GROWTH AND YIELD RESPONSE OF SOYBEAN (*GLYCINE MAX* L.) TO SEED INOCULATION AND VARYING PHOSPHORUS LEVELS

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ABSTRACT

These studies were carried out in the Department of Agronomy, University of Agriculture, Faisalabad during 2003. The objective was to assess the influence of different levels of phosphorus (30, 60, 90 and 120 kg/ha) and seed inoculation on growth and yield parameters of soybean. The experiment was laid out according to randomized complete block design with three replications and a net plot size of 2.25 x 5 meter. The seeds were inoculated with Rhizobium culture just before drilling. Data on growth and yield parameters were recorded using standard procedures and analyzed statistically using Fisher's analysis of variance technique. Least significant difference test at 5 percent probability was used to compare the differences among treatments means. The results revealed that phosphorus @ 90 kg per hectare with recommended application of N and gave higher seed yield (1911.12 kg/ha) against control (1274.07 kg).

KEYWORDS: *Glycine max;* Rhizobium; agronomic characters; Pakistan.

INTRODUCTION

Although Pakistan overwhelmingly has an agrarian economy, yet it is incapable to produce adequate edible oil for domestic requirement. The import bill of edible oils is second to petroleum and petro products. The indigenous production of edible oil has increased 2.4 times from 0.255 million tonnes (1979-80) to 0.606 million tonnes (2001-02). However, consumption has increased almost 3.5 times from 0.6 million tonnes (1979-80) to 2.089 million tonnes (2001-02). About 70 percent of edible oil needs are met through import (5). The substantial cause of this predicament is increasing gap between consumption and domestic production of edible oils. So, it is imperative to augment domestic oilseed production by cultivating non-conventional oilseed crops like soybean, sunflower, safflower and canola due to their high quality oil, greater yield potential and wider adaptability to our agro-climatic conditions.

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In Pakistan, soybean is grown on an area of 1.101 thousand hectares with an annual production of 1.266 thousand tonnes and an average seed yield of 1150 kg per hectare (5). Its per hectare yield is very low as compared to yield potential of existing cultivars. Among various options for improving production potential of soybean, use of Rhizobium inoculation is of prime importance. Researchers of many countries like USA, China etc. have found that inoculation of Rhizobium culture increased nodulation and yield of various crops. Rhizobium culture significantly affected number of pod bearing branches per plant, number of pods per plant, number of seeds per pod and 1000-seed weight (3, 10). Phosphorus is considered to be the most important nutrient for legumes, as it helps grain formation and root establishment. Soybean requires less nitrogen but phosphorus plays a pivotal role to get higher yield with better grain quality. Seed yield is significantly affected by phosphorus levels (2). Seed inoculation alone or with varying levels of NPK fertilizers tended to improve the plant growth and significantly differed from the control (8).

The present research was conducted to assess the influence of different P levels and seed inoculation on growth and yield of soybean.

MATERIALS AND METHODS

A research study was conducted in the Department of Agronomy, University of Agriculture, Faisalabad during autumn, 2003. Experiment comprised the following treatments.

T_1 = Control (no inoculation, no phosphorus)
T_2 = Inoculation only
T_3 = Inoculation + 30 kg P_2O_5/ha
T_4 = Inoculation + 60 kg P_2O_5/ha
T_5 = Inoculation + 90 kg P_2O_5/ha
T_6 = Inoculation + 120 kg P_2O_5/ha

The experiment was laid out according to randomized complete block design with three replications and a net plot size of 2.25 x 5 meter. The gross plot size was 2.25 x 7 meter. The crop was sown on 3rd September, 2003 using seed rate of 85 kg per hectare in 45 cm apart rows with a single row hand drill. The seeds were inoculated with Rhizobium (*Bradyrhizobium japonicum)* culture by adopting standard procedure just before drilling. Soil samples were taken before sowing of crop to a depth of 30 cm for physico-chemical analysis. Nitrogen @ 30 kg per hectare was applied to all plots. Urea and single super phosphate were used as a source of N and P, respectively.

The data were recorded on number of plants at harvest, plant height at maturity, leaf area index at flowering, number of pods per plant, number of seeds per pod, 1000-seed weight, biological yield, seed yield, harvest index, seed oil contents and seed protein content.

Data were analyzed statistically by using Fisher's analysis of variance technique and LSD at 5 percent probability was used to compare the differences among treatment means (14).

RESULTS AND DISCUSSION

1. Number of plants per m^2

The results (Table) show that no treatment affected the number of plants significantly. However, T_5 ranked first (38.88 plants/m^2).

2. Plant height

The plant height was significantly affected by seed inoculation and phosphorus application (Table). The maximum plant height (56.2 cm) was recorded in T_6 (inoculation + 120 kg P_2O_5/ha). It differed significantly from rest of all the treatments. The minimum plant height (49.37 cm) was observed in control. The increase in plant height due to inoculation and phosphorus application may be ascribed to pronounced vegetative growth. It might be due to the fact that inoculation started the nitrogen fixation during early growth stages of plant and similarly phosphorus application played a pivotal role in early root proliferation. These findings can be compared with Qureshi *et al.* (11) who have reported that plant height increased significantly due to inoculation and higher P rates.

3. Leaf area index

Leaf area index of soybean was significantly affected by seed inoculation and phosphorus application. Maximum leaf area index (5.95) was recorded in T_6 (inoculation + 120 kg P_2O_5/ha). It was, however, statistically at par with T_5. Minimum leaf area index (3.64) was observed in control. These findings are closely related to those of Rooge and Patel (12).

Table Production efficiency of soybean (*Glycine max* L.) as affected by different P levels and seed inoculation.

Treatment	No. of plants/m^2	Plant height (cm)	leaf area index	No. of pods/plant	No. of seeds/pod	1000-seed weight (g)
T_1	38.01	49.37e	3.46e	30.67e	2.30d	108.3d
T_2	38.39	51.03d	4.32d	31.97d	2.31d	119.0c
T_3	38.51	53.37c	4.81c	33.10c	2.40c	123.7bc
T_4	38.14	54.47bc	5.65b	33.37c	2.43c	127.7
T_5	38.88	54.87b	5.76ab	34.90b	2.66b	139.0a
T_6	38.37	56.20a	5.95a	36.53a	2.73a	138.0a
		Biological yield (kg/ha)	**Seed yield (kg/ha)**	**Harvest index (%)**	**Seed oil content (%)**	**Seed protein content (%)**
T_1		3481.48d	1274.07d	36.58b	18.57e	37.85d
T_2		4088.89c	1540.74c	37.57b	18.78de	39.13c
T_3		4251.85bc	1703.71b	40.06a	19.02cd	39.60c
T_4		4385.19b	1777.78b	40.53a	19.16bc	40.24d
T_5		4696.30a	1911.12a	40.69a	19.41ab	41.12a
T_6		4785.19a	1955.56a	40.85a	19.68a	41.35a

Any two means not sharing a letter in common differ significantly at 5% probability level.

4. Number of pods per plant

The data (Table) show that inoculation and different P levels with recommended dose of N had highly significant effect on the parameter. Maximum number of pods per plant (36.53) were recorded in T_6. This treatment differed significantly from rest of all other treatments. Minimum number of pods were observed in T_1 (control). The results are in line with those of Mandal and Sikder (9) who have also reported that growth and yield increased significantly with N availability, while P significantly increased the setting of pods and seeds.

5. Number of seeds per pod

Various levels of fertilizer and seed inoculation had highly significant effect on the number of seeds per pod. Maximum number of seeds (2.73/pod) were recorded in T_6 and minimum in control (2.30). It was, however, statistically at

par with T_2 (seed inoculation only). These results agree to those of Ali (2) who found that seed inoculation and increasing levels of P not only increased the seed yield but also the number of seeds per pod.

6. 1000-seed weight

The results (Table) reflect that P fertilizer and seed inoculation had a significant influence on 1000-seed weight. The highest value of 1000-seed weight (139.0 g) was recorded in T_5 (inoculation + 90 kg P_2O_5/ha). This was, however, statistically at par with T_6 (inoculation +120 kg P_2O_5/ha). Control plot gave minimum 1000-seed weight (108.3 g). Similar findings were observed by Ali *et al.* (4).

7. Biological yield

Different levels of P with recommended dose of N and seed inoculation had highly significant effect also on biological yield. Maximum biological yield (4785.19 kg/ha) was recorded in T_6. This treatment was statistically at par with T_5 (4696.30 kg/ha). The lowest biological yield was found in control (3481.48 kg/ha). The results indicated that nitrogen fixation by Rhizobium hastened the vegetative growth and phosphorus application improved the yield and yield components which are the possible reasons for substantial increase in biological yield. These results are similar to those of Khamparia (7) who reported that increasing rates of P in inoculated treatments increased biomass yield by 13.1 to 14.7 percent whereas, Rhizobium inoculation alone increased its yield by 19.6 percent.

8. Seed yield

Seed yield was also significantly affected by different P levels and seed inoculation (Table). Maximum seed yield (1955.56 kg/ha) was recorded in T_6. It was, however, statistically at par with T_5 (1911.12 kg/ha). Control treatment showed the lowest seed yield (1274.07 kg/ha). The higher seed yield in T_6 and T_5 might be due to increased growth under sufficient macro-nutrients status which improved the components of yield. Farani (6) also reported that seed yield increased with seed inoculation and varying phosphorus levels.

9. Harvest index

The data indicate that maximum harvest index (HI) (40.85%) was recorded in T_6 (inoculation + 120 kg P_2O_5/ha). The control treatment showed minimum HI value (36.58%) which was statistically at par with T_2 (seed inoculation only).

Ali (2) also reported that inoculation-cum-phosphorus application exhibited significant effect on HI of various legume crops.

10. Seed oil content

Significant effect on oil percentage was noted in different levels of phosphorus and seed inoculation. Maximum oil contents (19.68%) were found in T_6 which was statistically at par with T_5. Control treatment (T_1) showed minimum oil content (18.57%) which was, however, statistically at par with T_2. These results agree to those of Sable *et al.* (13).

11. Seed protein content

The comparison of treatment means (Table) reflects that maximum protein content (41.35%) was recorded in T_6 which was statistically at par with T_5 (41.12%). Ahmad (1) also reported that seed protein content increased with seed inoculation and varying levels of phosphorus.

CONCLUSION AND RECOMMENDATIONS

It is concluded that seed inoculation with Rhizobium in combination with phosphorus application @ 90 kg P_2O_5 per hectare performed better for harvesting a potent crop of soybean under irrigated conditions of Faisalabad.

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