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EFFECTS OF SEED RATE, ROW SPACING AND FERTILITY LEVELS ON YIELD ATTRIBUTES AND YIELD OF SOYBEAN 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. Lower seed rate i.e. 40 kg ha^{-1} produced significantly higher number of branches plant^{-1}, test weight, number of pods plant^{-1} and seeds pod^{-1}. Contrary to this, seed and straw yield were found significantly superior under seed rate of 80 kg ha^{-1} over 40 kg ha^{-1}. The extent of increase was 21.75% for grain yield and 20.68% for straw yield. Whereas row spacing of 45 cm proved significantly superior over 30 cm and remained at par with 60 cm for grain and straw yield. The extent of increase in grain yield at 45 cm row to row spacing was 13.14% when compared to 30 cm row to row spacing. Application of N_{80} P_{120} K_{80} kg ha^{-1}significantly improved the growth parameters viz., number of pods plant^{-1}, grain and straw yield over N_{40} P_{60} K_{40} kg ha^{-1}. The extents of increase were 12.5% for grain yield and 7.36% for straw yield.

Keywords: soybean, seed rate, fertility, row spacing, temperate, yield.

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 in our country 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. 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. Plant population is another important factor for higher yield realization through light penetration in crop canopy. If plant density is above the optimum, the plant growth may be poor due to competition for nutrients, light and space. On the other hand, if it is below optimum then the nutrients, space and light will not be utilized to their full extent, thus resulting into poor yield. For exploiting the potential of high yielding varieties, the optimum plant stand is very important non-monetary input. Solar energy being an unlimited, in exhaustible and non-pollutant, its efficient utilization for crop production could be major consideration especially for a row crop like soybean. Also for higher crop productivity, total leaf area per unit land area and light penetration to lower layers of the canopy assumes importance. Increasing or reducing the leaf area index from the optimum reduces the crop growth rate due to lesser energy capture or shading of lower canopy layers. Therefore, it is imperative to find out the optimum planting density to obtain optimum leaf area index and maintain it for longer period to improve yield potential of soybean. The optimum plant density with proper geometry of planting is dependent on variety, its growth habit and agro-climatic conditions. The row to row spacing with plant population should be maintained for getting better results from this crop.

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 m 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^oC 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 this photosynthetically active radiation interception (PARI) by crop was calculated using 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^oC 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 methods followed for the chemical analysis are 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 yield contributing characters viz., pods per plant, seeds per pod, 1000-seed weight showed significant variation at the different levels of seed rate tried (Table-1). There was a significant decrease in the number of pods per plant with increase in the seed rate from 40 to 60 and 80 kg ha^{-1}. Less number of pods was recorded at 80 kg ha^{-1} while as highest number of pods at 40 kg ha^{-1}. This was probably due to more availability of plant nutrients, moisture, space and light which resulted in better growth of the plants at lower density resulting in more number of pods per plant. Our results are in line with those of Prasad *et al*. (1993) and Abbas *et al*. (1994b) who had also recorded more number of pods per plant at lower density. The plant densities had a significant effect on number of seed per pod. However, lowest rate of 40 kg ha^{-1} produced significantly higher number of seeds per pod than all other sowing rates. This is due to more availability of plant nutrients, moisture, space and light in lower planting density. However, 1000-seed weight showed a decreasing trend with respect to increase in the sowing rates. Highest test weight was recorded at lowest sowing rate of 40 kg ha^{-1}. Better growth of individual plants at low plant density on account of more availability of space, moisture and light was presumably responsible for enhancement 1000 grain weight at low plant density.

Grain yield and straw yield showed significant variation due to seed rate (Table-2). There was a consistent increase in the seed yield with increase in seed rate from 40 kg ha^{-1} to 60 kg ha^{-1} and 80 kg ha^{-1}, during both the years. Pooled data of grain yield showed that seed rate of 80 kg ha^{-1} was having the highest grain yield of 23.66 quintals which was nearly 21% more than that at seed rate 40 kg ha^{-1}. This increase in the seed yield with increase in the seed rate might be due to better crop growth and increase in the number of plants/unit area. Thus increases the number of pods/unit area and ultimately increased the yield. Our findings with regarding to seed yield are in conformity with those of Rajput and Shrivastava (1999) and Yadav *et al.* (1999). They also reported an increase in the seed yield due to increasing the plant population/unit area. Significant increase was also reported on straw yield with increase in the seed rate. There was a consistent increase in the straw yield due to increasing seed rates. Seed rate of 80 kg ha^{-1} showed superiority over 40 kg ha^{-1} during both the years. However, seed rate of 60 kg ha^{-1} was at par with 80 kg ha^{-1} in 2004. The increase in the seed rate caused increase in the straw yield, this might be due to increasing trend

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observed in dry matter accumulation by having more number of plants/unit area.

Variation in seed rates in 2004 failed to show any significant impact on harvest index (Table-2). However, significant effect was recorded in 2005. Seed rate of 40 kg ha^{-1} was at par with that of 60 kg ha^{-1}, but further increase in seed rate from 60 kg ha^{-1} to 80 kg ha^{-1} decreased harvest index. It might be due to better solar radiation penetration at low plant density obtained at 60 kg ha^{-1} of seed as compared to 80 kg ha^{-1}. Among the yield attributing characters pods $plant^{-1}$ and 1000 seed weight proved to be significant influenced while seeds pod^{-1} was insignificant due to the spacings. With increase in row spacing, the pods per plant and 1000-seed weight goes on increasing. Highest number of pods $plant^{-1}$ and 1000 seed weight was recorded due to plants sown at wider row spacings of 60 cm as compared to other two spacings of 30 cm and 45 cm. The increase in pods $plant^{-1}$ and test weight of grains with respect to increase in row to row spacings was also reported by Khelkar *et al*. (1991) and Pant and Joshi (1978). This increase in test weight and pods per plant might be due to increase in seed size at wider spacing. Also the plants gets more nutrition and light at wider spacings as compared to closer spacings at which plants compete more from each other for sunlight, nutrition etc. At wider spacings there is better source sink relationship due to which yield attributing characters get increased.

Significant and consistent increase in grain yield and straw yield was recorded due to increase in row to row spacing from 30 cm to 45 cm and 60 cm. There was consistent increase during both the years. Grain and straw yield at wider spacing of 60 cm was superior then 45 cm and 30 cm row to row spacing. This was due to the fact that at 60 cm row spacing the number of rows/mt^2 get decreased and as the row to row spacing is decreased the number of rows/mt^2 get increase hence increasing the plant population per mt^2. Plant in close proximity has more competition as compared to wider spacings. Imporved yield attributing characters such as test weight, seeds pod^{-1} and number of pods per plant was recorded at higher spacings ultimately increasing the grain yield. However, spacing failed to have any significant impact on the harvest index during both the years of investigation.

Among the yield attributes only pods per plant were found significant. A seed per pod and 1000 seed weight was found to be non-significant due to application of fertilizers. But as we increased the fertility dose from N_{40} P_{60} K_{40} kg ha^{-1} to N_{80} P_{120} K_{80} kg ha^{-1} the yield attributing characters increased which might be due to better growth of plants at higher ratio of N, P and K. Both seed and straw yield were significantly affected by fertility levels during 2005. In 2004 only grain yield was significant while straw yield was non significant. As on each increment in fertility level from N_{40} P_{60} K_{40} to N_{60} P_{90} K_{60} and N_{80} P_{120} K_{80} both seed and straw yield increased. The increase in grain yield at highest fertility level was 4% in 2004 and 5.05% in 2005. The increase in seed and straw yield with increase in fertility levels is because of better growth and more yield attributing characters at higher N and P levels (Nayak *et al*., 1989).

Table-1. Effect of seed rate, row spacing and fertility levels on yield attributing characters.

Treatments	Pods $plant^{-1}$		Seeds pod^{-1}		1000-seed weight (g)	
	2004	2005	2004	2005	2004	2005
Seed rate						
R_1 (40 kg ha^{-1})	89.42	87.72	2.66	2.63	114.76	115.18
R_2 (60 kg ha^{-1})	74.07	73.42	2.54	2.47	108.52	108.75
R_3 (80 kg ha^{-1})	51.61	54.18	2.31	2.30	106.05	105.50
SE m$\pm$	0.359	0.816	0.031	0.018	0.357	0.155
CD (p = 0.05)	1.08	2.44	0.09	0.05	1.07	0.46
Row spacing						
S_1 (30 cm)	68.15	68.52	2.50	2.56	108.22	108.51
S_2 (45 (cm)	70.92	71.51	2.48	2.43	110.06	109.74
S_3 (60 cm)	76.84	75.23	2.45	2.41	111.20	111.18
SE m$\pm$	0.359	0.816	0.031	0.018	0.357	0.155
CD (p = 0.05)	1.08	2.44	NS	NS	1.07	0.46
Fertilizer ($N:P_2O_5:K_2O$ kg ha^{-1})						
F_1 (40:60:40)	69.98	70.26	2.37	2.45	109.24	109.82
F_2 (60:90:60)	71.24	71.67	2.46	2.47	109.90	109.89
F_3 (80:120:80)	73.75	73.33	2.48	2.48	110.18	109.72
SE m$\pm$	0.538	0.672	0.044	0.023	0.321	0.146
CD (p = 0.05)	1.54	1.93	NS	NS	NS	NS

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Table-2. Effect of seed rate, row spacing and fertility levels on grain yield (q ha^{-1}), straw yield (q ha^{-1}) and harvest index.

Treatments	Grain yield (q ha^{-1})			Straw yield (q ha^{-1})		Harvest index (%)	
	2004	2005	Pooled	2004	2005	2004	2005
Seed rate							
R_1 (40 kg ha^{-1})	19.24	19.73	19.48	36.79	35.54	31.80	33.60
R_2 (60 kg ha^{-1})	22.11	23.49	22.71	40.25	40.27	33.58	33.53
R_3 (80 kg ha^{-1})	23.42	23.91	22.92	41.66	42.89	32.27	31.95
SE m$\pm$	0.164	0.132	0.351	0.570	0.266	0.634	0.337
CD (p = 0.05)	0.48	0.39	2.23	1.71	0.80	NS	1.01
Row spacing							
S_1 (30 cm)	20.30	21.09	19.95	37.68	37.65	32.02	33.32
S_2 (45 (cm)	22.66	22.50	22.57	39.79	39.74	33.04	33.06
S_3 (60 cm)	23.11	23.53	23.98	41.23	41.31	32.60	32.71
SE m$\pm$	0.164	0.132	0.351	0.570	0.266	0.634	0.337
CD (p = 0.05)	0.48	0.39	2.23	1.71	0.80	NS	NS
Fertilizer ($N:P_2O_5:K_2O$ kg ha^{-1})							
F_1 (40:60:40)	21.49	21.76	21.59	39.08	38.78	32.43	33.11
F_2 (60:90:60)	22.16	22.50	22.32	39.59	39.61	32.78	33.12
F_3 80:120:80)	22.34	22.86	23.18	40.03	40.31	32.44	32.71
SE m$\pm$	0.208	0.196	0.321	0.601	0.280	0.577	0.280
CD (p = 0.05)	0.61	0.56	2.17	NS	0.80	NS	NS

CONCLUSIONS

With the increase in the seed rate the number of pods per plant decreased and with increasing the spacing and fertility levels it got increased significantly with highest number of pods $plant^{-1}$ at seed rate of 40 kg ha^{-1}, 60 cm row to row spacing and by the application of N_{80} P_{120} K_{80} kg ha^{-1} during both the years. However, fertility levels N_{40} P_{60} K_{40} kg ha^{-1} was found at par with N_{60} P_{90} K_{60} which was at par with N_{80} P_{120} K_{80} during both the years. Grain yield significantly increased due to increase in seed rate, however, seed rate of 60 kg ha^{-1} was found at par with seed rate of 80 kg ha^{-1}. Spacing and fertility also showed the same response of increase with respect to increase in row to row spacing and increase in fertility level. However, fertility level @ N_{60} P_{90} K_{60} kg ha^{-1} was found to be at par with N_{80} P_{120} K_{80} kg ha^{-1} during both the years.

Straw yield showed also increasing response with the increase in seed rate, spacing and fertility level. Significantly higher straw yield was recorded at higher seed rate of 80 kg ha^{-1} and at wider row to row spacing of 60 cm apart during both the years. However in the year 2004 seed rate of 60 kg ha^{-1} and 80 kg ha^{-1} were found at par. Also in the same year, spacing of 45 cm was found at par with spacing of 60 cm. Fertility levels only showed significant impact in 2005 with respect to straw yield with higher straw yield due to application of NPK in the ratio of N_{80} P_{120} K_{80} kg ha^{-1} which was at par with N_{60} : P_{90} : K_{60} kg ha^{-1}.

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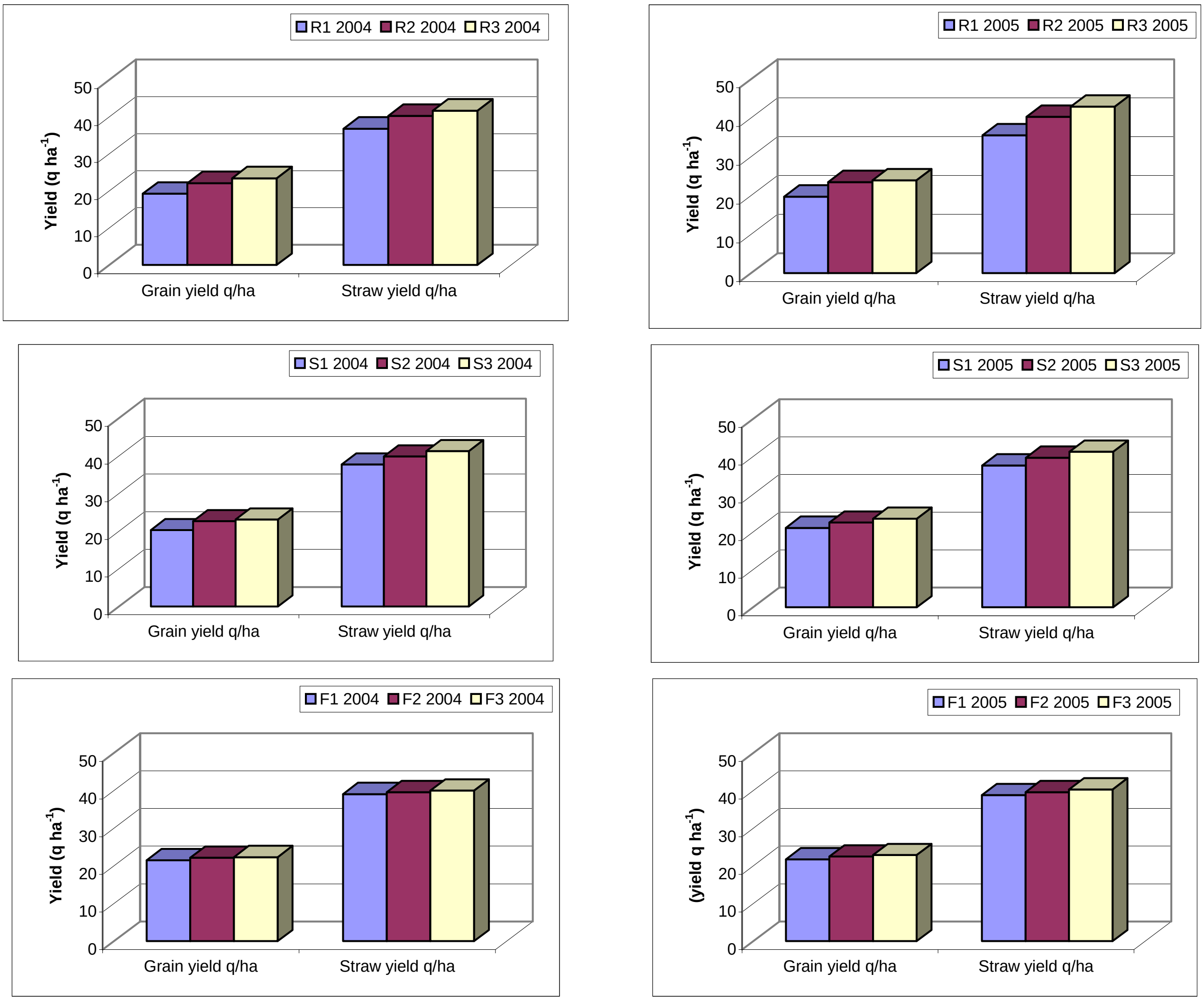

Figure-1. Effect of seed rate, row spacing and fertility levels on grain and straw yield (q ha^{-1}).

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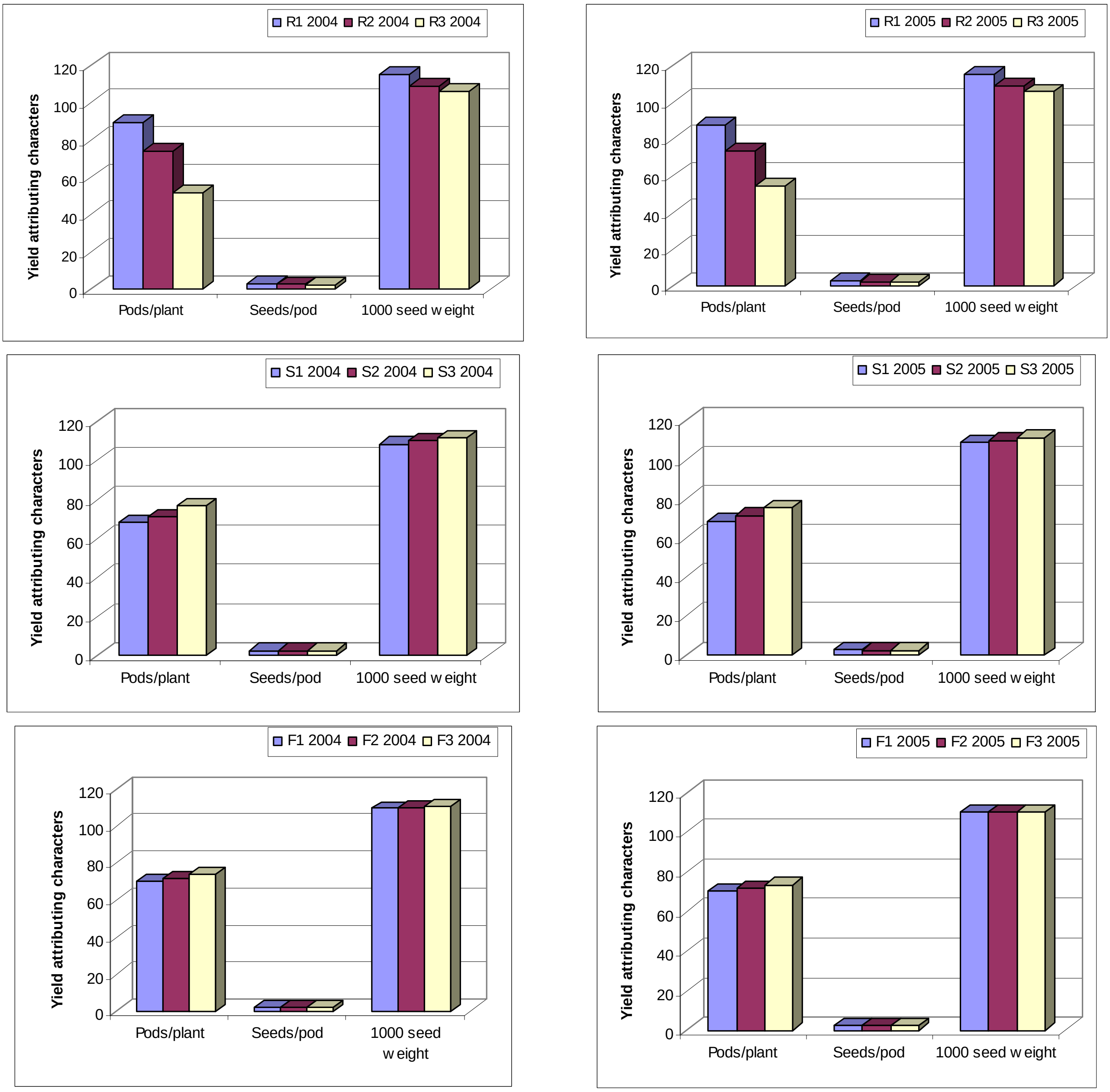

Figure-2. Effect of seed rate, row spacing and fertility levels on yield attributing characters.