INTERNATIONAL JOURNAL OF PLANT, ANIMAL AND ENVIRONMENTAL SCIENCES
IJPAES
Volume-4, Issue-2, April-June-2014
ISSN 2231-4490

Coden : IJPAES www.ijpaes.com
Received: 27th Feb-2014 *Revised: 28th March-2014* *Accepted: 30th March-2014*
Research article

THE EFFECT OF DIFFERENT LEVELS OF PHOSPHORUS FROM TRIPLE SUPER PHOSPHATE CHEMICAL FERTILIZERS AND BIOLOGICAL PHOSPHATE FERTILIZER (FERTILE 2) ON PHYSIOLOGICAL GROWTH PARAMETERS OF CORN (*SC704*) IN AHVAZ WEATHER CONDITIONS

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ABSTRACT: In order to study the effect of different levels of triple super phosphate chemical fertilizer and biological phosphate fertilizer (fertile 2) on the yield components of corn (*SC704*), this research was carried out in Shahid Salemi field located in Ahvaz in 2012 as a factorial experiment in randomized complete block design with 4 replications. The experiment included two factors: first, biological phosphate fertilizer (fertile 2) at three levels of 0, 100, 200 g/ha; second, triple super phosphate chemical fertilizer at three levels of 0, 60, 90 kg/ha of pure phosphorus (P_2O_5).The results showed that phosphate fertilizer (fertile 2), significantly increased growth indices such as total dry weight (TDW), leaf area index (LAI), crop growth rate (CGR), and net assimilation rate (NAR) in corn and generally improved corn production. In general, it could be said that the increase of yield is related to the increase of soluble phosphorus in soil so that phosphorus plays an important role in root development and prevention of the accumulation of phosphorus compounds and their negative effects on the absorption of some elements in the soil. With regard to the results obtained it seems like that the decrease of application of triple super phosphate chemical fertilizer to less than a half together with the use of biological phosphate fertilizer (fertile 2) is particularly important to achieve more grain yield in Ahvaz weather conditions.
Key words: Biological phosphate fertilizer (fertile 2), Triple super phosphate, Corn (*SC704*).

INTRODUCTION

Today, producing sufficient food is one of the most important priorities for human beings. Due to limited arable lands, increasing the yield per area unit is one of the most important solutions to meet the need for food which requires the use improved farming and breeding techniques in order to take advantage of maximum potential per area unit. Corn is one of the most important and suitable cereal crops for human nutrition, but it is mainly used for feeding the livestock as fresh and silage forage [22]. Phosphorus is one of the main elements required by plants which has a basic role in the formation of seeds and is found in large quantities in fruits and seeds. However, unusual and inappropriate use of phosphorous fertilizers has unfortunately imposed deleterious effects on agricultural community [17]. Nutrients imbalance in plants and the decrease of crop yield are among these effects [26]. Even though the application of such fertilizers is necessary to provide nutrients, biological fertilizers could be used as supplement to reduce chemical fertilizer consumption [13]. Biological fertilizers are made up of useful bacteria and fungi each of which is produced for a particular purpose. Such bacteria are usually settled around the roots and help absorb a certain element and cause the absorption of other elements and plant further growth [36]. One of these fertilizers is phosphate bio-fertilizer (fertile 2). Its high capability as a solvent for phosphate, climatic adaptability, stability during the storage, easy consumption, cheap transport, and compatibility with other fertilizers and pesticides are mentioned as the features of this kind of fertilizer [11]. Jat and Shaktawat showed that phosphate bio-fertilizer in comparison to triple super phosphate fertilizers considerably increased the yield [16]. Phosphate solubilizing bacteria secrete phosphatase and organic acids and thus make phosphate solution and increase the phosphate uptake by plants [34],[25]. Toro *et al.* [33] showed that the use of phosphate solubilizing bacteria increased the concentration of nitrogen and phosphorus in vegetative organs in comparison to the control treatment without using them. In an experiment, Peix *et al.* [23] reported that the use of phosphate solubilizing bacteria caused the increase solubility of insoluble phosphorus, increase of phosphorus uptake, and significant increase of yield in barley and peas.

Sylvia *et al.,* [32] concluded that in treatments which used phosphate biological fertilizer, the concentration of phosphorus and copper increased in corn's shoots and seeds. Goenadi *et al.* [9] reported that the use of bio-fertilizers and 50-75% chemical fertilizer led to a yield similar to the yield of the consumption of 100% chemical fertilizer. Using growth parameters particularly leaf area index is an appropriate tool for crop production and its capability of using light and it is defined as the ratio of leaf area to the ground area which is shaded by it. This index indicates the leaf area within the ground area unit [38]. The changes trend of leaf area index is such that it reaches its maximum a bit before corn earring and then it decreases since the lower leaves wither [37] .Growth rate as an important index of growth analysis of plant communities indicates the amount of dry matter accumulation in area unit of land in a certain unit of time [5], [18]. Crop growth rate is low in early stages because of insufficient vegetation and low percentage of light absorption, but it increases rapidly in proportion to plant development and the maximum growth rate is observed at flowering stage of crop [12].This research was carried out based on achieving the goals of sustainable agriculture and decreasing the use of chemical fertilizers and also examining the effects of phosphate bio-fertilizer (fertile 2),as an economically and environmentally efficient and a healthy fertilizer source, on the Changes in physiological indices of corn.

MATERIAL AND METHODS

This research was carried out in Shahid Salemi field 36 km away from northeast of Ahvaz at latitude 31° 36´ and longitude 48° 53´ and 51 m above the sea level. The kind of soil used in the experiment was clay loam with pH=7.8 and EC=6.7. It was a factorial experiment as randomized complete block design with 4 replications and two factors. The first factor included biological phosphate fertilizer (fertile 2) at three levels of 0, 100, 200 g/h and the second factor included triple super phosphate chemical fertilizer at three levels of 0, 60, 90 kg/ha of pure phosphorus (P_2O_5). The needed corn seeds were moistened by a little water before planting and were mixed by the contents of a 100-g package of phosphate biological fertilizer (fertile 2) as the desired factors in the experiment and then after complete drying of the seeds in the shade, they were planted manually by considering the density of 75000 plants per hectare in a space of 18 cm from each other on one side of the stack. The seeds were planted in early August. Each plot contained 6 planting lines as long as 5 m and as distant as 75 cm from each other. Nitrogen was used from urea source as much as 180 kg in two stages, so that 90 kg was used during the planting and the rest was added then as the head. Triple super phosphate fertilizer was used to provide the needed phosphorus according to each treatment need. In order to determine leaf area index (LAI) in this research, Equation (1) was used:

(1) $$LA = L \times W \times 0.75$$

$$LAI = \frac{\text{Occupied Leaves Area}}{\text{Ground Area}}$$

In which L is the leaf length, W is the leaf width, and 0.75 is the leaf area coefficient for corn [30]. In all samples, dry weight of shoots was measured. By measuring leaf area, dry weight of leaf and total shoots, the values of growth physiological indices including crop growth rate (CGR), net assimilation rate (NAR), and total dry weight (TDW) were calculated through the Equations (2) and (3) [30].

(2) $$CGR = W_2\text{-}W_1/GA\ (t_2\text{-}t_1)$$

(3) $$NAR = (W_2 - W_1 / t_2 - t_1) \times (\ln LA_2\text{-}\ln LA_1/LA_2\text{-}LA_1)$$

In these equations, LA_1 and LA_2 are the primary and secondary leaf areas respectively , GA is the ground area occupied by the crop (m^2), W_1 and W_2 are primary and secondary dry weight (g/m^2), t_1 and t_2 are primary and secondary sampling time (day). All growth indices are expressed according to post-planting date.

Data Analysis

The experiment data were analyzed by means of SAS software and in order to draw the diagrams Excel software was used and Duncan's multi range test was used to compare the means.

RESULTS AND DISCUSSION

Total Dry Weight (TDW)

Changes trend of dry weight in response to biological and chemical phosphorus fertilizers during the growth season followed relatively similar pattern in all treatments (Figures 1 and 2).

The highest dry weight of crop 102 days after planting by belonged to treatments with phosphate bio-fertilizer (fertile 2) (100 g/ha) and triple super phosphate fertilizer (60 kg/ha) by the average of 276.66 g/m^2 and 275.99 g/m^2 respectively. It seems that the reason is the increase of leaf area, photosynthesis improvement and the higher rate of photosynthesis in crop. On the other hand, the increase of crops biomass in proper nutrition conditions and the access of crop to enough water and food supply, particularly nitrogen and phosphorus have affected the increase of plant height through influencing cells division and growth. On the other hand, the solubility of insoluble phosphates by phosphorus solubilizing microorganisms and the secretion of growth enhancers such as auxin, gibberellins and cytokinin by such organisms increased the root growth and consequently the crop growth [27].

In different studies it has been observed that compound treatments increased the vegetative growth of plants and as a result the yield of grains and legumes in farming conditions increased, too [14]. Moreover, phosphorus increases nitrogen uptake and enhances plants resistance against diseases and controls the negative effect of additional nitrogen; it also improves photosynthesis and assimilates production due to the increase of leaf area, the increase of chlorophyll in leaf and macro and microelements by the root of plants. Most importantly, further development and more durability of leaf area led to generation of sufficient and strong physiological sources for absorbing more light and producing dry matter. Irani Poor et al. [15] showed that phosphate solubilizing bacteria increased total weight of dry matter in corn. Nazeri et al. [21] stated that dry matter accumulation was affected by phosphorus chemical fertilizers and phosphate bio-fertilizer and the highest total dry weight was observed in those treatments. These findings are consistent with the results obtained by Cavaglieri et al. [4].

In many scientific sources [10] ,[8] ,[2] the increase of crops yield has been mentioned as one of the most important effects of biological fertilizers, particularly in soils with low fertility. The increase of yield might be due to the increase of absorptive surface of roots through the access of crop to larger volume of soil.

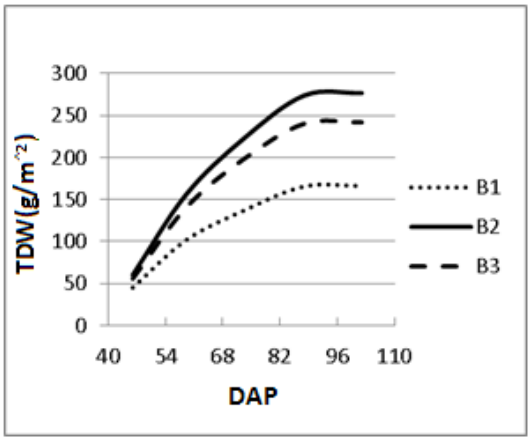

Figure (1) The effect of phosphate biofertilizer (Fertile 2) on total dry weight

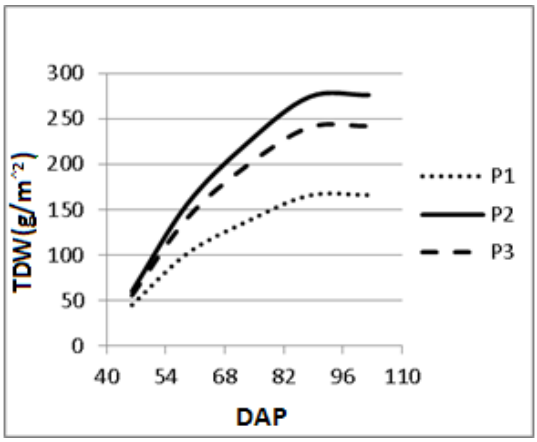

Figure (2): The effect of triple super phosphate on total dry weight

Leaf Area Index (LAI)

Investigating changes trend of leaf area index during the growth season in all studied treatments (Figures 3, 4) showed that at first the increasing trend of LAI at early growth stages was slow and then it got faster. The main reason of leaf area index reduction, was the increase of departure of nutrients from the leaf and their mobilization to grains which led to crop aging and its maturity [24], so that at the beginning of growth season LAI rate increased with a very low slope and then near physiological maturity stage it increased with high slope until at most 73 days after planting and then at the end of growth season it had a declining trend as the leaves got yellow and fell down. The highest leaf area 73 after planting date belonged to the treatment with 100 g/ha phosphate bio-fertilizer (fertile 2) by the average of 4.45 and treatment with 60 kg/ha triple super phosphate by the average of 4.4 Since the maximum leaf area index is seen at flowering stage [3], [19] , the more the leaf area at this time the more the crop is able to absorb the sunlight and to produce more assimilates [28] which finally affects the grains in pods and the grain yield [29]. It seems that the reasons are the increase of leaf area, photosynthesis improvement and the increase of photosynthesis capacity in plant.

Studies conducted by Subramanian et al. [31] showed that the use of chemical fertilizer and bio-fertilizer at the same time impressed crops physiology by increasing the rate of assimilates, changing the trend of assimilates in stems and roots and also the absorption of mineral elements in soil. Moreover, more development and better continuity of leaf area created a sufficient strong physiological source to use more and more light.

Ebrahim Poor et al. [7] showed that the maximum leaf area index 71 days after sowing date of corn belonged to the treatment with 50% chemical and bio-fertilizer. Allah Dadi et al. [1] showed that the highest leaf area index was obtained in tassling stage within the treatment with phosphate solubilizing bacteria and micorrhiza. The results of experiments by Nazeri et al. [21] indicated that treatments with 75% and 50% levels of phosphorus chemical fertilizer and phosphate microbial biofertilizer had the highest leaf area index.

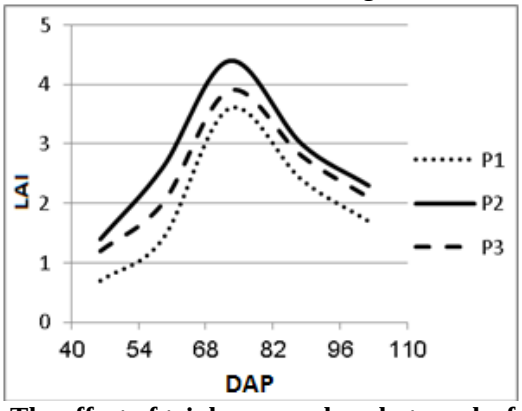

Figure (4): The effect of triple super phosphate on leaf area index

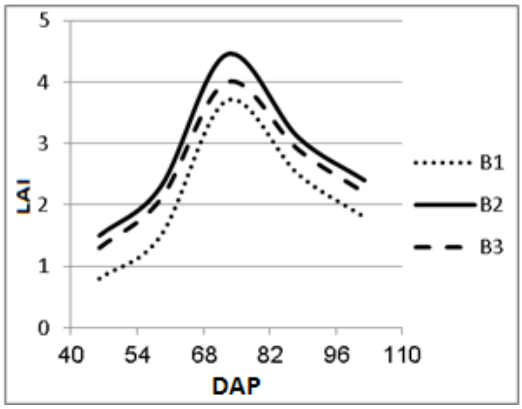

Figure (3) The effect of phosphate biofertilizer (fertile 2) on leaf area index

Crop Growth Rate (CGR)

Crop growth rate increased through the passage of time and after reaching its maximum level, it had a descending trend and at the end of growth season it decreased as the leaves got yellow and fell down. Crop growth rate was low in early stages and then gradually it increased it reached its maximum during the flowering stage when the foliage cover was complete. The decrease of CGR is due to the decrease of leaf area and the increasing shadow of upper leaves over lower ones and consequently the decrease and seize of assimilates production in lower leaves due to lack of light. As it is observed in Figures 5 and 6 the highest crop growth rates 73 days after sowing date belonged to the treatments with 100 g/ha phosphate biofertilizer (fertile 2) by the average of 40 g/m^2 per day and to the treatment with 60 kg/ha triple super phosphate by the average of 39 g/m^2 per day. Ebrahim poor et al [7] showed that phosphorus biological and chemical fertilizer increase crop growth rate 71 days after planting. Nanda et al [20] stated that corn seeds inoculation with biological fertilizers increased the corn yield significantly.

Wu et al. [35] reported that corn seeds inoculation with biological fertilizer increased CGR. They believed that the reason of this matter was the increasing access of crop to nutrients and better absorption of nutrients by the crop.Clarke and Simpson [6] stated that maximum CGR coincident with corn development stages (71days after sowing) was due to new photosynthetic organs and the presence of biological fertilizers had an important role in increasing durability of photosynthetic organs. Irani Poor et al. [15] showed that organic matter and phosphate solubilizing bacteria had increased corn growth rate. On the other hand, Nazeri et al. [21] reported that the crop growth rate was affected by phosphorus chemical fertilizer and phosphate microbial biofertilizer, so that the treatments with 75% and 50% phosphorus chemical fertilizer and phosphate microbial biofertilizer had the optimal state.

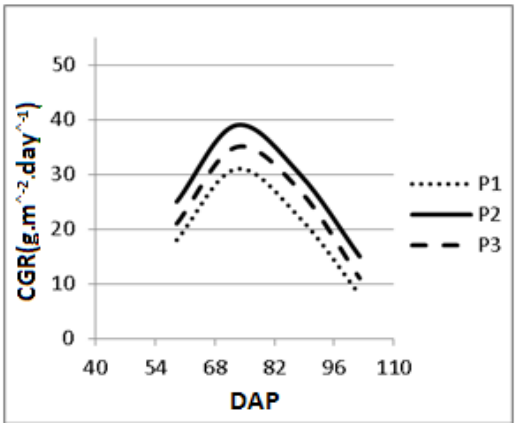

Figure (6**) The effect of triple super phosphate on crop growth rate**

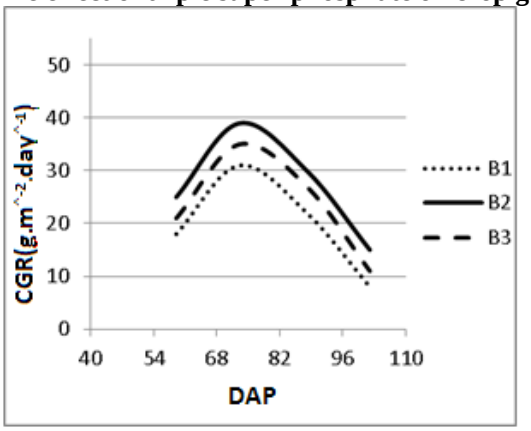

Figure (5**): The effect of phosphate biofertilizer (fertile** 2**) on crop growth rate**

Net Assimilation Rate (NAR)

NAR changes in all treatments had relatively similar descending trend, so that net assimilation rate at the beginning of growth season was high and then it had a descending trend until the end of growth season due to approaching physiological maturity stage and also leaves aging and their getting yellow (Figures 7 and 8). The reason could be the increase of leaves respiration in comparison to photosynthesis due to the increase of LAI and reciprocal shadowing of leaves and consequently the decrease of NAR. In other words, as the crop is growing and the LAI is increasing, further leaves are in the shadow and also the number of old withered leaves increases; therefore, the leaves photosynthetic ability decreases and consequently NAR reduces during a growing season.

At the end of growth season, due to the decrease of leaf area and mobilization of assimilates from leaves towards grains, net assimilation rate is minimized. Allen et al. [2] reported that biological fertilizers would increase the rate of cytokinin and chlorophyll in crops and ultimately would increase the crop growth rate. Nazeri et al. [21] stated that net assimilation rate of crops was affected by phosphorus chemical fertilizer and phosphate microbial biofertilizer. Ebrahim Poor et al. [7] showed that nitrogen biological fertilizer and phosphorus chemical fertilizer increased net assimilation rate.

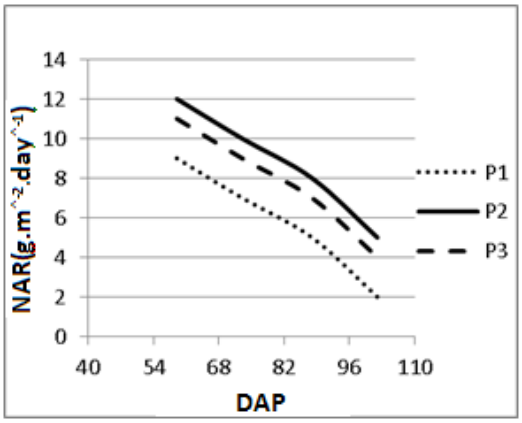

Figure (8**): The effect of triple super phosphate fertilizer on NAR**

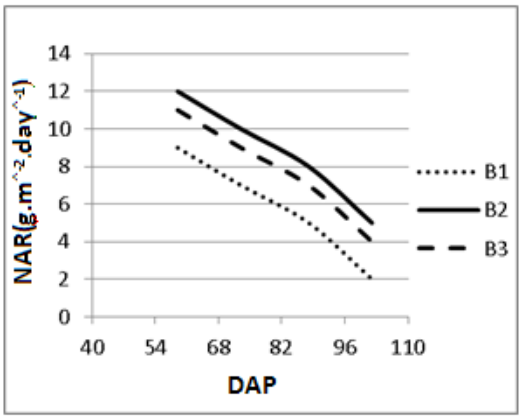

Figure (7): The effect of phosphate biofertilizer (fertile 2) on NAR

CONCLUSIONS

The obtained results indicate the significant role of phosphorus on growth indices, increase of yield, and improvement of corn production, in general.On the whole, it could be said that the increase of yield was related to the increase of consumed phosphorus by plant and also to the important role of this element in developing the root and preventing the accumulation of phosphorus combinations and their negative effects on the absorption of some elements in soil. Nutrients availability to plants largely depends on soil biological and chemical conditions. Phosphorus chemical fertilizers fixation under the soil existing conditions and changing them to forms which are not accessible for plants is the main problem. Therefore, fertile 2 phosphate bio-fertilizer in combination with appropriate amount of triple super phosphate chemical fertilizer reduces the need to phosphorus chemical fertilizers and increases their efficiency by releasing phosphorus gradually and changing it to absorbable form by plant.in fact, by settling in rhizosphere area, microorganisms use the roots exudates and provide the conditions for transforming insoluble phosphorus to usable form by for plants by changing pH or secreting enzymes. Moreover, such microorganisms have an important role in increasing correlation between the absorption of some elements like phosphorus, potassium, calcium, and nitrogen. Phosphate solubilizing bacteria in fertile 2 phosphate bio-fertilizer, by releasing organic acids and phosphatase acid, will cause enzymatic analysis of organic compounds and nutrients solution in soil and increase nutrients absorption in soil. Therefore, the importance of such microorganisms is not only due to their contribution to the absorption of certain elements but also other elements uptake and improvement of soil structure are the positive consequences of fertile 2 phosphate bio-fertilizer and thus the increase of phosphorus which is available for plants. In addition, this research showed that application of biological fertilizers could increase different growth indices; therefore, the decrease of application of chemical phosphorus fertilizer to 50%, without any significant decrease of crop yield, will be remarkably important both economically and environmentally.

ACKNOWLEDGMENT

Hereby, the Islamic Azad University of Ahvaz is highly appreciated for providing necessary facilities to conduct this research.

REFERENCES

[1] Allah Dadi, A., Zarabi, M., Akbari, Gh. , Iran Nejad, H. 2010. The effect of the combination of phosphorus fertilizer and biofertilizer on some physiological growth indices of grain corn in drought stress conditions. 1st national conference on sustainable agriculture and healthy product.

[2] Allen, M. F., Smith, W. K., Moore Jr, T. S. and Christensen, M. 1981. Comparative water relations and photosynthesis of mycorrhizal bouteloua gracilish. H.B.K lag ex steud new phytologist 88: 683-693.

[3] Bovetchko, S. M. and Tewaris, J. P. 1990. Root colonization of different hosts by the vesicular arbuscular mycorrhizal fungus Glomus dimorphicum, Plant and Soil, 129: 131-136.

[4] Cavaglieri, L. R., A. Passone, and M. G. Etcheverry. 2004. Correlation between screening procedures to select root endophytes for biological control of Fusarium verticillioides in Zea mays.Biological Control. 31: 259-62.

[5] Cousin, T.H., Burghoffer, A., Marget, P., Vinger, A., and Eteve, G. 1993. Morphological, physiological and genetic bases of resistance in pea to cold and drought. In K.B Singh and M.C.Saxena (Eds.), Breeding for stress tolerance in cool food legumes. P.311-320. John Willey and Sons, Chichester, UK.

[6] Clarcke, J.M., and Simpson, G.M.1978. Growth and analysis of Brassica napus cv. Tower. Canadian Journal of Plant Science 58: 587-595.
[7] Ebrahim Poor, F., Edie Zade, Kh., Ebrahimi, M.A.2011. the effect of application of biological fertilizers and chemical fertilizers on growth indices of corn in Shooshtar. 1st national conference on strategies to achieve sustainable agriculture,
[8] Gholami, A. 2000. The effect of micorrhiza fungi on growth indices and yield of maize in Shahroud. Doctorate thesis, Tarbiat Modares University, Tehran. P.85-170.
[9] Goenadi, D. H. 1998. Fertilization efficiency of oil palm through biofertilizer application. Pp. 370-376. In: Proceedings of International Oil Palm Conference, Nusa Dua, Bali.
[10] Hamidi, A., Ghalavan, A., Dehghan Shoar, M., Malakuti, M.J., Azghar Zade, A. , Chokan, R. 2006. The effect of application of plant growth promoting bacteria (PGPR) on the yield of forage maize. Journal of Research and Development. No. 70.
[11] Hashemi, A. 2008. Irrigated and rain-fed wheat farming using fertile 2 phosphate bio-fertilizer, summer.
[12] Hawkins, R.C., and Cooper, P.J. 1981. Growth, development and grain yield of maize.
Experimental Agriculture, 17:203-207.
[13] Heidary, kh.; Ghaderi, j. 2010 . the results of biologic fertilizer consumption in Kermanshah in recent years. 1st Congress on Fertilizer Challenges In Iran.
[14] Hoflich,G., Wiehe, W. and Kuhn, G. 1994. Plant growth stimulation with symbiotic and associative rhizosphere microorganisms. Experientia 50: 897-905.
[15] Irani Poor, R., Malakuti, M.J.2007 . the effect of organic matter and phosphate solubilizing bacteria on phosphorus absorption capacity from the source of phosphate soil using isotope dilution technique. 10th congress on soil science, Iran.
[16] Jat, B. L., and Shaktawat, M. S. 2003. Effect of residual phosphorus, sulphur and biofertilizers on productivity, economics and nutrient content of pearl millet (Pennisetum glaucum L.) in fenugreek (Trigonella foenum-graecum L.)-pearl millet cropping sequence. Indian Journal of Agricultural Sciences 73 (3): 134-137.
[17] Karimian, N. 2000. Consequences of excessive consumption of phosphat chemical fertilizers. Soil and Water Research Institute of Iran Publication No. 12. (In Persian).
[18] Keatinge, J.D.H., and Cooper, P.J.M. 1983. Kabuli chickpea as a winter-sown crop in Northen Syria: Moisture relations and crop productivity. Journal of Agricultural Science.,Cambridge, 100: 667-680.
[19] Manaffee, W. F. and J. W. Kloepper. 1994. Applications of plant growth promoting rhizobacteria in sustainable agriculture.In: Soil biota management in sustainable farming syshoots, Pankburst, C. E. , Doube, B. M., Gupta, V. V. S. R., and Grace, P. R., eds pp:23-31. CSLRO, pub. East Melbourne: Australia.
[20] Nanda, S.S., K.C. Swain, S.C. Panda, A.K. Mohanty, and M.A. Alim. 1995. Effect of nitrogen and biofertilizers in fodder rainfed upland conditions of Orisa. Current Agricultural Research, 8:45-47.
[21] Nazeri, P., Kashani, A., Mir Akhori, M., Mirshekari, F.2009. the effect of phosphate microbial biofertilizer containing zinc and phosphorus chemical fertilizer on crop growth rate and net assimilation rate in white bean. National conference on water, soil, plant, and agricultural mechanization.
[22] Noormohammadi, Gh.; Siadat, S.A. ; Kashani, A. 1997 . Cereal crops agriculture, 1st volume, Shahid Chamran University Publications, Ahwaz, pp.308-325.
[23] Peix, A., A. A, Rivas-Boyere and P. F., Mateos. 2001. Growth promotion of chickpea and barley by a phosphate solubilizing strain of mesorhizobium mediterraneum under growth chamber conditions. Soil biology and biochemistry. 33(1).110-103.
[24] Rakir, R. 2004. Effect of water stress at different development stages on vegetative
and reproductive growth of corn. Field Crops Research, 89 (1): 1-16.
[25] Rodr guez, h., and R. Fraga. 1999. Phosphate solubilizing bacteria and their role in plant growth promotion. Biotecnology Advances. 17: 319-339.
[26] Safari, H.; Malek Zadeh, A.2005. The effect of chemical and microbial phosphorus fertilizers on the yield and yield components of corn, 9th conference on Iranian soil science.
[27] Sattar, M. A., and Gaur, A. C. 1987. Production of auxins and gibberellins by phosphate dissolving microorganisms. Zentrabl Mikrologie 142: 393-395.
[28] Sharma, A. K. 2002a. Biofertilizers for Sustainable Agriculture. Agrobios, India. 407 pp.
[29] Sharma, A. K. 2002b. A handbook of organic farming. Agrobios, India. 627 pp.
[30] Shi, S.F., Goscho, G.J., and Rahil, G.S. 1981. Biomass production o sweet sorghum. Agronomy Journal 173:1027-1031.
[31] Subramanian, K. S., Charest, C., Dwyer, L. M., and Hamilton, R. I. 1997. Effects of arbuscular mychoriza on leaf water potential, sugar content and content during drought and recovery of maize. Canadian Journal of Botany 75: 1582-1591.

[32] Sylvia, D. M., Hammond, L. C., Bennett, J. M., Haas, J. H., and Linda, S. B. 1993. Field response of maize to a VAM fungus and water management.Agronomy Journal 85: 193-198.
[33] Toro, M., Azcon, R. and Barea, J.M., 1997. Improvement of arbuscular mycorrhiza development by inoculation of soil with phosphate- solubilizing rhizobacteria to improve rock phosphate bioavailability (32p) and nutrient cycling. Applied and Environmental Microbiology, 63(11): 4408- 4412.
[34] Turan, M., N. Ataoglu, and F. Sahin. 2006. Evaluation of the capacity of phosphate solubilizing bacteria and fungi on different forms of phosphorus in liquid culture. Sustainable Agricultural. 28 : 99–108.
[35] Wu, S.C., Cao, Z.H. Li, Z.G., Cheung, K.C., and. Wong, M.H. 2005. Effect of biofertilizer containing N-fixer, P and K solubilizers and AM fungi on maize growth: a greenhouse trial. Geoderma 125: 155-166.
[36] Yong, K., B. Bae, and Y. Choung. 2005. Optimization of biological phosphorus removal from contaminated sediments with phosphate- solubilizing microorganisms. Journal of Bioscience and Bioengineering. 99: 23-29.
[37] Yushida, S.1972. Physiological aspect of grain yield. Annual Reviews of Plant Physiology, 23:437-464.
[38] Yusuf, R.I., Siemens, J.C., and Bullock, D.G. 1999. Growth analysis of soybean under no-tillage and conventional tillage systems. Agronomy Journal, 91: 928-933.