EFFECT OF BALANCED MANURING BY MINERAL NPK AND BIO-FERTILIZER ON PEAS PRODUCTIVITY AND PROTEIN CONTENT

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ABSTRACT

Two field experiments were carried out during the winter seasons of 2008/09 and 2009/10 at a private farm in Disug district, Kafr El-Sheikh Governorate to investigate the response of pea plants, cv. Master B, to inoculation with the Rhizobium bacteria, foliar nutrition with free living bacteria (microbin) and rhizobium + N₂-fixer free living bacteria compared to uninoculated with balanced monuring by NPK rates. Four levels of inorganic NPK (1-without NPK, 2- 15 kg N + 25 kg P2O5 + native-K, 3- 40 kg N + 30 kg P₂O₅ + native-K and 4-60kg N + 30 kg P₂O₅ + native-K fed⁻¹) were application. Soil analysis shower high content of potassium (432 and 419 ppm available K). The results indicated that inoculation of pea seeds with biofertilizer (Rhizobia + free living bacteria), improved most vegetative characters, as well as green pods yield and its components, shelling ratio, seed yield and its components, seed germination percentage, leaf contents of chlorophyll and seed content of protein. Increasing NPK rate up to 40 kg N + 30 kg P₂O₅ + native-K was accompanied with significant increases in vegetative growth characters, as well as green pods yield and its components, shelling ratio, seed yield and its components, seed germination percentage, leaf contents of chlorophyll and seed content of protein. Rhizobia + free living bacteria biofertilizer combined with NPK rate at 40 kg N + 30 kg P_2O_5 + native-K appeared to be the most efficient treatment for more vigorous growth, green pods yield and its components, shelling ratio, seed yield and its components and seed germination percentage, as well as chlorophyll content in leaves and protein content in seeds.

INTRODUCTION

Peas (*Pisum sativum* L.), a cool weather crop, is one of the most popular crops grown in Egypt due to its high contents of protein, carbohydrates, vitamins and minerals. It can grow throughout different types of soils ranging from the light sandy looam to the heavy clay in texture. Most pea cultivars are grown for fresh and/or dry seeds yield. The pea cultivar used (Master B) is a short growing period, determinate growth habit and low fertilizer requirements (Fayad, 2004).

Selection of the grown cultivar and applying adequate supplementations of plant nutrients, organic or inorganic sources, are among the important factors that greatly affect variant phases of growth and development. Fertilization with suitable levels of inorganic N fertilizer was always thought to have an important role in enhancing growth and development of many different vegetable crops, grown in arid and semi-arid regions. However, the excessive use of inorganic N fertilizers represents the major factor of crop

production cost and creates some pollution of agro-ecosystem (Fisher and Richter, 1984. In addition, the continuous application of inorganic N fertilizers could affect appreciable deterioration of soil fertility. Under these circumstances, supplementing or substitutions on inorganic N with organic sources particularly those of microbial origin "biofertilizers" are really needed. Significant effects of untraditional fertilizers, particularly the biofertilizers, on growth and yield of legumes have been reported by several investigators (Hassouna and Aboul-Nasr, 1992 on soybean; El-Oksh et al., 1991; Shiboob, 2000 on bean; Choudhary et al., 1984; Elneklawy et al., 1985; Chandra et al., 1987; Feng et al., 1997; Merghany, 1999 and Bin Ishaq, 2002, on pea and El-Waraky and Kasem, 2007, on cowpea). They indicated that application of biofertilizer Rhizobia at 10 g.kg⁻¹ (containing a N2- fixing bacteria of the genera) significantly resulted in taller plants with more N concentrations in leaves, higher protein contents in seeds, and greater total yields than in the case of untreated control. Likewise, Mahmoud et al. (1994) found that inoculation of soybean seeds with appropriate bacterial strains (containing a N-fixing bacteria) before planting, in addition to 20 or 40 kg N fed.⁻¹ gave the highest mean value of total pod yield. Phosphorus one of the major essential elements of the many essential functions that phosphorus has in plant life, its role in energy storage and transfer is singly the most important. Phosphate compounds act as energy currency within plants. Energy obtained from photosynthesis and metabolism of carbohydrates is stored in phosphate compounds for subsequent use in growth and productive processes (Tisdal et al., 1985). Phosphorus is particularly important for leguminous plants possible by its influence on the activity of the Rhizobium bacteria (Mengle and Kirkby 1987). Also the reported that the amount of N₂ fixed may differ considerably from one site to another. This very much depends on soil factors such as soil pH, available P and K, the presence of heavy metals and the soil moisture regime. It is generally known that N₂ fiaxation by Rhizobium is enhanced in host plants well supplied with phosphate and K (Mengel et al., 1974). Inoculation of crops with Microbin (N₂ fixer free living bacteria) is mostly performed either through soil or foliar application. Microbin is one of the free living bacteria that have important roles in the physiological and metabolic processes of plants. Accordingly, Microbin is of a great necessity for adequate plant growth and productivity.

Thus, the main objective of this study is to investigate the influences of seed inoculation with the Rhizobium or Rhizobiat free living bacteria (Non symbiotic fixing bacteria) and balanced manuring by NPK, on growth, green pods and dry seed yield and seed quality of the pea plants.

MATERIALS AND METHODS

This work was carried out at Disuq district, Kafr El-Sheikh Governorate, during the winter seasons of 2008/09 and 2009/10. The main goals of these experiments were to investigate the influences of seed inoculation with the Rhizobium bacteria, Rhizobium + N_2 - fixer free living bacteria (Non symbiotic fixing bacteria) in addition to non inoculation under balanced manuring by

NPK and their interactions on vegetative growth characters, green pods and dry seed yield and their components of pea (*Pisum sativum* L.) Master B cultivar.

The soil of the experimental site was loamy clay in texture. Some properties of the experimental soil are presented in Table (1).

Season	Mecha	inical a	analysis	Toxturo	- nU*	EC**	ОМ	Available elements (ppm)			
	Sand (%)	Silt (%)	Clay (%)	Texture	рп	dSm ⁻¹	(%)	N	Р	к	
1 st 2 nd	10.0 9.5	50 51	40.0 39.5	Loamy Clay Loamy Clay	7.18 7.9	0.555 0.7	1.70 1.68	25 23	5.0 5.5	432 419	

Table (1): Some characteristics of the experimental soils.

* 1: 2.5 soil: water suspension.

** Soil past extract

Effective selected strain of pea rhizobial(Rhizobium leguinosarum biovar viceae) and microbin (N₂ fixer free living bacteria - Non symbiotic fixing bacteria) were kindly obtained from Biological Nitrogen Fixation Unit., Dept. of Soil Microbiology at Sakha Agric. Res. Station, ARC. The biofertilizer rhizobia or microbin were used at the rate of 10g kg-1 seeds. Seed inoculation was performed by adding an adequate amount of distilled water and Arabic jume and mixed thoroughly with the seeds and inoculate just before sowing. Uninoculated seeds (of the control treatment) were mixed with distilled water and Arabic gum. From the experimental soil analysis clear that it could be characetrised as low available-N, low available P and high available K. The sowing dates were 5 and 11 of November in the first and second season, respectively. Four levels of inorganic NPK (1-without NPK, 2- 15 kg N + 25 kg P_2O_5 + the native-K, 3- 40 kg N + 30 kg P_2O_5 + the native-K, 4-60kg N + 30 kg P_2O_5 + the native-K fed 1). Ammonium sulphate (20.5 % N) was the respective N source and the required amounts of the fertilizer were side banded at two equal portions at 30 and 45 days from seed sowing. Phosphorus fertilizer, in the form of single super phosphate (15.5% P₂O₅₎, was applied to the soil as one dose before the sowing. According to soil analysis the experimental soil had enough values of potassium (432 and 419 mg kg⁻¹ in two seasons, respectively) thus no potassium fertilizer was added.

The experiments were conducted using split-plot system in a randomized complete blocks design, with four replications. The main plots were devoted for three inoculation treatments (1- non inoculation, 2- inoculation with rhizobia, and 3- inoculation with rhizobia and microbin) whereas, the sub-plot were allocated for NPK fertilizer levels. Each sub-plot contained 5 rows, 5m in length and 0.6 m in width, comprising an area of 15 m². Spacing between plants within rows was 15 cm, and sowing was done on one side of row. Plants were thinned to two plants per hill after three weeks from sowing. The other recommended agricultural practices were done.

After 60 days from sowing, the following data were recorded:

1. Total chlorophyll content of leaves measured by the SPAD-501, a portable leaf chlorophyll meter (Minolta crop) was used for greenness

measurements (Marquard and Timpton, 1987) on fully expanded leaves (the fifth from the shoot tip) leaves without destroying them.

- 2. Vegetative traits, i.e., plant height, number of leaves plant⁻¹, number of branches plant⁻¹, leaf area plant⁻¹ and plant fresh weight.
- 3. Green pods yield and its components, the plants of the second and third rows were allocated to measure the following data, i.e., total green pods yield plant⁻¹ and feddan⁻¹, number of green pods plant⁻¹, weight of green pod, number of seeds pod⁻¹, weight of seeds pod⁻¹. Shelling ratio were measured by dividing the fresh weight of the green seeds extracted from 30 pods on the total weight of these pods.
- 4. After harvesting, dry seed yield and its components, and germination percentage were determined, the plants of the fourth and fifth rows allocated to measure the following data, i.e., dry seed yield plant⁻¹ and feddan⁻¹, weight of seeds pod⁻¹, seed index (weight of 100 seeds), dry seeds protein and seed germinability which measured by a random sample of 100 seeds from each treatment that was germinated on a filter paper in a sterilized Petri dish, using an incubator at a temperature of 24°C. Germinated seeds were daily counted starting 5 days after initiating the experiment and continued for 2 weeks. Germination percentage, thereafter, was calculated.

Data of the studied characters were statistically analyzed, using the standard methods of the randomized complete block design, using M-stat-C software (1996). The treatment means were compared according to Duncan's multiple range test (Duncan, 1955). Seed samples were oven dried, crashed and digested using sulphoric and perchloric acids methods according to Cottenie *et al.* (1982). Nitrogen in the digested seeds was determined by micro-kjeldahl method according to Jackson (1958), nitrogen content of pea seeds was multiplied by a factor of 6.25 to calculate the crude protein content. Soil samples were collected before sowing, air dried and finely ground for chemical and mechanical analysis according to Jackson (1958).

RESULTS AND DISCUSSION

I. Vegetative characters:

a. Effect of biofertilizer

The results in Table (2) clearly indicated that, in both seasons, the inoculation of pea seeds with the biofertilizer (Rhizobia + N_2 fixer free living bacteria) was responsible for significant increments in plant height, number of leaves, number of branches, leaf area, chlorophyll content and plant fresh weight, compared with the uninoculated treatment (control plants) or inoculation by rhizobia only. The beneficial effects of the biofertilizer on the above- mentioned growth traits may be related to the enhancing effects of non-symbiotic N₂-fixing bacteria on the morphology and/or physiology of the root system which promoted the vegetative growth to go forward. Moreover, Jagnow *et al.* (1991) and Noel *et al.*(1996) indicated that the non-symbiotic N₂-fixing bacteria, *Azotobacter* and *Azospirillum* strains, produced adequate amounts of IAA and cytokinins which increased the surface area per unit root

length and enhanced root hair branching with an eventual increase in the uptake of nutrients from the soil. Carletti *et al.* (1996) demonstrated that plants inoculated with *Azospirillum* displayed an increase in total root length by 150%, compared with the uninoculated control. The results reported by Shiboob (2000), on bean; Micanovic *et al.* (1997); Bin Ishaq (2002) and El-Waraky *et al.* (2013) on pea and El-Waraky and Kasem (2007) and Masoud and Mehesen (2013) on cowpea confirmed our findings concerning the stimulating effects of biofertilizer on vegetative growth characters.

b. Effect of NPK levels

Data presented in Table (2) showed that all growth parameters were significantly affected by increasing rate of NPK fertilization in both growing seasons, the highest NPK fertilization rate gave the tallest plants as well as the higher chlorophyll content. While, the highest mean values of number of leaves, number of branches, leaf area and plant fresh weight were obtained from application of 40 kg N + 30 kg P₂O₅ + native-K fed⁻¹, whereas without NPK or/and 15 kg N + 25 kg P₂O₅ + native-K fed⁻¹ rate produce the lowest value of each character, respectively. The positive results of the added N effects could be related to the important role of nitrogen and its vital contribution to several biochemical processes in the plant, related to growth (Marscher, 1986) and to its role in assimilating the photosynthetic reaction. Furthermore, plants with high nitrogen contents had higher levels of indigenous auxin and high gibberellin activity (Rajagopal and Rao, 1974). The present results matched well with those obtained by Knany et al. (2002), El-Bably and El-Waraky (2007), El-Waraky (2007), El-Waraky and Kasem (2007) and Masoud and El-Waraky (2012) on cowpea; Shiboob (2000) on bean and Bin Ishaq (2002) on pea. This means that 30 kg P₂O₅ fed ⁻¹ was the best phosphorus rate to the studied pea. Similar results were reported by Knany et al (2002) on cowpea.

c. Effect of biofertilizer inoculation and NPK levels interaction

The effects of interaction between biofertilizer (inoculation) and NPK fertilization rates on vegetative growth characters appeared significant in both seasons (Table3). At 40 kg N + 30 kg P₂O₅ + native-K fed⁻¹, inoculation of pea seeds with the biofertilizer (Rhizobia + N₂-fixer free living bacteria) increased plant height, number of leaves plant⁻¹, number of branches plant⁻¹, leaf area plant⁻¹ and plant fresh weight compared with those of the uninoculated and without NPK levels. On the other hand, 60 kg N + 30 kg P₂O₅ + native-K fed⁻¹, inoculation of pea seeds with the biofertilizer (Rhizobia + N₂-fixer free living bacteria) produced the highest values of chlorophyll content. increased The combination of 40 kg N + 30 kg P₂O₅ + native-K fed⁻¹, inoculation of pea seeds with the biofertilizer (Rhizobia + N₂-fixer free living bacteria) was the best treatment for improving most studied vegetative characters. The enhancing effects of the mentioned treatment combinations could be expected, since each of the studied factors reflected promoting effects on the morphology or/ and physiology of root system, which in turn encouraged the vegetative growth to go forward.

2-3

These results are in agreement with those obtained by Knany *et al.* (2002), El-Waraky (2007), El-Waraky and Kasem (2007) and Masoud and El-Waraky (2012) on cowpea; Shiboob (2000) on bean and Bin Ishaq (2002) on pea.

II. Green pods yield and its components

a. Effect of biofertilizer inoculation

Data presented in Table (4) clearly indicated that significant increments in total yield of green pods, number of green pods plant⁻¹, weight of green pod, number of seeds pod⁻¹, weight of seeds pod⁻¹ and shelling percentage, were obtained as a result of seed inoculation with the biofertilizer (Rhizobia + N₂-fixer free living bacteria), in both growing seasons. Increasing growth and total yield after the inoculation of pea seeds with the biofertilizer (Rhizobia + N₂-fixer free living bacteria), which contains genera of non-symbiotic N₂-fixing bacteria, might be due to increasing the biological N₂-fixation, the production of phytohormones or both; as mentioned by Jagnow *et al.*, (1991). The present results agreed to a great extent with those reported by Shiboob (2000); on bean and Bin Ishaq (2002) and EI-Waraky *et al.* (2013) on pea who showed significant positive effects on green pods yield and its components due to the inoculation of seeds with different biofertilizer types.

b. Effect of NPK levels

Regarding the effects of the used NPK fertilizer levels on total yield of green pods and its components, the results in Tables (4) indicated generally that NPK fertilization with 40 kg N + 30 kg P_2O_5 + native-K fed⁻¹, significantly, increased total green pods yield, number of green pods plant^{-1,} weight of green pod, number of seeds pod⁻¹, weight of seeds pod⁻¹ and shelling percentage in both seasons, as compared with the unfertilized control. The highest mean values of all measured characters were recorded for the 40 kg N + 30 kg P_2O_5 + native-K fed⁻¹. The present results are in accordance with those reported by Shiboob (2000), who reported that soil application of nitrogen at the rate of 40 kg N fed⁻¹, significantly, increased number of green pods plant⁻¹ and the yield of green pods was significantly increased with increasing N levels up to 80 kg N fed⁻¹. Similar results on pea were recorded by Bin Ishaq (2002).

c. Effect of biofertilizer inoculation and NPK levels interaction

The interaction effects between the biofertilizer (Rhizobia or/and Rhizobia + free bacteria) and the applied NPK levels on green pods yield and its components are presented in Table (5). The results, generally, showed that seed inoculation with rhizobia or/and seed inoculation with rhizobia and N₂ fixer free living bacteria significantly increased total green pods yield, number of green pods plant⁻¹, weight of green pod, number of seeds pod⁻¹, weight of seeds pod⁻¹ and shelling percentage in both growing seasons, compared with those of uninoculated ones. The treatment combination of the inoculation with biofertilizer (Rhizobia + N₂-fixer free living bacteria) plus 40 kg N + 30 kg P₂O₅ + native-K fed⁻¹ rate gave the highest values for all yield traits, the differences were significant in both seasons.

4-5

The resultant increase on total yield of green pods may be attributed to the increments on the number of pods plant⁻¹, average weight of green pod, and number and weight of seeds pod⁻¹. Apparently, the promoting effects of biofertilizer and NPK application on growth of pea plants were reflected on the increased total yield and its components. These results are in line with those obtained by Shiboob (2000) on common bean, who reported that the application of 20 or 40 kg N fed.⁻¹ combined with the biofertilizer increased number and weight of green pods plant⁻¹ and total green pods yield as well. Similar conclusion was obtained by Bin Ishaq (2002) on pea. On the other hand, phosphorus is highly required element for plants and microorganisms growth and activity. The mineral P in soil solution plays an essential role in P cycle and plants nutrition. These results are agreement with those obtained by Scheffer and Schachtschable, 1992 and Samavat *et al.*, 2012.

III. Dry seed yield and its components

a. Effect of biofertilizer inoculation

Data recorded in Table (6) indicated that inoculation of pea seeds with the biofertilizer (Rhizobia + N₂-fixer free living bacteria) significantly increased average seed yield plant⁻¹, total seed yield fed.⁻¹, weight of seeds pod⁻¹, seed index (weight of 100-seeds), dry seed protein content and seed germination percentage over those of the rhizobia only or/and uninoculated plants (control), in both seasons. The detective positive effects of biofertilizer on quantity and quality of pea yield (Table 6) might be related to its beneficial effects on vegetative growth characters (Table 2), which probably supplied more photosynthesis and hence might help in increasing yield potential, as mentioned by Jagnow et al. (1991). The present results agreed to a great extent with those reported by Chauhan et al. (1996), who reported that inoculation of seeds of (Barssica juncea L.) with Azotobzcter and Azospirillum bacteria, significantly, increased number of pods plant⁻¹ and seed yield compared with the control treatment. In this concern, Bin Ishaq (2002) and El-Waraky et al. (2013) on pea, and El-Waraky and Kasem (2007) and Masoud and Mehesen (2013) on cowpea showed significant positive effects on dry seed yield and its components due to the inoculation of seeds with different biofertilizer types.

b. Effect of NPK levels

Data in Table (6) cleared that application rate with the 40 kg N + 30 kg P_2O_5 + native-K fed⁻¹ gave the highest values for all yield significantly, where they increased average seed yield plant⁻¹, total seed yield fed.⁻¹, weight of seeds pod⁻¹, seed index (weight of 100-seeds), dry seeds protein and seed germination percentage over those obtained from either the control treatment or the lower or/ and higher rates application, (15 kg N + 25 kg P_2O_5 + native-K or 60kg N + 30 kg P_2O_5 + native-K fed⁻¹), in both seasons. These results seemed to be in general accordance with those reported by Edij *et al.* (1975), who found that seed yield of bean and its components were significantly increased with increasing nitrogen rates from 40 to 200 kg N ha.⁻¹. Also, Nassar and El-Masry (1989) reported significant seed yield increase with nitrogen application up to 160 kg fed⁻¹, ditto Bin Ishaq (2002) found that the soil application of N at the rate of 40 or 60 kg fed.⁻¹ gave the highest mean

values of pea seed yield. The later reported that the increase in seed yield to be related to the increments on number of pods plant⁻¹ rather than to increase in weight of seeds pod⁻¹. Lau and Stephenson (1993) explained the increase in seed yield, as a result of N fertilization, on the basis that the pollen grains produced by plants in high nitrogen treatment sired significantly more seeds than the pollen grains from low nitrogen plants. Similar results on cowpea were recorded by Knany *et al.* (2002), El-Bably and El-Waraky (2006), El-Waraky and Kasem (2007) and Masoud and El-Waraky (2012).

c. Effect of biofertilizer ilnoculation and NPK levels interaction

Table (7) showed the comparisons among the various treatment combinations of biofertilizer (Rhizobia or/and rhizobia + free bacteria) and the applied NPK levels on seed yield and its components and germination percentage of pea plants.

The comparisons among the mean values of each character indicated that seed inoculation with the biofertilizer (Rhizobia + free bacteria) and 40 kg N + 30 kg P₂O₅ + native-K fed⁻¹, resulted in significant increases in average seed yield plant⁻¹, total seed yield fed.⁻¹, weight of seeds pod⁻¹, seed index (weight of 100-seeds), dry seeds protein and seed germination percentage compared with those of all treatment combinations which were treated with only one factor (Table 7) and the control treatment (without biofertilizer and NPK). Apparently, the promoting effects of biofertilizer and NPK application on growth of pea plants were reflected on the increased total seed yield and its components. These results are in the same line with those obtained by Bin Ishag (2002) on pea, who reported that the application of N at the rate of 40 or 60 kg fed.⁻¹ combined with the biofertilizer Halex-2, significantly, increased dry seed yield plant⁻¹ and feddan⁻¹, number of dry pods plant⁻¹, weight of seeds pod⁻¹, seed index and seed germination percentage. Similar results on cowpea were recorded by Knany et al. (2002), El-Bably and El-Waraky (2007), El-Waraky and Kasem (2007) and Masoud and El-Waraky (2012). Phosphorus an important element for legumes due to its role in microbial activity. These results are agree with those obtained by Stancheva et al., 2006 who reported that P application increased pea biomass, nodulation parameters and N₂ fixation activity.

6-7

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تأثير التسميد المعدنى المتزن من النيتروجين والفوسفور والبوتاسيوم والتسميد الحيوى على انتاجية البسله ومحتواها من البروتين يـونس بيـومي أحمـد الـورقي*، علـى محمـد محمـد الدسـوقي مسـعود* و رمضان اسماعيل كنانى**

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أجريت دراسة حقلية لمدة عامين خلال الموسم الشتوى لعامى ٢٠٠٩/٢٠٠٨ ، ٢٠٠٩/٢٠٠٩ م فى منطقة دسوق – محافظة كفر الشيخ لدراسة استجابة نباتات البسله صنف ماستر بى للتلقيح البكتيرى بالريزوبيا والبكتريا المثبته للازوت لاتكافلى (الميكروبين) والتسميد المتزن من النيتروجين والفوسفور والبوتاسيوم بتركيزات (١٥ كجم ن + ٢٥ كجم فوءاًه + البوتاسيوم الموجود بالارض)، (٤٠ كجم ن + ٣٠ كجم فوءاًه + الموجود بالارض من البوتاسيوم)، (٦٠ كجم ن + ٣٠ كجم فوءاًه + الموحسور على من البوتاسيوم) بالاضافه الى الكنترول بدون تسميد. حيث التضح من تحليل التربه في الموجود على ٢٠٠٩

أوضحت النتائج أن تلقيح بذور البسله بالريزوبيا والميكروبين قد أدى الـى تحسين صفات النمـو الخضـرى ومحصـول القرون الخضـراء ومكوناتـه ونسبة التصـافي ومحصـول البـذور ومكوناتـه ونسبة انبـات البذور علاوة على زيادة محتوى الاوراق من الكلورفيل ومحتوى البذور من البروتين.

وقد بينت النتائج ان التسميد المتزن من النيتروجين والفوسفور والبوتاسيوم حتى ٤٠ كجم ن + ٣٠ كجم فو¹أه + الموجود بالارض من البوتاسيوم / فدان صاحبه زيادة معنوية في النمو الخضرى ومحصول القرون الخضراء ومكوناته ونسبة التصافي ومحصول البذور ومكوناته ونسبة انبات البذور، بالاضافه الى زيادة معنوية في محتوى الاوراق من الكلورفيل ومحتوى البذور من البروتين. هذا ولقد وجد أن التلقيح البكتيرى بالريزوبيا و الميكروبين مع التسميد المتزن من النيتروجين والفوسفور والبوتاسيوم ٤٠ كجم ن + ٣٠ كجم فوراًه + الموجود بالارض من الكلورفيل ومحتوى البذور من البروتين. هذا ولقد وجد أن التلقيح البكتيرى والريزوبيا و الميكروبين مع التسميد المتزن من النيتروجين والفوسفور والبوتاسيوم ٤٠ كجم ن + ٣٠ كجم فوراًه + الموجود بالارض من البوتاسيوم / فدان كان أكثر المعاملات كفاءة حيث أعطت أعلى نمو خضرى و محصول للقرون الخضراء ومكوناته و نسبة تصافى للقرون ومحصول البذور ومكونات

و نسبة انبات للبذور بالاضافه الى زيادة محتوى الأوراق من الكلورفيل ومحتوى البذور من البروتين.

قام بتحكيم البحث

أ.د / هالة عبد الغفار السيد
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كلية الزراعة – جامعة المنصورة	
كلية الزراعة – جامعة كفر الشيخ	

Treatments	Plant height (cm)		Number of leaves/plant		Number of branches/plant		Leaf are (cr	ea/plant n²)	Chlor Conten ur	ophyll t SPAD nit	Plant fresh weight (g)	
	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd
noculation												
Non inoculation	56.4 c	52.5 c	23.2 c	21.5 c	1.5 c	1.3 c	665.7 c	621.5 c	40.2 c	38.8 c	91.2 c	83.8 c
noculation by Rhizobia	62.1 b	55.9 b	25.1 b	23.1 b	1.9 b	1.7 b	694.8 b	653.3 b	41.9 b	40.8 b	100.8 b	93.1 b
Inoculation by Rhizobia	66.9 a	60.3 a	26.5 a	23.7 a	2.1 a	1.9 a	743.1 a	696.0 a	43.1 a	42.1 a	105.8 a	99.8 a
Free bacteria +												
				F	ertilizer le	evels						
Without	56.7 d	51.8 d	23.2 c	21.2 c	1.6 d	1.4 c	619.0 d	576.1 d	39.2 d	37.9 d	86.1 d	79.4 d
15k N+25 P₂O₅ + native- K	60.9 c	56.5 c	24.5 b	22.8 b	1.7 cd	1.6 b	694.7 c	650.8 c	41.3 c	40.2 c	97.1 c	90.2 c
40k N+30 P ₂ O ₅ + native- K	63.7 b	57.8 b	26.3 a	23.6 a	2.2 a	1.9 a	763.2 a	717.7 a	42.5 b	41.4 b	109.7 a	101.7 a
60k N+30 P ₂ O ₅ + native- K	65.9 a	58.9 a	25.7 a	23.5 a	1.9 b	1.9 a	727.8 b	683.1 b	43.8 a	42.8 a	104.2 b	97.6 b

Table (2): Effect of biofertlizer inoculation and NPK fertilizer levels on vegetative characters on pea plants in 2008/09 and 2009/10 seasons.

Means designated by the same letter at each column are not significantly different at the 0.05 level of probability, according to Duncan's Multiple Range Test .

Table (3): Effect of the interaction between biofertilizer inoculation and NPK fertilizer levels on vegetative characters on pea plants in 2008/09 and 2009/10 seasons.

	Treatments		Plant height		per of	Numbo	of branches	Loof are	a/nlant	Chlore	ophyll	Plant fresh	
Inoculation	Fertilizer levels	(cm)		leaves/plant		Number ,	/plant	cr	n²)	Conten ur	t SPAD hit	weigl	ht (g)
		1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd
Non noculation	Without I5k N+ 25 P ₂ O ₅ + native-K	52.3 e 55 2 de	46.2 f	21.2 g	19.7 f 21 5 d-f	1.3 f 1 3 f	1.2 e 1 3 de	580.3 f 648 4 e	539.6g	37.6 g 39.6 f	35.7 g 38 1 f	80.2f 87 5e	74.1g 80.7fg
noculation	$10k N + 30 P_2O_5 + native - K$	58.5 cd	54.7 c-e	24.2 d-f	21.8 c-e	1.8 d	1.5 c-e	735.6b-d	680.3bc	41.5 de	39.7 df	101.5bc	92.8c-e
	50K N + 50 T 205 + Hauve- N	59.7 bc	55.5 с-е	24.7с-е	23.0 а-е	1.5 e	1.3 de	698.5 d	653.5с-е	42.1 cd	41.6 bc	95.7cd	87.5ef
Inoculation	Without I5k N + 25 P₂O₅ + native-K	57.3 cd 60.8 bc	51.9 e 55.4 c-e	23.6 ef 24.6 c-e	21.3 ef 23.5 a-d	1.7 de 1.8 d	1.4 de 1.6 cd	625.5 e 695.4 d	586.3fg 659.2cd	39.6 f 41.8 de	38.4 ef 40.7 cd	85.7ef 100.3bc	77.5g 91.5de
,	40k N + 30 P ₂ O ₅ + native- K 60k N + 30 P ₂ O ₅ + native- K	63.0 b	57.7 b-d	26.3 bc	24.2 ab	2.3 b	2.0 ab	748.5 bc	697.5bc	42.5 b-d	41.5 bc	112.7a	103.6ab
Inoculation	Without	60.5 bc	57.2 b-c	24.8 b-e	22.6 b-e	1.8 d	1.5 c-e	651.3 e	602.5ef	40.4 ef	39.8 de	92.5de	86.7ef
by Rhizobia	5k N + 25 P ₂ O ₅ + native-K Wk N + 30 P ₂ O ₅ + native- K k N + 30 P ₂ O ₅ + native- K	66.9 a	60.3 ab	26.3 bc	23.4 a-d	2.0 c	1.8 bc	740.3 bc	680.6bc	42.5 b-d	41.7 bc	103.6b	98.4b-d
r Free pacteria		69.7a 70.9 a	62.4 a	26.4 a 26.6 b	24.8 a 23.9 ab	2.5 a 2.2 b	2.3 a 2.0 ab	775.3 ab	725.5ab	43.7 D 45.7 a	42.8 ab 44.2 a	114.8a 112.5a	105.5ab

Means designated by the same letter at each column are not significantly different at the 0.05 level of probability, according to Duncan's Multiple Range Test

	Total green pods yield				No. of green		Woig	bt of	No. of	soods/	Weig	ht of	Shalli	na ratio
Treatments	Per plant (g)		Per feddan (ton)		pods/ plant		green pod (g)		pod		seeds/ pod (g)		(%)	
	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd
	Inoculation													
Non inoculation	89.2 c	70.9 c	2.98 c	2.53 c	16.5 c	14.8 c	5.4 c	4.9 b	8.9 b	8.8 a	3.8 c	3.3 c	70.6 c	69.1 b
noculation by Rhizobia	104.9 b	89.5 b	3.51 b	3.14 b	17.7 b	16.7 b	5.8 b	5.4 a	9.1 a	9.0 a	4.2 b	3.8 b	71.2 b	69.8 b
noculation by Rhizobia Free bacteria +	114.9 a	96.5 a	3.86 a	3.39 a	19.0 a	17.3 a	6.0 a	5.6 a	9.2 a	9.1 a	4.3 a	3.9 a	72.0 a	70.8 a
					Fertili	izer level	S							
Without	79.1 d	66.7 d	2.66 d	2.90 d	15.4 d	14.2 d	5.0 d	4.7 c	8.6 d	8.3 b	3.6 d	3.2 c	70.5 d	68.9 b
$15k \text{ N} + 25 \text{ P}_2\text{O}_5 + \text{native-K}$	91.9 c	82.9 c	3.28 c	3.04 c	16.9 c	16.3 c	5.5 c	5.1 b	9.1 c	9.1 ab	3.9 c	3.5 b	70.7cd	69.8 b
$40k N + 30 P_2O_5 + native- K$	128.4 a	99.8 a	4.18 a	3.62 a	19.9 a	17.7 a	6.4 a	5.6 a	9.4 a	9.2 a	4.6 a	4.0 a	72.3 a	70.4 a
PUK IN+ 30 P_2O_5 + native- K	112.9 b	93.1 b	3.68 b	3.21 b	18.8 b	16.8 b	6.0 b	5.6 a	9.2 bc	9.1 ab	4.3 b	3.9 ab	71.7 b	70.5 a

Table (4): Effect of biofertilizer inoculation and NPK fertilizer levels on green pods yield and its components of pea plants in 2008/09 and 2009/10 seasons.

Means designated by the same letter at each column are not significantly different at the 0.05 level of probability, according to Duncan's Multiple Range Test.

Table (5): Effect of the interaction between biofertilizer inoculation and NPK fertilizer levels on green pods yield and its components of pea plants in 2008/09 and 2009/10 seasons.

Treatments		Total green pods yield										Weight of			
		Per plant		Per feddan		No. of	No. of green		Weight of		No. of seeds/		/ pod	Shellin	g ratio
Inocula-	Fertilizer levels	(g)		(ton)		pous, plant		green pou (g)		pou		(9)		(78)	
tion		1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd
Non inoculation	Without 15k N+25P ₂ O ₅ + native-K 40k N + 30 P ₂ O ₅ + native- K 60k N + 30 P ₂ O ₅ + native- K	60.7g 83.7f 112.2cd 100.2de	44.1d 75.4c 83.5bc 80.7c	2.04h 2.90fg 3.85b-d 3.14e-g	1.33e 2.76cd 3.29a-d 2.72cd	13.2f 16.1de 18.7bc 17.8b-d	10.5b 15.7a 16.7a 16.2a	4.6f 5.3e 6.0b-d 5.6de	4.3f 4.8ef 5.0de 5.3c-e	8.3d 9.0ab 9.4a 9.2ab	8.0d 9.0ab 9.2a 9.0ab	3.2g 3.7f 4.3cd 4.0d-f	2.9e 3.3de 3.5cd 3.5cd	69.6e 69.8de 71.7a-c 71.4a-d	67.4d 68.9cd 70.0a-c 70.0a-c
Inoculation by Rhizobia	Without 15k N + 25 P ₂ O ₅ + native-K 40k N + 30 P ₂ O ₅ + native- K 60k N + 30 P ₂ O ₅ + native- K	83.7f 91.8ef 128.7b 115.7bc	77.4c 81.9bc 103.3ab 95.2a-c	2.73g 3.38d-f 4.10ab 3.84b-d	2.43d 3.14a-d 3.67ab 3.30a-d	15.4e 17.0c-e 19.8ab 18.7bc	16.1a 16.4a 17.5a 16.7a	5.2e 5.4e 6.3ab 6.2bc	4.9de 5.0de 5.9ab 5.7a-c	8.6cd 9.2ab 9.4a 9.2ab	8.4cd 9.2a 9.2a 9.2a	3.7f 3.8ef 4.7ab 4.4bc	3.4cd 3.5cd 4.2ab 4.0ab	70.2c-e 70.4b-e 72.4a 71.9ab	69.4b-c 70.0a-c 69.4a-d 70.2a-c
Inoculation by Rhizobia +Free bacteria	Without 15k N + 25 P ₂ O ₅ + native-K 40k N + 30 P ₂ O ₅ + native- K 60k N + 30 P ₂ O ₅ + native- K	92.8ef 100.3de 144.2a 122.7bc	78.6c 91.3a-c 112.7a 103.3ab	3.21e-g 3.57c-e 4.59a 4.07bc	2.83b-d 3.23a-d 3.90a 3.58a-c	17.5b-e 17.6b-e 21.2a 19.8ab	16.1a 16.9a 18.8a 17.5a	5.3e 5.7c-e 6.8a 6.2bc	4.9de 5.4bc 6.0a 5.9ab	8.8bc 9.2ab 9.4a 9.2ab	8.6bc 9.2a 9.2a 9.2a	3.8ef 4.1c-e 4.9a 4.4bc	3.4cd 3.8bc 4.3a 4.2ab	71.6a-c 71.9ab 72.8a 71.8a-c	69.8a-c 70.4a-c 71.7a 71.2ab

Means designated by the same letter at each column are not significantly different at the 0.05 level of probability, according to Duncan's Multiple Range Test.

		Dry	seed yield		Waight of	coodo por	Sood	ndov	Dry seeds	s protein	Seed germination	
Treatments	Per plant (g)		Per feddan (ton)		poc	i (g)	(g)	(%)		(%)	
	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd
Inoculation												
Non inoculation Inoculation by Rhizobia Inoculation by Rhizobia Free bacteria +	28.1 c 31.4 b 35.1 a	24.1 c 28.5 b 32.0 a	0.85 c 0.96 b 1.07 a	0.74 c 0.85 b 0.97 a	1.77 c 1.48 b 1.83 a	1.62 c 1.71 b 1.76 a	18.85 b 20.20 a 19.97 ab	18.23 c 18.98 b 19.35 a	23.20 c 23.63 b 24.03 a	22.48 c 23.03 b 23.38 a	81.2 c 83.6 b 84.3 a	80.8 c 81.8 b 83.1 a
					Fertilizer	· levels						
Without 15k N + 25 P₂O₅ + native-K 40k N + 30 P₂O₅ + native- K 60k N + 30 P₂O₅ + native- K	24.0 d 29.3 c 38.7 a 34.2 b	20.7 d 27.4 c 34.7 a 30.1 b	0.74 d 0.92 c 1.14 a 1.04 b	0.63 d 0.84 c 1.02 a 0.92 b	1.53 d 1.74 c 1.94 a 1.85 b	1.45 c 1.67 b 1.86 a 1.79 ab	17.79 d 19.03 c 21.67 a 20.20 b	17.43 d 18.33 c 20.03 a 19.60 b	22.77 c 23.53 b 24.00 a 24.17 a	21.70 c 22.67 b 23.63 a 23.83 a	80.3 d 82.1 c 85.2 a 84.5 b	78.7 d 81.5 c 84.2 a 83.2 b

Table (6): Effect of biofertilizer inoculation and NPK fertilizer levels on dry seed yield and its components of pea plants in 2008/09 and 2009/10 seasons.

Means designated by the same letter at each column are not significantly different at the 0.05 level of probability, according to Duncan's Multiple Range Test.

Table (7): Effect of the interaction between biofertilizer inoculation and NPK fertilizer levels on dry seed yield and its components of pea plants in 2008/09 and 2009/10 seasons.

Treatments	Treatments		Dry seed yield							Dry se	eds	Seed	
Inoculation Fertilizer levels		Per plant (g)		Per feddan (ton)		Weight of seeds/ pod (g)		Seed index (g)		protein (%)		germination (%)	
		1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd	1 st	2 nd
Non	Without	19.1g	14.3d	0.65f	0.49j	1.45g	1.36g	17.50c	17.00h	22.00f	21.10g	78.9f	78.1de
inoculation	15k N + 25 P ₂ O ₅ + native-K	26.2ef	25.3bc	0.81e	0.73h	1.66e	1.61de	18.40bc	17.90f-h	23.20de	22.00f	80.0e	80.5cd
	40k N + 30 P ₂ O ₅ + native- K	35.2bc	29.7bc	1.03c	0.91de	1.88c	1.81ab	20.00bc	19.30b-d	23.70b-d	23.3b-d	83.2c	82.9a-c
	60k N + 30 P ₂ O ₅ + native- K	32.0cd	27.2bc	0.90d	0.82fg	1.78d	1.68cd	19.50bc	18.70d-f	23.90a-d	23.5a-d	82.7c	81.5bc
Inoculation	Without	24.8f	23.1c	0.71f	0.63i	1.54f	1.46fg	17.57c	17.40gh	22.90e	21.70fg	80.5de	77.4e
bv Rhizobia	15k N + 25 P ₂ O ₅ + native-K	29.8de	27.4bc	0.92d	0.85ef	1.75d	1.67cd	19.00bc	18.10e-g	23.50с-е	22.90de	82.7c	81.4bc
.,	40k N + 30 P ₂ O ₅ + native- K	38.8ab	32.7b	1.14b	1.07bc	1.96ab	1.87a	21.17ab	20.30ab	24.00a-c	23.60a-c	82.9ab	84.6a
	60k N + 30 P ₂ O ₅ + native- K	32.2cd	30.9bc	1.06c	0.92d	1.88c	1.85ab	20.40a-c	20.10ab	24.10a-c	23.90ab	85.2b	83.9ab
Inoculation	Without	28.2d-f	24.8bc	0.87de	0.76gh	1.61e	1.54ef	18.30bc	17.90f-h	23.4c-e	22.30ef	81.4d	80.5cd
bv Rhizobia	15k N + 25 P ₂ O ₅ + native-K	31.9cd	29.6bc	1.03c	0.95cd	1.81d	1.75bc	19.70bc	19.00с-е	23.9a-d	23.10cd	83.5c	82.6a-c
+ Free	40k N + 30 P ₂ O ₅ + native- K	41.9a	41.5a	1.24a	1.13a	1.98a	1.89a	23.83a	20.50a	24.3ab	24.00a	86.5a	85.1a
bacteria	60k N + 30 P₂O₅ + native- K	38.3ab	32.2b	1.15b	1.02b	1.90bc	1.84ab	20.70a-c	20.00a-c	24.5a	24.10a	85.7ab	84.3a

Means designated by the same letter at each column are not significantly different at the 0.05 level of probability, according to Duncan's Multiple Range Test.