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EFFECT OF SEED RATE, ROW SPACING AND FERTILITY LEVELS ON GROWTH AND NUTRIENT UPTAKE OF SOYBEAN (*Glycine max.* L.) UNDER TEMPERATE CONDITIONS

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ABSTRACT

A field experiment was conducted at Shalimar Campus during kharif seasons of 2004 and 2005 on a silty clay loam soil, medium in available N and K, low in available P to study the production performance of soybean as influenced by seed rate, row spacing and fertility levels under temperate conditions. The experiment comprising 27 treatment combinations viz., 3 levels each of seed rate (40, 60 and 80 kg ha^{-1}), row spacing (30, 45 and 60 cm) and fertility (40:60:40, 60:90:60 and 80:120:80 of N: P_2O_5 :K_2O kg ha^{-1}) was laid out in split plot design replicated thrice. Application of N_{80} P_{120} K_{80} kg ha^{-1}significantly improved the growth parameters viz., plant height, LAI, number of nodules $plant^{-1}$, fresh nodule weight and dry matter accumulation. Uptake of nutrients both N and P were increased with increase in fertility levels. Significantly more protein and oil content were also recorded at highest fertility level of N P_2O_5 K_2O i.e. N_{80} P_{120} K_{80} kg ha^{-1}.

Keywords: soybean, seed rate, fertility, row spacing, growth, nutrient uptake.

INTRODUCTION

Soybean designated as 'miracle bean' has established its potential as an industrially vital and viable oilseed crop in many areas of India. The area under this crop is increasing steadily and at present it is cultivated on 5.8 thousand hectares with a productivity of 1028 kg ha^{-1} (Chandel, 2002), which is very low in comparison to the world average of 2,922 kg ha^{-1} (Anonymous, 1995). Soybean now has been established as one the most important oilseed crop in the world, accounting for more than 50 per cent of oilseed produced and 30 per cent of the total supply of all vegetable oils. It is unique two in one crop having both high quality protein (43%) and oil (20%) content. The protein form of soybean is equivalent to that of meat, milk products and eggs in quality.

Soybean mainly on account of its dietic, industrial, agricultural and medicinal importance, its products have various uses. The Soya meal is an important human food and Soya flour is essential in the various preparations viz, bread, cakes, muffins, biscuits and pastry. As a medicament, the soybean is of great importance in diabetic dietary.

Soybean plays a vital role in agricultural economy of India. The low productivity of the crop is due to several constraints, one among the important is unbalanced nutrition (Sharma *et al.*, 1996). For its optimum yield realization, it is necessary to optimize the nutrient inputs. Fertilizer application is very important practice and at present the most baffling as well. Studies carried out, indicate that soybean shows inconsistent response to application of nitrogen, phosphorus and potassium. High soybean yield demand high fertilizer dosage, applied directly to the crop or acquired through preceding crops. Another feature of sound fertilization practice is that all the nutrients (N, P and K) applied should be in balanced proportion to indicate the high production efficiency.

MATERIALS AND METHODS

A field experiment entitled "Production performance of soybean (*Glycine max.* L.) as influenced by seed rate, row spacing and fertility levels under temperate conditions" was conducted for two consecutive years (2004 and 2005), at the experimental farm on a silty clay loam soil, medium in available N and K, low in available P of the Division of Agronomy, which is situated 16 km away from city centre that lies between 34^0 08′ N latitude and 74^o 83′ E longitude at an altitude of 1587 metres above the mean sea level. The experiment comprising 27 treatment combinations viz., 3 levels each of seed rate (40, 60 and 80 kg ha^{-1}), row spacing (30, 45 and 60 cm) and fertility (40:60:40, 60:90:60 and 80:120:80 of N : P_2O_5 : K_2O kg ha^{-1}) was laid out in split plot design replicated thrice. The following observations were recorded during the course of present investigation. The plant height of five randomly selected plants from each plot was measured from ground level to the base of fully unfolded top leaf at 30 days interval right from sowing. The number of nodules of five randomly selected plants were counted and average per plant was calculated at 30, 60, 90 days after sowing. Nodules which were counted for nodule number, were taken and average of nodule weight were calculated in terms of mg/plant. Plant samples collected from penultimate rows of each plot using quadrant of 0.25 m^2 and all the plants comes under quadrant were cut from ground level at 30, 60, 90 and 120 days after sowing and were sun dried for 3-4 days, then the samples were oven dried at 60-65^{o}C for 40 hours to a constant weight. Dry matter accumulation was recorded in grams per 0.25 m^2 and expressed as kg ha^{-1}. Leaf area index was measured by canopy analyzer (ACCU PAR Plant Canopy Analyzer) at 30, 60, 90 and 120 days after sowing. By using Ceptometre light intensity received above the canopy and at soil surface was measured and from these photosynthetically active radiations

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interception (PARI) by crop was calculated using the formulae.

$$\text{PARI \%} = \frac{\text{PAR above the crop canopy} - \text{PAR at soil surface}}{\text{PAR above the crop canopy}} \times 100$$

The number of branches of 10 randomly selected plants was taken from each plot and average number of branches was calculated. The number of pods of five randomly selected plants from each plot was counted and the average of the five was calculated and presented as number of pods per plant. The number of seeds per pod was recorded from the randomly selected 20 pods for reporting from each plot. Average number of seeds per pod was then computed. After threshing, sample of 1000-seeds from each plot was taken and its weight was recorded and expressed as grams. After sun drying for a few days the harvested crop from respective net plot, was threshed manually. Seed yield was recorded and expressed as ACCU PAR Plant Canopy analyzer q ha^{-1}. It was worked out by deducting the seed yield from the total above ground biological yield (bundle weight before threshing) for each treatment. Plant samples collected at 30, 60, 90, 120 and at harvest were sun dried for 48 hours in the field and then oven dried at 60-65^{o}C for 48 hours to a constant weight. The dry weight was recorded in grams and then converted into q ha^{-1}. The samples were ground and subsequently used for chemical analysis. The method followed for the chemical analysis is as under. Oven dried samples were ground in a Wiley's mill to 32 meshes at different intervals. Nitrogen content was estimated by digesting 0.5 g samples with 10 ml of concentrated sulphuric acid and digestion mixture. Total nitrogen was determined by Micro-Kjeldahl's method. Phosphorus content of ground samples was determined by 'Vanado-molybdo-phosphoric yellow method' using systronics spectrophotometer by digestion in diacid mixture. The crude protein (%) in soybean seed was worked out by multiplying its nitrogen content with 6.245.Two grams, oven dried crushed seed samples was taken in a test tube of NMR (Nuclear magnetic resonance) and corked tightly. This test tube was inserted into the chamber of NMR after standardization of the same with known sample. Two consecutive readings were taken for each entry and its average was taken as oil percentage the software used for analysis was 'INDOSTAT'.

RESULTS AND DISCUSSIONS

The experiment included three levels of seed rate (40, 60 and 80 kg ha^{-1}). Plant height an index of general growth of plant, showed significant and consistent increase with the increase in seed rates (80 kg ha^{-1}) at all the growth stages of the crop (Table-1). Lower seed rates of 40 kg ha^{-1} and 60 kg ha^{-1} produced statistically shorter plants. The taller plants at higher seed rates might be due to competitive effect among the plants for sunlight. Khelkar *et al.* (1991) and Pramila and Kodandaramiah (1997) have also reported that an increase in plant density ha^{-1} resulted in progressive increase in plant height. Seed rate showed significant effect on nodule number and fresh weight of nodules 90 DAS. However, at 120 DAS no nodules were observed. A decreasing trend in the nodule number was observed with respect to increasing in seed rate, with maximum nodule number at seed rate of 40 kg ha^{-1} and at 60 DAS. But as increasing seed rate from 40 to 60 to 80 kg ha^{-1} fresh nodule gets decreased. This might be because of less population of roots having less number of nodule and smaller in size having less fresh weight. Increase in the seed rate might have created competitive conditions and the plant roots couldn't proliferate in the soil profile.

The present study revealed a significant and consistent increase in dry matter production with enhancement of seed rate upto 80 kg ha^{-1}. The increase in dry matter accumulation with higher plant density could be attributed to more number of plants per unit area as well as more LAI. Ravichandran and Ramaswami (1993) also reported increasing trend in dry matter production with increase in plant density.

Significant and consistent increase in LAI was recorded with respect to seed rate upto 90 DAS which on further at 120 DAS went on decreasing during both the years. Higher values of LAI with higher planting rates of 80 kg ha^{-1} may be ascribed to the more plant stand coupled with taller plants achieving more leaves thus having more LAI. Our results are in line with those of Sharma (1993) who reported that LAI significantly improved with higher plant densities. In case of PAR interception similar trend was recorded as that of LAI in both the years and at all the stages. The enhancement in planting density upto 80 kg ha^{-1} the photosynthetically active radiation interception goes on increasing. That means with increase in the plant population more solar radiation is harvested. Seed rate of 80 kg ha^{-1} showed greater PAR interception than 40 kg ha^{-1} and 60 kg ha^{-1}. Higher interception of solar radiation under higher seed rates might be the result of higher plant population with high LAI. This increased LAI is responsible for higher PAR interception. Shibles and Weber (1965), Lairungruang and Norman (1977) and Costa *et al.* (1980) also reported increase in LAI with higher plant densities.

Nitrogen uptake showed significant increase at all the stages except at 30 DAS during both the years. Effect of seed rate indicated an increasing trend of N uptake with the increase in the plant population. Maximum uptake of nitrogen was recorded at seed rate of 80 kg ha-1 at 120 DAS (Table-2). Similar trend in case of phosphorus uptake was observed at all the growth stages during both the years of crop season. The phosphorus uptake increase was recorded upto seed rate of 80 kg ha^{-1} and with maximum uptake at 80 kg ha^{-1} and seed rate of 40 kg ha^{-1}. However, similar findings were also reported by Jatinder Kumar and Badiyala (2004) that with the increasing in the sowing

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rates the uptake of nutrients i.e. nitrogen, phosphorus and potassium also increased.

Increase in protein content of seed was recorded only upto 60 kg ha^{-1} in 2005 which decreased at 80 kg ha^{-1}, while in 2004 seed rate 60 kg ha^{-1} was found at par with that 80 kg ha^{-1}. Highest protein content at seed rate 60 kg ha^{-1} and 70 kg ha^{-1} was also reported by Jasani *et al.* (1994). This increase in protein content upto seed rate of 60 kg ha^{-1} is the result of plants getting optimum requirement of nitrogen when sown at optimum level and any increase in the seed rate causes decrease in the protein content of the seeds.

Besides protein content, the data regarding oil content showed an increasing in the values with each increment in the seed rates during both the years. Highest oil content of 18.93% based upon pooled average of two years was recorded due to highest seed rate of 80 kg ha^{-1}. Results confirm the findings of Prasad *et al.* (1993) and Jatinder Kumar and Badiyala (2004). This increase in oil content might be due to the fact that there is a negative correlation between oil and protein content.

Table-1. Effect of seed rate, row spacing and fertility levels on plant height, nodule number and leaf area index.

	90 Days after sowing					
Treatments	**Plant Height** 2004	**Plant Height** 2005	**Nodule No.** 2004	**Nodule No.** 2005	**LAI** 2004	**LAI** 2005
Seed rate						
R_1 (40 kg ha^{-1})	116.07	117.71	16.74	16.08	5.40	5.39
R_2 (60 kg ha^{-1})	122.28	123.21	13.38	13.91	6.57	6.45
R_3 (80 kg ha^{-1})	127.53	129.75	8.99	6.17	7.62	7.72
SE m$\pm$	1.097	0.721	0.578	0.440	0.083	0.036
CD (p=0.05)	3.29	2.16	1.73	1.32	0.21	0.10
Row spacing						
S_1 (30 cm)	117.54	117.47	10.58	10.77	5.76	5.85
S_2 (45 (cm)	123.90	126.12	12.83	12.02	6.88	6.80
S_3 (60 cm)	124.45	127.08	12.83	12.02	6.96	6.90
SE m$\pm$	1.097	0.721	0.578	0.440	0.083	0.036
CD (p=0.05)	3.29	2.16	1.73	1.32	0.25	0.10
Fertilizer ($N:P_2O_5:K_2O$ kg ha^{-1})						
F_1 (40:60:40)	119.44	120.51	12.08	11.79	6.20	6.26
F_2 (60:90:60)	120.40	124.56	12.82	12.76	6.60	6.51
F_3 (80:120:80)	126.05	127.59	14.20	14.33	6.80	6.78
SE m$\pm$	0.879	0.829	0.446	0.488	0.104	0.036
CD (p=0.05)	2.52	2.37	1.28	1.40	0.30	0.10

Table-2. Effect of seed rate, row spacing and fertility levels on nutrient uptake, protein and oil content.

Treatments	90 Days after sowing				At harvest			
	N Uptake		P Uptake		Protein content %		Oil content %	
	2004	2005	2004	2005	2004	2005	2004	2005
Seed rate								
R_1 (40 kg ha^{-1})	77.42	81.76	12.25	11.39	37.22	37.35	17.87	18.46
R_2 (60 kg ha^{-1})	81.14	84.42	17.04	16.45	39.38	39.62	18.47	19.08
R_3 (80 kg ha^{-1})	89.73	88.57	17.89	17.88	39.53	38.52	18.58	19.09
SE m$\pm$	0.346	0.497	0.347	0.133	0.507	0.175	0.190	0.113
CD (p=0.05)	1.13	1.49	0.98	0.40	1.52	0.52	0.57	0.34
Row spacing								
S_1 (30 cm)	72.43	69.42	12.13	13.91	38.05	38.95	18.13	18.92
S_2 (45 (cm)	78.64	75.16	14.53	14.16	38.80	38.64	18.32	19.03
S_3 (60 cm)	87.23	84.23	15.27	15.12	39.28	38.89	18.57	19.08
SE m$\pm$	2.346	0.497	0.347	0.133	0.507	0.175	0.190	0.113
CD (p=0.05)	6.69	1.49	0.92	0.34	NS	NS	NS	NS
Fertilizer ($N:P_2O_5:K_2O$ kg ha^{-1})								
F_1 (40:60:40)	73.56	78.46	14.32	13.44	38.27	38.28	17.94	18.60
F_2 (60:90:60)	78.42	84.42	14.73	13.97	38.74	39.21	18.44	19.06
F_3 (80:120:80)	85.56	91.36	14.89	14.78	39.12	39.60	18.64	19.37
SE m$\pm$	0.530	0.50	0.082	0.132	0.234	0.216	0.176	0.135
CD (p=0.05)	1.65	1.43	0.24	0.38	0.85	0.62	0.50	0.39

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