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Vegetative Growth, Yield Components, and Seed Yield Response of Inoculated and Un-inoculated Soybean Regard to Fertility Regimes

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Abstract: Field trials were performed during summer, 1990, 1991 and 1993 at agronomy experimental field, Agriculture Research Institute, Tando Jam. Soybean seed inoculated and with *Rhizobium japonicum* and un-inoculated were sown and treated with various NPK levels (0-0-0, 50-25-0, 50-50-0, 75-75-0, 75-100-0, and 75-100-50 kg NPK/ha). Days to maturity, branches, pods, seeds/pod, seed weight, seed index and seed yield^{-ha} affected significantly ($P<0.01$) by inoculation treatment during all three seasons. Seed inoculation resulted significantly improved growth and yield, the increase in yield was associated with the increase of all yield components. Similarly, fertilizer regimes had pronounced effect on all the characters studied. Application of 75-100-50 kg NPK^{-ha} improved growth and yield attributes which in turn caused more yield^{-ha} in each season. It may be argued that soybean seed may be inoculated and fertilized with 75-100-50 kg NPK^{-ha} to get better yield, assuming that all soils have an equal initial fertility level.

Key words: Soybean, Inoculation, NPK level, Season, Production, Growth, Yield

Introduction

Soybean seed contains only twenty percent oil yet it is the major source of edible oil in the world. Soybean oil is primarily used in vegetable ghee manufacturing, besides it has numerous industrial uses. It is a protein rich crop and its seed contains 37-40 percent high quality protein. The major use of soybean meal is in livestock and poultry feed Chaudhry, *et al.*(1988) and Martin, *et al.* (1978). Seed inoculation with specific *Rhizobium sp.*, increased nodulation by absorbing atmospheric nitrogen symbiotically. The crop can fix 14 and 300 kg N^{-ha}, depending upon its yield potential, the availability of soil N, and genetic interaction between the host genotype and the *Rhizobium japonicum* strain Cassman, *et al.*(1981). Rainfall, drought, salinity, acidity, low P, and the presence of toxic ions hinders the establishment of symbiotic N fixation in tropical soils, results either by directly or indirectly reducing host photosynthesis Singleton, *et al.* (1983). Positive response of N, P and K in soybean crop was observed as reported by Akhtar, *et al.* (1988), Milanez, *et al.* (1978) Sorenson and Penas, (1978), Chaudhry and Mehraj, (1987), Souza, *et al.* (1979), Daminov and Eramotova, (1890), Romosan, *et al.* (1979), Cardero, *et al.* (1980) Cassman, *et al.* (1981), Terman, (1979), Hussain, *et al.* (1984) and Walker, *et al.* (1985). Since K is not recommended for soybean in the province of Sindh Chaudhry, *et al.* (1988). Keeping the above facts in view an experiment was conducted for three seasons to evaluate vegetative growth, yield components and seed yield of soybean regard to seed inoculation and fertility regimes.

Materials and Methods

Field experiments were conducted during summer, 1990, 1991 and 1993 (Crop planted during 1992 was damaged due to heavy rain) at Agronomy Experimental Field, Agriculture Research Institute, Tando Jam. *Rhizobium japonicum* inoculated and un-inoculated seed of a soybean variety Hampton was planted during the Ist week of June at the rate of 50 kg/ha in each season using a quadruplicated RCBD design having a net plot area of 3 x 5 meter. Six fertility regimes viz. 0-0-0, 50-25-0, 50-50-0, 75-75-0, 75-100-0, and 75-100-50 kg NPK^{-ha} were tested. The fertilizer was applied in the form of Urea, SSP, and SOP. Whole SSP and SOP was applied at the time of land preparation, while Urea was dressed in split dose (sowing, flowering, and grain formation). All the required cultural operations were adopted uniformly throughout the growing period. Soil sampling was made before sowing of crop at the depth of 0-30cm to determine the fertility status of the soil. Texture of the soil was assessed according to Moodi, *et al.* (1954). pH, E.C. and $CaCO_3$ was determined as suggested by Kanwar and Chopra (1959). Organic matter, total N and available P was obtained according to Jackson (1958), while exchangeable K was determined by Cottenie (1980). For recording agronomic observation (days to maturity, plant height, branches/plant, pods/plant seeds/pod, seed weight/plant, and seed index) normal looking five plants were selected randomly from each plot and tagged. At harvest seed yield/plot obtained and expressed as yield/ha. The data collected were subjected to pooled analysis of variance, to test the superiority of treatment mean LSD test was applied at alpha 0.05 following Gomez and Gomez (1984).

Results and Discussion

Physico-chemical properties of soil before sowing of crop: The result of soil analysis (Table-1) indicated that soil was clay loam in texture, the pH ranged from 7.9 - 8.0, ECe. 0.98 - 1.30 dS/m, $CaCO_3$ 8.0 - 9.5 %, which reveals that soil was calcareous in nature and Alkaline in reaction. Low in organic matter (0.74 - 0.83 %), and total N (0.04-0.05 %). Malherbe (1963) reported that soil containing 0.05 % N are poor, 0.05-0.10 % medium, 0.10-0.20 % fairly fertile and more than 0.20 % fertile but these ranges of nitrogen depend on type of soil, climatic conditions and crop be grown. The Olsen P was very low (6.30-7.00 ppm) according to the level described by Chaudhry and Memon (1969), P in soil having clay loam texture 11-20ppm available P low and 40-45ppm very high. Soil analysis further indicated that exchangeable K was optimum (180.35-205.45ppm). Donahue, *et al.* (1987)

reported that whenever soil contains less than 59ppm K are deficient, 150-249ppm optimum and above 350ppm excessive. Thus the fertility status of present soil was very low.

Table 1: Physico-chemical properties of soil before sowing of soybean crop at 0-30 cm depth during three season

Determination	Year		
	1990	1991	1993
Sand %	29.50	28.00	27.00
Silt %	36.00	37.00	36.50
Clay %	34.50	35.00	34.50
Textural class	Clay loam	Clay Loam	Clay loam
pH	8.00	8.00	7.90
Ece. (dS/m)	1.30	1.25	0.98
$CaCO_3$ %	8.00	8.80	9.50
O.M. %	0.74	0.80	0.83
Total N%	0.04	0.042	0.05
Available P ppm	6.30	6.82	7.00
Exchangeable Kppm	180.35	190.00	205.45

The above values are average of four replicates.

Effect of seed treatment: Significantly different trends ($P<0.01$) for days to maturity, plant height, branches/plant, pods/plant, seeds/ pod, seed weight/plant, seed index and total seed yield/ha were found over seed treatment. Seed inoculation resulted prolonged maturity period, taller plants, greater bearing of branches, pods, seeds, heavier seeds, seed index, and produced maximum seed yield as compared to un-inoculated soybean (Table-2). This demonstrated that seed inoculation improved nodulation, vegetative growth and yield components which in turn caused more seed yield. These results are supported by previous workers Memon and Jamro, (1991), Tanner and Anderson, (1964), Sachansky, (1977), Racca and Bodrero, (1982), and Yazdi-Samadi and Zali, (1982).

Effect of fertility regime: Days to maturity, plant height, branches, pods, seeds, seed weight, seed index and seed yield differed significantly ($P<0.01$) between the levels of fertility (Table-2). Plots treated with 75-100-50 kg NPK^{-ha} prolong maturity, increased plant height, branches, pods, seeds, seed weight, seed index, and seed yield, (Table-3). This explains that soybean responded to K fertilizer. Since no K was recommended to soybean in South Sindh, the present findings proved that soybean crop respond K fertilizer and it need to be applied. Akhtar (1988) also reported that application of nitrogen in combination with P and K increased pods/plant, seed index and seed yield/ha. However, Lutz and Jones (1975) reported that application of PK failed to increased yield but addition of N increased soybean yield. Milanez, *et al.* (1978) reported increased soybean yield with NP application. Soreson and Penas (1978) and Chaudhry, and Mehraj (1987) found linear relation of N with seed yield. Souza, *et al.* (1979) obtained higher seed yield with combined application of NPK. Similar results have also been reported by Daminov and Eramotova (1980) and Romosan, *et al.* (1979), Cardero, *et al.* (1980). However, Cassman, *et al.* (1981) stated that N alone did not increase yield as compared to NPK combined. Terman (1979) noted that seed yield of soybean in response to NPK was more over NP, PK, NK, and N alone. Hussain, *et al.* (1984) described that number of pods, seeds, seed weight, and seed yield increased with increasing N upto 75 kg^{-ha}. Walker, *et al.* (1985) reported significant effect of NPK on yield of soybean.

Effect of season

Days to maturity, plant height, branches, pods, seeds, seed weight, seed index and seed $yield^{-ha}$ changed over season (Table-2). Soybean planted during summer, 1993 recorded significantly maximum seed yield, as compared to 1990 and 1991 seasons. This may be due to continuous use of rhizobium result in more N fixation as well as better weather conditions particularly low rain (Table-3).

Effect of interaction: Treatment and season interaction was significant ($P<0.01$) for plant height, branches and total seed yield. Whereas, other characters studied were not affected by the interaction (Table-3). During all three seasons seed inoculated plot displayed higher yield and vegetative growth but this increase was more during 1993 as compared to 1990 and 1991.

Branches and seed $yield^{-ha}$ was significantly ($P<0.01$) different between season and fertilizer interaction. However, other parameters studied were not affected (Table-2). Increasing fertilizer upto 75-100-50 kg NPK^{-ha} during each season produced greater number of branches, and seed yield, as compared to NP alone at the same dose, indicated that addition of K fertilizer in each season had beneficial impact in boosting yield, the increment in yield was comparatively high in 1993 season, this may be due to better fertility status of the soil which is the result of continuous application of rhizobium.

Significant differences in days to maturity, plant height, branches, pods, seed weight, seed yield due to treatment and fertilizer interaction was observed (Table-2). Higher dose of 75-100-50 kg NPK^{-ha} prolong crop maturity, increased plant height, branches, seeds, seed weight, and finally seed yield., the increase in growth, yield components and seed yield was significantly more in seed inoculated plots, when compared with un-inoculated soybean, indicating that seed inoculation improved the ability of plant to better uptake of nutrients.

The detailed analysis of Season x Treatment x Fertilizer interaction (Table-2) influenced that number of pods, and seed $yield^{-ha}$ significantly ($P<.0.5$) However, other characters were not affected by the interaction. Seed inoculation and application of a fertilizer dose of 75-100-50 kg NPK^{-ha} during each season gave significantly higher seed yield, this indicates that rhizobium and high dose of NPK treated plots did not gave maximum yield during all seasons, due to change in fertility status of the soil. Yield recorded in 1993 was more than did 1990 and 1991 seasons. This shows that the fertility of the soil was better in 1993 which is the result of regular dressing soybean seed year after year. It may be argued that soybean inoculated and treated with 75-100-50 kg NPK^{-ha} gave significantly greater seed yield during all three seasons (1990, 1991, and 1993) over un-inoculated soybean under the same dose. However, seed yield recorded during 1993 was more.This suggests that the fertility of soil was better in 1993 as compared to 1990 and 1991 seasons respectively.

Table 2: Analysis of variance for vegetative growth, yield components and seed yield of soybean as affected by NPK combination levels, inoculation and seasons

Source of Variation	Degree of Freedom	Day of Maturity	Plant Height	Branches per plant	Pods per plant	Seeds per pod	Seeds weight per plant	Seed Index	Yield t/ha
Years (Y)	2	93.950**	211.094**	22.890**	168.180**	0.254**	123.356**	3.892**	0.634**
Replications within years	9	8.020NS	5.429NS	0.410NS	2.827NS	0.085NS	11.051NS	0.246NS	0.015NS
Treatment (T)	1	539.904**	625.338**	35.920**	525.174**	6.987**	1233.063**	75.169**	3.450**
Y X T	2	3.696NS	50.920**	1.551**	2.278NS	0.131NS	10.358NS	0.489NS	0.106**
Fertilizer (F)	5	1752.829**	615.626**	56.280**	759.608**	5.620**	1690.894**	54.914**	1.915**
Y X F	10	3.274NS	2.572NS	0.553**	2.96NS	0.137NS	1.637NS	0.136NS	0.055**
T X F	5	70.885**	16.496**	0.449*	10.516**	0.343NS	24.980**	0.193NS	0.043**
Y X T X F	10	1.250NS	3.699NS	0.090NS	6.127NS	0.083NS	2.576NS	0.055NS	0.033*
Pooled Error	99	4.805	1.655	0.162	1.284	0.073	2.839	0.118	0.006
Total	143								

* = Significant at P<0.05 percent level of probability
** = Significant at P<0.01 percent level of probability NS = Non significant

Table 3: Vegetative growth uield components and seed yield of soybean as affected by different N, P and K levels and inoculation and seasons

Traits	Day to Maturity	Plant Height	Branches Per Plant	Pods Per Plant	Seeds Per Pod	Seed weight Per plant	Seed Index	SeedYield t/ha
NPK levels kg/ha								
0.0.01	104.12f	29.18f	4.91f	25.25f	1.52e	29.19f	10.95f	1.75f
50.25.0	116.75e	34.78e	6.18e	30.35e	2.01d	36.35e	11.78e	1.95e
50.50.0	121.05d	37.33d	7.28d	33.88d	2.31c	40.99d	12.73d	2.10d
75.75.0	122.98c	39.57c	7.97c	35.47c	2.91b	48.58c	13.34c	2.17c
75.100.0	123.96b	41.40b	8.73b	37.94b	2.72a	46.72b	14.34b	2.36b
75.100.50	128.81a	41.17a	8.97a	41.12a	2.82a	53.44a	14.97a	2.54a
S.E	0.450	0.260	0.080	0.230	0.060	0.340	0.070	0.020
P<0.05	0.900	0.520	0.160	0.460	0.120	0.680	0.140	0.040
P<0.01	1.190	0.690	0.210	0.610	0.160	0.900	0.180	0.050
Seed inoculation								
Seed inoculation	21.55a	39.66a	7.80a	35.91a	2.54a	44.64a	13.73a	2.30a
Seed Un-inoculation	117.68b	35.49b	6.81b	32.09b	2.10b	38.79b	12.29b	1.99b
S.E.	0.260	0.150	0.050	0.130	0.030	0.200	0.040	0.010
P<0.05	0.520	0.300	0.100	0.250	0.060	0.400	0.080	0.020
P<0.01	0.690	0.400	0.130	0.350	0.290	0.530	0.110	0.030
Seasons								
1990	119.21b	36.73b	7.01c	33.35b	2.32b	41.57b	13.08b	2.10b
1991	118.46c	36.03c	8.81a	32.54c	2,25c	40.19c	12.70c	2.06c
1993	121.17a	39.96a	8.09b	36.11a	2.39a	43.38a	13.26a	2.28a
S.E.	0.320	0.190	0.060	0.160	0.040	0.240	0.050	0.010
P<0.05	0.640	0.190	0.120	0.320	0.080	0.480	0.140	0.020
P<0.01	0.840	0.510	0.160	0.420	0.110	0.630	0.130	0.030

Values followed by similar letters are not significantly different at alpha = 0.05 by Tukey's honestly significant difference test.

This may be due to continuous application of rhizobium. It is concluded that soybean seed should be inoculated with suitable *Rhizobium* sp. and fertilized with 75-100-50 kg NPK/ha for getting better seed yield.

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