMA). Native mycorrhizal spore population in rhizosphere at zero time and after 3 years of experimentation was determined by the method of Gerdemann and Nicolson (1963). Soil dehydrogenase activity (assessed at flowering stage of *kharif*, 2008) was determined colorimetrically by the reduction of 2,3,5 triphenyl tetrazolium chloride (TTC) to triphenyl formazan (TPF) by the method of Casida (1977). Fluorescein diacetate, 3′, 6′-diacetylfluorescein (FDA) activity in soil was determined by hydrolyzing the FDA and fluorescein released was quantified by spectrophotometer (Aseri and Tarafdar, 2006).

All agronomic parameters including nodule number, nodule biomass, pod number and grain yield were recorded. Pests and disease incidence were also recorded during crop stand. Protein and oil contents in grains were determined using INFRATEC (1225 Grain Analyser).

Statistical analysis of data

The data was analyzed using the analysis of variance (JMP Software; SAS Institute Inc., 1995). The least significant differences (LSD) were used to separate the treatment means using DMRT test (Costat statistical software, Cohort Berkeley, Calif.).

RESULTS AND DISCUSSION

Soil organic carbon, rhizobium population

Higher rhizobial population and organic carbon content in rhizosphere soil (at 30 days after sowing) was observed in the treatments applied with 200kg per ha Wellgro-soil alone or in combination with fertilizers and was found to be significantly higher than control plots. However, organic carbon in these plots was significantly higher than RDF applied plots and at par with 100 kg per ha Wellgro-soil applied plots. In general, the rhizobial population of Wellgro-soil applied plots was found at par with RDF applied plots. Under field experimentations enhancement in organic carbon was also reported recently due to application of poultry manure or FYM (Behera *et al.*, 2007; Chiezey and Odunze, 2009).

Build up of mycorrhizal population and soil enzyme activities

Arbuscular mycorrhizal fungi (AMF) population, fluorescein diacetate (FDA) and soil dehydrogenases activity observed in rhizosphere soil of soybean was influenced significantly due to application of Wellgro-soil (alone or in combination with fertilizers) when compared with control and fertilized alone plots (Fig. 1). Maximum AMF count (12.16 spores per /10 soil) was observed in plots applied with Wellgro-soil @ 200 kg per ha +50 per cent RDF.

However, this population was at par with plots applied with 200kg Wellgro-soil alone or 100 kg Wellgro-soil applied with fertilizers. FDA and dehydrogenases activity also showed the similar trend as observed with AMF count (Fig. 1). Since AMF species do not seem to be plant specific species, these fungi are generally have low host specificity may allow mycelial networks of a particular fungus in the soil to be connected directly to roots of plants of different species forming hyphal links between their mycorrhizal roots (Cardoso and Kuyper, 2006). Higher AMF spore density in soils of organically managed systems was reported by many workers (Oehl *et al.*, 2004; Galvez *et al.*, 2001). However, the actual importance of AMF to the functioning of organic agro-ecosystems and in particular to crop performance remains to be determined. In present study the increased population of native AMF due to Wellgro-soil application is supporting higher yield. Gossling *et al.* (2006) pointed out that low input systems such as organic farming are generally more favorable to AMF and AMF have the potential to substitute for the fertilizers. Higher biological activity including soil enzymes due to application of organics was also observed by Manna *et al.* (2003). They showed that higher biological activity is due to the presence of easily water-soluble carbon, which acts as a source of energy for soil organisms and has a positive correlation with soil microbial biomass C.

Agronomic parameters, protein and oil content

The agronomic parameters i.e., nodule number, pods and grain yield were found highest in the treatment applied with 50 per cent or 75 per cent RDF along with 200 kg per ha Wellgro-soil and was found significantly higher when compared to plants grown in control plots (Table 1). The grain yield of RDF and Wellgro-soil 200kg per ha alone plots produced significantly higher yield when compared to yield obtained in control plots. The yield at 50 per cent or 75 per cent RDF + 200 kg per ha Wellgro-soil combination was numerically higher than Wellgro-soil @ 200kg per ha alone and RDF alone, but was statistically at par. Recently, Behera *et al.* (2007), while studying long-term wheat-soybean system applied with organic and inorganic inputs showed sustainable yields in plots applied with organic manures in combination with fertilizers.

In general higher values of nodule number and biomass were recorded in plots where Wellgro-soil @ 200 kg per ha was applied than RDF alone (Table 1). In concurrence with our results, Haiti *et al.* (2006) reported that an integrated supply of nutrients through organic and inorganic sources could be an effective practice of nutrient management for increasing water-use efficiency and yield of soybean in Vertisols of central India. No significant differences and trend in protein

Table 1. Response of Wellgro-soil on growth, yield of soybean 'JS 93-05' and some parameters of soybean grown for three years (*kharif* 2006-2008)

Treatments	Year*	No. of nodules /plant	Pods /plant	Seed yield (t/ha)	O.C % (30days)	*Rhizobium* population (CFU/g soil)	Protein (%)	Oil (%)
T1-control	2006	33	20.93	1.84	0.33	79×10^4	40.93	16.42
	2007	12.3	26.6	1.63	0.43	2.6×10^4	37.98	14.13
	2008	25	26.7	1.29	0.42	0.74×10^4	37.08	-
	mean	**23.43c**	**24.74d**	**1.58e**	**0.39d**	**27.44×10^4**	**38.66**	**15.81**
T2-Wellgro-soil @100 kg/ha	2006	49	25.0	1.97	0.35	68×10^4	40.91	16.71
	2007	16.0	30.1	1.89	0.52	1.2×10^4	37.96	14.14
	2008	31.6	29.5	1.42	0.54	3.58×10^4	40.32	-
	mean	**32.2ab**	**28.2c**	**1.76d**	**0.47abc**	**24.26**×10^4	**39.73**	**15.42**
T3-Wellgro-soil @200 kg/ha	2006	52.33	28.06	2.09	0.38	149×10^4	41.71	16.92
	2007	19.66	33.73	1.94	0.52	11.3×10^4	38.95	14.07
	2008	32	29.93	1.67	0.56	5.09×10^4	38.16	-
	mean	**34.66ab**	**30.57abc**	**1.9c**	**0.48ab**	**55.13**×10^4	**39.6**	**15.49**
T4-RDF @ 20:26.2:16.6 Kg NPK/ha	2006	51.73	25.87	2.25	0.36	160×10^4	41.22	16.93
	2007	15.0	35.4	2.23	0.49	8.6×10^4	37.93	14.27
	2008	28	33.06	1.78	0.43	1.61×10^4	39.79	-
	mean	**31.58b**	**31.44ab**	**2.08ab**	**0.43cd**	**56.73**×10^4	**39.65**	**15.60**
T5-75% RDF+Wellgro-soil @100 kg/ha	2006	55.26	26.6	2.06	0.38	153×10^4	40.67	16.67
	2007	19.0	30.2	2.05	0.48	12.6×10^4	38.51	14.78
	2008	31	32.06	1.73	0.50	4.11×10^4	40.59	-
	mean	35.08ab	29.62bc	1.94bc	**0.45bc**	**56.57**×10^4	**39.92**	**15.72**
T6-75% RDF+Wellgro-soil @ 200 kg/ha	2006	52.4	27.46	2.34	0.37	140×10^4	40.79	16.62
	2007	14.67	33.8	2.43	0.47	14.0×10^4	37.98	14.2
	2008	36.66	36.46	1.92	0.56	3.38×10^4	35.18	-
	mean	**34.57ab**	**32.57ab**	**2.23a**	**0.47abc**	**52.46**×10^4	**37.98**	**15.41**
T7-50% RDF+Wellgro-soil @100 kg/ha	2006	44.66	26.6	2.25	0.36	122×10^4	41.54	16.77
	2007	21.33	31.7	1.98	0.45		36.3	13.62
	2008	29.33	35.46	1.65	0.50	2.42×10^4	39.24	-
	mean	**31.77b**	**31.25abc**	**1.96bc**	**0.44bcd**	**49.9**×10^4	**39.02**	**15.18**
T8-50% RDF+Wellgro-soil @ 200 kg/ha	2006	55.66	29.0	2.41	0.41	165×10^4	41.60	16.64
	2007	30.0	36.2	2.36	0.59	22.3×10^4	38.2	14.55
	2008	34	33.76	1.76	0.57	2.96×10^4	36.26	-
	mean	**39.89a**	**32.98a**	**2.18a**	**0.52a**	**63.42**×10^4	**38.68**	**15.59**
LSD (0.05)		**7.15**	**2.86**	**0.13**	**0.052**	**NS**	**NS**	**-**

**Data are mean of three years experimentation; the means followed by same letter did not differ significantly by DMRT (ANOVA) at P =0.05; NS, non significant; protein and oil in seeds is at 7-9% moisture; At zero time organic carbon (0.36%) and rhizobial population (0.8X10⁴); LSD, least significant difference*

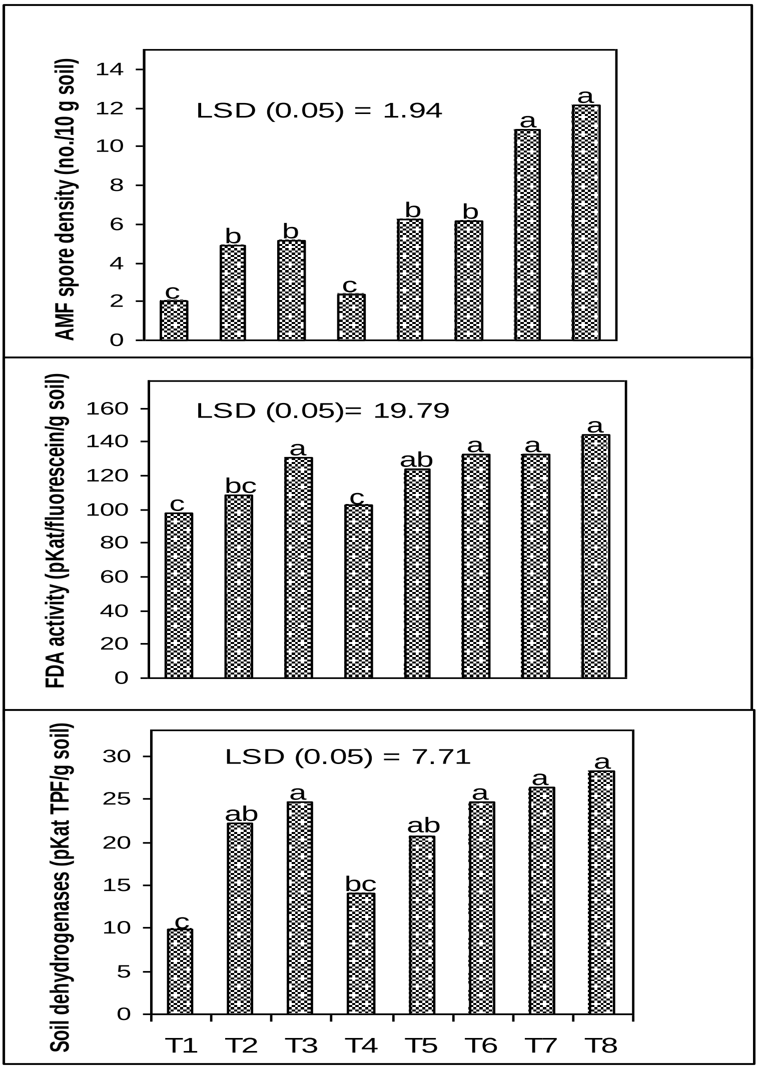

Figure 1. Influence of Wellgro-soil application over three years on mycorrhizal population and soil enzyme activities in the rhizosphere of soybean (variety JS 93- 05) grown on Vertisols.

Where, T1, control; T2, Wellgro-soil @100 kg/ha; T3, Wellgro-soil @200 kg/ha; T4, RDF @ 20:26.2:16.6 Kg NPK/ha; T5, 75% RDF+Wellgro-soil @100 kg/ha; T6, 75% RDF+Wellgro-soil @ 200 kg/ha; T7, 50% RDF+ Wellgro-soil @100 kg/ha; T8, 50% RDF+Wellgro-soil @ 200 kg/ha; Bars are mean of three replications; the means followed by same letter did not differ significantly by DMRT (ANOVA) at P =0.05; ns, non significant; At zero time mycorrhizal population =0.18 spores/g soil.

and oil content of grains was found across the treatments.

To conclude, the effect of Wellgro-soil application continuously for three years @ 100 kg per ha + 75 per cent of RDF or Wellgro-soil @ 200 kg per ha alone or with fertilizers as a basal dose produced higher and comparable grain yield with recommended dose of fertilizers in soybean cultivar '93-05', improved organic content in soil, nodulation and maintained high population of *Rhizobium* and mycorrhizal fungi and had higher soil enzymes activities when compared to other treatment combinations. More over, the increased population and enzymatic activities of below-ground system supporting higher productivity in the current study necessitates the efficient use and manipulation of native AMF along with organic amendments and reduced doses of fertilizers for long-term soybean stability and productivity.

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Epidemiological Aspects of Target Leaf Spot of Soybea

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ABSTRACT

Regression equations were used as models to predict the target leaf spot of soybean caused by Corynespora cassiicola *at Palampur for two consecutive years (2005 – 2006) using critical weather parameters. The mean minimum relative humidity (77.45%) and mean bright sunshine hours (3.15 h) were important predictors of target leaf spot in soybean cultivars Shivalik and Bragg. Mean minimum RH (77.45%), minimum temperature (19.25^{o}C) and bright sunshine hours (3.15 h) were important predictors in cultivars Palam Soya, whereas mean minimum temperature (19.25^{o}C) and bright sunshine hours (3.15 h) were important predictors in Hara Soya under ~~at~~ Palampur conditions. The validation test showed that the models predicted target leaf spot reasonably well. However, future validation is needed to improve their predictive ability.*

Key words: *Corynespora cassiicola*, epidemiological parameters, soybean, Target leaf spot

Target leaf spot [*Corynespora cassiicola* (Berk & Curt) Wei.] is considered potentially serious especially on late maturing varieties of soybean at Palampur. The pathogen is cosmopolitan and is abundant in the tropics where it often causes distinct leaf spot on a wide range of host plants. Conidia are splashed or blown to leaves and cause infection when free moisture is present or when RH above 80 per cent (Nyvall, 1989). The fungus infecting hypocotyls, root and stem is of a different race than the one infecting leaf, pod and stem (Nyvall, 1989). Target leaf spot of soybean is comparatively a recent disease in Himachal Pradesh recorded first in 1996-97. Since then, it has been appearing in an epidemic form during each successive year in areas known for soybean growing. Although resistance sources in soybean to the disease have been identified, yet information regarding the disease initiation, its recurrence and spread, host range factors affecting disease

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development and management under Himachal Pradesh conditions is lacking. As per documented literature, no work has been done in India on different aspects of the disease. The present paper reports the first information on environmental parameters affecting the disease and development of the regression models to predict the disease.

MATERIALS AND METHODS

Field trials were laid out at the experimental farm during *kharif* season during second/third week of June 2005 and 2006 depending on the time of onset of rains each year. Four different cultivars of soybean, namely Shivalik (highly susceptible), Bragg (susceptible), Palam Soya (moderately resistant) and Hara Soya (resistant) were used for this study. The crop was raised as per the package recommended by the University. The experiments were laid out in randomized block design and replicated four times. The seeds were sown 2.5 cm deep with row-to-row and plant to plant distance of 35 cm × 15 cm, respectively. Each treatment plot of 2m × 3 m consisted of 9 rows of each soybean cultivars. Disease progress in time was studied by recording the severity of target leaf spot right from appearance of first disease symptoms at 10-day intervals. The disease was quantified by counting number of lesions per diseased leaf on at least five plants for each observation and scored on 0-9 point scale as described by Mayee and Datar (1986).

Grade type	*Disease severity*	*Reaction*
0	0	Highly resistant
1	< 1	Resistant
3	1-10	Moderately resistant
5	11-25	Moderately susceptible
7	26-50	Susceptible
9	> 50	Highly susceptible

Data were pooled at the end of the experiment to ascertain the relative effectiveness of each treatment against the disease. Disease severity was determined by using McKinney (1923) formula as given below.

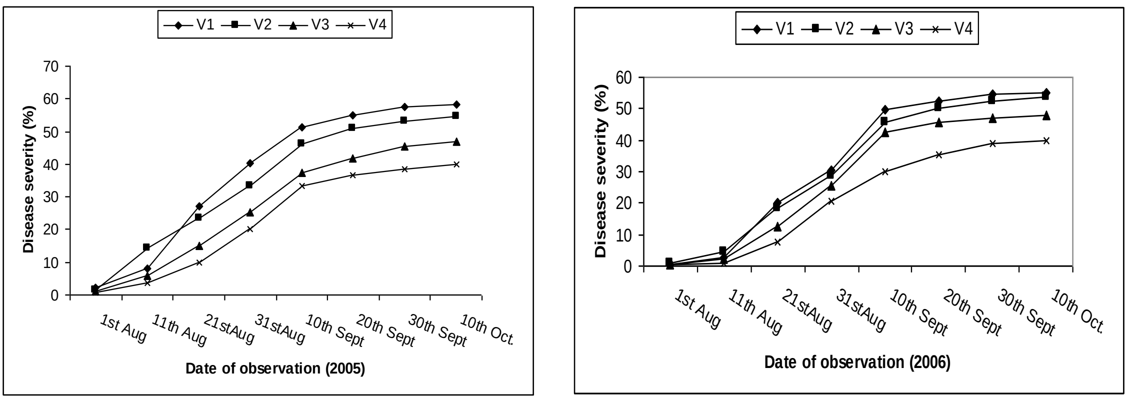
Disease severity (%) = Sum of numerical ratings x 100/Total number of ratings x Maximum grade

The progress of the disease was correlated with meteorological factors such as temperature, relative humidity, bright sunshine hours and rainfall to determine the role of weather variables on the development of the disease. Meteorological data were recorded with effect from first week of August till last week of October from the meteorological observatory of the University during both the years (2005-2006). The role of environmental factors in the development of disease was further established by multiple regression analysis amongst different parameters of an epidemic.

The data collected during the course of investigation were subjected to appropriate statistical analysis (Gomez and Gomez, 1984). The significance of difference was tested at 1 and 5 per cent level of probability. Simple correlation and stepwise multiple and partial regression analysis were performed between the disease and six independent factors, i.e. maximum temperature (X_1), minimum temperature (X_2), maximum relative humidity (X_3), minimum relative humidity (X_4), bright sunshine hours (X_5) and rainfall (X_6). The multiple linear model: Y = a + bixi + e was used to describe the functional relationship where, Y = Predicted mean disease severity; a = Intercept; bi = Partial regression coefficient for xi (i =1------n); xi = Independent variables (i = 1-----n); e = Random error

RESULTS AND DISCUSSION

Out of four cultivars (Fig. 1), Shivalik exhibited maximum disease (58 and 55%) followed by Bragg (55 and 54 %), Palam Soya (47 and 48%) and Hara soya (40% in both the years) during 2005 and 2006, respectively. Palam Soya and Hara Soya being comparatively early maturing cultivars, showed low disease during both the years. Similar pattern of disease severity in these cultivars was observed during 2006 even under low disease pressure, where Shivalik showed higher disease severity (55%). Hartwig (1959) also reported that target leaf spot development was heavy on lines that were late maturing.



V_1 – Shivalik V_2 – Bragg V_3 – Palam Soya V_4 – Hara Soya

Fig. 1. Progress of target spot development in different soybean cultivars during 2005 and 2006

The mean value of critical weather variables for disease initiation and development during August to October 2005 – 2006 were rainfall of 459.4 mm, minimum and maximum relative humidity of 77.45 per cent and 88.35 per cent, and minimum and maximum temperature of 19.25°C and 26.65°C with 3.15 h of bright sunshine hours. However, the weather was more congenial for disease development in late maturing varieties during September/ October period. There was abundant moisture availability and overall weather was usually cool with the maximum temperature around 25°C. Periods of drought during August and September have been reported to retard the development of target leaf spot on soybean. Hartwig (1959) observed that target spot is potentially more serious disease on varieties maturing during October or later. Disease losses are seldom observed prior to mid-August. Highly susceptible varieties were found to defoliate three weeks prior to maturity. However, Subero (1975) observed *C. cassiicola* causing extensive spots on leaf, capsule and stem at flowering stage leading to defoliation under discontinuous rain and high relative humidity. Drought stress during this period retarded disease development. Sinclair and Backman (1982) showed that disease was initiated when there was continuous moisture on the leaf and RH was around 80 per cent.

Multiple correlation coefficients between various epidemiological parameters ranged between 0.8477 and 0.9534 (Table 1) indicating significant relationship between disease and weather variables. The parameters taken into consideration during the course of investigation contributed > 84 per cent variation in disease in different cultivars with respect to the disease severity. Regression equations derived for predicting variation in disease development revealed that different weather variables could influence the disease severity in a positive direction if given weather variables prevail in an area for a specific period. Multiple correlation coefficients between disease severity and group of independent variables were highly significant during both the years. It is evident that the correlation coefficient was more (0.9534) during 2005 than in 2006 (0.8977). The coefficients of determination also indicated that maximum temperature and maximum RH were responsible for 0.9091 and 0.8059 variations in disease severity during 2005 and 2006, respectively.

The coefficients of multiple determinations also indicated that maximum temperature and maximum RH were responsible for 0.9091 and 0.8059 variations in disease severity during 2005 and 2006 respectively. The multiple regressions showed that a unit change in maximum RH and maximum temperature influenced the disease severity up to the extent of 1.1387, 8.969 units in Bragg and Shivalik respectively, during 2005 whereas in 2006, a unit changes in maximum RH and maximum temperature influenced disease severity up to the extent of 0.5540, 35.1482 units in Shivalik and Bragg, respectively. Jones and Jones (1984) reported the optimum temperature range for disease development on sunny tomatoes was 20-28° C for lesions forming on leaf blade, petiole and stem. A 16 h continuous wet period following inoculation was required for disease development, but a 24 h wet period greatly increased severity.

In pooled analysis all factors were significant but negatively correlated (Table 2) except minimum relative humidity and bright sunshine hours that were positively correlated to disease severity in Shivalik and Bragg whereas in Palam Soya and Hara Soya, minimum temperature and bright sunshine hours were positively correlated to disease severity. The multiple correlation coefficients were highest (0.8074) in Hara Soya. The coefficients of

Table 1. Multiple correlation coefficients between epidemiological parameters of target spot of soybean during 2005 and 2006

Variety	Regression equation (2005)	Regression equation (2006)	R (2005)	R (2006)	R^2 (2005)	R^2 (2006)
Shivalik	Y = 578.8097 + 0.5540X1* – 19.9894X3* – 1.7612X4** – 0.0743X6**	Y= 194.2865+ 8.9692X3 – 16.1349X4* – 13.3449X5 – 0.2346X6**	0.8794	0.8977	0.7734	0.8059
Bragg	Y = - 280.0089+ 11.4086X1* – 8.8000X2 + 35.1482X3** – 36.3574X4** – 50.8932X5 – 0.0943X6*	Y = 84.8498 + 1.1387X1 – 0.3075X3 – 6.2842X4* – 0.1520X6**	0.9193	0.8778	0.8452	0.7705
Palam Soya	Y = - 104.6638+ 8.6686X1* – 6.8790X2+ 22.4193X3** – 26.1227X4** – 38.6275X5 – 0.0926X6*	Y = 212.9323 – 4.4762X3 – 2.4406X4* – 0.1281X6**	0.9440	0.8477	0.8912	0.7186
Hara soya	Y = - 147.0030+ 8.8851X1* – 7.0797X2+ 23.4690X3** – 25.6286X4** – 39.1728X5 – 0.0918X6*	Y = 197.1083 – 3.7090X3 – 3.3524X4** – 0.0945X6**	0.9534	0.8573	0.9091	0.7349

*X_1 =Max. relative humidity ; X_2 =Min. relative humidity; X_3 = Max. temperature; X_4 = Min. temperature; X_5 = Bright sunshine hours; X_6 = Rainfall; Y= Disease severity; R = Multiple correlation coefficient; R^2 = Coefficient of multiple determination; * Significant at 1%; ** Significant at 5%*

Table 2. Pooled multiple correlation coefficients between epidemiological parameters of target spot of soybean

Variety	Regression equation	R	R^2
Shivalik	Y = 236.5350 – 0.1354X1**+ 0.1912X2** – 6.2278X3 – 1.4204X4** + 1.0796X5** – 0.0982X6**	0.7954	0.6327
Bragg	Y = 257.6738 – 0.2919X1**+ 0.1941X2** – 0.70324X3 – 1.1081X4**+ 1.4597X5** – 0.0768X6**	0.7793	0.6073
Palam Soya	Y = 273.6509 – 0.4778X1**+ 0.0361X2** – 8.2124X3+0.9847X4**+1.4673X5** – 0.0789X6**	0.8056	0.6490
Hara Soya	Y = 228.5662 – 0.1865X1** – 0.1962X2** – 6.5332X3+ 0.5402X4**+ 0.3771X5** – 0.0707X6**	0.8074	0.6519

*X_1 =Max. relative humidity ; X_2 =Min. relative humidity; X_3 = Max. temperature; X_4 = Min. temperature; X_5 = Bright sunshine hours; X_6 = Rainfall; Y= Disease severity; R = Multiple correlation coefficient; R^2 = Coefficient of multiple determination; ** Significant at 5%*

multiple determinations also indicated that minimum RH, temperature and BSS were responsible for >60% variation in disease severity among four cultivars of soybean. So that a unit changes in minimum relative humidity and bright sunshine hours influenced disease severity up to the extent of 0.1912, 1.0796 units in Shivalik.

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Attitude and Acceptance of Soy-foods Among Consumers

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ABSTRACT

Foods that contain whole soybean are good source of protein for vegetarians because they provide all the nutrients that people need to stay healthy. Consumers prefer products with less fat, less cholesterol and less calories, which contains nutrients and fiber. Soy-foods give an effective solution to the needs these consumers. Soy-foods like soy-milk, cheese, and yogurt sit side by side in the dairy case with milk products. The present study was undertaken to understand the knowledge, attitude, preference and acceptability of consumers for different types of soy-foods. Respondents were chosen from the two categories, i.e. the health conscious and the consumers suffering from certain diseases like diabetes, heart problems, obesity etc. The health conscious consumers were between 26-35 years whereas respondents in patient category were more than 36 years. Knowledge about health benefits of soy-food is more in the patients' group as compared to health conscious group. None of the consumers were having knowledge of any negative effect of excessive intake of soy-foods. Overall, the consumers in both the categories had a positive attitude towards soy-foods but more towards soy-milk and soy-paneer (tofu). Soy-milk and soy-paneer were more preferred than dairy milk and paneer in both the categories of consumers.

Keywords: Acceptability, attitude, knowledge, preference, soy-food

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Soybean is a very versatile bean. Many food items like soy-milk, soy-sauce, miso (soy-paste), tempeh (soy-cake), tofu (soy-*paneer*), soy-flour, soy-*namkeen* and soy-flakes are prepared from soybean. Soybean is also sometimes added to foods like breads, cereals, and meat products, and used as a meat substitute in products such as soy-burgers and soy-hot dogs. Foods that contain whole soybean are good source of protein for vegetarians because they provide all the amino acids, a type of nutrient that people need to stay healthy.

The increasing evidence that a good diet is linked to good health and prevention of major disorders such as heart disease and cancer, has led the consumers to demand more healthy foods and beverages. Consumers prefer products with less fat, less cholesterol and less calories, which contains nutrients and fiber. Soy-food gives an effective solution to the needs of these consumers (Kumar, 2007).

Soybean provides various health benefits like increase in height, weight, hemoglobin levels and improves cognitive properties (intelligence and memory power) in children, reduces blood cholesterol levels and hence prevent heart diseases (Lichtenstein, 1998). Diets that include 25 to 50 g of soy protein a day can help to lower levels of LDL cholesterol and hence heart diseases. It is very useful for diabetic patients, prevents digestive disorders and helpful in prevention of cancer and combating osteoporosis.

Despite a long list of benefits that soybean preparations provide to human beings, the intake of it has not caught up with the consumers. Researches show that the acceptance of soy-food is highly correlated to the consumer attitudes towards soy-food and prior information about the health effects of soy-protein (Faller *et al.*, 1999). Drake and Gerard (2003) found that the consumption of dairy food was more frequent as compared to the soy-foods. Chandrashekhar (2004) established results for the acceptance of soy-products as they are more economical, nutritionally beneficial and have scope for inclusion in the dairy meal pattern. Thomas *et al.* (2004) suggested soy-foods as partial or complete replacement of traditional meat, dairy and egg products. Hence, the present study was undertaken to understand the perception and acceptability of soy-foods among consumers. The specific objective of the study was to study the consumers' knowledge, attitude, preference and acceptability of soy-foods.

MATERIALS AND METHODS

To carry out the research, exploratory research design was followed. The population for the study consisted of soy-food consumers of Ludhiana (Punjab), who are either health conscious/gym goers or are suffering from some diseases like diabetes, heart disease or blood pressure. The sample for this study consisted of 100 consumers of soy-foods (50 health conscious and 50 with health problems). Respondents were chosen using snowball sampling technique. The respondents were contacted at the gyms, hospitals, parks, health centers, etc. Data was collected through structured and non-disguised questionnaire on various parameters of knowledge, attitude, preference and acceptability of the consumers for soy-foods. Their demographic profile was also collected. The data was analyzed using statistical techniques like means, averages, percentages and Z-test. The parameter on which data was collected was operationalised as follows.

Knowledge: The term 'knowledge' refers to the knowledge about various health benefits, negative effects and constituents of soy-food. The responses on these aspects from both the categories under consideration were gathered. In addition, their knowledge about ease of availability of soy-foods in the market was also assessed on 3-point scale from easily available (2) to not available (0).

Attitude: Attitude has been measured according to the Fishbein model of attitude measurement where overall effect for/against various soy-products was assessed based on the multiplicative effect between the attributes expected and present in soy-foods.

For calculating the attitude parameter Fishbein attitude-toward-object model (Schiffman and Kanuk, 1992) was taken in form of the following equation.

$$\text{Attitude} = \sum_{i=1}^{n} p_i e_i$$

Where, Attitude is separately assessed overall measure of affect for or against attitude object; p_i = strength or belief that the attitude object contains the i_{th} attribute; e_i = evaluative dimensions associated with i_{th} attribute; and $\sum$ indicates a salient attributes by which the p_i and e_i combinations are summated.

***Preference**:* Preference for the study refers to the preference of various types of soy-foods over the traditional food products.

Acceptability: Acceptability of various soy-food types for the health conscious and the patients categories was studied on a scale from high to low acceptability.

RESULTS AND DISCUSSION

Profile of the respondents

The profile based on age, gender and occupation of respondents (Table 1) showed that 48 per cent of the respondents in the health conscious category were between 26-35 years of age. Of them, 80 per cent were males and 20 per cent females and occupation-wise 44 per cent students followed by 34 per cent servicemen and 22 per cent businessmen. In the patients' category, most of the respondents (40%) that consume soy-foods were of more than 45 years of age. Seventy-two per cent of them were males where as 28 per cent were females. Majority among these were servicemen (50%) followed by businessmen (36 %) and students (14 %).

Knowledge of the respondents about soy-foods

***Knowledge of major contents of soy-foods*:** The responses on the knowledge of respondents about the major components and health benefits of soy-foods (Table 2) revealed that in the health conscious as well as patients categories, majority of the respondents (84% and 76%, respectively) knew about the major components of soy-food. Further, they also knew about the presence of protein (100 % and 84 %, respectively) and fat (70 % and 73 %, respectively) in soy-foods. Presence of vitamins, minerals and carbohydrates was also known to quite a large number of respondents. About 50 per cent of the

Table 1. Distribution of respondents according to age, gender and occupation (N=100)

Category	Health conscious (No)	Patients (No)
Age (Yrs)		
15-25	12 (24)*	6 (12)
26-35	24 (48)	8 (12)
36-45	10 (10)	16 (32)
> 45	4 (8)	20 (40)
Gender		
Male	40 (80)	36 (72)
Female	10 (20)	14 (28)
Occupation		
Students	22 (44)	7 (14)
Servicemen	17 (34)	25 (50)
Businessmen	11 (22)	18 (36)

Table 2. Knowledge about soy-foods (N = 100)

Category	Health conscious (No)	Patients (No)
Major components of soy-foods		
Yes	42 (84)*	38 (76)
No	-	5 (10)
Some what	8 (16)	7 (14)
Different contents of soy-foods (Multiple responses)		
Protein	50 (100)	38** (84)
Carbohydrate	10 (20)	15 (33)
Fat	35 (70)	33 (73)
Mineral	26 (52)	29 (64)
Vitamin	31 (62)	27 (60)
Health benefits of soy-foods		
Yes	25 (50)	25 (50)
No	17 (34)	13 (26)

****Figures in parenthesis are percent values;***
****n = 45***

respondents also had knowledge of the health benefits of various soy-foods. On the whole health conscious category was comparatively more knowledgeable on this aspect.

Ease of availability of soy-foods in the market: Information gathered about the ease of availability of different soy-foods in the market on a 3 point scale (Table 3) revealed that among the health conscious group soy-milk led the availability (1.80) followed by soy-*paneer* (1.76) and soy-*namkeen* (1.42). In the patients group, soy-*paneer* led the availability (1.76) followed by soy-milk (1.7) and soy-flour. The two samples were compared for the ease of availability of different soy-foods in the market. Z values for all types of soy-food were non-significant except in case of soy-flour, which showed that both the categories differed in their views with regard to the availability of soy-foods.

Table 3. Ease of availability of soy-foods in the market (N=100)

Soy-foods	Health conscious category (Mean)	Patients category (Mean)	Z-value
Soy-milk	1.80	1.70	1.25
Soy-oil	1.36	1.52	1.27
Soy-*paneer*	1.76	1.76	-
Soy-flour	1.28	1.68	-3.13*
Soy-flakes	1.30	1.48	1.15
Soy-*namkeens*	1.42	1.60	1.23

** 5% level of significance, μ=1*

Knowledge of any negative effect of soy-foods: Certain negative effects, like thyroid imbalance has been found to some extent due to excess consumption of soy-foods. None of the respondent from both the categories had any knowledge on any of the negative effect of consuming soy-foods.

Source of information about soy-foods: Responses sought from respondents from both the categories about the different sources from which they got the information about soy-foods on a 3-point scale (Table 4) brought out that it was mostly from friends and relatives from where maximum number of respondents got the information about soy-foods in both the categories. From other sources, either they got the information only sometimes or very rarely. Z values for all the factors were found to be non-significant. Hence, both the samples agree on the source from which they obtain the information about soy-foods.

Table 4. Source of information about soy-foods

Sources	**Health conscious category (Mean)**	***Patients category (Mean)***	**Z-value**
Friends	2.24	2.06	1.21
Relatives	2.06	2.06	-
News paper	1.72	1.72	-
TV	1.62	1.5	0.77
Radio	1.84	1.72	0.85
Magazine	1.76	1.76	-
Internet	1.74	1.68	0.144

μ=1 $Z_{(table)}$=1.96

Attitude of the respondents towards soy-foods

The attitude of consumers towards soy-foods was ascertained by using Fishbein attitude-toward-object model. All the parameters like brand, taste, flavour, availability, cost and texture for various soy products were judged on present experiences (p) and future expectations (e) on a scale from strongly disagree (-2) to strongly agree (+2). The mean score for each parameter were calculated for present experience and future expectations. Further two means were multiplied for each parameter to find "pe" and all the "pe" were summed to find the attitude for a product in each category.

Attitude of consumers towards soy-products: Attitude of consumers toward various soy-products, i.e. soy-milk, soy-oil, soy-*paneer*, soy-flour, soy-flakes and soy-*namkeen* (Table 5) showed that soy-milk was easily available (2.04 and 2.32), but its flavour was not liked (0.08 and 0.88) by both the sets of respondents. Respondents felt that no established brand was available and market price of soy-milk was also high. Flavour (-0.16) of soy-milk as well as that of soy-oil (-0.28) was also not liked by the health conscious people. The texture of soy-*paneer* did not appeal to the people from health conscious category. However, and patients category considered cost to be very high, but expressed liking for the taste for soy-*paneer*. -There was a negative attitude of health conscious people towards cost and texture of soy-flour where as the brand and the flavour was disliked by patients' category for the product. The case was *vice versa* in case of soy-flakes. There was a negative attitude towards cost and texture of soy-flakes in patients group and towards brand and flavour in the health conscious category. The health conscious category had a negative attitude and patients category a low positive attitude towards soy-*namkeen*.

Table 5. Attitude of consumers towards soy-products (N=100), μ=0

Soy-foods and characters	Health conscious category			Patients category		
	p	e	Pe	P	E	Pe
Soy-milk						
Brand	0.40	1.6	0.64	0.40	1.80	0.72
Taste	0.04	2.0	0.08	0.44	2.0	0.88
Flavour	-0.08	2.0	-0.16	0.24	2.0	0.48
Availability	1.02	2.0	2.04	1.16	2.0	2.32
Cost	0.12	2.0	0.24	0.04	2.0	0.08
Texture	0.16	1.2	0.19	0.04	1.2	0.048
Sum			**4.08**			**4.528**
Soy-oil						
Brand	0.30	2.0	0.60	0.12	2.0	0.24
Taste	0.12	2.0	0.24	0.10	2.0	0.20
Flavour	-0.14	2.0	-0.28	0.14	2.0	0.27

Availability	0.04	1.6	0.06	0.30	2.0	0.60
Cost	-0.08	2.0	-0.16	-0.08	2.0	-0.16
Texture	0.10	2.0	0.20	0.04	1.6	0.064
Sum			**0.68**			**1.224**
Soy-paneer						
Brand	0.40	1.6	0.64	0.40	1.8	0.72
Taste	0.04	2.0	0.08	1.16	2.0	2.32
Flavour	-0.08	2.0	-0.16	0.04	2.0	0.08
Availability	1.02	2.0	2.04	0.04	1.2	0.048
Cost	0.12	2.0	0.24	-0.24	2.0	-0.48
Texture	-0.16	2.0	-0.32	0.44	2.0	0.88
Sum			**2.52**			**3.568**
Soy-flour						
Brand	0.20	2.0	0.40	-0.14	2.0	-0.28
Taste	0.02	2.0	0.04	0.02	2.0	0.04
Flavour	0.40	2.0	0.80	-0.04	2.0	-0.08
Availability	0.12	2.0	0.24	0.16	2.0	0.32
Cost	-0.08	2.0	-0.16	0.30	2.0	0.60
Texture	-0.16	2.0	-0.32	0.10	2.0	0.20
Sum			**1.0**			**0.08**
Soy-flakes						
Brand	-0.14	2.0	-0.28	0.20	2.0	0.40
Taste	0.02	2.0	0.04	0.02	2.0	0.04
Flavour	-0.04	2.0	-0.08	0.40	1.2	0.48
Availability	0.16	2.0	0.32	0.12	2.0	0.24
Cost	0.30	2.0	0.60	-0.08	2.0	-0.16
Texture	0.10	2.0	0.20	-0.16	2.0	-0.32
Sum			**0.80**			**0.68**
Soy-namkeen						
Brand	-0.24	2.0	-0.48	0.24	2.0	0.48
Taste	0.12	2.0	0.24	-0.04	2.0	-0.08
Flavour	0.30	2.0	0.60	0.30	1.6	0.48
Availability	-0.04	2.0	-0.08	0.12	2.0	0.24
Cost	-0.18	2.0	-0.36	-0.18	2.0	-0.36
Texture	0.02	2.0	0.04	0.02	2.0	0.04
Sum						**0.80**

Overall attitude of consumers towards soy-foods: After getting attitude score of soy-food consumers for each soy-food, an overall attitude of respondents based on Fishbein attitude towards object model (Table 6) showed that consumers in both the categories had a more positive attitude towards soy-milk and soy-*paneer* as compared to other soy-products. Soy-flour is liked more by health conscious and soy-oil by patients' category. Remaining soy-foods were liked equally. Spearman's rank correlation coefficient (r) of 0.37 shows that there is slight agreement in the responses of the two categories *i.e.,* some of the soy-foods that are liked by both the categories are same and some are different. Correlation coefficient was tested at 5% level of significance; t_{cal} = 0.7965 and t_{table} (4, 0.05) = 2.132. Since t_{cal} < t_{table} for (n-2) degree of freedom, we can say that the value of 'r' is non significant at 5% level of significance.

Table 6. Overall attitude of consumers towards soy-foods (N=100)

Soy-food	Health conscious category	Patients category
	Pe	Pe
Soy-milk	4.08 (1)*	4.52 (1)
Soy-*paneer*	2.52 (2)	3.56 (2)
Soy-oil	0.68 (5)	1.22 (3)
Soy-floor	1.00 (3)	0.80 (4)
Soy-flakes	0.80 (4)	0.68 (6)
Soy-*namkeen*	-0.04 (6)	0.80 (4)

*μ=0; * Figures in parenthesis are ranks*

Preference of soy-foods over traditional food

Assessment of the preferences of soy-food over other analogous traditional food (Table 7) revealed that soy-milk was preferred over dairy milk by both the categories of consumers. In health conscious group, 64 per cent and in patients group 70 per cent of the respondents preferred soy-milk. The preference for soy-*paneer* was similar to soy-milk as in the health conscious group, 72 per cent and in patients group 68 per cent of the respondents revealed liking for soy-*paneer* over dairy *paneer*. Soy-oil was less preferred as compared to other oils in both the categories. In health conscious group, 70 per cent respondents and in patients group 54 per cent of the respondents preferred other oils to soy-oils. Soy-flakes were less preferred over corn flakes in both the categories, as only 38 per cent liked the soy-flakes. Soy-*namkeen* is less preferred as compared to other *namkeens* in both the categories.

Table 7. Preference for Soy-foods over analogous traditional foods (N=100)

Food	Health conscious category (No)	Patients category (No)
Milk		
Soy-milk	32 (64)*	35 (70)
Dairy milk	18 (36)	15 (30)
Oil		
Soy-oil	15 (30)	23 (46)
Other oils	35 (70)	27 (54)
Paneer		
Soy-*paneer*	36 (72)	34 (68)
Dairy-*paneer*	14 (28)	16 (32)
Flakes		
Soy-flakes	17 (34)	19 (38)
Corn flacks	33 (66)	31 (62)
Namkeen		
Soy-*namkeen*	14 (28)	13 (26)
Other *namkeens*	36 (72)	37 (74)

**Figures in parenthesis are percent values*

Buying preferences: Rating of preferred present sources of buying soy-foods evaluated (Table 8) on a three point scale ranging from mostly (2), sometimes (1) and never (0) showed that the health conscious people were mostly buying soy-foods from specialized soy-outlets (1.62), followed by gyms (1.36) and grocery store (1.0). Those belonging to patients' category too had mostly been buying soy-foods from specialized soy-outlets (1.5) followed by grocery stores (0.96), and departmental stores (0.92). Door to door vendors were not preferred by either of the groups. There had been a significant difference in the responses of both the categories in case of gyms as a preferred source of buying (Z value 5.30).

Table 8. Preferred present sources of buying soy-food (N=100)

Sources	Health conscious category (Mean)	Patients category (Mean)	*Z-value*
Specialized soy outlets	1.62	1.5	0.44
Grocery store	1	0.96	0.21
Gyms	1.36	0.6	5.30*
Door to door vendors	0	0	----
Departmental stores	0.96	0.92	0.21

5% level of significance. μ=1

Preferred future sources of buying soy-foods: Further quarries on future sources of buying soy-foods from consumers (Table 9) revealed that the health conscious people mostly plan to buy soy-foods from gyms they visit it routinely followed by specialized soy-outlets, door to door vendors, grocery stores and departmental stores. Respondents from patients' category mostly plan to buy soy-foods from grocery stores followed by specialized soy-outlets, departmental stores, door-to-door vendors and gyms. Spearman's rank correlation coefficient (r) came out to be -0.5. Negative rank correlation showed that respondents in two categories plan to buy soy-food from different outlets. Rank correlation was tested at 5 per cent and found non-significant ($t_{cal} < t_{table}$ for n-2 degree of freedom). This information will facilitate the marketers of soy-food to focus their efforts towards reorienting their distribution channel.

Table 9. Preferred future sources of buying soy-food in future by the respondents (N=100)

Source	Health conscious category	Patients category
	Rank score	Rank score
Grocery store	130 (4)*	200 (1)
Specilised soy-outlets	165 (2)	190 (2)
Departmental stores	110 (5)	150 (3)
Door to door venders	140 (3)	110 (4)
Gyms	205 (1)	100 (5)

t cal = -0.933 and t_{table} (2, 0.05) = 2.353 , r=-0.5;
** Figures in parenthesis are ranks;*

Purpose to consume soy-food: The objective of soy-food consumption stated was different for both the groups of respondents (Table 10). The analysis showed that the health conscious respondents were more inclined towards bodybuilding and health improvements as compared to the taste or disease prevention traits of soy-foods. On the other hand patients had more fascination for health improvement and disease prevention as compared to the taste or body building traits of soy-foods. Spearman's rank correlation coefficient for both the groups was 0.3. Since the rank correlation coefficient is near to 0, there is somewhat agreement in the order of ranks. Testing the significance of correlation coefficient, it was found that $t_{cal} < t_{table}$ for (n-2) degree of freedom and 'r' is non-significant at 5 per cent level of significance. These categories were not correlated as far as the purpose to consume soy-foods was concerned.

Table 10. Purpose of respondents to consume soy-foods (N=100)

Source	Health conscious category	Patients category
	Rank score	Rank score
Body building /fitness	160 (1)*	100 (3)
Disease prevention	95 (3)	145 (2)
Health improvement	150 (2)	160 (1)
Taste	95 (3)	95 (4)

t cal = 0.6593, t_{table} (2, 0.05)= 2.920; Figures in parenthesis are ranks*

Acceptability of soy-foods

A 5-point Likert scale ranging from strongly unacceptable (SUA) to strongly acceptable (SA) was utilized to ascertain the acceptability of different types of soy-foods by the respondents. The analysis revealed that soy-*paneer* (1.60) led the acceptability among the health conscious people, which was followed by soy-milk (1.44), soy-flakes (1.40) and soy-*namkeen* (1.22). Soy-flour (0.32) and soy-oil (0.22) had very less acceptance. Among patients, soy-milk had maximum acceptability (1.56) followed by soy-*paneer* and soy-oil (1.40), and soy-flour (1.22). Soy-*namkeen* (0.32) and soy-flakes (0.22) showed very less acceptability (Table 11). Z-values for both the sample means were significant except soy-milk and soy-*paneer* indicating that remaining soy-foods significantly differed as far as the acceptability is concerned by the respondents in both the categories.

Table 11. Acceptability of soy-foods by respondents (N=100)

Soy-food	Health conscious category (Mean)	Patients (Mean)	Z-Value
Soy-milk	1.44	1.56	-0.74
Soy-oil	0.22	1.40	-8.42*
Soy-*paneer*	1.60	1.40	1.24
Soy-flour	0.32	1.22	-5.79*
Soy-flakes	1.40	0.22	8.38*
Soy-*namkeen*	1.22	0.32	5.78*

** 5% level of significance, μ=0*

Frequency to consume soy-foods: The frequency of consumption of various types of soy-foods as well indicated their acceptability (Table 12). Responses of respondents from health conscious category revealed that among various soy-foods, the consumption of soy-milk tops the list (62%) followed by that of soy-*paneer* (42%) on daily consumption basis. Soy-oil, soy-flour and soy-*namkeen* were used irregularly or occasionally by 50 per cent of the consumers. Soy-flakes are consumed once or twice a week by 38 per cent of consumers or irregularly by 30 per cent of consumers. Out of the people suffering from certain diseases (Patients category), 40 per cent of them consumed soy-milk, 20 per cent each soy-oil and soy-flour on daily basis. Forty per cent respondents reported to consume soy-*paneer* once/twice a week. Soy-flakes and soy-*namkeen* were less frequently consumed.

Table 12. Frequency of soy-foods consumption by respondents (N = 100)

Frequency of consumption	Soy-milk (No)	Soy-oil (No)	Soy-*paneer* (No)	Soy-flour (No)	Soy-flakes (No)	Soy-*namkeen* (No)
	Health conscious category (N = 50)					
Daily	31 (62)*	-	21 (42)	-	-	-
Once/twice a week	4 (8)	14 (28)	9 (18)	5 (10)	16 (32)	10 (20)
More than twice a week	10 (20)	11 (22)	10 (20)	11 (22)	10 (20)	5 (10)
Once a month	-	-	-	9 (18)	9 (18)	11 (22)
Irregular/occasional	5 (10)	25 (50)	10 (20)	25 (50)	15 (30)	24 (48)
	Patients category (N = 50)					
Daily	31 (62)	-	21 (42)	-	-	-
Once/twice a week	4 (8)	14 (28)	9 (18)	5 (10)	16 (32)	10 (20)
More than twice a week	10 (20)	11 (22)	10 (20)	11 (22)	10 (20)	5 (10)
Once a month	-	-	-	9 (18)	9 (18)	11 (22)
Irregular/occasional	5 (10)	25 (50)	10 (20)	25 (50)	15 (30)	24 (48)

Figures in parenthesis are per cent values

Problems faced in consumption of soy-foods: The problems faced by respondents in consuming soy-foods (Table 13) brought out that the negative taste perception was the common problem between the two categories of respondents. This was followed by inconvenience in preparation of soy-foods, cost factor and confusing health/ nutritional information. Instant availability was the last bottleneck in soy-food consumption. Rank correlation coefficient of 1 showed that both the sets of respondents face the same problems in soy-food consumption.

Table 13. Problems faced in soy-food consumption by the respondents (N=100)

Problems faced	**Health conscious category**	**Patients category**
	Rank score	**Rank score**
Not readily available	135 (5)*	127 (5)
Confusing health/ nutritional information	160 (4)	170 (4)
Costly (compared to traditional foods)	180 (3)	178 (3)
Negative taste perception	231 (1)	232 (1)
Inconvenience in preparation	189 (2)	190 (2)

* *Figures in parenthesis are ranks*

Soy-foods are high protein meals which can prove to be excellent substitute of non - vegetarian diet and serve as potential source of protein for Indian populace to mitigate wide spread energy-protein malnutrition. Health conscious and people suffering from certain diseases have started including it in their diet, but only soy-milk and soy-*paneer* have found greater acceptability between these two groups. People have a positive attitude towards various types of soy-foods, especially soy-milk and soy-*paneer*. People need to be made more aware of the health benefits of soy-foods and negative perceptions about taste, price etc. need to be corrected. Understanding the knowledge, attitude and acceptability of consumers will help the marketing managers to identify market opportunities and develop targeted promotion plans for soy-foods. The findings of this survey will help the marketers to formulate and reorient their marketing strategies and researchers can improve upon the products according to the consumer attitudes and preferences.

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Transformed Post-soybean Introduction Farming Scenario in Madhya Pradesh

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ABSTRACT

A study was conducted to visualize the impact of soybean cultivation in the "Soya State", Madhya Pradesh. The data were collected using well-designed interview schedule containing relevant questions on how soybean has affected farmers' lifestyle as well as overall farming scenario? Majority of the respondents perceived soybean cultivation as a major driving force for their socio-economic development. A steady increase in the farmers' inclination to grow soybean was observed during the last five decades, while, decreasing their area in traditionally grown crops like sorghum, pigeon pea, groundnut, cotton and black gram. During soybean introduction many changes in the overall farming scenario of Madhya Pradesh have occurred. The change was recorded in the land holding pattern of farmers which revealed that small and marginal farmers have further reduced their land holdings while larger farmers have not only managed their holdings but also added newer areas to their total farm size. The cost of cultivation as well as rates fetched by the soybean showed an upward trend with passage of time during these five decades. An inverse relationship between the labour availability and wages was also observed. The gathered opinion from farmers brought out that fertilizer consumption and insect-load appeared to have increased with time. It seems that in spite the irrigation facilities have increased during these 50 years particularly that of canal, tube wells and ponds, soybean by and large, remained to be a rainfed crop. However, the farmers have shifted from bullock drawn implements to tractor drawn implements. This led to limiting number of animals with farmers, thereby progressive reduction in the use of manures. Subsequent to the introduction of soybean, the socio-economic status of the farmers has improved.

Keywords: Farming scenario, fertilizer consumption, implements, labour availability, land holding, post-independence, socio-economic status, transform

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The golden crop soybean has shown phenomenal growth, both in area and production, in a limited span of four decades and has positioned itself as an integral part of cropping systems traditionally followed by farmers of Madhya Pradesh. Presently, its cultivation is concentrated in *Malwa* Plateau, *Vindhya* Plateau, *Satpura* Hills, *Narmada* Valley and some part of *Bundelkhand* region with an area of 5.1 million hectares with estimated production of 5.8 million tones during *kharif* 2008 (www.sopa.org). The farming community of this region has witnessed its introduction and commercial exploitation along with problems and efforts/intervention by public and private sector comprising many players to promote the cultivation of the crop, marketing, policy reforms and changes in overall cropping pattern (Dupare *et al.*, 2008). The crop has glorified the state of Madhya Pradesh as "Soya State", which has been one among major player of yellow revolution experienced in the country. At national scenario, it competes neck and neck with respect to area and production to leading oilseed crop like groundnut among the oilseeds and continues to contribute significantly to the edible oil availability (more than 20% of total oil produced) in the country. Soybean has also been instrumental in offsetting the import bill on edible oil by about 50 per cent by export of soy meal (Joshi *et al*, 2008). It is believed that the crop has also contributed enormously to the socio-economic upliftment of the farmers and rural economy of this state (Badal *et al.*, 2000). The present study was conducted to know the perceived socio-economic impact of soybean among the farmers of the state and to document the changes resultant to its commercial cultivation in the overall agricultural/farming scenario.

MATERIAL AND METHODS

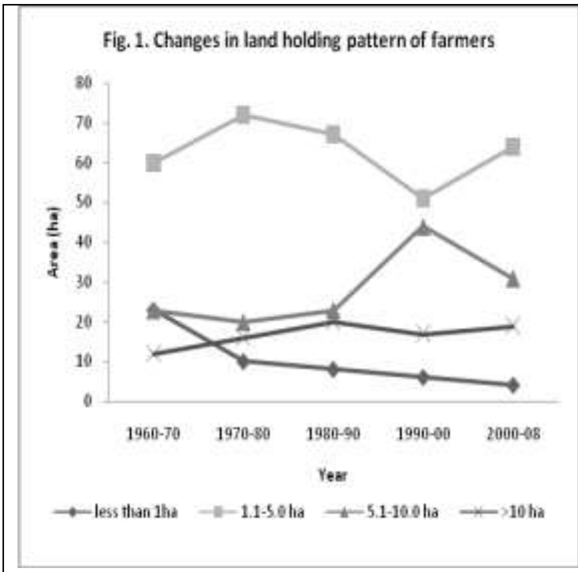
An effort was made in the present investigation to study the perceived impact of soybean cultivation among the soybean farmers of Madhya Pradesh. The study is confined to the major soybean producing regions of Madhya Pradesh, which owes maximum area (about 5.1 million hectares) under soybean (9.6 million hectares) in the country. Out of 48 soybean-growing districts, 6 of them located in agro-ecological zones of *Malwa* Plateau (Indore, Dewas and Ujjain), *Satpura* Hills (Betul), *Vindhya* Plateau (Hoshangabad and Vidisha) and *Narmada* Valley (Badwani) were purposively selected on the basis of area coverage by the crop. The sample size comprised of randomly selected 118 farmers from these districts. The data were collected from respondents with the help of meticulously designed interview schedule, which after testing its validity and reliability through pilot study, was administered on the respondents of this investigation. The data so obtained was analyzed using standard statistical tools like, mean, standard deviation, percentage and correlation coefficients.

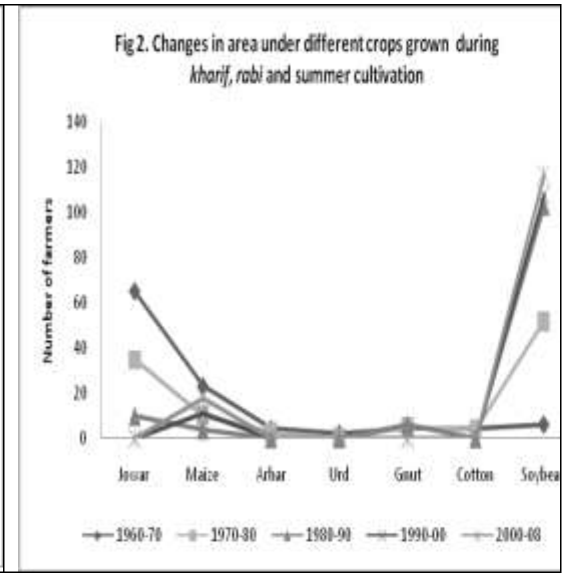
RESULTS AND DISCUSSION

The study was conducted to see the perceived impact of soybean cultivation among the farmers of Madhya Pradesh, which has completed nearly four decades after the initial introduction and commercial exploitation of the crop. Out of 118 respondents contacted for this study, 104 (88.00 %) cited soybean to be the major crop enterprise for their socio-economic upliftment beside potato (13%). Other crops and enterprises like garlic, onion, wheat, sugarcane and vegetables etc., were also observed to be the possible factors as reflected by few farmers. Nearly 91 per cent farmers of Madhya Pradesh stated that soybean being the prime driving force for their socio-economic prosperity. The perception of the farmers about how far the soybean crop has contributed and the changes occurred in the overall farming scenario among them is outlined in the text below.

Changes in land holding pattern of the farmers

An overall scenario of the changes in land holding pattern of farmers during the last four decades (Fig 1) brings out the consequences of continuous land fragmentation, thereby a regular decrease in the number of small and marginal farmers (land holding <1 ha). There appears to be a potential danger of disappearance of this sect of farmers. The farmers with land holding between 1.1 to 5 hectares outnumbered other categories and showed an increasing trend during first decade followed by a decline till forth decade and then again build up at the end of fifth decade. Larger holdings (5.1- 10 ha) showed an increasing trend till forth decade and then a decline during the fifth decade. During 4th and 5th decade, there appears to be an adjustment between the farmers holding the land between 1.1 and 5.0 hectare and 5.1 and 10 hectares. There appears to be a gain in number of farmers holding over 10 hectares of land during five decades. The data, within the framework of 118 numbers of farmers, revealed a tendency to increasing the land owned by medium and large farmers. This trend is likely to be on the expense of small and marginal farmers with land holding of less than one hectare. It is quite evident that the poor farmers, largely belonging to small and marginal category, till their land in diverse and difficult conditions are becoming still poorer and finding difficult to retain their holdings. On the contrary, farmers with moderate to large holdings are successfully involved in increasing their land holdings. The situation warrants the attention of policy makers to implement suitable strategy favouring marginal and small farmers so that their existence continues.





Changes in area under different crops grown by farmers

Assessing the data (Fig 2) gives us an idea to how soybean has progressed from meager area to occupy a coveted position in the cropping patterns followed by the farmers of Madhya Pradesh besides establishing itself as an integral part of their livelihood. The data also revealed the efforts of development departments to disseminate the farm technologies to motivate the farmers to adopt more remunerative cropping systems rather than following traditional fallow-*rabi* crops on Vertisols. It is obvious that sorghum, and maize were the major *kharif* crops grown during 1960s along with some area under arhar, urd, groundnut, and cotton (Gadge, 2003). A steady increase in the farmers' inclination to grow soybean was observed during the last 5 decades while decreasing their area in other crops (Dupare *et al.*, 2008). However, maize has managed to keep its existence on account of its utility as mixed crop in soybean and its increasing utilization as poultry feed and fish-meal. A cash crop of soybean which initially started growing largely on fallow lands with assured yield, ease in cultivation and lower cost of cultivation with ample market avenues has replaced these crops and is till now favored by the farmers in absence of more remunerative and suitable competitive alternative crops.

Changes in the farmers' area and productivity of soybean

During the past 50 years of introduction and establishment of soybean in India, there has been an increasing inclination of farmers for cultivation of the crop, possibly on account of simultaneous emergence of the market and remunerative price available to them. Soybean fascinated most to the farmers with land holding 1.1 to 5.0 hectare followed by 5.1 to 10 hectares as revealed by the steady increase in number of farmers growing soybean. Farmers with land holdings larger than 10 hectares, too showed an increasing trend but at a lower pace. The trend of increase in number of farmers owning less than 1 hectare were not that consistent over the period under consideration (Table 1). Although, the farmers with land holding of above 10 ha showed inhibition for cultivation of soybean during initial years of introduction, gradually took cultivation in subsequent years.

On the productivity front, it is unequivocally established that there had been a consistent gain over a period of time. Respondents' response revealed that the number of farmers harvesting 1 t/ha or less during crop introductory period decreased with concomitant increase in number of farmers harvesting between 1.5 to 3.0 t/ha with the establishment of the crop. Major number lies with harvest level of 2.5 t/ha in the framework of the study. This also indicated that over a period of time, the production technology generated through research could effectively percolate among farmers with guided efforts made by extension machinery. Availability of a good number of high yielding varieties specific to agro-ecological regions with resistance/tolerance to biotic and abiotic stresses and the strong back up of production technology firms the belief that there is a strong possibility of achieving higher productivity under Indian conditions in future.

Spread of soybean varieties

Research on soybean started taking shape earlier then the crop could cover sizable area. The research on breeding of improved varieties through All India Coordinated Research Project on Soybean (established in 1967) and National Research Centre for Soybean (established in 1987) could maintain a continuous flow of soybean varieties for farmers. Gradual shift in varietal scenario (Table 2) affirms that the indigenous soybean variety *Kalitur* served as the vehicle for the soybean revolution in the country, especially in the Central India. Majority of farmers at the time of commercial introduction of soybean in the country and between 1970 and 1980, were growing this variety (Tiwari *et al.,* 1999).

Table 1. Periodic changes in area under soybean and productivity levels of farmers (N=118)

Period	Holding size				Productivity (q/ha) from different land holdings			
	<1 ha	1.1-5.0 ha	5.1-10 ha	>10 ha	10 t/ha	1.5 t/ha	2.5 t/ha	3.0 t/ha
1960-70	1 (00.84)*	2 (01.69)	2(01.69)	0(00.00)	3(00.54)	2(01.69)	0(00.00)	0(00.00)
1970-80	16 (13.55)	43(36.44)	10(08.47)	3(00.54)	6(05.08)	21(17.79)	41(34.74)	4(03.38)
1980-90	6 (05.08)	76(64.40)	17(14.40)	8(06.77)	5(04.23)	13(11.01)	63(53.38)	16(13.55)
1990-00	4 (03.38)	66(55.93)	32(27.11)	13(11.01)	0(00.00)	7(05.93)	76(64.40)	22(18.64)
2000-08	13 (11.01)	64(54.23)	28(23.72)	13(11.01)	0(00.00)	7(05.93)	70(59.32)	41(34.75)

** The figures in parenthesis are per cent values*

Subsequently, the development and release of improved yellow seed coated varieties replaced *Kalitur*, mainly on industrial preference, yield and price grounds. The only emerging concern is that the farmers, in general, have been banking on few varieties (Tiwari, 2003; Badal *et al*., 2000), which does not nurture varietal cafeteria approach. During last few years, JS 335, MAUS 47, JS 93 05 and JS 95 60 are the most preferred varieties by the farmers. The situation calls for more concentrated extension efforts to convince farmers on the virtues of newer varieties and make them aware on the advantage of adopting varietal cafeteria approach to sustain productivity of the crop. At the same time adoption of crop rotations for extended period considering the inclusion of other *kharif* crops like maize as sole crop or intercrop with soybean (Vyas et al) should be a part of future strategy to ensure crop diversification and sustain productivity. The onus also lies on the State Department of Agriculture to precisely foresee the varietal need of the farmers and indent for breeder seed so that the certified seed of improved varieties may be made available through seed chain.

Changes in cost of cultivation and market rates of soybean

The cost of cultivation as well as rates fetched by the farmers for soybean has shown upward trends with passage of time during these five decades (Table 3). The increase in cost of cultivation during later years appeared to be driven by the higher returns, improved economic status of farmers and dissipation of improved production technology. Cost of cultivation, which use to be less than Rs 1, 000 during the sixties touched as high as Rs 12, 000 at present. As a matter of fact, the adoption of recommended package should have involved only Rs 8, 051 per ha (Tiwari and Joshi, 2002). This shows enthusiasm of farmers to go for unwarranted supplementation of inputs not recommended by the system and needs to be curbed.

Table 2. Changing varietal scenario of soybean varieties over time (N=118)

Variety	Period				
	1960-70	1970-80	1980-90	1990-00	2000-08
Kalitur	5	86	18	-	-
Punjab1	-	8	52	18	-
JS2	-	15	30	3	-
PK 472	-	2	-	3	-
JS 71 05	-	-	19	40	21
JS 72 44	-	-	24	43	4
JS 1608	-	-	1	1	2
JS 72-280	-	-	8	19	2
Samrat	-	-	13	26	24
JS 335	-	-	13	52	96
Ankur	-	-	6	-	-
BS 2	-	-	-	2	6
PK 1044	-	-	-	3	20
JS 80 21	-	-	-	1	-
NRC 7	-	-	-	2	22
T 49	-	-	-	2	-
JS 93 05	-	-	-	-	74
MAUS 47	-	-	-	-	98
NRC 12	-	-	-	-	9
JS 95 60	-	-	-	-	1
NRC 37	-	-	-	-	1

Table 3. Changes in cost of cultivation and market rates of soybean (N=118)

Period	Cost of cultivation (Rs/ha)				Market rates of soybean (Rs/t)				
	<1000	1001-2000	3000-6000	8000-12000	<3000	4000-5000	7000-10000	12000-14000	>20000
1960-70	3(02.54)	2(01.69)	0(00.00)	0(00.00)	2(01.69)	3(02.54)	0(00.00)	0(00.00)	0(00.00)
1970-80	27(22.88)	41(34.74)	4(03.38)	0(00.00)	5(04.23)	58(49.15)	9(07.62)	0(00.00)	0(00.00)
1980-90	0(00.00)	49(41.52)	48(40.67)	0(00.00)	0(00.00)	34(28.81)	61(51.69)	0(00.00)	0(00.00)
1990-00	0(00.00)	12(10.16)	70(59.32)	24(20.33)	0(00.00)	0(00.00)	82(69.49)	24(20.33)	0(00.00)
2000-08	0(00.00)	0(00.00)	55(46.61)	63(53.38)	0(00.00)	0(00.00)	0(00.00)	67(56.77)	51(43.22)

** The figures in parenthesis are per cent values*

Similarly, the price of soybean in the market, which happened to be around Rs 3, 000 per t in the beginning, has progressively shown a buildup touching Rs 28, 000 per t in last couple of years. This is going to be a motivating factor for the farmers to bring more and more area under the cultivation of soybean. However, there is a need to multiply the number of procuring points for soybean produced in the line of 'Soy-Chaupals' established by ITC by public and private sector agencies to ensure remunerative price to farmers with minimum cost on transportation.

Changes in farm labour wages and availability pattern

There has been an inverse relationship between the farm labour availability and wages. Information provided by the farmers revealed ample availability of agricultural labour at wages not even exceeding Rs 20/day during the sixties. With the expense of time, the situation gradually reversed and by the end of reported period labour availability became scarce with wages reaching above Rs 80/day (Table 4). This led to non-availability during critical growth period and led to increase in cost of cultivation.

Table 4. Changes in farm labour wages and their availability (N=118)

Period	Labor wages (Rs/day)					Labour availability			
	< 20	21-40	41-60	61-80	>80	Available	Not available	Less available	Very less available
1960-70	32(27.11)	5(04.23)	0(00.00)	0(00.00)	0(00.00)	57(48.30)	1(00.84)	0(00.00)	0(00.00)
1970-80	47(39.83)	29(24.57)	0(00.00)	0(00.00)	0(00.00)	68(57.62)	11(09.32)	0(00.00)	0(00.00)
1980-90	0(00.00)	85(72.03)	14(11.86)	0(00.00)	0(00.00)	76(64.40)	0(00.00)	23(19.49)	0(00.00)
1990-00	0(00.00)	32(27.11)	72(61.01)	8(06.77)	3(02.54)	64(54.23)	13(11.01)	37(31.35)	0(00.00)
2000-08	0(00.00)	0(00.00)	20(16.94)	49(41.52)	45(38.13)	60(50.84)	0(00.00)	0(00.00)	57(48.30)

* *The figures in parenthesis are per cent values*

Fertilizer application to soybean crop

The gathered opinion from farmers brought out that fertilizer consumption appeared to have increased over time (Table 5). This denotes the realization and awareness of farmers on crop nutrition to optimize productivity. But, the concern is that the dependence on inorganic fertilization is on increase without realization of the role of organic manures/residues recycling in improving soil health (Nambiar and Ghosh, 1984; Hegde *et al*, 1993) and thereby sustaining productivity. Farmers' information revealed that they are shunning with the golden practice of recycling of organic matter / residues, which provides good soil health and sustain productivity of crops. Usage of inorganic fertilizer revealed that (i) farmers had banked more on SSP and DAP during earlier years are now switching to IFFCO (12:32:16) showing awareness on balanced nutrition, (ii) use of urea has picked up with time, (iii) the use of potassium is also picking up, (iv) the farmers with potato in crop sequence felt that the fertilizers applied to potato crop are adequate for soybean as well, and (iv) the awareness on micronutrient requirement is being conceived by the farmers. The scenario on nutrient management showed that although there is concern over non/minimal use of organic resources on one side, on the other side development of a good tendency of providing balanced nutrition. However, the existing practice of skewed and non-judicious application of fertilizers needs to be curbed on priority to sustain crop yields and minimize environmental pollution. To motivate farmers on adoption of integrated nutrient management to provide balanced nutrition to the crops, a serious extension effort is needed so that the soil quality can be maintained/improved to sustain productivity of crops.

Table 5. Change in fertilizer use scenario (N=118)

Fertilizer/ Manure	FYM	SSP	MOP	DAP	IFFCO	No application*	Neem cake	Urea	Ammonium Sulphate	Micro-nutrient
1960-70	24	4	-	-	-	-	-	-	-	-
1970-80	24	31	17	4	6	-	-	-	-	-
1980-90	2	44	27	12	6	11 (13)	2	17	1	-
1990-00	11	42	29	57	26	5 (19)	-	24	-	-
2000-08	0	55	28	49	73	29 (22)	-	50	-	4

*FYM – Farmyard manure, SSP –Single superphosphate, MoP – Muriate of potash, IFFCO- 12:32:16, * Figures in parenthesis denote number of farmers opined that the fertilizers applied to potato crop are adequate for soybean as well.*

Insect-pest and disease infestation on soybean

The biotic stresses, particularly on account of insect-pests, during crop growth period is known to cause considerable yield loss (Sharma, 1999). The insect-load as perceived by the farmers has increased with time (Table 6). With the large area coming under soybean crop beyond 45 years, the insect damage could reach serious proportions. Although the awareness of the farmers on diseases is less, the increasing number of farmers reported the occurrence of soybean diseases. There is a need to create awareness among farmers for the use of appropriate agro-chemicals at right time and right method of application based on integrated approach.

Table 6. Changing awareness on insect-pest infestation and disease occurrence (N=118)

Period	Insect pest infestation			Disease occurrence			
	No pest	Less	More	No disease	Less	More	No podding
1960-70	58(49.15)*	6(05.08)	0(00.00)	58(49.15)	6(05.08)	0(00.00)	0(00.00)
1970-80	59(50.00)	17(14.40)	0(00.00)	58(49.15)	16(13.55)	0(00.00)	0(00.00)
1980-90	63(53.38)	26(22.03)	8(06.77)	64(54.23)	25(21.18)	8(06.77)	0(00.00)
1990-00	15(12.71)	60(50.84)	36(30.50)	19(16.10)	62(52.54)	28(23.72)	1(00.84)
2000-08	0(00.00)	11(09.32)	98 (83.05)	0(00.00)	12(10.16)	99(83.89)	5(04.23)

** The figures in parenthesis are per cent values*

Availability of irrigation facility and agricultural implements with the farmers

Availability of adequate quantities and quality of irrigation water may serves as a boon to agriculture. As per information gathered from the farmers, it seems that the irrigation facilities have increased during these 50 years, particularly that of canal, tube wells and ponds (Table 7). River water does not seem to be available for irrigation in recent years. Although the capability of farmers for irrigation is increased, they seldom irrigate soybean crop (http://dacnet.nic.in /ends/At_Glance_2008_new.html).

The message is to go to the farmers that the global climatic change has led to disturbed distribution of rainfall causing delayed onset of monsoon and intermittent dry spells during crop growth period and hence if they resort to surface water conservation methods and provide irrigation, particularly during dry spell at the time of pod fill to optimize the productivity of soybean and other crops.

Table 7. Change in irrigation potentials over time (N=118)

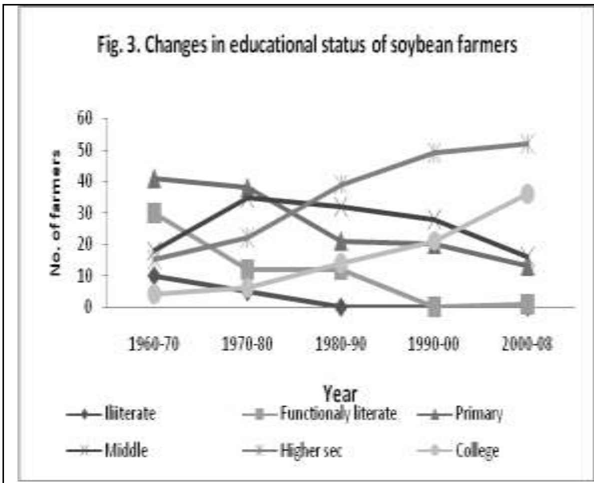
Period	Irrigation facility				Farm implements			
	Well	River	Canal	Tube well	Pond	Bullock drawn	Tractor drawn	Custom hire
1960-70	44(37.28)	9(07.62)	5(04.23)	-	0(00.00)	73(61.86)	2(01.69)	0(00.00)
1970-80	63(53.38)	10(08.47)	29(24.57)	5(04.23)	0(00.00)	74(62.71)	10(08.47)	0(00.00)
1980-90	70(59.32)	4(03.38)	27(22.88)	25(21.18)	0(00.00)	59(50.00)	41(34.74)	0(00.00)
1990-00	55(46.61)	0(00.00)	30(25.42)	64(54.23)	0(00.00)	34(28.81)	77(65.25)	3(02.54)
2000-08	61(51.69)	0(00.00)	37(31.35)	85(72.03)	2(01.69)	20(16.94)	94(79.66)	0(00.00)

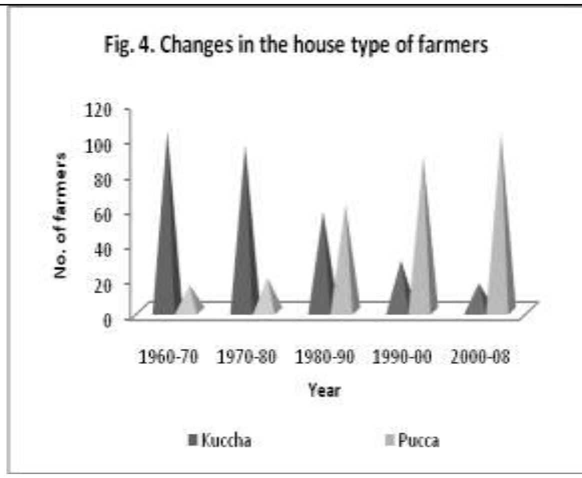
** The figures in parenthesis are per cent values*

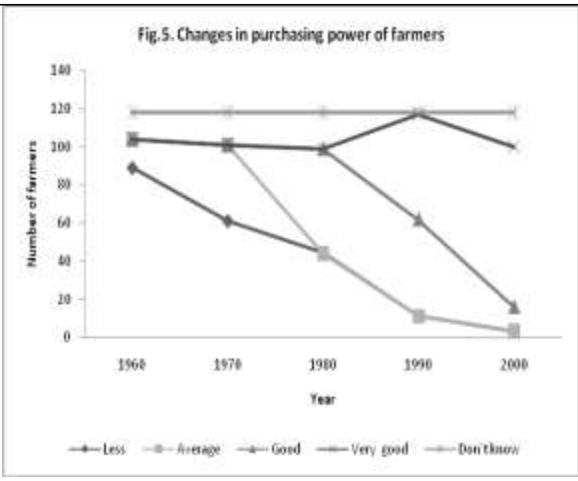
The farmers opined that there is a progressive increase in farm mechanization during last five decades. However, the farmers have shifted from bullock drawn implements to tractor drawn implements. This led to limiting number of animals with farmers, thereby progressive reduction in the use of manures. It is undisputed fact that there is a need of farm mechanization to remove drudgery and reduce the cost of cultivation, but not on the cost of farming system in which farm animals constituted active component.

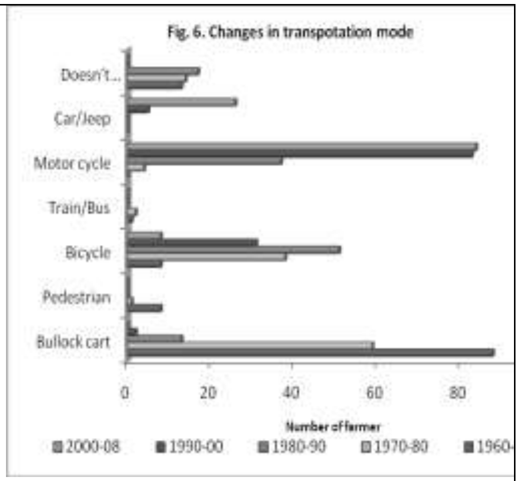
Changes in socio-economic status of the farmers

The socio-economic status of farmer has considerably improved (Badal *et al.*, 2000; Gadge, 2003) subsequent to the inclusion of soybean in their cropping systems as obvious from the information on various indices from the respondents. In general, the inclination towards the education was build up as there has been a progressive increase in number of farmers educated to higher secondary and college level with concomitant decrease in number of farmer in illiterate, functionally literate, primary and middle level categories (Fig. 3). Increase in the prosperity among the farmers is reflected in replacement of *kaccha* to *pacca* houses in the rural area of *Malwa* plateau of Madhya Pradesh (Fig. 4). Prosperity of soybean growers was also reflected in the enhancement of purchasing power as well. The purchasing power of farmers showed a consistent improvement over years and by 2000-2008; most of the farmers belonged to very good category (Fig. 5). Limited number of farmers belonging to do not know category are probably the small and marginal ones, who could not feel the impact of cultivation of soybean crop (Fig. 6).









On the basis of foregoing study it was concluded that the soybean was major vehicle for the socio-economic development of farmers of 'Soya-State' i.e., Madhya Pradesh. Perceptible changes have occurred in the land holding pattern, cropping sequence, varietal adoption, productivity levels, farm mechanization, market rates, labor wages and their availability besides upliftment in educational levels, transport mode, purchase power and type of houses.

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Performance of Soybean Variety JS 95-60 Under Real Farm Conditions in *Malwa* Plateau of Madhya Pradesh

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ABSTRACT

Frontline demonstrations conducted on soybean with soybean variety JS 95-60 in Ujjain district of Madhya Pradesh during 2007 and 2009 under oilseed programme with three modules, namely package demonstration, varietal component and seed village showed that farmers could increase the soybean productivity significantly by switching over to improved variety and adoption of production technology. The maximum productivity 2588 kg per ha and profitability of Rs 35, 378 per/ ha was achieved under full package demonstration, followed by other interventions. This increase in productivity amounted to 64 per cent over farmers practice. Varietal intervention alone could result in 20 per cent increase in seed yield of soybean. More than 94 per cent farmers revealed positive perception towards adoption of new variety, JS 95-60 on account of traits like high yield, early maturity, lesser insect-pest attack and apt fitting in cropping pattern. The average cost of cultivation with full scientific technology was higher by 14.8 per cent over farmers practice but the corresponding increase in profit was higher by 54 per cent.

Key words: Extension gap, net returns, technology gap

Soybean [*Glycine max* (L.) Merrill] is an important oilseed crop of central India, which is considered to play a vital role in the national and oil economy of country. During past few years, the export earnings of soy meal have touched Rs 70, 000 million in addition to supplementing edible oil production by more than 25 per cent. Among the districts of *Malwa* plateau, Ujjain occupies a coveted position with maximum area of 4, 42, 000 ha with a productivity of 1,300 kg per hectare and total production of 0.574 million tonnes (Report, 2009). Soybean area in the division has consistently been growing since 1980-81 and with the result the crop occupies about 90 per cent area during *kharif* at present.

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Although, the average productivity of the district (1, 300 kg/ha) is higher than national average of 1, 000 per hectare, the potential productivity achievable through improved varieties (3, 000 - 3, 500 kg/ha) and adoption of improved technology by farmers (around 2, 000 kg/ha) remains to be achieved. This requires concerted efforts to create awareness and convince the extension agencies as well as the farmers about the improved varieties and research emanated production technology so as to improve productivity levels under real farm conditions. Of the extension methodologies, laying out demonstrations on farmers' fields on 'seeing and believing' principle has proved to be the best in the past. In view of this, the *Krishi Vigyan Kendra* laid out frontline demonstrations with the objectives of (i) demonstrating the utility of improved soybean varieties and research emanated production technology on enhancing crop productivity, (ii) assessing the contributing factors governing higher productivity, and (iii) to receive farmers' feedback on provided technology.

MATERIAL AND METHODS

In the year 2007-08, the *Krishi Vigyan Kendra* selected operational area in the form of clusters from Ujjain, Ghatiya and Mehidpur blocks of Ujjain district. Each cluster covered an area of 20-25 villages. These clusters were under continuous surveillance of Krishi Vigyan Kendra and the scientists concerned were interacting with the farmers to gather first hand information on their status, problems related with soybean production and needed interventions. Ascertaining the need for an early genotype fitting in cropping systems in these clusters, an improved newly released short duration (85 days) variety JS 95-60 was selected for intervention through frontline demonstrations. Between 2007 and 2010, 39 on full package, 19 on varietal component and 300 demonstrations on seed production of JS 96-60 covering 15 villages were organised. The full package component included, one summer ploughing, 2.5 t/ha of farmyard manure, recommended dose of fertilizers ($N:P_2O_5:K_2O:S$; 20:80:20:20) tailored on the basis of soil test values, 80 kg seed per ha, seed treatment with Vitavax @ 2 g/kg seed, one *Dora* and need based pest management schedule. The results were compared with farmers practice which involved high seed rate of 125 kg per ha, close row spacing of 25 to 30 cm, application of 400 kg single super phosphate or 100 kg diammonium phosphate per hectare, no seed treatment and faulty and inappropriate use of pesticide. Varietal component included only the intervention of variety JS 95-60 as compared to farmers variety. The seed production programme of JS 95-60 was by providing 15 kg seed per farmer to be grown as per the recommended package of practice with due considerations to the norms of seed production such as isolation, roughing etc. supervised by the scientists with a view to develop seed hubs in targeted villages. Two villages from each cluster; Jalalkhedi and Dewrakhedi from Ujjain, Gadroli and Bichhod from Ghatiya, and Jharda and Maklakhedi from Mehidpur were selected randomly for collection of data. All the demonstrations (58) on full package and varietal component in these six villages were located on roadside with prominent display boards to facilitate farmers in the cluster to visit and get convinced with the technology imparted.

The data, utilizing well-structured schedule developed for the purpose on socio- economic status of soybean growers and perception/adoption of technology imparted under frontline demonstrations organized were collected from 120 growers. The economic benefit accrued by adoption of improved production technology including the introduction of improved variety JS 95-60 was worked out. The key indicators were (i) crop yield comparison (ii) perception for technology adoption, and (iii) economic analysis.

Statistical analysis by deriving mean and, standard deviation and interpretation of the collected data was done as per the procedure laid out in Cochran and Cox (1965). The technology and extension gaps were worked out (Kadian *et al.*, 1997) as follows.

Technological Gap = (Potential yield - Demonstration yield)

Extension gap = (Demonstration yield - Farmers yield)

RESULTS AND DISCUSSION

Status of soybean growers in study area

The data collected on age of soybean growers (Table 1) revealed that almost 40 per cent were younger (below 30 yrs) followed by middle aged (30-50 yrs) and older (above 50 yrs). It was also noticed that most of farmers in middle age group delegated their responsibility of farming to younger generation instead of doing it themselves. This was an added advantage in percolation of interventions given, as younger people were more amenable and responsive (Waghdhare and Dupare, 1997).

Table 1. General status of soybean growers in the study area (N = 120)

Category	Frequency	Percentage
Age of soybean growers		
Less than 30 years (Young)	48	40
Between 30 and 50 (Middle aged)	40	33
More than 50 (Old)	32	26
Range: 20-65; Mean: 38; SD: 10.84		
Educational status		
Illiterate	26	21.66
Able to read and write	36	30.00
Up to primary level	38	31.67
Middle school and above	20	16.66
Mean: 30; SD: 8.48		
Land holding		
Less than 1 ha (Marginal)	22	18.3
Between 1 and 2 ha (Small)	20	16.7
Between 2 and 4 ha (Semi –medium)	36	30.0
Between 4 and 10 ha (Large)	24	20.0
More than 10 ha (Very large)	18	15.0
Range: 1-10 ha; SD: 8.06		

The educational status of soybean growers is considered to be an important factor facilitating adoption of newer technologies. Among the farmers under study, only about 22 per cent were illiterate, 30 per cent were able to read and write and remaining 48 per cent belonged to categories with education level up to primary level and above. The lower number of illiterates was a positive factor facilitating the transfer newer technology (Waghdhare and Dupare, 1997).

As per SREP, ATMA (2006), the land holding in the Ujjain district use to be large, but in subsequent years, there has been a change in scenario on account of land fragmentation increasing the smaller holdings. Still the majority of the farmers (65%) belonged to categories (semi-medium to very large) and comparatively resource rich to adopt technology Irrespective of size of land holding, the farmers are inclined to cultivate soybean and this crop has become subsistence for them. Similar observation was recorded earlier (Rai *et al.*, 2002). Igodan *et al*. (1988) reported a significant positive relationship between land holdings (farm size) and adoption and observed that socio-economic status of farmers had strong positive relationship with adoption. This report implied that the higher the socio-economic status, the higher the tendency to adopt innovation because, farmers who are more exposed to formal extension information have a high propensity towards adoption than those with less exposure.

Farmer's perception towards adoption of JS 95-60

The soybean variety JS 95- 60 was notified and released for the cultivation by farmers only in the year 2007. In a short span of time the farmers of Ujjain district remarkably accepted it (Table.2). The data collected for the clusters under study revealed that in Ujjain and Ghatiya, the acceptance level was 57 to 75 per cent and was comparatively low in Mehidpur. The low adoption (14-32%) in Mehidpur cluster can be accounted for larger distance from the district headquarters and possible limited frequency of visit of extension functionaries.

Table 2. Area occupied by soybean variety JS 95-60 during 2009-10

Cluster/Village	Total area (ha) under soybean	Area (ha) under soybean variety JS 95-60	Area occupied by soybean variety JS 95-60 (%)
Ujjain cluster			
Jalalkhedi	380	220	58
Dewrakhedi	240	180	75
Baamora	840	560	67
Ghiya cluster			
Gadroli	400	220	55
Bichhod	920	690	75
Panbadodiya	700	520	74
Mehidpur cluster			
Jharda	1375	445	32
Maklakhedi	329	85	26
Paatakhedi	415	57	14

Source: DDA, Agriculture Ujjain report, 2009

Adoption of any new technology by the farmers is possible only if they are having positive perception towards the technology that leads to final adoption. With this view, perceptions of the farmers towards improved soybean variety developed by Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur under All India Coordinated Research Project on Soybean were studied (Table 3). Probing into the high adoption of soybean variety JS 95-60, revealed that there has been a positive perception of soybean growers towards the acceptance of this variety on account of several favourable traits noticed by them. Since, the farmers were convinced on early maturity (93.3 %), very low shattering tendency (80 %) and for apt fitting in multiple cropping (62.5 %), the expressed agreement for varietal replacement has turned out in successful adoption of the variety in area under the study (Table 2). The lesser attack by insect-pests was an added advantage which led to higher adoption of the intervened new improved variety, JS 95-60 (Table 3).

Table 3. Perception of soybean growers towards JS 95-60 (N = 120)

Opinion of the respondents	Disagree (%)	Agree (%)
Good for replacement	5.80	94.2
Early maturing	6.70	93.3
Very low shattering behaviour	20.00	80.00
Feasibility for multiple cropping	37.50	62.50
Less prone to attack of insect-pests	25.80	74.20
Limited cost of plant protection	23.30	76.70

Yield performance of soybean under FLD

All the 358 frontline demonstrations in the three clusters of Ujjain district with soybean variety JS 95-60 performed consistently better over farmers practice and locally cultivated varieties, namely 7322, JS-335 and Samrat (Table 4). With full package of technology including variety JS 95-60, the yield levels ranged from 2271 to 2588 kg per ha, which is approximately 64 and 38 per cent higher than farmers practice. The moment only one component, the variety JS 95-60 was given as an intervention, the yield level on an average dropped down to 22 per cent as compared to performance of the variety under full package. Nevertheless it showed about 20 per cent increase over farmers' varieties. This indicated that for optimising the productivity, the improved variety as well as crop management is equally important. The demonstration on seed production to develop a village as source of quality seed revealed that if farmers are educated on seed production aspect, this could serve as potent and alternative source of quality seed of improved varieties. Some total of all the 358 demonstration revealed that the average yield was almost 40 per cent higher than farmers' practice. Higher seed yield levels of soybean in frontline demonstrations organised under AICRP System have been retreated in recent report (DOR, 2009). The worked out technology and extension gaps revealed that there is a need to exert on both the fronts through concerted research and extension efforts. There exists a good potential to abridge these gaps and nearly double the existing national productivity of 1 tonne per ha with the technology in hand. It also shows a greater feasibility of variety in the farmers field for adoption, which is also supported by the perception percentage for various traits of JS 95-60 (Table 3) and these results are in conformity with those reported by Kadian *et al*. (1997) and Rao *et al*. (2007).

Table 4. Yield performance of demonstrated full package and components (Pooled for three years)

Cluster	Technology demonstrated	No. of Demo-nstration	Experimental yield* (kg/ha)	Demo-nstration yield (kg/ha)	FP Yield (kg/ha)	Increase over FP (%)	Technolo-gical gap	Exten-sion gap
Ujjain	Full package	34	3000	2588	1580	63.79	4.12	10.08
	Varietal component	14	3000	1897	1609	17.89	11.03	2.87
	Seed village	136	3000	2046	1375	48.8	16.25	6.71
Ghatiya	Full package	5	3000	2271	1641	39.39	7.29	6.3
	Varietal component	3	3000	1926	1483	29.87	10.74	4.43
	Seed village.	98	3000	2046	1175	74.12	9.54	8.71
Mehidpur	Full package	0	3000	0	0	0	0	0
	Varietal component.	2	3000	1840	1590	15.72	11.6	2.5
	Seed village	66	3000	1957	1340	46.04	10.43	6.17
		Mean		**1841**	**1310**	**37.29**	**9.00**	**5.31**

** The average experimental yield on the Krish VigyanKendra for JS 95-60*

Economic evaluation of the demonstrations organized revealed that although the imparted technology led to increase in cost of cultivation, it was coupled with sizable increase in gross and net returns culminating into C:B ratio from 2.36 to 3.73 as compared to farmers practice wherein it varied from 2.08 to 2.51 (Table 5). This indicated the varietal potential as well as the impact of imparted technology. Early maturing soybean variety JS 95-60 proved to be a good option to adopt in place of local and old varieties to be included in soybean cultivation on varietal cafeteria approach. Similarly, as revealed by imparting cultural practices, particularly based on integrated approach can pave a long way to increase the productivity and harvest the varietal potential.

The results of the study clearly re-establish that convincing the growers on newer technology by laying out frontline demonstrations is the most effective extension method. The varietal component and improved production technology, both are equally important for optimizing soybean yields. Educating farmers on quality seed production on seed village concept can help in raising seed replacement rate of high volume crop like soybean.

Table 5. Economical analysis of frontline demonstrations conducted

Cluster	Technology	Yield (kg/ha)		Average cost of cultivation (Rs/ha)		Average returns (Rs/ha)				B:C ratio	
						Gross		Net			
		FLD	FP	FLD	FP	FLD	FP	FLD	FP	FLD	FP
Ujjain	Full package	2588	1580	12500	9500	47878	29230	35378	19730	2.83	2.08
	Varietal component	1897	1609	9500	9000	35095	29767	25595	20767	2.69	2.31
	Seed village	2046	1375	8000	7250	37851	25438	29851	18188	3.73	2.51
	Mean	**2177**	**1521**	**10000**	**8583**	**40275**	**28145**	**30275**	**19561**	**3.09**	**2.30**
Ghatiya		2271	1641	12500	9750	42014	30359	29514	20609	2.36	2.11
	Varietal component	1926	1483	9500	9000	35631	27436	26131	18436	2.75	2.05
	Seed village	2046	1175	8000	6985	37851	21738	29851	14753	3.73	2.11
	Mean	**2081**	**1433**	**10000**	**8578**	**38499**	**26511**	**28499**	**17932**	**2.95**	**2.09**
Mehidpur	Full package	-	-	-	-	-	-	-	-	-	-
	Varietal component	1840	1590	9500	9000	34040	29415	24540	20415	2.58	2.27
	Seed village	1957	1340	8000	7475	36205	24790	28205	17315	3.53	2.32
	Mean	**1266**	**977**	**5833**	**5492**	**23415**	**18068**	**17582**	**12577**	**2.04**	**1.53**

Note: Sale price of soybean 18500/t

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A Fuzzy-logic Based On-line Disease Diagnosis System for Soybean

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ABSTRACT

This paper presents a fuzzy-logic based on-line disease diagnosis system for soybean. The novel fuzzy-logic approach used is the rule-promotion or empowerment methodology for improved diagnostic judgments. The system developed also uses the concepts of text-to-speech conversion tools to introduce an intelligent multimedia interface into the system. The system is developed using ASP.NET web-application framework provided in Microsoft Visual Studio. NET. The source code for O-O inference engine is written using C#. The Microsoft Speech SDK (5.1) is used to develop text to voice multimedia interface. The dynamic knowledge base is implemented using SQL server.

Key words: Disease diagnosis, fuzzy-logic, expert system, knowledge base, rule patterns, rule promotion, text-to-speech conversion

Among biotic factors, the insect-pests and diseases together cause yield losses to the extent of 32 per cent (Sharma and Shukla, 1997). Presently more than 100 diseases have been reported to inflict soybean crop in different parts of the country, thirty-five of them are important in India (Gupta, 2001). Annual yield losses due to these diseases in the country are in the tune of 12 per cent of the total production (Gupta and Chauhan, 2005). World wide annual yield losses from diseases alone in soybean are in the tune of 10-30 per cent of the total production. To protect and manage soybean crop from the devastating diseases leading to such high yield losses, one has to be proactive to diagnose them in order to contain them by prioritized eco-friendly integrated disease management approach. The experts for disease management are limited in numbers throughout the country and also they are not easily available at times of need. So, to facilitate the extension workers, farmer advisors and the

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growers to diagnose and take appropriate course of management, many diagnostic experts systems are already developed (Boyd and Sun, 1994; Caristi *et al.*, 1987; Cirio *et al.*, 1998; Donahue *et al.*, 1991; Gonzalez-Andujar *et al.*, 2006; Latin and Rettinger, 1987; Michalski *et al.*, 1983; Sanchez *et al.*, 1993; Wang, 1999; Yialouris and Sideridis, 1996; Yialouris *et al.*, 1997; Zhang *et al.*, 1993)

For disease diagnosis, most of the expert systems are stand-alone and a very few are web-based (Kolhe and Gupta, 2006; Kolhe *et al.*, 2007). A web-based interactive system for risk management of potato late blight was developed in Michigan (Wharton *et al.*, 2008). Most of the expert systems have a static knowledge base with static reasoning and inference techniques. So, the decision-taking power of these conventional systems remains same throughout the life of the system unless the knowledge engineer changes it explicitly. They lack in effective interactive user interface as they are devoid of multimedia tools. Therefore, a fuzzy-logic based on-line disease diagnosis system for soybean was developed at Directorate of Soybean Research, Indore, India.

MATERIAL AND METHODS

Soybean disease knowledge base

A knowledge base contains domain knowledge required for solving a specific problem. In our system, knowledge base was represented in the form of rule base. To create knowledge base, first of all, the domain knowledge was thoroughly investigated. For this, the knowledge acquisition method used was based on human interviewing (Scott *et al.*, 1991). During interview, the crop disease experts defined the diseases expected by the system to be able to examine different cases for each disease and a feasible way of containing the diseases. All the crop disease symptoms were classified according to:

- the crop age based on date of sowing (30, 60, 90, 120 days after sowing)
- the plant growth stages (seed, seedling and well grown plant)
- the part of the plant on which the infection was observed (root, leaf, seedling stem, bud, pod, seed, etc.)
- the type of infection (spots, lesions, pustules, fungal structures, mycelium, mottling, etc.)
- the type of expression of the infection (brown, water soaked, irregular, sunken, raised, etc.)

In this way, the diagnostic knowledge was divided into knowledge domains based on the 'date of sowing' of the crops as main-domain and 'part affected' as sub-domain.

Knowledge representation

This diagnostic knowledge was represented as the production rule, or simply *rule.* A rule consists of an IF part and a THEN part (also called a condition and an action). The IF part lists a set of conditions in some logical combination. In our case, we followed the object-attribute-value (O-A-V) knowledge representation method (Harmon and King, 1985), which easily fit, into any rule-based ES development tool. The condition of a rule in this method was represented as a simple sentence which is either true or false, or an OAV triplet.

Uncertainity management

To deal with uncertain knowledge, a rule may have association with it a confidence factor (CF) or a weight. The confidence factor represents the confidence that we have in a piece of evidence. There are numerous ways in which confidence factors can be defined, and how they are combined during the inference process. The most general way is the use of *fuzzy logic*, invented by Lotfi Zadeh (Zadeh, 1965). It is a multi-valued logic to express different degrees of certainty or uncertainty of assertions. Our system used the certainty factors as shown on the multi-valued scale (Harmon and King, 1985).

If CF = 1 then "Definite"
< CF <1 then "Almost certain"
0.6< CF <= 0.8 then "Probably"
0.3 < CF < =0.6 then "Slight evidence"
0 < CF < = 0.3 then "Ignored"

Intelligent inference using fuzzy-logic

The system uses the input provided by user and uses forward chaining mechanism (Ignizio, 1991) to access the appropriate rules and relate to the final disease to reach at some conclusions and gives advice about most appropriate solution for the specific problem. Sometimes the user doesn't provide sufficient set of symptoms to reach final conclusion. In this case, using the backward chaining mechanism and rule patterns, system extracts some more logical questions stored in the form of rules in the knowledge base and prompts the user to select from it and then tries to reach the final inference. In newly experimented rule-promotion fuzzy logic based intelligent inference model, our dynamic knowledge base stores the history of rule patterns and promoted rules derived from diagnosis sessions with successful decisions for efficient decision-making in future sessions.

Rule-promotion fuzzy logic

In the conventional rule based expert system, the domain expert's confidence in a rule remains unchanged so the inference drawing power of the system also remains the same over the years. Looking to this drawback, in our system the inference technique is made more powerful by the introduction of a new approach called rule-promotion or rule empowerment. This approach is based on the natural belief that the confidence in rules increases gradually if the rules repetitively result in right decision. Thus, the difference in conventional inference drawing approach and our new rule promotion approach is that former methods attach constant values of CFs to rules whereas we are experimenting with variable/dynamic values of CFs based on fuzzy logic; former methods use the same original CF as initially given by domain experts for all the decisions throughout the life time of the ES while in our approach for each new session, an improved CF is assigned to all the rules based on the results of the earlier diagnosis session. So, if a rule is repetitively being used in successful conclusion it is promoted or empowered to higher confidence-level by increasing its confidence factor (CF) by the equivalent promotion/empowerment factor (PF). This new confidence factor of the rule is its promoted or empowered rule confidence factor (PCF). All the future disease diagnosis judgments are based on this improved confidence i.e PCF.

RESULTS AND DISCUSSION

The system was developed using ASP.NET web-application framework provided in Microsoft Visual Studio. NET. It was coded using C# .NET 2005 as it supports object-oriented technology. The dynamic knowledge base was implemented using SQL server. Our system included the concepts of text-to-speech translation and these features can be used comfortably with applications built using the Microsoft .NET framework. The Microsoft Speech SDK (version 5.1) was used to develop text to voice user interface. This SDK provides a nice collection of methods and data structures that integrate very well in the .NET 2005 framework.

The real time on-line disease diagnosis system can help an agriculturalist in disease diagnosis, in taking appropriate quick decision/judgment in real time field conditions by harnessing the analytical and decision-making capabilities of disease experts. Through Internet online access, the user can login into the system to get the benefits of the system (Fig. 1). It provides systematic, user-friendly interface for member registration, knowledge acquisition and management, intelligent disease tutor, intelligent disease diagnosis and user-maintenance. The users can login into the system either for knowledge management or for disease diagnosis and management. By using the knowledge management interface, the domain experts' knowledge can be added and managed as and when needed. For starting disease diagnosis consultation session, the user gives inputs of all the symptoms observed by him in the infected fields based on the date of sowing (main-domain) and part affected (sub-domain).

Fig. 1 The home page of the system showing login window

A case study of bacterial blight

As an example of the use of the system assume that in the infected field, if small, angular, translucent, not raised at center, water soaked yellow to light brown spots appear on leaves of the plant at well grown plant stage and also leaves become ragged. The user can understand these symptoms by listening it by clicking the hyperlink 'Audio' provided in front of individual symptoms. These symptoms will be entered along with all the other symptoms in the web-form (Fig. 2) one by one at client-level by clicking the checkboxes. This user-request goes to the server along with all the symptoms-values through web-browser and processed in the business-logic layer. Here the intelligent inference technique based on rule-promotion fuzzy logic is applied that is coded in the code behind pages and stored in server.

The knowledge and facts for processing the users' diagnostic queries is obtained by establishing Open Database Connectivity (ODBC) with the SQL Server database at back-end. It stores the knowledge-domain. The results are presented in a list of all the diagnosed diseases in the form of normal HTML pages (Fig. 3). They are produced based on the inputs. The inference technique is applied from the stored inference engine. The diagnosed disease is Bacterial blight in this example. It uses the promoted confidence factor (system generated) (0.99) when the initial domain-expert confidence factor is 0.8. Thus, the conclusion with the promoted rules has also improved as "Almost Certain: the disease is Bacterial blight" when compared to initial (before promotion) conclusion as "Probably the disease is Bacterial blight".

The user interface has provision to view or hear in audio form, the complete inference technique used by the system to reach the present conclusion by pressing 'Inference Technique' button as shown in Fig. 3. It also provides the most effective control measure and other details of the diagnosed disease in the textual and audio forms with the help of 'Control Measure' and 'Disease Detail' buttons (Fig. 3). The system prompts the user for picture-based confirmation of the disease with the help of the button provided for it. This allows the user to view the different photographs stored in the knowledge base and to confirm the diagnosed disease.

The development of a real-time on-line disease diagnosis system for soybean has helped soybean growers in disease diagnosis, in taking appropriate quick decision /judgment in real time field conditions by harnessing the analytical and decision-making capabilities of disease experts. The real-time application of the system can minimize

Fig. 2. The screen where all the symptoms observed on the infected plants is entered by the user

Fig. 3. The screen showing the diagnostic decision as the Bacterial blight with confidence (0.99).

yield losses due to massive disease attacks to a great extent by providing awareness of pre-disposing climatic factors, making the exact diagnosis and management expertise available on WWW at right time at right place in the right form at minimum cost. This real–time technological tool will soon be available on the institute website http://www.nrcsoya.nic.in. It can also be used as a consultation tool and a good source of knowledge for farmers/cultivars, agriculture advisors/extension workers, researchers, managers and farmers' advisory agencies like Farmers Call Centers, Agricultural Technology Information Centres, E-Choupals etc.

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On-line Soybean Germplasm Information System

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ABSTRACT

To facilitate an easy, efficient, accurate and rapid retrieval of the information on germplasm accessions, an on-line Soybean Germplasm Information System (SGIS), using web technologies viz., Active Server Pages (ASP), Hyper Text Markup Language (HTML), JAVA script and COM components, was developed at Directorate of Soybean Research, Indore. A data management system for germplasm data has also been developed as a separate module using Visual Basic (6.0) to facilitate the digitization and updation of crop-specific germplasm data. The system provides the retrieval of the required information on 25 characters on more than 2000 germplasm accessions in the form of comparison tables, pie charts, bar/line graphs and reports in user-friendly manner. The paper discusses the functionality of the system and experiences gained during development phase along with its benefits for the end-user.

Key words : germplasm, information system, software, soybean

Soybean exhibits a wide genetic variability worldwide. The total number of soybean germplasm accessions available with different countries/institutions is 1,47,000 (Nelson, 1999). Nearly 4000 accessions belonging to indigenous as well as exotic category (Annual Report, 2008-09) are being maintained at the Directorate of Soybean Research at Indore, which also serves as the National Active Germplasm Site (NAGS) and mandated to supply germplasm accessions for research to institutes engaged to develop location specific varieties in the country. The task of effective management of germplasm and documentation of inherent traits to strengthen the breeding programs is of utmost

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importance. Managing huge data of germplasm manually is a cumbersome, time-consuming and error-prone process demanding lot of manpower. The retrieval of specific germplasm information is also very difficult in present state. The present work facilitates the ease of management and handling valuable information on existing germplasm and accessions being acquisitioned. A few germplasm information systems are already available on web (http://gcmd.nasa.gov/records/GCMD_MUSA_MGIS.html; http://www.ars-grin.gov/) but they are dedicated for specific use and are useful for location-specific information. Therefore, an on-line Soybean Germplasm Information System (SGIS) for efficient management of data, rapid and accurate retrieval of information was developed which involves very less development cost. The SGIS was developed with the objectives of (i) collation of data on 25 different characters to create a database, (ii) to develop an efficient data management system for easy addition, updating and management of germplasm data and (iii) to develop a user-friendly system to retrieve the information on germplasm accession specifically needed for different objectives. The designed SGIS is user-friendly and inclusive of different Graphical User Interface (GUI) tools. The SGIS can offer the information in the form of comparison tables, pie charts, bar/line graphs and reports by using a mouse and minimal keyboard operations.

MATERIAL AND METHODS

Data collection and digitization

For the creation of database, the data on 25 characters of soybean germplasm was gathered and compiled to generate the information useful to different end-users. To facilitate the digitization process of crop-specific germplasm data and updation of it, a database entry system for germplasm data was developed using MS-ACCESS, which had different user-friendly data-entry forms to enter the collected data into the system. The MS-ACCESS database was finally converted into SQL SERVER database to link it to on-line SGIS through open database connectivity (ODBC). The main database table has different fields for 25 characters. Since the Catalogue number and Accession name fields have no duplicate values, these were used for unique identification of records. At present, the table has more than two thousands records. Each record is a set of 25 fields and depicts one germplasm accession with 25 characters and the final data is stored in the form of numeric values of the descriptors (Table 1).

Table 1. The database table showing the 25 characters of the germplasm included in the SGIS along with numeric values of the descriptors

S.No.	Characters	Field names	Descriptors
1.	Catalogue No.	CATNO	-
2.	Accession name	ENTRY	-
3.	Alternate Identity	AI	-
4.	PI No.	PINO	-
5.	Origin	ORG	-
6.	Species	SP	-
7.	Stem termination	STT	3 = determinate, 5 = semi determinate, 7 = indeterminate
8.	Pubescence	PB	1 = present, 0 = absent
9.	Pubescence colour	PBC	1 = grey, 2 = light brown, 3 = tawny
10.	Pubescence density	PBD	7 = normal, 9 = dense
11.	Leaflet shape	LFS	3 = narrow, 5 = intermediate, 7 = broad
12.	Leaf colour	LC	1 = light, 2 = green, 3 = dark green
13.	Pod colour	PC	3 = tan, 5 = brown, 7 = black
14.	Seed coat colour	SCC	1 = yellowish white, 2 = yellow, 3 = green, 4 = buff, 5 = reddish brown, 6 = grey, 7 = imperfect black, 8 = black
15.	Hilum colour	HC	1 = yellow, 2 = light brown, 3 = brown, 4 = green, 5 = grey, 6 = imperfect black, 7 = black, 8 = others
16.	Seed coat luster	SCL	3 = shiny, 5 = intermediate, 7 = dull
17.	Flower colour	FC	3 = white, 7 = purple
18.	Days to flowering	DFL	-
19.	Days to maturity	DMT	-
20.	100 seed weight	SWT	-
21.	Seed yield per plant (g)	YPL	-
22.	Maturity group	MG	Early maturing line (up to 95 days), Medium maturing line (96 to 110 days), Late maturing line (above 110 days)
23.	Oil content (%)	OC	-
24.	Protein content	ProC	-
25.	Remarks	REM	-

System requirements

The system was designed using web-technologies viz. Active server pages (ASP), HTML, JAVA Script in JAVA Applets. ASP has advantages like choice of scripting languages-VB Script or Jscript and it involves no extra cost of buying any development software. For graphical representation of the data, COM components were used. The clients can run the system on Pentium IV computers with Windows XP/2000 operating system with 128 MB RAM and at least 20 MB memory on the hard disk having IE5 and above. The server requirements include the Pentium IV computers with Windows 2000/2003 server operating system having a functional Internet Information Server (IIS) on it. The PC should have at least 512 MB RAM and 100 MB free memory. For database SQL SERVER 2000 is required with ODBC support on computer.

RESULTS AND DISCUSSION

The designed on-line SGIS is made user-friendly using GUI tools like command buttons, hyperlinks, list-box, combo-box, textbox, embedded pictures and using third party COM components and JAVA Applets. It is completely mouse-driven. One can login using authorized user name and password provided by the administrator as shown in the home page of the system (Fig. 1). The user has different options to choose the different modes of data representation depending on his needs (Fig. 2). The user can make selections for graphical representation, simple search or advance search for textual representation and audio system for information retrieval. The simple search option of the search engine, is meant to retrieve information only on one parameter while the advance search option helps in creating complicated queries using "AND" or "OR" operators on any number of parameters. The query request reaches to the remote server using HTTP REQUEST protocol in client-side script in ASP through the web-browser. The query is processed at the server using the server side script and using the ODBC, the final required data is filtered out from the remote data-server. The final response is served by the server using HTTP RESPONSE protocol in the server-side script in ASP and presented to the client through web-browser. In this way the required information in various forms like comparison tables (Fig. 3), reports, colored pictures, bar/line graphs and pie-charts (Fig. 4) can be generated with few mouse clicks.

Fig. 1. The home page of on-line soybean germplasm information system

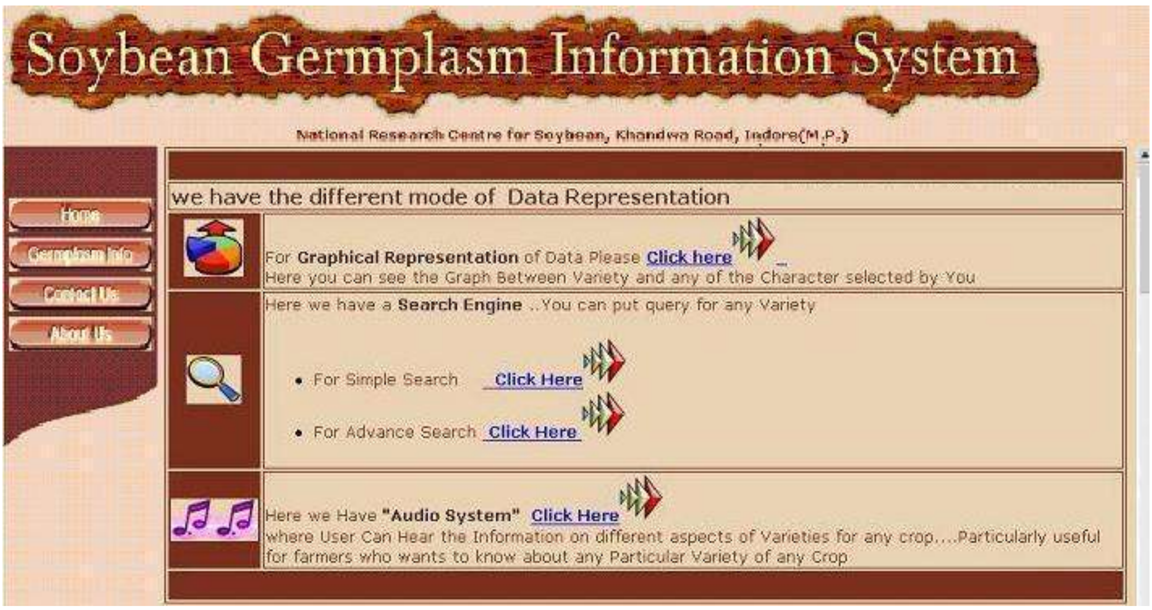

Fig. 2. The screen showing different options for choosing different mode of data representation

Catalogue No.	Accession Name	Stem termination	Pubescence	Pubescence colour	Pubescence density	Leaflet shape	Leaf colour	Pod colour	Seed coat colour	Hilum colour	Seed coat lustre	Flower colour	Days to flowering
1982	BC-22993	SemiDeterminate	Present	Grey	Normal	Broad	Light green	Tan	Yellow	Brown	Intermediate	Purple	68
1983	BC-22994	Determinate	Present	Grey	Normal	Intermediate	Green	Tan	Yellow	Brown	Dull	Purple	62
1985	BC-22997	SemiDeterminate	Present	Grey	Normal	Intermediate	Light green	Tan	Yellow	Brown	Intermediate	Purple	68
1987	BC-23001	SemiDeterminate	Present	Grey	Normal	Intermediate	Green	Tan	Yellow	Brown	Intermediate	Purple	62
1988	BC-23003	SemiDeterminate	Present	Grey	Dense	Intermediate	Green	Tan	Yellow	Brown	Intermediate	Purple	53
1990	BC-23005	SemiDeterminate	Present	Grey	Normal	Narrow	Light green	Tan	Yellow	Brown	Intermediate	Purple	39
1998	BC-341825	Determinate	Present	Grey	Normal	Narrow	Dark green	Tan	Yellow	Others	Shiny	Purple	37
1999	BC-343305	Determinate	Present	Grey	Normal	Intermediate	Green	Tan	Yellow	Brown	Intermediate	Purple	37
2000	BC-343306	Determinate	Present	Grey	Normal	Intermediate	Green	Tan	Yellow	-	-	White	37
2002	BC-343308	Determinate	Present	Grey	Dense	Intermediate	Green	Brown	Yellow	Light brown	Intermediate	Purple	37
2008	BC-350664	Determinate	Present	Grey	Normal	Broad	Green	Tan	Yellow	Grey	Intermediate	Purple	37
2009	BC-350665	SemiDeterminate	Present	Grey	Normal	Intermediate	Green	Tan	Yellow	Grey	Intermediate	Purple	37
2010	BC-350667	Determinate	Present	Grey	Normal	Intermediate	Green	Tan	Yellow	Grey	Intermediate	Purple	37
2011	BC-350668	Determinate	Present	Grey	Dense	Broad	Green	Tan	Yellow	Grey	Intermediate	Purple	42
2012	BC-350672	Determinate	Present	Grey	Normal	Intermediate	Green	Tan	Yellow	Grey	Intermediate	White	37
2013	BC-350675	Determinate	Present	Grey	Dense	Intermediate	Green	Tan	Green	Grey	Intermediate	White	37
2014	BC-350677	Determinate	Present	Grey	Normal	Intermediate	Green	Tan	Yellow	Grey	Intermediate	White	37
2015	BC-350680	SemiDeterminate	Present	Grey	Normal	Intermediate	Light green	-	Yellow	Grey	Intermediate	Purple	32

Fig. 3. The retrieval of germplasm information in tabular form

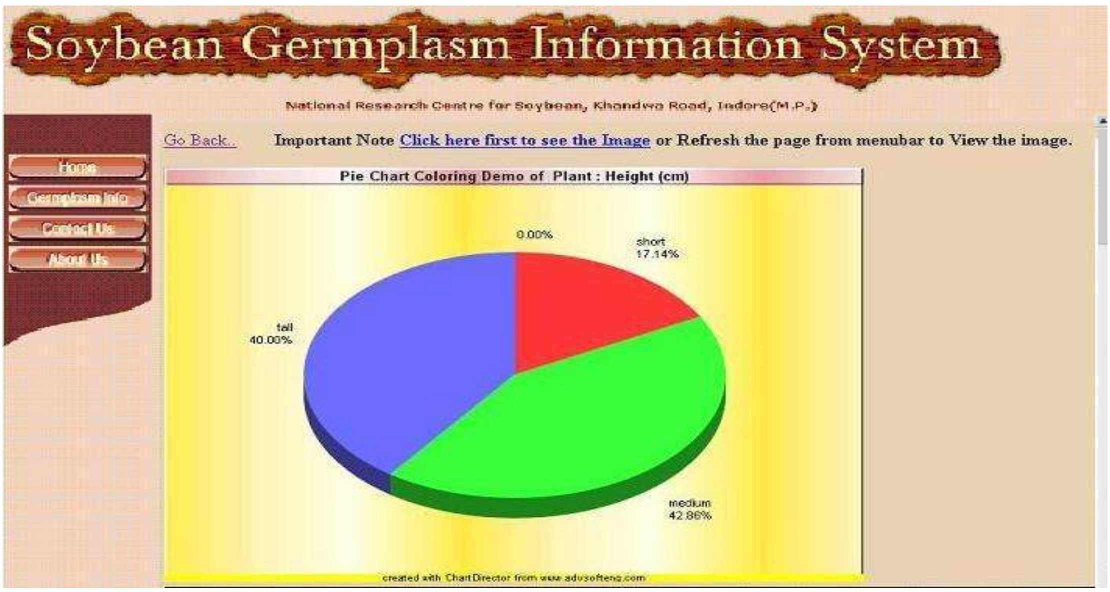

Fig. 4. The retrieval of germplasm information in the form of pie-chart

Although, the system deals with 25 characters at present, it has provision to include more characters and acquisitioned germplasm accessions in future. The system facilitates distinctness and similarity comparisons of different germplasm available in the database based on specific set of given values of the characters. The system also has the versatility to be used for digitization of germplasm resource of any of the crop commodity.

The system is being successfully implemented at the Directorate and is very informative for different end-users. The system is being loaded at the website of the Directorate (http://www.nrcsoya.nic.in) for use at large. This package not only serves as a reservoir for keeping a wealth of numerous character information of different germplasm resources in digital form but also as a ready-reckoner-kit for rapid and accurate retrieval of information in user-friendly manner in various forms. Its features like on-line help; attractive and user-friendly GUI and accurate, rapid retrieval of information in the form of comparison tables, reports, color photos, bar/line graphs, pie-charts etc. make it of practical utility. The package has versatility to be used for other crop commodity as well.

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Study on Heritability and Genetic Advance of Seed Quality Traits in Soybean [*Glycine Max (*L.) Merrill]

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Key words: Abscisic acid content, genetic advance, heritability seed quality

Soybean is a poor storer as it loses viability very rapidly under warm and humid conditions of storage (Delouche and Baskin, 1973). Maintenance of seed viability up to the prescribed germination standard from harvest till next sowing season is one of the major problems associated with the seed production of soybean in India. It has been observed that even optimal storage conditions cannot stop process of deterioration, once started, however it can still minimize the extent of deterioration and maintain satisfactory germination till planting. Abscisic acid is a naturally occurring plant hormone, which is involved in plant growth and development (Addicott and Lyon, 1969). In mature seeds, relatively higher levels of abscisic acid have been found in some species and its occurrence resulted in dormancy and inhibition of germination (Dure, 1975 and Sondheimer *et al*., 1968). Earlier studies suggested that acquisition of desiccation tolerance is correlated with increase in abscisic acid content of the embryo. It plays an important role in stimulated growth and protein accumulation in embryos of soybean during early phase embryogenesis. Eisenberg (1984) suggested that during the cotyledon stage when cells were rapidly dividing, abscisic acid inhibits the growth and storage protein synthesis in between the early and late maturation stages. Abscisic acid prevents precocious germination and facilitated storage protein synthesis. Particularly in soybean, the abscisic acid content in mature seeds is known to influence the germination capacity of the seed. Therefore, there is need to know the heritability of seed quality traits in soybean so that these traits may be incorporated during varietal improvement programmes.

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Three soybean genotypes *viz*., AGS 334, Bhatt and T-49, were selected on the basis of their performance for seed longevity test. AGS 334 was considered as poor seed longevity restorer, T 49 as good restorer whereas Bhatt was moderate restorer having 1.013, 10.043 and 1.300 µM ABA contents, respectively. These three selected genotypes crossed in full diallel fashion, which included both direct and reciprocal crosses along with respective parents, were evaluated in RBD under field condition. The recommended package of practices was followed for raising a good crop. The random sample from resulted six F_1s and their parents were used to estimate the abscisic acid content, germination percentage and 100 seed weight during 2007. The observations were recorded for 100-seed weight (g), germination percentage (freshly harvested seed as well as after storage every two month interval) and abscisic acid contents. The abscisic acid content in the samples was measured by indirect ELISA according to Walker-Simmons (1987) and Norman *et al.* (1986) with some modifications. ELISA was carried out in Crop Physiology Laboratory, G.K.V.K., University of Agriculture Sciences, Bangalore.

The perusal of analysis of variance for mean squares for different characters (Table 1) indicated that the mean squares due to genotypes studied were found to be highly significant for these traits.

Table 1. Analysis of variance for seed quality characters in soybean

Source of variation	D. F.	Mean Square		
		Germination (%)	100-seed weight (g)	Abscisic acid content (µM)
Replication	2	4.335	0.054	0.009
Genotype	8	502.167**	16.131**	247.259**
Error	16	29.915	1.169	8.251

*** Significant at 1 % probability level*

The phenotypic coefficient of variation for abscisic acid content (75.61) was maximum followed by 100 seed weight (17.85) and germination percentage (16.64). The magnitude of genotypic coefficients of variation for these traits followed the same pattern (Table 2). However, environmental coefficients of variation for germination percentage (1.99) was maximum followed by 100 seed weight (1.57) and for abscisic acid content (0.93). Heritability estimates (percentage) in broad sense was highest for abscisic acid content (90.61) followed by germination (84.03) and 100 seed weight (81.01), respectively. The highest genetic advance

Table 2. Estimates of broad sense heritability for seed quality characters

Characters	Genotypic coefficient of variation	Phenotypic coefficient of variation	Environmental coefficient of variation	Heritability$_{(bs)}$ (%)	Genetic advance
Germination (%)	16.52	16.64	1.99	84.03	25.84
100-seed weight (g)	17.78	17.85	1.57	81.01	4.60
Abscisic acid content (µM)	75.61	75.61	0.93	90.61	18.38

was recorded for germination per cent (25.84), followed by abscisic acid content (18.38) and 100 seed weight (4.60), respectively.

The present study revealed that the broad sense heritability estimates for abscisic acid content, germination percentage and 100 seed weight were quite high. It means that the error coefficients of variation were quite low. The high values for broad sense heritability estimates indicated that these are less influenced by environmental factors. High heritability for abscisic acid content and germination percentages were associated with high genetic advance indicating predominance of additive genetic control in the inheritance these traits. Therefore, high genetic gain is expected from selection for the improvement these traits. Similar result were also reported by Alam *et al.* (1983), Sharma *et al.* (1986), Jangale *et al.* (1994) and Roy and Roquib (1998).

However, the low heritability estimates for 100 seed weight was associated with low genetic advance indicating non-additive genetic control in the inheritance of this character. Therefore, low genetic gain expected from selection in such a situation and the results found in this study for 100 seed weight did not agree with the finding of Karnwal and Singh (2009).

Thus, on the basis of heritability and genetic advance it can be suggested that during selection process main emphasis should be given for abscisic acid content and germination percentage for genetic enhancement for seed germinability in soybean.

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Effect of Different Doses of Sulphur on Productivity and Quality of Soybean [*Glycine max* (L.) Merrill]

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Madhya Pradesh is a major soybean producing state and accounts for major share of the India's produce on account of large hectarage. The national productivity in India is very low (1.0 t/ha) as compared to the world average 2.5 t/ha (Anonymous, 2008). Sulphur is one of the essential secondary plant nutrients, of which the importance in Indian Agriculture is being increasingly emphasized. Its role in enhancing the crop production, particularly in oilseeds and pulses has been reported by many research workers. Sulphur deficiency causes 12-15 per cent reduction in seed yield of soybean (Kandpal and Chandel, 1993 and Sharma, 2003). Since no sufficient information on soybean response to sulphur application on medium black clay soil of Madhya Pradesh is available, the present study was undertaken to know the effect of sulphur levels on productivity and quality of soybean.

A field experiment was conducted during the *kharif* 2007 and 2008 at Krishi Vigyan Kendra farm, Shajapur, Madhya Pradesh. The soil of experimental site belonged to Vertisols and was clayey in texture with pH 7.80, available N 218, P_2O_5 13, K_2O 580 and S 9.75 kg per ha. The experiment was laid out in randomized block design with four replications. The treatments consisted six levels of sulphur (0, 10, 20, 30, 40 and 50 kg/ha) applied as basal as per the treatment through gypsum (20% S) with a recommended dose of 20 kg N + 60 kg P_2O_5 + 20 kg K_2O per hectare. Soybean variety JS 93-05 was sown at 45 cm apart in rows using 80 kg seed per ha in last week of June and harvested in last week of September during both the years.

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The seed samples were analysed for protein and oil contents by following the procedure described in AOAC (1984).

A regular increase in seed and straw yield of soybean was noticed with increasing levels of sulphur application (Table 1). All the levels of sulphur applied through gypsum significantly increased the seed and straw yield over control. The higest level of applied sulphur (50 kg S/ha) resulted in maximal seed and straw yields of soybean, which was 37 per cent and 45 per cent (630 and 854 kg/ha) higher over control (1674 and 1858 kg/ha), respectively. Similar results have earlier been reported by Dwivedi and Bapat (1998) and Sharma (2003).

Table 1. Effect of different doses of sulphur on productivity and quality of soybean (Two years pooled data)

Sulphur levels (kg/ha)	Seed yield (kg/ha)	Straw yield (kg/ha)	Oil content (%)	Protein Content (%)	Protein Content (%)	Net Return (Rs/ha)	C:B Ratio
0	1674	1858	19.68	34.39	37.32	16110	1:2.79
10	1786	2008	20.12	37.38	40.57	17790	1:2.97
20	1921	2170	20.26	37.61	40.82	19815	1:3.20
30	2075	2367	20.31	37.85	41.08	22125	1:3.45
40	2208	2556	20.43	37.97	41.21	24120	1:3.68
50	2304	2712	20.54	38.03	41.27	25560	1:3.84
CD (P = 0.05)	**48.9**	**41.8**	**0.052**	**0.122**	**0.146**	**2120.2**	**-**

Increasing levels of sulphur significantly improved the quality of soybean in terms of protein and oil contents. The increase in oil (4.37%) and protein (10.58%) contents with the application of 50 kg S per ha over control (19.68 and 37.32 %, respectively) was noticed. Increase in oil content due to sulphur application can be attributed to the key role played by sulphur in biosynthesis of oil in oilseed plants.

The increase in protein content may be accounted for the increase in synthesis of sulphur containing the amino acids like cysteine, cystine and methionine consequent upon supplementation of sulphur. Such beneficial effects of sulphur fertilization were also reported by Nagar *et al.* (1993), Sharma (2003) and Tandon (1984). Application of gypsum produced significantly higher content of oil and protein. This may be attributed to higher availability of sulphur from gypsum. The superiority of gypsum over other sources has also been reported by Kandpal and Chandel (1993) in soybean.

The economic evaluation revealed that the net returns and B:C ratios showed an increasing trend with increasing levels of sulphur. The maximum net returns of Rs. 25, 560 per ha had accrued by the use of sulphur @ 50 kg S per ha with C:B ratio of 1:3.84. In comparison, the net returns and C:B ratio in control treatment observed were Rs. 16, 110/ha and 1:2.79, respectively. These results confirm the findings of Ramamoorthy *et al* .(1996).

The results of the study suggest that it will be economically viable to apply sulphur @ 50 kg per ha through gypsum in Vertisols to enhance the productivity of soybean and to improve the oil and protein contents in seeds.

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Evaluation of Fungicides, Neem Products and Bioagents against Target Leaf Spot of Soybean Caused by *Corynespora cassiicola*

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Soybean [*Glycine max* (L.) Merrill] has acquired worldwide importance as a primary source of vegetable oil and protein. In India, the crop has experienced a phenomenal increase in area with about 6221.0 (000′ ha) with an annual production of 5856.7 (000′ tonnes) during the last two decades. In Himachal Pradesh, soybean is grown as a sole crop in nearly 6000 ha in Kangra, Mandi, Hamirpur, Una and Kullu districts. In many areas of Himanchal Pradesh, it is intercropped with maize with an annual production of about 1000 tonnes (Anon., 2003). The main diseases of the crop are brown spot (*Septoria glycines* Hemmi), stem and pod blight [(*Diaporthe phaseolorum* (Cke. & Ell.) Sacc. var. *sojae* (Lehman) and *Colletotrichum truncatum* (Schw.) Andrus & W.D. Moore], target leaf spot [*Corynespora cassiicola* (Berk & Curt) Wei], bacterial blight [*Pseudomonas syringae* pv. *Glycinea* (Coerper) Young, Dye & Wilkie] and bacterial pustule [*Xanthomonas campestris* pv. *Glycines* (Nakano) Dye]. Among these, target spot is comparatively a recent disease in Himachal Pradesh. It has been appearing in epidemic form from last 7-8 years. The present studies were carried out under laboratory conditions to assess different management strategies for containing the pathogen.

C. cassiicola isolated from the diseased sample using standard isolation procedures and pure culture was maintained in PDA slants. The pathogenicity tests were performed with highly susceptible soybean cultivar Shivalik. Surface sterilized seeds (with 0.1% mercuric chloride) were sown in pots filled with autoclaved soil. Inoculum load of 4×10^5

spores/ml for disease initiation was standardized through the use of a haemocytometer. At two leaf stage, plants were spray inoculated with homogenized spore suspension of the pathogen and incubated at 25±1°C temperature and 90% RH in a growth chamber for 48 h. Inoculated plants after incubation were shifted to cage house benches, watered regularly with distilled water and observed daily for the appearance of characteristic disease symptoms.

Fungicides (Bavistin and Dithane M-45) were tested by poisoned food technique. For this, desired quantity of fungicide were measured and mixed with sterilized PDA and poured aseptically in sterilized Petri plates. Medium without bio-pesticide and fungicide served as check. Five mm disc was cut from the 7-10 days old culture of pathogen and placed in center of each plate. Each treatment was replicated thrice, with three plates in each replication. Data on mycelial growth were recorded when control Petri plate was fully covered. Per cent inhibition was calculated by Vincent (1947) formula as given below.

I = C – T/C x 100, where I = % inhibition; C = growth in control; and T = growth in treatment

Bio-pesticides were also tested by poisoned food technique as per method described above. Antagonistic activities of local strains of *T. harzianum, T. koningii, T. pseudokoningii* and *Aspergillus* spp. with commercial formulations of *T. viride* were tried for their efficacy against the pathogen. Bio-agents were tested by dual culture method. Five mm diameter disc of pathogen taken from the margin of four days old colony was placed at one end and mycelial disc of antagonist at the opposite end of Petri dish having solidified medium. The plates containing PDA medium inoculated with pathogen alone, served as control. Three replications were kept for each treatment. The plates were incubated at 25 ± 1°C and observations on mycelial growth were recorded when the central plate was fully covered. The per cent inhibition of mycelial growth was calculated according to Vincent (1947) formula.

The data collected during the course of these investigations were subjected to appropriate statistical analysis, wherever necessary using standard procedures as per Gomez and Gomez (1984). The significance of difference was tested at 1 and 5 per cent level of probability.

Two fungicides, namely Bavistin and Dithane M-45 were evaluated against *C. cassiicola in vitro*. Bavistin was tested at 0.03, 0.04, 0.05 per cent and Dithane M-45 at 0.20, 0.25 and 0.30 per cent. The data on per cent inhibition (Table 1) revealed that both the fungicides at all the concentrations inhibited the mycelial growth of *C. cassiicola* to varying extent. In case of Dithane-M 45, all the concentrations proved effective resulting in 100 per cent inhibition. A similar trend in toxicity of fungicides was noticed in Bavistin except at 0.03 per cent concentration, which gave 91.33 per cent inhibition. Thus, both fungicides systemic and non-systemic were found highly effective in inhibiting mycelial growth of the test fungus. The finding is in corroboration with that of Yadav *et al.* (1988) wherein they evaluated eight fungicides, of which Benlate (benomyl @ 1000 ppm) followed by Dithane M-45 (mancozeb @ 2500 ppm) gave good control of *C. cassiicola* on sesame. Mehrotra (1989) also reported successful control of the disease *Ceiba pentandra* by the application of Bavistin (carbendazim) at two-week interval in forest nursery. Dithane M-45 was almost equally effective followed by Blitox (copper oxychloride) and Captaf (captan). According to Das (1978) two sprays of mancozeb at monthly intervals gave good control of target leaf spot of jute whereas highest yield was achieved when the crop was sprayed with Bavistin. Parakhia *et al.* (1989) reported that Bavistin and Thiophanate phenyl were effective in checking the growth of *C. cassiicola* in cotton under *in vitro* conditions.

Table 1. Effect of fungicides on mycelial growth of *Corynespora cassiicola*

Fungicide	Concentration (%)	Mycelial growth (radial, mm)	Inhibition (%)
Dithane M-45	0.2	-	100.0 (90.00)*
	0.25	-	100.0 (90.00)
	0.3	-	100.0 (90.00)
Bavistin	0.03	2.6	91.33 (75.87)
	0.04	-	100.0 (90.00)
	0.05	-	100.0 (90.00)
Control	-	30.0	-
CD (P = 0.05)	**-**	**-**	**8.86**

**Figures in parentheses are arc sine transformed values*

The data on *in vitro* evaluation of 14 bio-agents for their antagonistic activity against *C. cassiicola* (Table 2) revealed that HMA-3 and RMA-6 were most effective in restricting the growth of *C. cassiicola* and gave maximum inhibition of 89.66 per cent followed by SMA-1, JMA-2 and DMA-10 with 85 per cent inhibition, whereas DMA-8 resulted in 70.33 per cent inhibition which was significantly different from HMA-3 and RMA-6. *Aspergillus* sp. was also effective giving 80.66 per cent inhibition of mycelial growth.

Zukhovskaya (1980) investigated 114 fungal isolates from *Aspergillus japonicus* and *Penicillium spicidisporum,* which were the most antagonistic fungi to *C. cassiicola.* Jayasuriya (1997) studied the use of potentially antagnostic fungi to control *C. cassiicola* of *Hevea* spp. Banik and Krishnamurthy (2004) found that *Penicillium funiculosum* was effective in inhibiting *C. cassiicola* under *in vitro* conditions.

Table 2. Effect of bio-agents on the mycelial growth of *C. cassiicola*

Bioagent	**Mycelial growth (radial, mm)**	**Inhibition (%)**
T. harzianum (SMA-5)	8.9	74.00 (59.38)*
T. harzianum (SMA-1)	4.3	85.66 (67.74)
T. harzianum (JMA-2)	4.3	85.66 (67.74)
T. harzianum (RMA-6)	3.3	89.66 (71.28)
T. harzianum (JMA-4)	6.3	80.66 (63.91)
T. koningii (DMA-8)	9.3	70.33 (57.01)
T. koningii (JMA-11)	7.3	77.33 (61.55)
T. koningii (HMA-7)	5.3	82.66 (65.37)
T. koningii (DMA-10)	4.3	85.66 (67.73)
T. pseudokoningii (SMA-12)	7.3	77.33 (61.55)
T. pseudokoningii (HMA-3)	3.3	89.66 (71.28)
Aspergillus spp.	6.3	80.66 (63.91)
Ecoderma (*T. viride*)	6.3	80.66 (63.91)
Tricoguard (*T. viride*)	7.3	77.33 (61.54)
Control	35.0	-
CD (P = 0.05)	**-**	**2.81**

**Figures in parentheses are arc sine transformed values*

Three bio-pesticides Achook, Wanis and Neemgold were tested at 0.05, 0.1, 0.5 per cent concentrations. The data (Table 3) revealed that all the bio-pesticides, at all the concentrations, inhibited the mycelial growth of *C. cassiicola* to varying extent. Among these Wanis at highest concentration 0.5 per cent proved to be most effective resulting in 100 per cent inhibition whereas at lowest concentration (0.05%) it gave 82.60 per cent inhibition. Achook and Neemgold proved effective at 0.5 per cent concentration resulting in 62.00 per cent and 76 per cent inhibition and both were significantly different from each other in their effects. Kumar *et al.* (1979) studied spore germination of *C. cassicola*, which was completely inhibited by onion, garlic, kalanchoe and parthenium extracts. Athukoralage *et al.* (2001) showed that hexane extract of the stem bark of *Gordonia dassanayakei* had high antifungal activity against the pathogen.

Table 3. Effect of bio-pesticides on the mycelial growth of *C. cassiicola*

Biopesticide	Concentration (%)	Mycelial growth (radial, mm)	Inhibition (%)
Achook	0.05	15.3	51.33 (45.74)*
	0.1	12.0	57.66 (49.39)
	0.5	11.0	62.00 (51.92)
Wanis	0.05	5.3	82.66 (65.50)
	0.1	2.6	91.33 (72.95)
	0.5	-	100.0 (90.00)
Neemgold	0.05	14.3	54.00 (47.29)
	0.1	12.6	59.00 (50.26)
	0.5	7.3	76.00 (60.73)
Control	-	32.0	-
CD (P = 0.05)	**-**	**-**	**5.55**

**Figures in parentheses are arc sine transformed values*

The above results obtained under *in vitro* conditions will be useful to attempt a management package for the target leaf spot of soybean after evaluating them under field conditions.

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Efficacy of a Herbal Formulation Against *Spodoptera litura* Fab.

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Of late tobacco caterpillar, *Spodoptera litura* Fab. has become a serious insect-pest of soybean. During last one decade, there have been three outbreaks on soybean – one during the *kharif* 2000 in Rajasthan, second during *kharif* 2004 in Madhya Pradesh and the third recently during *kharif* 2008 in Maharashtra. It not only defoliates the plants in early stage but also feeds on flowers and young developing pods at later stage. The extent of damage potential and the variety of chemical insecticides *S. litura* withstood, calls for tapping alternate methods for its effective, cheaper and eco-friendly management.

Over 2400 plant species have been reported to possess pesticidal properties (Raheza, 1998; Singh, 2000; Sundarrajan and Kumuthakalavalli, 2000). Many of them like *Acacia arabica, Vitex negundo, Azaridachta indica* etc. have proven insecticidal as well as medicinal values, and show synergistic effects when used in combination (Babu *et al*., 2000). Taking clue from this fact, a herbal preparation used to treat oral disorders by Ayurved doctors, has been tested for its possible efficacy against *S. litura*. The preparation essentially consisted of – extracts of Dadima (*Punica granatum*), Tumburu (*Zanthoxylum alatum*), Babula (*Acacia arabica*), Nirgundi (*Vitex negundo*), Vidanga (*Embelia ribes*), Triphala and powders of Vikranta (*Adiantum lunulatum*), Nimba (*Azadirachta indica*) and Ajmoda (*Apium graveolens*).

The stock solution was prepared by dissolving 70 g of the product in 280 ml distilled water. Efficacy of the product was assessed against II, III and IV instars of *S. litura* at ten concentrations viz. 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100 per cent along with control (water alone). Each treatment was replicated thrice. Ten pre-starved (for 3 hrs) larvae were released in plastic petri plates (15 cm diameter) containing fresh soybean

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Table 1. Larval mortality (%) in different larval instars of *S. litura* at different intervals

Con-centration (%)	II nd instar				III rd instar				IV th instar			
	30 min	3 h	24 h	Mean	30 min	3 h	24 h	Mean	30 min	3 h	24 h	Mean
10	3.3	3.3	6.7	**4.43**	0.0	6.7	6.7	**4.47**	0.0	6.7	6.7	**4.47**
	(6.15)	(6.15)	(12.29)	**(8.20)**	(0.00)	(12.29)	(12.29)	**(8.19)**	(0.00)	(12.29)	(12.29)	**(8.19)**
20	6.7	13.3	6.7	**8.90**	3.3	13.3	13.3	**9.97**	3.3	13.3	13.3	**9.97**
	(12.29)	(17.71)	(12.29)	**(14.10)**	(6.15)	(17.71)	(17.71)	**(13.86)**	(6.15)	(17.71)	(17.71)	**(13.86)**
30	10.0	70.0	80.0	**53.33**	13.3	36.7	50.0	**33.33**	6.7	40.0	46.7	**31.13**
	(15.00)	(57.00)	(63.44)	**(45.15)**	(17.71)	(36.93)	(45.00)	**(33.21)**	(12.29)	(39.23)	(43.08)	**(31.53)**
40	46.7	80.0	80.0	**68.90**	23.3	36.7	90.0	**50.00**	16.7	40.0	80.0	**45.57**
	(43.08)	(63.44)	(63.44)	**(56.65)**	(28.28)	(36.93)	(75.00)	**(46.74)**	(21.14)	(39.23)	(63.44)	**(41.27)**
50	46.7	83.3	83.3	**71.10**	26.7	50.0	100	**58.90**	20.0	53.3	90.0	**54.43**
	(43.08)	(66.15)	(66.15)	**(58.46)**	(31.00)	(44.91)	(90.00)	**(55.30)**	(23.86)	(48.85)	(75.00)	**(49.24)**
60	53.3	93.3	96.7	**81.10**	30.0	53.3	96.7	**60.00**	33.3	50.0	96.7	**60.00**
	(48.85)	(83.86)	(83.86)	**(72.19)**	(33.12)	(48.85)	(83.86)	**(55.28)**	(26.57)	(45.00)	(83.86)	**(51.81)**
70	56.7	100.0	100.0	**85.57**	43.3	63.3	100.0	**68.87**	43.3	56.7	96.7	**65.57**
	(52.77)	(90.00)	(90.00)	**(77.59)**	(41.55)	(52.86)	(90.00)	**(61.47)**	(41.55)	(52.77)	(83.86)	**(59.39)**
80	63.3	100.0	100.0	**87.77**	46.7	66.7	100.0	**71.13**	43.3	56.7	96.7	**65.57**
	(57.00)	(90.00)	(90.00)	**(79.00)**	(43.07)	(55.08)	(90.00)	**(62.72)**	(41.55)	(52.77)	(83.86)	**(59.39)**
90	80.0	100.0	100.0	**93.33**	63.3	66.7	100.0	**76.67**	53.3	60.0	100.0	**71.10**
	(66.15)	(90.00)	(90.00)	**(82.05)**	(52.86)	(57.00)	(90.00)	**(66.62)**	(46.92)	(50.85)	(90.00)	**(62.59)**
100	86.7	100.0	100.0	**95.57**	73.3	93.3	100.0	**88.87**	56.7	66.7	100.0	**74.47**
	(75.00)	(90.00)	(90.00)	**(85.00)**	(60.00)	(72.29)	(90.00)	**(74.10)**	(48.93)	(55.08)	(90.00)	**(64.67)**
Control	0.0	0.0	0.0	**0.00**	0.0	0.0	0.00	**0.00**	0.0	0.0	0.0	**0.00**
	(0.00)	(0.00)	(0.00)	**(0.00)**	(0.00)	(0.00)	(0.00)	**(0.00)**	(0.00)	(0.00)	(0.00)	**(0.00)**
SEm±	(4.80)	(3.55)	(3.31)	**(3.89)**	(3.47)	(3.37)	(4.70)	**(3.85)**	(3.25)	(3.45)	(6.10)	**(4.27)**
CD at 5%	(14.16)	(10.47)	(9.76)	**(11.46)**	(10.24)	(9.94)	(13.86)	**(11.35)**	(9.59)	(10.18)	(17.99)	**(12.59)**

leaves. Different concentrations were sprayed with hand sprayer. Observations were recorded on larval mortality after 30 minutes, 3 hr and 24 hr of treatment. Entire set of experiment was kept in the entomological chamber maintained at 26 ± 1 ^{0} C and 80 ± 5 per cent relative humidity.

Results indicated that the larval mortality increased with the increase in concentration of the extracts and with the passage of time (Table 1). Extracts at 10 and 20 per cent concentrations did not seem to be effective against all the three instars and even after 24 hrs of exposure. However, 70 per cent and 80 per cent larval mortality was recorded in II instar larvae with 30 per cent concentration after 3 hr and 24 h of exposure respectively, which increased to 100 per cent after 3 h of exposure with 70 per cent concentration. In case of III instar larvae, 40 per cent concentration inflicted 90 per cent whereas 50 per cent and above concentration caused 100 per cent larval mortality after 24 h. Fourth instar larvae took little longer time to register

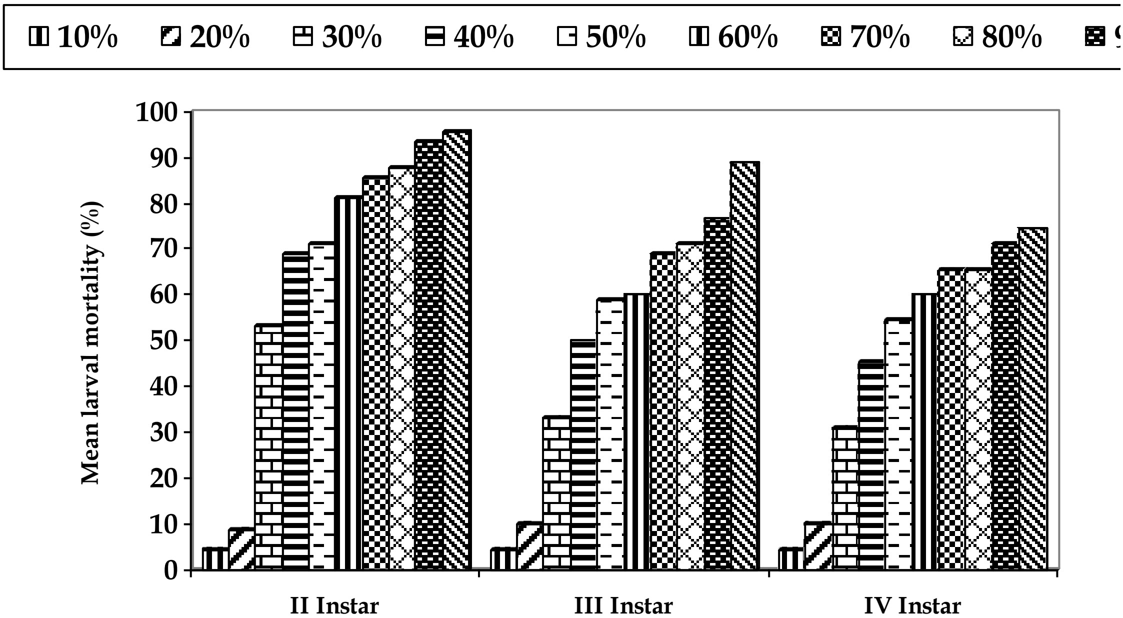

Fig. 1. Larval mortality of *S.litura* with different concentrations (%)

appreciable mortality. In this case, 90 per cent mortality was achieved in 24 h with 50 per cent concentration, which increased with increase in concentration, recording 100 per cent mortality with 90 per cent and 100 per cent concentrations.

Interestingly, more than 96 per cent mortality was observed in all the instars (II, III and IV) after 24 h with 60 per cent and above concentrations.

On the basis of mean over duration (Fig. 1), it is evident that II instar larvae are most susceptible as compared to later instars as the IV instar larvae recorded least mortality even at the highest concentration as compared to II and III instar larvae.

In earlier studies, Desai and Desai (2000) recorded more than 30 per cent mortality in *S. litura* with seven plant extracts including *Azadirachta indica, Pongamia pinnata*, and *Vitex negundo*. Higher mortality in present investigation could be attributed to synergistic interaction of *V. negundo, Azaridachta indica* and *Acacia arabica* among themselves as well as with other ingredients of the herbal product. Srinivasan *et al.* (2004) also reported larvicidal activities of petroleum ether extract of *V. negundo, Argemone mexicana, Datura metel* and *Annona squamosa* at different concentrations against *S. litura*. Quick knockdown effect against IV instar *S. litura* larvae certainly offer a great promise for management of the pest in soybean and other crops.

Further studies can be undertaken to assess the efficacy of this preparation fortified with some potential plant extracts.

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Impact of Front Line Demonstrations on Soybean by Adoption of Improved Production Technology

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Soybean is a premier oilseed crop in the world sharing about 41 per cent of total area under oilseed crops (Vyas *et al.* 2003). It has become a very popular rainy season crop among the farmers of central India. It is also known as "Wonders Bean" due to its medicinal and nutritional properties and also feasibility of its cultivation even under aberrant weather conditions. After the introduction of the crop and its subsequent inclusion in the traditional cropping systems in the country, it has led to improvement of socio-economic status of farmers and provided employment in villages and cities where soya-based industries are located. During last few years, the productivity of soybean in India is stagnated around 1000 kg/ha and is much lower than world average (2430 kg/ha) Hence, there is a need to make extension efforts to enhance the productivity by the introduction of available high yielding varieties and production technology among soybean farmers.

Present study deals with the front line demonstrations undertaken at farmers' fields with funding from DAC, Government of India over years to demonstrate and convince farmers on the effectivity of research emanated production technology in enhancing soybean productivity in Jhabua district of Madhya Pradesh. Although this district has about 35, 000 ha under soybean, the productivity is low and hovers around 800-1000 kg per ha.

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Jhabua district represents XII Agro-Climatic Zone (Jhabua Hills) of Madhya Pradesh. It is occupied with light to medium black soils having shallow to medium depth and full of gravels. The land has rolling and undulating topography and the area experiences hot semi-arid climatic regime (Tomar *et al.*, 1995). Total *kharif* cropped area of the district is around 3,60,000 ha. The major crops grown are maize (1,12,000 ha) black gram (75,000 ha), soybean (35,000 ha), cotton (40,000 ha) and paddy (22,000 ha).

Krishi Vigyan Kendra, Jhabua started conducting FLDs on soybean from 1992 onwards. Under these demonstrations only critical inputs were supplied to selected farmers. Various tools of Participatory Rural Appraisal (PRA) were utilized for identifying the critical inputs/technology for improving the soybean productivity under real farm conditions. Identified critical inputs were bio-fertilizers and fungicides for seed treatment, fertilizers for supplying phosphorous, zinc and sulphur and appropriate insecticides for managing insect-pests based on economic threshold level (Sharma, 2005). The results of FLDs conducted on farmers' fields for 10 years (1992-2004) were recorded and the performance of technology was evaluated on the basis of yield, net return, per rupee return and cost of unit production.

The results of these Folds' conducted in tribal area of Jhabua district of Madhya Pradesh under real farm conditions revealed an average seed yield of 1,632 kg/ha by adopting improved technology of soybean cultivation as compared to farmers practice (1, 060 kg/ha). The increase in yield by 51 per cent establishes the viability of production technology imparted (Table 1) and brings out the possibility of increasing yield levels of soybean in Jhabua district. A similar increase in seed yield of soybean by 53 per cent in Sehore (Vyas *et al.,* 2003) and 31.40 per cent in Sagar (Singh *et al.*, 2005) districts of Madhya Pradesh have been documented earlier.

Economic analysis revealed per hectare gross return of Rs 14, 198/- obtained in demonstration plots, while it was Rs.9, 222/- in case of farmers' practice. Thus, adoption of improved technology could result in additional gross returns of Rs 4, 976/- per ha over farmers practice. In spite of higher cost of cultivation (Rs 4, 350/-) for demonstration plots, the net returns worked out to Rs 4, 312/- per ha i. e. 77.9 per cent higher over farmers' practice. The returns on per rupee invested obtained through improved production technology were 2.26, which was 50.6 per cent higher than the farmers practice. The imparted soybean production technology reduces the cost of per unit production (Rs./1000 kg) by 23.3 per cent.

The results of these FLDs over years clearly brings out that the productivity of soybean in Jhabua district can conveniently be raised to one and half times by practicing the research emanated production technology and in turn can help farmers to consolidate their economic status.

Table 1. Impact of improved production technology of soybean cultivation on productivity through FLD's (1992-2004)

Year	Number of Demonstrations	Average yield (kg/ha)		Additional over farmers' practice	
		Demonstrations	Farmers' Practice	Yield (kg/ha)	% Increase
1992	10	1880	1250	630	50.4
1993	06	1600	1025	575	56.1
1994	10	1050	0850	200	23.5
1996	25	2375	1475	900	61.0
1997	18	2640	1525	1115	73.1
1998	17	1990	1050	940	89.5
2001	12	1060	0860	200	23.3
2002	11	1140	0858	282	32.9
2003	13	1035	0690	345	50.0
2004	12	1550	1025	525	51.2
Mean		**1632**	**1061**	**571**	**51.1**

Table 2. Economic analysis of Front Line Demonstrations conducted on soybean (1992-2004)

Particulars	Demonstrations	Farmer's Practice	Additional over Farmers Practice	% increase over Farmers Practice
Average yield (kg/ha)	1632	1060	571	51.0
Gross return (Rs/ha)	14198	9222	4976	53.9
Cost of cultivation (Rs/ha)	4350	3686	664	18.0
Net returns (Rs/ha)	9848	5536	4312	77.9
Per rupee return	2.26	1.50	0.76	50.6
Cost of Production (Rs./1000 kg)	2665	3477	812	23.3

** Rate of produced soybean Rs.870 per 100 kg*

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SOYBEAN RESEARCH

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