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# 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 Disuq 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 + $N_2$-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 $P_2O_5$ + native-K, 3- 40 kg N + 30 kg $P_2O_5$ + native-K and 4-60kg N + 30 kg $P_2O_5$ + 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 $P_2O_5$ + 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 $N_2$ 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 $N_2$ fiaxation by Rhizobium is enhanced in host plants well supplied with phosphate and K (Mengel *et al.*, 1974). Inoculation of crops with Microbin ($N_2$ 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).

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

| Season | Mechanical analysis | | | Texture | pH* | EC** $dSm^{-1}$ | OM (%) | Available elements (ppm) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sand (%) | Silt (%) | Clay (%) | | | | | N | P | K |
| 1st | 10.0 | 50 | 40.0 | Loamy Clay | 7.18 | 0.555 | 1.70 | 25 | 5.0 | 432 |
| 2nd | 9.5 | 51 | 39.5 | Loamy Clay | 7.9 | 0.7 | 1.68 | 23 | 5.5 | 419 |

*** 1: 2.5 soil: water suspension.**
**** Soil past extract**

Effective selected strain of pea rhizobial( *Rhizobium leguinosarum* biovar *viceae* ) and microbin ($N_2$ 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% $P_2O_5$), 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 $m^2$. 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$^{o}$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 $N_2$-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 $N_2$-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 $P_2O_5$ + native-K $fed^{-1}$, whereas without NPK or/and 15 kg N + 25 kg $P_2O_5$ + 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 $P_2O_5$ $fed^{-1}$ was the best phosphorus rate to the studied pea. Similar results were reported by Knany *et a*l (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 $P_2O_5$ + native-K $fed^{-1}$ , inoculation of pea seeds with the biofertilizer (Rhizobia + $N_2$-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 $P_2O_5$ + native-K $fed^{-1}$, inoculation of pea seeds with the biofertilizer (Rhizobia + $N_2$-fixer free living bacteria) produced the highest values of chlorophyll content. increased The combination of 40 kg N + 30 kg $P_2O_5$ + native-K $fed^{-1}$, inoculation of pea seeds with the biofertilizer (Rhizobia + $N_2$-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 + $N_2$-fixer free living bacteria), in both growing seasons. Increasing growth and total yield after the inoculation of pea seeds with the biofertilizer (Rhizobia + $N_2$-fixer free living bacteria), which contains genera of non-symbiotic $N_2$-fixing bacteria, might be due to increasing the biological $N_2$-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 El-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 plant$^{-1}$. Arisha and Bardisi (1999) illustrated that total 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 $N_2$ 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 + $N_2$-fixer free living bacteria) plus 40 kg N + 30 kg $P_2O_5$ + 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 + $N_2$-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 iInoculation 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 $P_2O_5$ + 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 Ishaq (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 $N_2$ fixation activity.

6-7

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# تـأثير التسـميد المعدنى المتـزن مـن النيتـروجين والفوسـفور والبوتاسـيوم والتسـميد الحيوى على انتاجية البسله ومحتواها من البروتين

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أجريت دراسة حقلية لمدة عامين خلال الموسم الشتوى لعامى ٢٠٠٨/٢٠٠٩ ، ٢٠٠٩/٢٠١٠ 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 فو٢أ٥ + البوتاسيوم الموجود بالارض)، (٤٠ كجم ن + ٣٠ كجم فو٢أ٥ + الموجود بالارض من البوتاسيوم )، (٦٠ كجم ن + ٣٠ كجم فو٢أ٥ + الموجود بالارض من البوتاسيوم ) بالاضافه الى الكنترول بدون تسميد. حيث اتضح من تحليل التربه فى الموسمين انها تحتوى على ٤٣٢ و ٤١٩ مليجرام / كجم تربه بوتاسيوم وهذا يكفى البسله .

أوضحت النتائج أن تلقيح بذور البسله بالريزوبيا والميكروبين قد أدى الى تحسين صفات النمو الخضرى ومحصول القرون الخضراء ومكوناته ونسبة التصافى ومحصول البذور ومكوناته ونسبة انبات 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 فو٢أ٥ + الموجود بالارض من البوتاسيوم / فدان صاحبه زيادة معنوية فى النمو الخضرى ومحصول القرون الخضراء ومكوناته ونسبة التصافى ومحصول البذور ومكوناته ونسبة انبات البذور، بالاضافه الى زيادة معنوية فى 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 فو٢أ٥ + 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 ومكوناته و نسبة انبات للبذور بالاضافه الى زيادة محتوى الأوراق من الكلورفيل ومحتوى البذور من البروتين.

**قام بتحكيم البحث**

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

| Treatments | Plant height (cm) | | Number of leaves/plant | | Number of branches/plant | | Leaf area/plant ($cm^2$) | | Chlorophyll Content SPAD unit | | Plant fresh weight (g) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $1^{st}$ | $2^{nd}$ | $1^{st}$ | $2^{nd}$ | $1^{st}$ | $2^{nd}$ | $1^{st}$ | $2^{nd}$ | $1^{st}$ | $2^{nd}$ | $1^{st}$ | $2^{nd}$ |
| **Inoculation** | | | | | | | | | | | | |
| 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 |
| Inoculation 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 + Free bacteria | 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 |
| **Fertilizer levels** | | | | | | | | | | | | |
| 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 $P_2O_5$ + 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 $P_2O_5$ + 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 $P_2O_5$ + 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 |

**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 (cm) | | Number of leaves/plant | | Number of branches /plant | | Leaf area/plant ($cm^2$) | | Chlorophyll Content SPAD unit | | Plant fresh weight (g) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Inoculation | Fertilizer levels | $1^{st}$ | $2^{nd}$ | $1^{st}$ | $2^{nd}$ | $1^{st}$ | $2^{nd}$ | $1^{st}$ | $2^{nd}$ | $1^{st}$ | $2^{nd}$ | $1^{st}$ | $2^{nd}$ |
| Non inoculation | Without | 52.3 e | 46.2 f | 21.2 g | 19.7 f | 1.3 f | 1.2 e | 580.3 f | 539.6g | 37.6 g | 35.7 g | 80.2f | 74.1g |
| | 15k N+ 25 $P_2O_5$ + native-K | 55.2 de | 53.8 de | 22.7 fg | 21.5 d-f | 1.3 f | 1.3 de | 648.4 e | 612.5d-f | 39.6 f | 38.1 f | 87.5e | 80.7fg |
| | 40k 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 |
| | 60k N + 30 $P_2O_5$ + native- K | 59.7 bc | 55.5 c-e | 24.7c-e | 23.0 a-e | 1.5 e | 1.3 de | 698.5 d | 653.5c-e | 42.1 cd | 41.6 bc | 95.7cd | 87.5ef |
| Inoculation by Rhizobia | Without | 57.3 cd | 51.9 e | 23.6 ef | 21.3 ef | 1.7 de | 1.4 de | 625.5 e | 586.3fg | 39.6 f | 38.4 ef | 85.7ef | 77.5g |
| | 15k N + 25 $P_2O_5$ + native-K | 60.8 bc | 55.4 c-e | 24.6 c-e | 23.5 a-d | 1.8 d | 1.6 cd | 695.4 d | 659.2cd | 41.8 de | 40.7 cd | 100.3bc | 91.5de |
| | 40k N + 30 $P_2O_5$ + 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 |
| | 60k N + 30 $P_2O_5$ + native- K | 67.2 a | 58.9 a-c | 25.8 bc | 23.6 a-c | 2.0 c | 1.8 bc | 709.7 cd | 670.3c | 43.5 bc | 42.7 ab | 104.5b | 99.8bc |
| Inoculation by Rhizobia + Free bacteria | 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 |
| | 15k N + 25 $P_2O_5$ + 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 |
| | 40k N + 30 $P_2O_5$ + native- K | 69.7a | 61.1 ab | 28.4 a | 24.8 a | 2.5 a | 2.3 a | 805.4 a | 775.4a | 43.7 b | 42.8 ab | 114.8a | 108.7a |
| | 60k N + 30 $P_2O_5$ + native- K | 70.9 a | 62.4 a | 26.6 b | 23.9 ab | 2.2 b | 2.0 ab | 775.3 ab | 725.5ab | 45.7 a | 44.2 a | 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**

**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.**

| Treatments | Total green pods yield: Per plant (g) | | Total green pods yield: Per feddan (ton) | | No. of green pods/ plant | | Weight of green pod (g) | | No. of seeds/ pod | | Weight of seeds/ pod (g) | | Shelling ratio (%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd |
| **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 |
| Inoculation 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 |
| Inoculation 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 |
| **Fertilizer levels** | | | | | | | | | | | | | | |
| 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 N+ 25 $P_2O_5$ + 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 |
| 60k N+ 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 |

**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.**

| Inocula-tion | Fertilizer levels | Total green pods yield: Per plant (g) | | Total green pods yield: Per feddan (ton) | | No. of green pods/ plant | | Weight of green pod (g) | | No. of seeds/ pod | | Weight of seeds/ pod (g) | | Shelling ratio (%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd |
| Non inoculation | Without | 60.7g | 44.1d | 2.04h | 1.33e | 13.2f | 10.5b | 4.6f | 4.3f | 8.3d | 8.0d | 3.2g | 2.9e | 69.6e | 67.4d |
| | 15k N+25$P_2O_5$ + native-K | 83.7f | 75.4c | 2.90fg | 2.76cd | 16.1de | 15.7a | 5.3e | 4.8ef | 9.0ab | 9.0ab | 3.7f | 3.3de | 69.8de | 68.9cd |
| | 40k N + 30 $P_2O_5$ + native- K | 112.2cd | 83.5bc | 3.85b-d | 3.29a-d | 18.7bc | 16.7a | 6.0b-d | 5.0de | 9.4a | 9.2a | 4.3cd | 3.5cd | 71.7a-c | 70.0a-c |
| | 60k N + 30 $P_2O_5$ + native- K | 100.2de | 80.7c | 3.14e-g | 2.72cd | 17.8b-d | 16.2a | 5.6de | 5.3c-e | 9.2ab | 9.0ab | 4.0d-f | 3.5cd | 71.4a-d | 70.0a-c |
| Inoculation by Rhizobia | Without | 83.7f | 77.4c | 2.73g | 2.43d | 15.4e | 16.1a | 5.2e | 4.9de | 8.6cd | 8.4cd | 3.7f | 3.4cd | 70.2c-e | 69.4b-c |
| | 15k N + 25 $P_2O_5$ + native-K | 91.8ef | 81.9bc | 3.38d-f | 3.14a-d | 17.0c-e | 16.4a | 5.4e | 5.0de | 9.2ab | 9.2a | 3.8ef | 3.5cd | 70.4b-e | 70.0a-c |
| | 40k N + 30 $P_2O_5$ + native- K | 128.7b | 103.3ab | 4.10ab | 3.67ab | 19.8ab | 17.5a | 6.3ab | 5.9ab | 9.4a | 9.2a | 4.7ab | 4.2ab | 72.4a | 69.4a-d |
| | 60k N + 30 $P_2O_5$ + native- K | 115.7bc | 95.2a-c | 3.84b-d | 3.30a-d | 18.7bc | 16.7a | 6.2bc | 5.7a-c | 9.2ab | 9.2a | 4.4bc | 4.0ab | 71.9ab | 70.2a-c |
| Inoculation by Rhizobia +Free bacteria | Without | 92.8ef | 78.6c | 3.21e-g | 2.83b-d | 17.5b-e | 16.1a | 5.3e | 4.9de | 8.8bc | 8.6bc | 3.8ef | 3.4cd | 71.6a-c | 69.8a-c |
| | 15k N + 25 $P_2O_5$ + native-K | 100.3de | 91.3a-c | 3.57c-e | 3.23a-d | 17.6b-e | 16.9a | 5.7c-e | 5.4bc | 9.2ab | 9.2a | 4.1c-e | 3.8bc | 71.9ab | 70.4a-c |
| | 40k N + 30 $P_2O_5$ + native- K | 144.2a | 112.7a | 4.59a | 3.90a | 21.2a | 18.8a | 6.8a | 6.0a | 9.4a | 9.2a | 4.9a | 4.3a | 72.8a | 71.7a |
| | 60k N + 30 $P_2O_5$ + native- K | 122.7bc | 103.3ab | 4.07bc | 3.58a-c | 19.8ab | 17.5a | 6.2bc | 5.9ab | 9.2ab | 9.2a | 4.4bc | 4.2ab | 71.8a-c | 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.**

**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.**

| Treatments | Dry seed yield | | | | Weight of seeds per pod (g) | | Seed index (g) | | Dry seeds protein (%) | | Seed germination (%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Per plant (g) | | Per feddan (ton) | | | | | | | | | |
| | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd |
| **Inoculation** | | | | | | | | | | | | |
| Non inoculation | 28.1 c | 24.1 c | 0.85 c | 0.74 c | 1.77 c | 1.62 c | 18.85 b | 18.23 c | 23.20 c | 22.48 c | 81.2 c | 80.8 c |
| Inoculation by Rhizobia | 31.4 b | 28.5 b | 0.96 b | 0.85 b | 1.48 b | 1.71 b | 20.20 a | 18.98 b | 23.63 b | 23.03 b | 83.6 b | 81.8 b |
| Inoculation by Rhizobia + Free bacteria | 35.1 a | 32.0 a | 1.07 a | 0.97 a | 1.83 a | 1.76 a | 19.97 ab | 19.35 a | 24.03 a | 23.38 a | 84.3 a | 83.1 a |
| **Fertilizer levels** | | | | | | | | | | | | |
| Without | 24.0 d | 20.7 d | 0.74 d | 0.63 d | 1.53 d | 1.45 c | 17.79 d | 17.43 d | 22.77 c | 21.70 c | 80.3 d | 78.7 d |
| 15k N + 25 $P_2O_5$ + native-K | 29.3 c | 27.4 c | 0.92 c | 0.84 c | 1.74 c | 1.67 b | 19.03 c | 18.33 c | 23.53 b | 22.67 b | 82.1 c | 81.5 c |
| 40k N + 30 $P_2O_5$ + native- K | 38.7 a | 34.7 a | 1.14 a | 1.02 a | 1.94 a | 1.86 a | 21.67 a | 20.03 a | 24.00 a | 23.63 a | 85.2 a | 84.2 a |
| 60k N + 30 $P_2O_5$ + native- K | 34.2 b | 30.1 b | 1.04 b | 0.92 b | 1.85 b | 1.79 ab | 20.20 b | 19.60 b | 24.17 a | 23.83 a | 84.5 b | 83.2 b |

**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 | | Dry seed yield | | | | Weight of seeds/ pod (g) | | Seed index (g) | | Dry seeds protein (%) | | Seed germination (%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Inoculation | Fertilizer levels | Per plant (g) | | Per feddan (ton) | | | | | | | | | |
| | | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd | 1st | 2nd |
| Non inoculation | 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 |
| | 15k N + 25 $P_2O_5$ + 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 $P_2O_5$ + 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 $P_2O_5$ + 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 by Rhizobia | 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 |
| | 15k N + 25 $P_2O_5$ + native-K | 29.8de | 27.4bc | 0.92d | 0.85ef | 1.75d | 1.67cd | 19.00bc | 18.10e-g | 23.50c-e | 22.90de | 82.7c | 81.4bc |
| | 40k N + 30 $P_2O_5$ + 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 $P_2O_5$ + 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 by Rhizobia + Free bacteria | 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 |
| | 15k N + 25 $P_2O_5$ + native-K | 31.9cd | 29.6bc | 1.03c | 0.95cd | 1.81d | 1.75bc | 19.70bc | 19.00c-e | 23.9a-d | 23.10cd | 83.5c | 82.6a-c |
| | 40k N + 30 $P_2O_5$ + 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 |
| | 60k N + 30 $P_2O_5$ + 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.**