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By B.K. Abdul Jabbar , H.M. Saud
*Ezra Research Station, Ezra, Daraa, Syria*

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*GJSFR-D Classification : FOR Code: 100103, 070103*

EFFECTS OF PHOSPHORUS ON BIOLOGICAL NITROGEN FIXATION IN SOYBEAN UNDER IRRIGATION USING SALINE WATER

# Effects of phosphorus on biological nitrogen fixation in soybean under irrigation using saline water

B.K. Abdul Jabbar [α] , H.M. Saud [Ω]

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## I. Introduction

Soybean is considered one of the most important legumes because it contains a good percentage of protein and improves soil characters through its ability to produce root nodule. Rhizobium is affected by many different environmental factors such as soil physical and chemical properties (temperature, humidity and salt concentration in soil). Nitrogen fixation is affected by many factors such as the presence and density of nodulating bacteria in the root zone during the emergence and formation of root hairs. In case of symbiotic relation between plant and specialized bacteria, bacteria and plant will thus be more tolerant to environmental stress conditions like drought and soil conditions, which limit growth like rising in soil and irrigation water salinity (Idris et al., 1986). The biological system needs energy which provides hydrogen reductant and also the energy for ATP system in nitrogenase reactions. Thus, adding phosphorus may reduce stress in the symbiotic relation between root bacteria and legume plant in case of rising salinity levels which come from soil and irrigation water (Dixon and Wheeler, 1986).

*Author [α Ω] : Department of Agrotechnology, Faculty of Agriculture University Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia.*

The effect of high salt content on nitrogen fixation ability of alfalfa could be detrimental (Wilson, 1970). Bhardwaj (1974) mentioned that pulse crops decrease the number of nodules on highly salt-affected land even though native Rhizobia are known to be present. Therefore, this study aims at determining the effect of irrigation by saline water (3.5 dS /m) and adding different levels of phosphorus on Rhizobium and plant growth. The salinity level was fixed at 3.5 dS /m since this is the average level of soil salinity in many experimental station administered by the Ministry of Agriculture, Iraq.

## II. Materials and Methods

As shown in Table 1, an experiment was carried out on Serdang series soil. The Ground soil was put in 20 kg pots, and 33.7 g of calcium carbonate was added to each pot to raise the soil pH. All pots were left for 2 weeks with irrigation to ensure that CaCo3 was totally absorbed in the soil. A soil sample was taken to measure the pH after adding calcium carbonate. Before planting of the seeds, four levels of phosphorus were used 0, 40, 80, 120 kg P /ha, nitrogen was added as urea at 40 kg N /ha and potassium sulphates was also added at 100 kg K /ha Soybean seed (variety AGS190) was used, and Bradyrhizobium strain UPMR020 was applied as bacterial inoculation. During the experiment, all the pots were irrigated using saline water with a concentration of 3.5 dS /m.

## III. Experimental Design and Determination of Growth Parameters

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replicates, and plants were harvested after 16 weeks. The treatments were: 1- Control 2- 40 kg of P /ha 3- 80 kg of P /ha 4- 120 kg of P /ha 5- UPMR020 6- UPMR020+ 40 kg of P /ha 7- UPMR020+ 80 kg of P /ha 8- UPMR020+ 120 kg of P /ha. The parameters recorded in this experiment were: number of nodules /plant, weight of nodules mg /plant, plant dry weight g /plant, root dry weight g /plant, plant height (cm), number of pods /plant and weight of pods g /plant.

## IV. Results

### a) Number of nodules

The number of bacterial nodules increased significantly in plants inoculated with UPMR020, compared with non-inoculated plants (P≤0.01) Figure 1. Adding phosphorus at different levels led to an increase in bacteria nodules, which was progressive until 120 kg of P /ha having 3.50 nodules /plant. This increase was significant at (P≤0.01) in spite of irrigation by saline water. The interaction between bacterial inoculation and different levels of phosphorus revealed significant differences at (P≤0.01) in the number of nodules at all levels of phosphorus; the best interaction was the inoculated treatment with 120 kg of P /ha giving 40.50 nodules /plant.

### b) Weight of nodules

Results in Figure 2 indicate an increase in the weight of dry nodules when soybean seeds were inoculated with bacteria and the increase was significant at (P≤0.01). The effect of adding different levels of phosphorus increased the weight of root nodules, compared with control. The highest increase in the weight of nodules was at 120 kg of P /ha having a nodule weight of 52.50 mg /plant. The results demonstrate the obvious interaction between bacteria inoculant and phosphorus level whereby nodule weight increased in response to higher levels of P.

### c) Plant dry weight

The effect of bacterial inoculation and phosphorus on increasing the dry weight of green parts of the plants showed in Figure 3. The difference in increase between inoculated and non-inoculated treatments was significant (P≤0.01). The role of phosphorus fertilization was obvious in increasing the dry weight whereby the dry weight increased from 13.34 g /plant for control to 16.59, 22.52 and 27.79 gm /plant for 40, 80, 120 kg of P /ha. The interactions between bacterial inoculation and different levels of phosphorus had obvious effect in increasing the weight of the dry matter, whereas interaction between bacterial inoculation and 120 kg of P /ha showed the highest amount 45.75 g /plant followed by 36.54, 38.29 and 38.83 g /plant respectively for P fertilization 0, 40 and 80 kg of P /ha.

### d) Plant height

The results in Figure 4 indicate an increase in plant height whereby inoculated treatment increases significantly, compared to non-inoculated treatments at (P≤0.01). The increase in phosphorus levels enhanced plant height, and the highest plants were at 120 kg of P /ha, which gave 12.25 cm /plant compared with 0, 40, 80 kg of P /ha. The interactions between bacterial inoculation and phosphorus levels revealed significant increase at (P≤0.01) particularly in the interaction between 120 kg of P /ha and the bacterial inoculation which gave 43.75 cm /plant, followed by 40, 80 kg of P/ha and inoculation alone.

### e) Number of pods

As shown in Figure 5, the effect of bacterial inoculation increased the number of pods under inoculation treatments. This can be compared with non inoculation at (P ≤0.01), which gave 27.50 pods /plant for inoculation and 6 pods /plant for control. The role of phosphorus fertilizer was obvious in increasing the number of pods from 40 kg of P /ha to 120 kg of P /ha which gave the highest number of pods 12.50 pods /plant. The interactions between bacterial inoculation and phosphorus levels were significant at all levels P≤0.01, especially in the interaction between 120 kg of P /ha and bacterial inoculation giving 41.50 pods /plant, compared with inoculation alone with 27.50 pods /plant.

### f) Weight of pods

The weight of pods as affected by phosphorus levels and Rhizobium inoculation showed in Figure 6. The results demonstrated that adding Rhizobium alone without any input of P increased pod weight much more than the treatment with P without inoculation (P ≤0.01). Also, Rhizobium inoculation significantly increased pod weight with an increase in the amount of P. The highest pod weight was obtained with 120 kg of P /ha with a value of 7.75 g /plant. The lowest amount of pod weight was shown by control treatment. The results suggested the importance of inoculation with Rhizobium to increase pod weight (P≤0.01).

### g) Root dry weight

As shown in Figure 7, the effect of bacterial inoculation and phosphorus on root dry weight was obvious as the root dry weight significantly increased under bacterial inoculation (P≤0.01), compared with non bacterial inoculation. The root dry weight under bacterial inoculation was 20.55 g /plant, whereas there was 10.18 g /plant in control. This proves the continuity of growth and distribution of roots in soil under soil circumstances. Adding phosphorus in different levels led to a significant increase in root dry weight under 120 kg of P /ha at (P≤0.01), compared with other levels. The interactions between bacterial inoculation and phosphorus showed significant differences, particularly between bacterial inoculation and 120 kg of P /ha as compared to other interactions at (P≤0.01). The increase in the root dry weight emphasizes the role of phosphorus in soil plus the nitrogen fixed by nodulation bacteria, which resulted in the improvement of plant growth compared with non-inoculated plants.

## V. Discussion

The response of soybean to bacterial inoculation was obvious through increasing all parameters. Biological fertilization by nodules bacteria improved the growth and yield of soybean. Increasing phosphorus levels improved plant growth and fixed atmospheric nitrogen by specialized bacteria, which benefitted soybean and increased the studied parameters.

The decrease in plant parameters under low phosphorus treatments with or without bacterial inoculation may be due to the negative effect of low phosphorus on the nodule capacity to fix nitrogen as a result of small nodules. On the other hand, the effect of low phosphorus on nodules formation and functions may be due to low exchange between shoot and nodules, which is the proper way to decrease leaf photosynthesis with the decline in the available phosphorus (Tsvetkova and Georgiev, 2003). In this experiment, the balancing in nutrient elements especially phosphorus contributed to the growth and survival of bacteria.It reduced salt stress in spite of irrigated plants by water with Ec= 3.5 dS/ m.

Un-inoculated plants produced fewer nodules and had lower dry matter than inoculated plants, which confirms the result obtained by Hafeez et al. (1988). Accordingly, Hafeez found that bacterial inoculation and using saline water with suitable concentration had obvious effect on both bacteria and plant and suggested that salinity had an indirect effect on biological nitrogen fixation. The bacteria are generally more capable to survive with salinity than their host plants.

Since soybean is considered moderately sensitive to salinity, irrigation by saline water with a concentration of 3.5 dS /m did not much affect plant parameters. According to Keating and Fisher (1985), soybean has a higher tolerance to salinity (3.5 to 5.4 dS /m) than green gram, black gram and pigeon pea, all cultivated in the same soil salinity.

In line with Wilson (1985), inoculation with suitable Rhizobium strain showed good tolerance of high salinity. Accordingly, Wilson found that Siratro plants depend on symbiotic nitrogen fixation. They show a better tolerance of salinity compared with Cooper (glycine), which appear to be less resistant than Siratro cells to injury at high tissue salts concentrations.

Adding saline water with 3.5 dS /m did not have inhibitory effect on plant nodulation, which is in accordance with Douka et al. (1984). In their experiment it was found that additional NaCl to soil- agar slopes displayed higher or equal nodulation compared with plants grown without any addition of NaCl.

Adding phosphorus to legumes increases plant parameters, paralleled with an increase in phosphorus levels. Deficiencies in phosphorus are most likely to be manifested in decreasing the growth of the legumes, which in turn reduces total nitrogen fixation and effect the nodule formation. These results confirmed the results mentioned in FAO (1984) on soybean; it showed that application of phosphorus alone increased the number of nodules per plant and per unit volume of soil.

Fertilization with phosphorus and bacterial inoculation increased the number of nodules and other plant parameters. Hoque and Haq (1994) also reached the same results when they treated several legumes with Rhizobium and phosphorus and they found an increase in the number of nodules and maximum growth features with inoculation and phosphorus. In line with the result of a study on lentil by Abdallah (1986), using 120kg of P/ ha with bacterial inoculation increased the number of nodules, number of pods and plant dry weight.

## VI. Conclusion

Using bacterial inoculation was very effective on all plant parameters where adding UPMR020 showed significant increase in the plant growth, compared with the control. This experiment indicated that UPMR020 with 120 kg of P /ha was the best and most effectinve combination for soybean plants under irrigation by saline water (3.5 dS /m).

## References Références Referencias

1. Abdallah, M.M. (1986). Effect of phosphatic fertilizers and trace elements application on growth, yield and quality of lenti Assiut. Journal of Agricultural Science. 17(1): 121- 132.
2. Bhardwaj, K.K. (1974). Growth and symbiotic effective-ness of indigenous Rhizobium species in a saline- alkaline soil. Procedure of Indian Academy of Science. 40: 540- 543.
3. Dixon, R.O.D and Wheeler, C.T. (1986). Nitrogen fixation. New York: Chapman and Hall Publishing
4. Douka, C.E., Xenoulis, A.C. and Paradellis, T. (1984). Salinity tolerance of a
5. Rhizobium meliloti strain isolated from salt affected soils. Folia Microbiol. 29:316- 324.
6. Hafeez, F., Aslam, Z. and Malik, K. (1988). Effect of salinity and inoculation on growth, nitrogen fixation and nutrient uptake of Vigna radiate L. Plant and Soil. 106: 3-8.
7. Idris, M., Ashraf, M. and Malik, K.A. (1986). Response of mungbean (Vigna Radiata L.) to Rhizobium inoculation for effective nodulation and nitrogen fixation under field conditions. Pakistan journal of Soil Science. 41- 46.
8. Fao. (1984). Legume inoculants and their use. A pocket manual jointly prepared by NIFTAL project, USA

9. Hoque, M. and Haq, M.F. (1994). Rhizobial inoculation and fertilization of lentil in Bangladesh. Lens Newsletter. 21(2): 29- 30.
10. Keating, B.A. and Fisher, M.J. (1985). Comparative tolerance of tropical grain legumes to salinity. Australian journal of Agricultural Researches. 36: 373-383.
11. Tsvetkova, G.E. and Georgiev, G.I. (2003). Effect of phosphorus nutrition on the nodulation, nitrogen fixation and nutrient use efficiency of Bradyrhizobuim japonicum soybean (Glycine max L. merr) symbiosis. Bulgarian Journal of Plant Physiology. 331- 335.
12. Wilson, J.R. (1985). Comparative response to salinity of the growth and nodulation of Macroptilium atropurpureum cv. Siratro and Neonotonia wightii cv. Cooper seedlings. Australian journal of agricultural Researches. 36: 589-599.
13. Wilson J.R. (1970). Response to salinity in Glycine. VI, some effects of a range of short term salt stresses on growth, nodulation and nitrogen fixation of Glycine. Australian journal of agricultural Researches. 21: 571- 582.


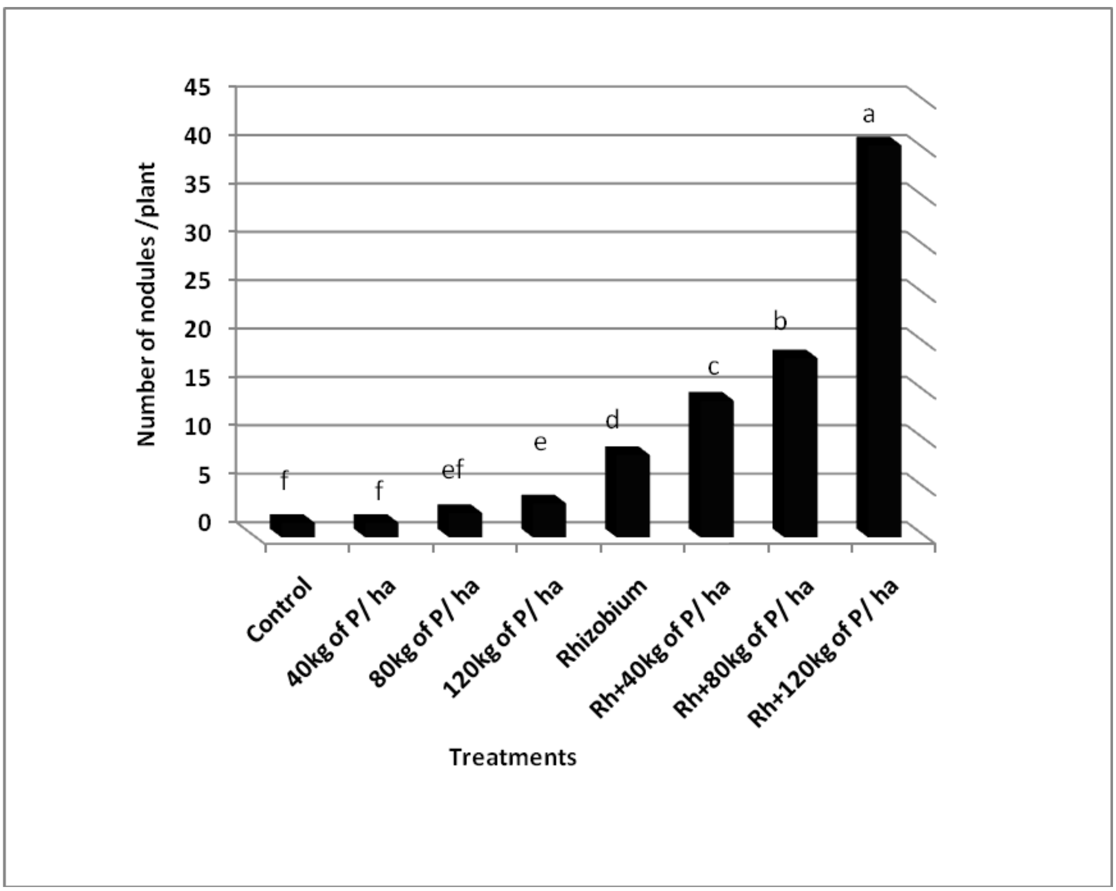


*Figure 1 :* Effect of phosphorus and bacterial inoculation on number of nodules under irrigation by saline water. The letters above the bars represents significant differences at 0.01 level of significance.

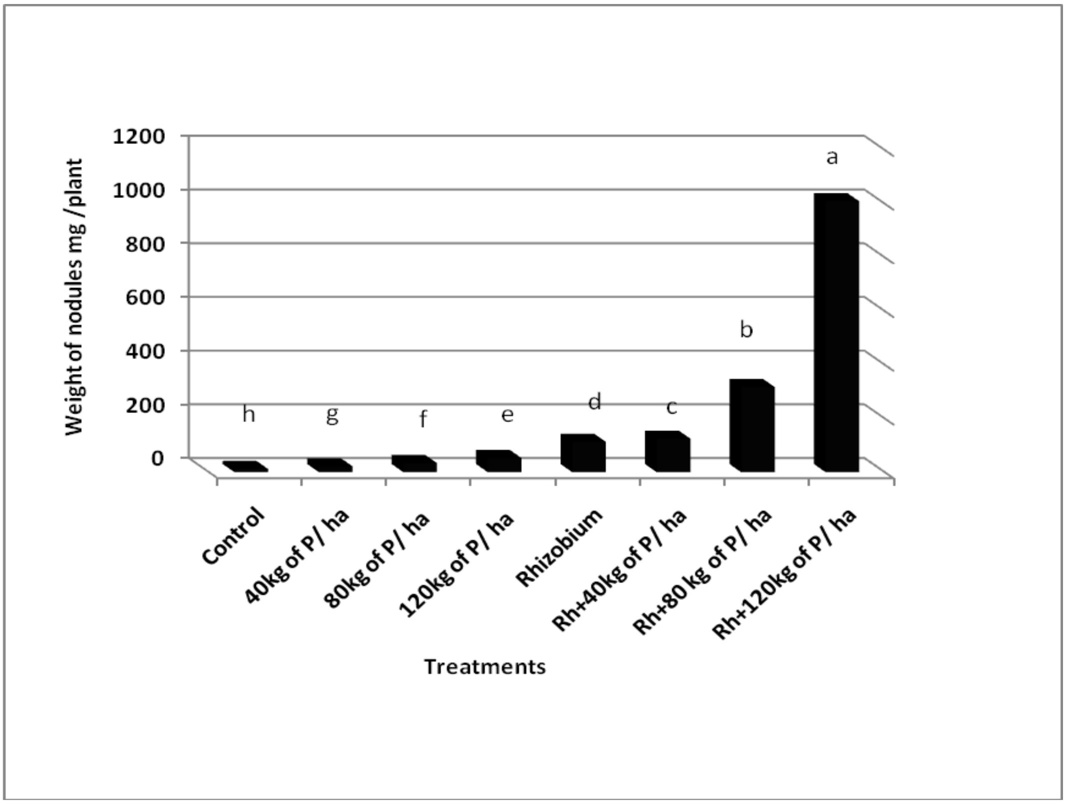


*Figure 2 :* Effect of phosphorus and bacterial inoculation on weight of nodules under irrigation by saline water. The letters above the bars represents significant differences at 0.01 level of significance.

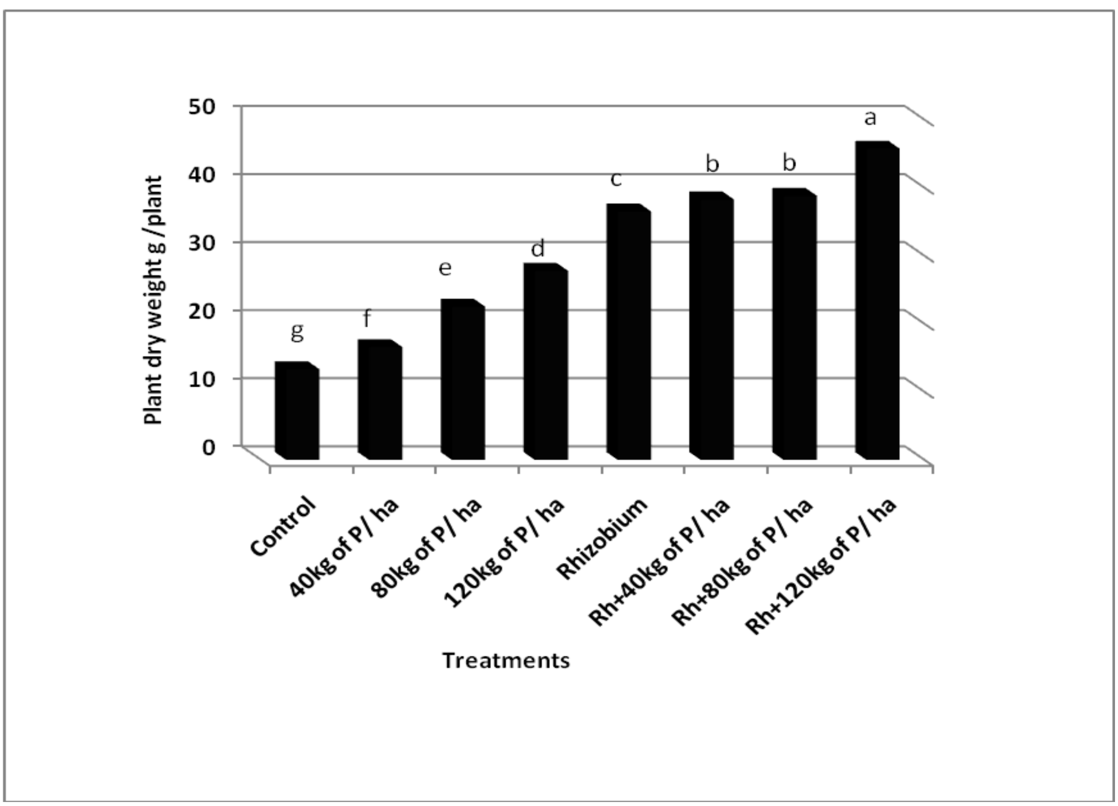


*Figure 3 :* Effect of phosphorus and bacterial inoculation on plant dry weight under irrigation by saline water. The letters above the bars represents significant differences at 0.01 level of significance.

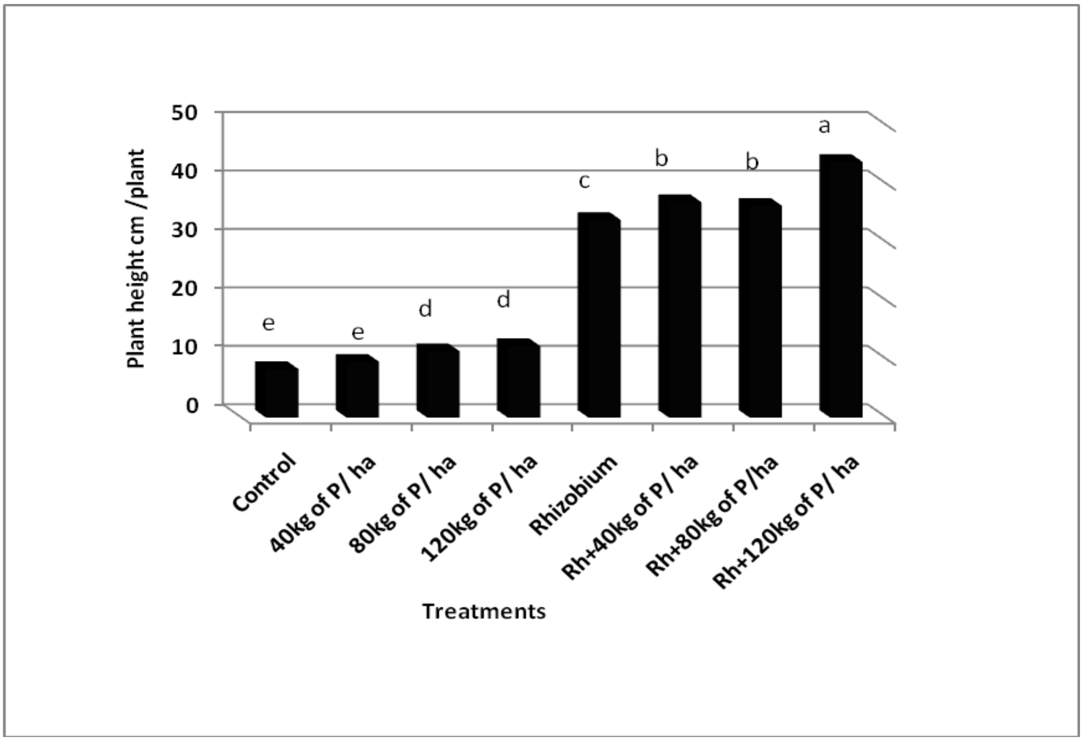


*Figure 4 :* Effect of phosphorus and bacterial inoculation on plant height under irrigation by saline water. The letters above the bars represents significant differences at 0.01 level of significance.

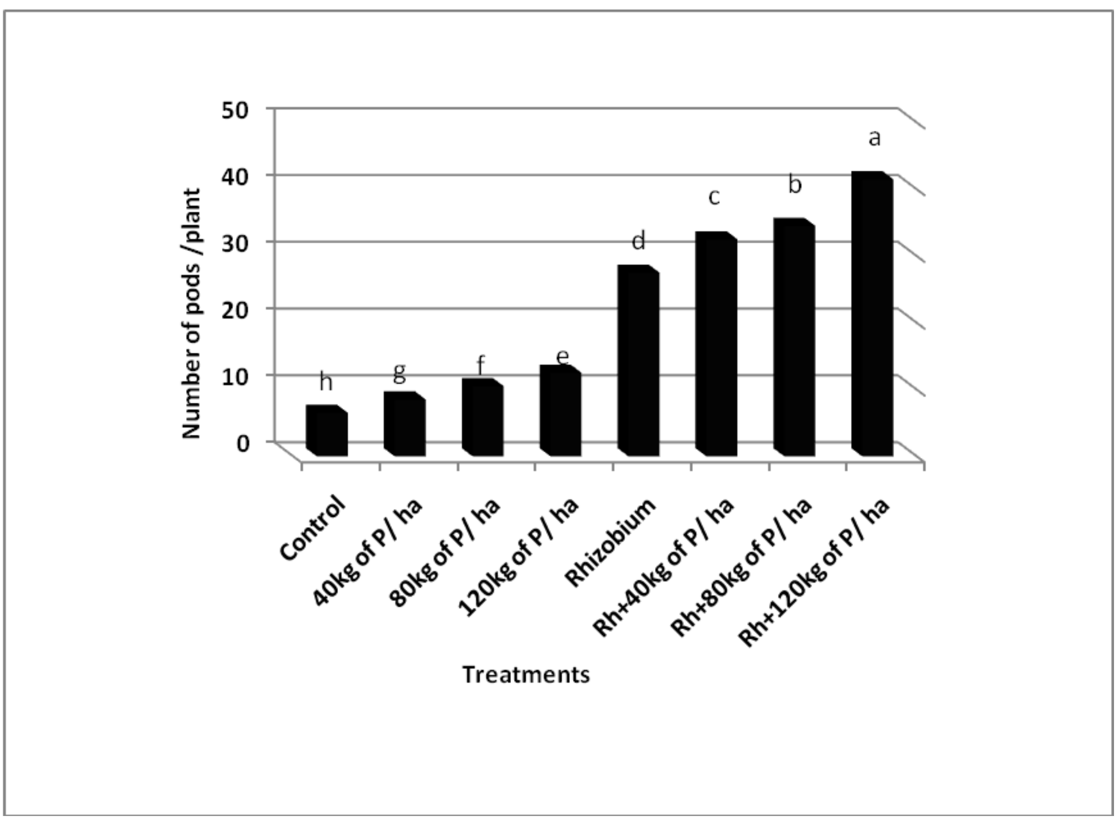


*Figure 5 :* Effect of phosphorus and bacterial inoculation on number of pods under irrigation by saline water. The letters above the bars represents significant differences at 0.01 level of significance.

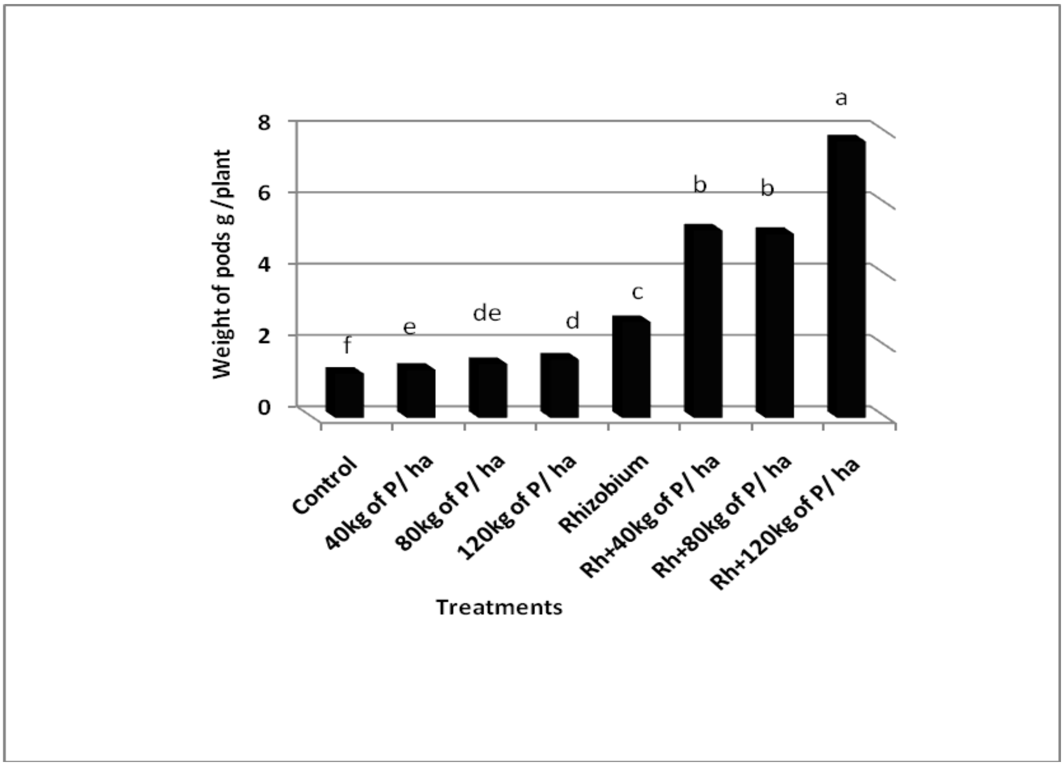


*Figure 6 :* Effect of phosphorus and bacterial inoculation on weight of pods under irrigation by saline water. The letters above the bars represents significant differences at 0.01 level of significance.

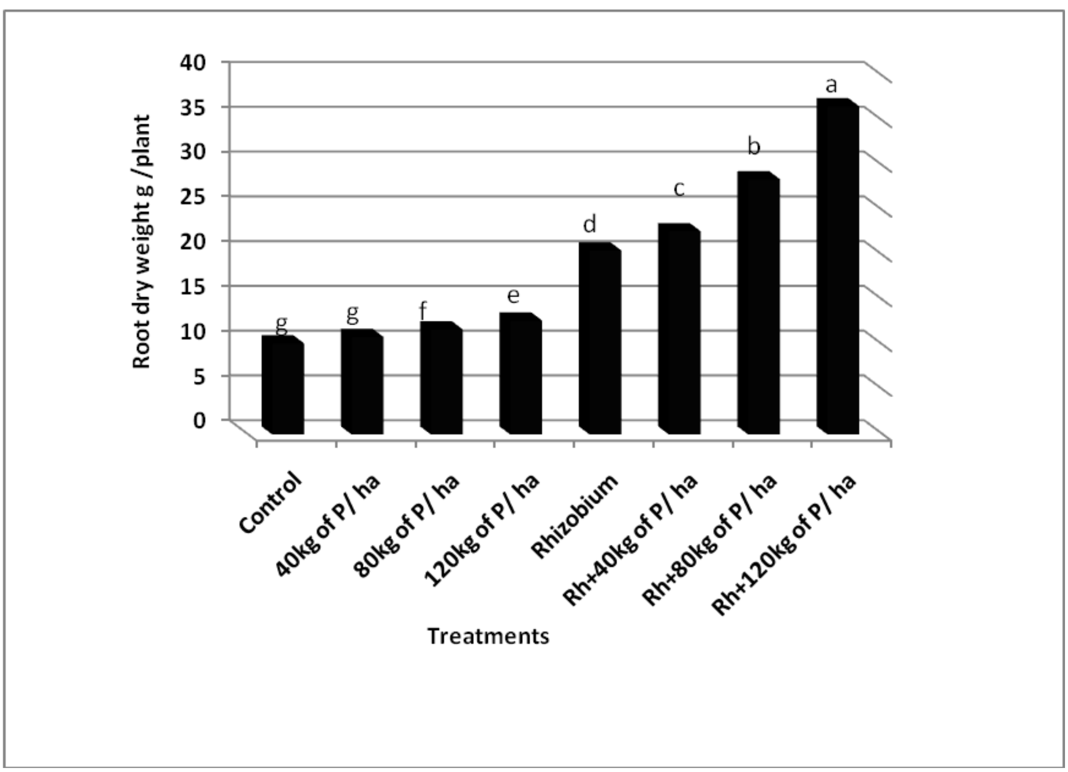


*Figure 7 :* Effect of phosphorus and bacterial inoculation on roots dry weight under irrigation by saline water. The letters above the bars represents significant differences at 0.01 level of significance.

Table (1)

The chemical properties of Serdang soil series

| Analyses | Results |
|---|---|
| pH | 4.2 |
| N % | 0.13 |
| Available P(ppm) | 2.50 |
| Available K(ppm) | 12.30 |

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