Pakistan Journal of Applied Science 2(5): 560-562, 2002

Yield of Soybean as Affected by Water Stress and Phosphorus Levels

[1]B.R.Kazi, [2]F.C.Oad, [2]G.H Jamro, [2]L.A.Jamali, and [3]L. Kumar
[1]Arid Zone Research Institute, PARC, Umerkot, Pakistan
[2]Sindh Agriculture University Tandojam, Pakistan
[3]Agriculture Research Institute, Tandojam, Pakistan

Abstract: Field experiments on soybean variety Hampton-266A were carried out for three years at Sindh Agriculture University, Tandojam on silt loam soil. Factorial experiments in Randomized Complete Block with four replications were carried out with three soil moisture stress levels (3, 5 and 8 bar tension) and two fertility levels (NPK 50-60-30 and 50-90-30 $kg.ha^{-1}$). The data demonstrated that seed yield was highly significantly affected by moisture stress and fertility levels. The seed yield reduced by 28 and 20 percent at 8 and 15 bars respectively as compared to 3 bar soil moisture stress. The seed yield was about 10 percent more in 90 kg P_2O_5 per hectare as compared to 60 kg P_2O_5 per hectare. It is therefore suggested that soybean crop should be irrigated when soil moisture reaches at the level of 3 bar, where satisfactory yield could be obtained.

Keywords: Soybean yield, water stress, phosphorus

Introduction

Soybean is an important multipurpose crop and richest source of proteins, compared to all pulses and food grains. Soybean crop seldom attains its full yield potential because limitations on physiological processes imposed by environmental stresses. It is true that insects and diseases some times drastically reduce yields, but in the long run such reductions are small, compared with those caused by unfavourable weather. Soybean is leguminous crop and frequently does not respond to larger inputs of inorganic nitrogen and its mycorhizal roots generally assure adequate phosphorus available for crop growth. Other factors for yield reduction are various cultural practices including fertilizer and irrigation management. Very little information regarding water requirement of the crop under irrigated areas are available for the soybean grower. Mayaki *et al.* (1976) reported that all the aerial components were adversely affected by soil water stress. Kadhem *et al.* (1985) concluded that yield and other agronomic responses are sensitive to the water stresses during whole growing seasons. Further, Huck *et al.* (1984) noted that the water stress decreased the seed weight. Cox and Jilliff (1986) reported that moisture stress reduced seed yield from 27 to 87 percent when the crop was subjected to a moisture deficit ranging from 18 to 70 percent. Carlson *et al.* (1982) observed yield reduction due to moisture stress which varied from 20 to 50 percent. Weber (1968) found that fertilizers (NPK) some what compensated for moisture deficiency at vegetative phase and obtained positive response of nitrogen and phosphorus application for seed yield. Marcus *et al.* (1983) reported that yield reduction in soybean crop occurred due to soil moisture stress. Keeping in view the above findings and considering paramount importance of proper use of irrigation and fertilizers for high yields, the present study was carried out to investigate the effect of soil moisture stress and fertility levels on the seed yield of soybean.

Materials and methods

Experiments on soybean variety Hampton-266A were carried out for three years at Malir Experimental Farm, Sindh Agriculture University, Tandojam on silt loam soil having 23.5% moisture holding at field capacity. Factorial experiments in Randomized Complete Block with four replications were carried out. The details of the soil moisture stress and fertility levels are as under:

Soil Moisture Stresses	**Fertility Levels (NPK)**
M1= Irrigation at 3 bar	F1=50-60-30 $Kg.ha^{-1}$
M2= Irrigation at 5 bar	F2=50-90-30 $Kg.ha^{-1}$
M3= Irrigation at 8 bar	

All the agronomic operations were carried out in all plots uniformly and fertilizer was applied at the specified rates as well as same was calculated for individual plots. Whole P and K was and was incorporated at the time of seedbed preparation before the sowing of the crop, whereas, N was applied in two splits at flower and pod formation. Irrigation was applied to all the plots when the soil moisture stress reached specified growth depletions level in the top 0-60 cm of soil depth and subsequent irrigations were applied to the respective plots as soon as the designed stress was recorded in 0-60 cm soil profile. The quantity of irrigation water applied was calculated on the basis of soil moisture deficiency by soil sampling before irrigation application. For the purpose of applying measured quantity of irrigation water cut throat flumes of right size were installed in the middle of channel and near the point from where water was applied. The time required to obtain the desired depth of irrigation for each plot, was calculated as under:

t = 27.53646 (d x a)/q

Where = t = Time required to irrigate (hours)
d = Depths of water to be applied (cm)
a = Area (ha)
q = Discharge in litres (per second)

The soil moisture stress was monitored during the entire growth period of the crop. When the soil moisture dropped to 3,5 and 8 bar tensions in upper 60 cm depth, the water was added to compensate the deficiency. Yield estimation was made at the time of crop harvest using crops cutting method. For this purpose, 0.5 meter border strip was left and the rest of the plot area was harvested and yield per hectare was calculated. The statistical analysis was done for the average of three years data, according to the methods out lined by Steel and Torrie, (1980).

Results and Discussion

The effect of soil moisture stress and fertility levels on the seed yield of soybean crop is presented in Table 1. It is evident from the result that the seed yield reduced with the corresponding increase in the soil moisture tension from 3 bars to 5 and 8 bars. The highest seed yield of 2.44 $t.ha^{-1}$ was obtained when the crop received irrigation at 3 bar tension and fertility level was 50-90-30 NPK $kg.ha^{-1}$. The seed yield of 2.34 $t.ha^{-1}$ was obtained when the crop was irrigated at 3 bar tension, but the fertility rate was 50-60-30 NPK $Kg.ha^{-1}$. Similar trend of yield performance was obtained when the crop was irrigated at 5 bar tension with a fertility level of 50-90-30 NKP $kg.ha^{-1}$. The lowest soybean yield was recorded when the crop received irrigation at 8 bar tension and fertilizer rate was 50-60-30 NPK $kg.ha^{-1}$.

When the performance of the crop was averaged for various soil moisture treatments, it was noticed that there was a substantial decrease in the seed yield due to increase in soil moisture stress. There was 28% increase in the seed yield when the crop received irrigation at 3 bar soil moisture tension in comparison to the crop receiving irrigation at 8 bar soil moisture tension. The effect of fertility levels on the yield resulted in an increase of 10% due to increase in phosphorus level from 60 to 90 kg P_2O_5 per hectare.

The water use for the seed yield of the soybean indicates that the yield gap went on increasing with the reduction in water use between two fertility level means. The yield reduction from M1 to M2 was less sharp than from M2 to M3 stress level. The effect of soil moisture stress levels was highly significant. The reduction in seed yield was observed due to all the three soil moisture stress levels. The soybean crop is highly sensitive to soil moisture stress in any stage. This was also observed by Range and Odell (1960) that 70% variation in the soybean yield occurred due to soil moisture stress. Jamro and Larik (1990) and Huck *et al.* (1984) observed that the yield was significantly reduced due to water stress. In the same way Jamro *et al.* (1994) and Marcus *et al.*(1983) reported the yield increased with a linear fashion in irrigation and simulated ET. Mecket *et al.* (1981) and Jamro *et al.* (1994) estimated 20% yield loss due to stress. Carlson *et al.* (1982) reported yield reduction due to moisture stress varying from 20-50 percent. All the above mentioned research workers have reported the losses in grain yield of soybean crop due to soil moisture stress. However, the range of the yield loss was much higher than recorded during the present study. This may be due to the fact that the soil moisture variation in their studies was also higher, while the deficit range tested in the present study was from 70-90%. Since the variation from one treatment to another was 10% only, yield differences were somewhat lower in the present case. The seed yield significantly increased due to increase in the fertility level. The present findings confirm the results obtained by the other workers. The effect of phosphorus application from 60-100 lbs P_2O_5 per acre was found to have an increase in seed yield significantly (Carter and Hartwig, 1962). Similarly, Jakhro, *et al.* (1993) noted in Mungbean. Weber (1968) found that fertilizers (NPK) somewhat compensated for moisture deficiency at vegetative phase. They also obtained positive response of nitrogen and phosphorus application for seed yield. The higher fertilizer rate was able to produce seed yield statistically similar to those obtained from less water stressed plants. This implies compensation of fertilizer for moisture deficit. The overall results proved that soybean crop is sensitive to soil moisture stress beyond 3 bars. Therefore, maximum seed yield could be obtained at appropriate levels of irrigation and soil moisture stress should not be more than 3 bars. The soybean crop also requires fertility levels, which should be in between 50-90 $kg.ha^{-1}$.

Table 1: Effect of Soil Moisture Stress and Fertility Levels on the Grain Yield ($t.ha^{-1}$) of Soybean (average of three years)

Moisture Stress (Bars)	Fertility levels (NPK $kg.ha^{-1}$) 50-60-30	50-90-30	Mean	Increase over Severe Stress (%)
3	2.34	2.44	2.39	28.0
5	2.13	2.33	2.23	20.0
8	1.71	2.01	1.86	-
Average	2.06	2.26	-	-
Moisture :	Cdi = 0.135	Cdii = 0.175		
Fertility:	Cdi= 0.130	-		
C.V (%)= 2.21				

References

Carter, J.L. and E.E. Hartwig, 1962. The Management of Soybeans. Advance Agron. 14: 359-412.

Carlson, R.E., M.K. Abadchi and R.H. Shaw, 1982. Comparison of Nodal Distribution and Yield Components of Indeterminate Soybean under Irrigated and Rainfed Conditions. Agron. J. 74: 531-535.

Cox, W.J. and G.D. Jilliff, 1986. Growth and Yield of Sunflower and Soybean under Soil Water Deficit. Agron. J. 78: 226-230.

Huck, M.G., G. Hoogenboom and C.M. Peterson, 1984. Partitioning of Dry Matter in Water Stressed Soybean. USDA-ARS and Ala. Agric. Exp. Sta. Auburn Univ. Agronomy Abst.

Jakhro, A.A., U.A. Buriro, G.H. Jamro and M.B. Kumbhar, 1993. Effect of Phosphorus Fertilization on Nodulation, Growth and Yield of Mungbean Vigna Mungo. Sci. Int. (Lahore).5 : 189-190.

Jamro, G.H. and A.S. Larik, 1990. Photosynthesis of Field Grown Field Bean under Drought. Pak. Phyton. 2: 47-52.

Jamro, G.H., G.S. Posypanov, V.N. Posypanov, T.P. Kobzova, Y.E. Koshken and U.A. Buriro, 1994. Effect of Soil Moisture on Biological Nitrogen Fixation in Pot Grown Phaseolus Vulgaris L. Sarhad J. of Agric. 3: 209-216.

Kadhem. F.A., J.E. Specht and J.H. Williams, 1985. Soybean Irrigation Serially Limited During Stages R1 to R6. J. Agronomic Responses Agron. J. 77: 291-298.

Marcus, K., G. Wiebold, W.J. Mchutrey and J.E. Deining, 1983. Effects of Moisture Stress History on Soybean Uni. Of Maryland. Agron. Abst.

Mayakai, W.C., R.C. Stone and J.D. Teare, 1976. Irrigated and non Irrigated Soybean, Corn and Grain Sorghum Root System. Agron. J. 68: 532-534.

Mecket, L.W., D.B. Egli, R.E. Phillips and J.E. Legett, 1981. Effect of Water Stress on Soybean Seed Growth Characteristics. Univ. of Kentucky. Agronomy Abst.

Runge, E.C.A. and R.T. Odell, 1960. The Relationship Between Pre-cipitation, Temperature and the Yield of Soybeans on Agronomy. South Farm Urtana Illinois. Agron. J. 52: 245-247.

Steel, R.G. and J.H. Torrie, 1980. Principles and Procedures of Statistics. McGraw Hill Book Co. Inc. New York.

Weber, C.R., 1968. Physiological Concepts for High Soybean Yields. Field Crop Abst. 21, 312-7.