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# EFFECT OF FARMYARD MANURE, PLANT DENSITY AND BIOFERTILIZER TREATMENTS ON GROWTH AND YIELD OF SUGAR BEET

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## ABSTRACT

Two field experiments were conducted at El-Serw Agricultural Research Station, Damietta Governorate, during 2008/2009 and 2009/2010 seasons, to study the effect of farmyard manure (0, 10, 20 and 30 $m^3$/fad), plant densities (33600, 42000 and 56000 plant/fad), four biofertilizer treatments (without treated, inoculation seeds with Cerialine, Netrobine at 450 g/fad and 90 kg N/fad as a mineral fertilizer)and their interactions on growth and yield of sugar beet .

The obtained results indicated that farmyard manure had a significant effect on average values of root fresh weight, sucrose %, purity % and yields of top, root and sugar/fad in both seasons. Increasing farmyard manure rate up to 30 $m^3$/fad significantly increased root fresh weight, top yield/fad, root yield/fad as well as sugar yield/fad but, decreased sucrose % and purity % as compared to control (without added farmyard manure) in both seasons**.**

Plant density significantly affected all studied traits in both seasons. The highest plant density 56000 plant/fad gave the highest values of sucrose %, purity %, top yield /fad, root yield /fad and sugar yield/fad, but it gave the lowest root fresh weight. On the contrary, the heaviest root was recorded with the lowest plant density 33600 plant/fad as compared with other studied plant densities in 2008/2009 and 2009/2010 seasons.

Results indicated that fertilization treatments had a significant effect on all studied characters in both seasons. Applying nitrogen as a mineral fertilizer at a rate of 90 kg N/fad gave the highest values of root fresh weight, top yield/fad, root yield/fad and sugar yield/fad as compared with all other fertilization treatment, in 2008/2009 and 2009/2010 seasons. In this connection, cerialine biofertilizer followed the mineral nitrogen of the mentioned previously traits.

The interaction between farmyard manure rates and plant densities, the interaction between farmyard manure rates and biofertilization treatments and the interaction between plant densities and biofertilization treatments were significantly affected all studied traits in both seasons. The interaction effect among farmyard manure, plant density and fertilization treatments was significant on all studied characters in both seasons. Plants received 30 $m^3$/fad farmyard manure at the highest plant density 56000 plant/fad and fertilized by 90 kg N/fad gave the highest top yield/fad 33.65 and 39.28 tons, root yield/fad 40.76 and 39.20 tons as well as sugar yield/fad 7.11 and 6.75 tons compared to all other this interaction treatments in 2008/2009 and 2009/2010 seasons, respectively.

Generally, it could be recommended that applied farmyard manure at the rate of 30 $m^3$/fad for sugar beet plants sown at plant density of 56000 plant/fad, and fertilized by 90 kg N/fad gave the highest root and sugar yield/fad at North Delta, Damietta Governorate, Egypt

## INTRODUCTION

Sugar beet (*Beta vulgaris L*.) is considered the second important sugar crop in Egypt and in many countries all over the world after sugar cane (*Sacchurum officinarum L.)*.Sugar beet plays a prominent role for sugar production in Egypt . Recently , Egypt face a great problem concerned with the lake of sugar production to feed an increasing population .So increasing sugar production is necessary to meet demands of population . One of the approaches to increase sugar production is raising sugar beet production per unit area. Sugar beet production in Egypt is limited by various factors such as plant density and fertilization. Nitrogen is among the principal factors limiting yield of sugar beet production . Recently , pollution has drawn a lot of attention at local and international levels. One of the important sources of pollution is the use of various chemicals in agriculture. Increasing amounts of mineral fertilizer constitutes is considered a major reason of soil pollution. So minimizing the use of these chemicals is a way to reduce pollution. One way to reduce the application of mineral nitrogen fertilizer is the use of farmyard manure and biofertilization. Farmyard manure increases the organic matter content which serves several advantages like conservation and slow release of nutrients, improvement of soil physical conditions and preservation of soil moisture. These advantages lead to the increase in soil fertility and productivity. Hamoud (1992), Mokadem (2000), Taleghani *et al. (*2006) and Hanackova *et al.* 2008 showed that using farmyard manure surpassed the check treatment (without farmyard manure) in fresh weight of root and root, top and sugar yields/fad Percentage of sucrose was tended to decrease with the addition of farmyard manure.

The plant density has important role to obtain maximum yield of sugar beet. Abdalla *et al* .(1995), Bhullar *et al.* (2010) and Zenin and Ashcheulov 2010 found that sucrose %, purity % and yields of root and top (ton /fad ) significantly increased with increasing plant density.

Biofertilizers technologies are based on enhancing and improving the naturally existing nutrient transformation activities in the soil profiles, when the inoculants should be able to be adapted to the environmental conditions prevailing in the site of application. Whereas, inoculation seeds of various $C_3$ and $C_4$ plants with associative nitrogen-fixing bacteria led to improve plant growth and yield Eid (1982). So, biological nitrogen fixation of sugar beet with non-symbiotic nitrogen fixers play an important role in increasing growth and yield as well as decreasing chemical nitrogen fertilizer requirements and consequently minimizing environmental pollution by mineral fertilizers.

El-Hawary (1999) showed that average of root fresh weight, top yield, root yield and sugar yield were significantly increased with increasing nitrogen fertilizer rate. Maareg and Badr (2001) in Egypt, reported that cerialine caused an increase in length, diameter and weight of roots, fresh weight of foliage, TSS %, sucrose %, purity % and sugar yield/fad of sugar beet. Kandil *et al*. (2002) and Ramadan *et al.* (2003), in Egypt, confirmed that biofertilization treatments significantly increased root and foliage fresh weights, root, top and sugar yields/fad The highest means of previously

mentioned characteristics were resulted from inoculation seeds of sugar beet with Rhizobacterin.

Therefore this investigation was conducted to study the effect of farmyard manure, plant density, biofertilizer treatments and their interactions on growth and yield as well as quality of sugar beet under North Delta conditions at Damietta Governorate.

## MATERIALS AND METHODS

Two field experiments were conducted at El-Serw Agricultural Research Station, Damietta Governorate, during 2008/2009 and 2009/2010 seasons, to study the effect of farmyard manure, plant density , biofertilizer treatments and their interactions on growth and yield of sugar beet (*Beta vulgaris L.*) cv. Kawemira

**Studied factors:-**

**I- Farmyard manure treatments:**

Farmyard manure was applied while seedbed preparation at the rates of:

1- Without added farmyard manure (control). 2- 10 $m^3$/fad.

3- 20 $m^3$/fad. 4- 30 $m^3$/fad.

**II- Plant density:**

Plant densities studied were as follows:

1- 56000 plants/fad (planning at 15 cm between hills)

2- 42000 plants/fad (planning at 20 cm between hills)

3- 33600 plants/fad (planning at 25 cm between hills)

Sugar beet seeds were sown on one activated side of ridge width of 50 cm at the previously mentioned hill spacing:

**III- Biofertilizer treatments:**

Biofertilizer treatments were used as follows:

1- Without biofertilizer (control).

2- Inoculation sugar beet seeds with Cerialine (450 g/fad).

3- Inoculation sugar beet seeds with Netrobine (450 g/fad).

4- Applied 90 kg N/fad as a mineral fertilizer.

Sugar beet seeds inoculated with Cerialine and Netrobine directly before sowing.

Cerialine (*Azospirillum brzsilense* and *Bacillus polymyxa*) and Netrobine (*Azotobacter spp* and *Azospirillum spp* ) as commercial products were produced by Biofertilizer Unit, Agriculture Research Center (ARC), Giza, Egypt, which included free-living bacteria able to fix atmospheric nitrogen in the rhizosphere of soil. Nitrogen fertilizer at a rate of 90 kg/fad in the form of urea (46 % N) was applied as a side-dressing in two equal dose, one half after thinning (35 days after sowing) and the other before the third irrigation (70 days after sowing).

The experiments were laid out in split-split plot design with three replications. The main plot were assigned to farmyard manure, sub plots were occupied with plant densities and sub-sub plots were allocated to biofertilizer treatments .Each sub sub-plot area of 10.5 $m^2$ (6 ridges x 0.5 m width x 3.5 m long).

Physical and chemical analysis of the soil experimental site during of 2008/2009 and 2009/2010 seasons are presented in Table 1. Farmyard manure was analyzed before applying in the experiment soil and data are shown in Table 2.

The preceding crop was rice in both seasons. The experimental site was prepared as usual for sugar beet crop. Sugar beet seeds were hand sown on 1st and 5th October in 2008/2009 and 2009/2010 seasons, respectively. Plants were thinned at the age of 30 days from planting to obtain one plant/hill. The common agricultural practices for growing sugar beet according to the recommendations were followed, except the factors under study.

**Table 1: Physical and chemical analysis of soil at the experimental site in 2008/2009 and 2009/2010 seasons:**

| Soil properties | | Season | |
|---|---|---|---|
| **Physical analysis** | | **Season 2009** | **Season 2010** |
| Particle size distribution | Coarse sand, % | 1.99 | 1.88 |
| | Fine sand, % | 8.85 | 9.32 |
| | Silt, % | 22.36 | 22.5 |
| | Clay, % | 66.90 | 66.55 |
| Texture class | | Clay | Clay |
| **Chemical analysis** | | | |
| Organic matter, % | | 0.91 | 0.94 |
| Available phosphorus (ppm) | | 9.32 | 9.47 |
| Available potassium (ppm) | | 194.23 | 198.12 |
| Total nitrogen (ppm) | | 42.34 | 44.52 |
| Electrical conductivity (E.C.ds/$m^2$) | | 3.92 | 3.37 |
| Exchangeable sodium, % | | 8.87 | 8.32 |
| pH | | 7.25 | 7.50 |

**Table 2: Analysis of the farmyard manure (FYM) used in the experiments in 2008/2009 and 2009/2010 seasons:**

| Properties | | 2008/2009 Season | 2009/2010 Season |
|---|---|---|---|
| **pH** | | 08.04 | 07.51 |
| **Electrical conductivity (E.C. ds/$m^2$)** | | 03.27 | 03.12 |
| **Organic matter, % (O. M, %)** | | 10.63 | 10.40 |
| **C/N ratio** | | 12.04 | 11.92 |
| **Total elements (ppm)** | **N** | 00.01 | 00.02 |
| | **P** | 00.27 | 00.30 |
| | **K** | 03.96 | 03.74 |
| **Moisture, %** | | 030.0 | 30.00 |

At harvest time five plants were randomly taken from each plot to estimate the following traits:-

1- Root fresh weight (g).

2- Sucrose percentage: It was estimated by using Sacharimeter set.

3- Purity, %: It was estimated according to the following formula:

$$Purity\% = \frac{Sucrose,\%}{TSS,\%} x100$$

The plants of the three middle ridges of each sub-sub plot were harvested and separated to roots and foliage and the following data were recorded.

4- Top yield/faddan (ton) 5- Root yield/faddan (ton)

6- Sugar yield/faddan (ton): it was calculated by multiplying root yield by root sucrose %.

All data were statistically analyzed according to the technique of analysis of variance (ANOVA) for the split split-plot design by means of "MSTAT-C" Computer software package and least significant difference (LSD) method was used to test the differences between treatment means at 5 % levels of probability, as published by Gomez and Gomez 1984.

## RESULTS AND DISCUSSION

Average of root fresh weight , sucrose % , purity % , top yield/fad, root yield/fad and sugar yield/fad as affected by farmyard manure, plant density, biofertilization treatments and their interaction in 2008/2009 and 2009/2010 seasons are shown in Tables 3-8.

**A- Farm yard manure effects:-**

Results recorded in Tables 3-8 show clearly that farmyard manure had a significant effect on average values of all previously mentioned traits in both seasons. Increasing farmyard manure rates from 0 up to 30 $m^3$/fad gave 47.53 and 48.37%, 38.89 and 51.59 %, 56.97 and 51.37 % as well as 35.49 and 28.74 % increase in root fresh weight, top yield/fad, root yield/fad as well as sugar yield/fad in 2008/2009 and 2009/2010 seasons, respectively. Applying farmyard manure at the rate of 30 $m^3$/fad surpassed 10 and 20 m3/fad in root yield by 32.72 and 10.97% as well as 32.13 and 9.13% and in sugar yield/fad by 22.56 and 4.44 % as well as 19.24 and 2.32 % in 2008/2009 and 2009/2010 seasons, respectively. On the other hand, sucrose % and purity % were significantly decreased with increasing farmyard manure rate in both seasons. The highest values of sucrose % 20.47 and 20.32 as well as purity % 84.72 and 84.35 were recorded without added farmyard manure in 2008/2009 and 2009/2010 seasons, respectively.

The increase in root yield caused by increasing farmyard manure may be attributed to the high of organic matter content farmyard manure increases which serves several advantages like conservation and slow release of nutrients, improvement of soil physical conditions and preservation of soil moisture. These advantages lead to the increase in soil fertility which led in turn to increasing of the productivity of plants. These results are in harmony with those of Mokadem 2000 and Hanackova *et al*. 2008.

**B- Plant density effects:-**

Results recorded in Tables 3-8 show clearly that plant density significantly affected all traits in both seasons. The highest plant density, i.e. 56000 plant/fad gave the highest values of sucrose % 19.34 and 19.05, purity % 83.52 and 82.98, top yield 24.67 and 27.20 tons/fad, root yield 28.26 and 28.05 tons/fad and sugar yield 5.39 and 5.29 tons/fad, while the heaviest root 812.58 and 832.16 g was recorded with the lowest plant density 33600 plant as compared with other plant densities in 2008/2009 and 2009/2010 seasons, respectively.

The increase in yields of root and sugar per faddan by increasing plant density might be attributed to sucrose % produced the adequate root having the highest sucrose % and having the highest number of roots/faddan which gave the heaviest root yield per faddan as well as it gave the highest sugar yield/faddan because sugar yield/faddan is a function of root yield multiplying with sucrose %, therefore it was the superior plant density due to gave the higher yields than the other plant densities used under study. These results are in agreement with those of Abdalla *et al.* 1995 and Bhullar *et al*. 2010.

**C- Biofertilizer treatments effects:-**

Results presented in Tables 3-8 indicate that biofertilizer treatments had a significant effect on all studied characters in both seasons. Applying nitrogen as a mineral fertilizer at a rate of 90 kg/fad gave the highest values of root fresh weight 837.75 and 794.47 g , top yield/fad 25.59 and 29.03 tons, root yield/fad 29.79 and 26.02 tons and sugar yield/fad 5.49 and 5.22 tons as compared with all other biofertilizer treatments, in 2008/2009 and 2009/2010 seasons, respectively. In this connection, the mineral nitrogen followed by cerialine biofertilizer which gave the significant increase of root fresh weight, top yield/fad, root yield/fad and sugar yield/fad compared to notrobine biofertilizer and control in both seasons, but sugar beet plants unfertilized with any fertilizer gave the highest sucrose % 19.57 and 19.37 as well as purity % 84.59 and 84.29 compared to all other biofertilizer treatments in 2008/2009 and 2009/2010 seasons, respectively

The increase in sugar yield due to the mineral nitrogen at a rate of 90 kg /fad may be due to increasing vegetative growth which led to increasing net assimilation rate and increased root growth rate, thus increased root yield per faddan the decrease in sucrose %, therefore sugar yield increased. The increase in sucrose % and purity % caused by unfertilization are in the same line with those obtained by El-Hawary 1999.

**D- Interactions effect:-**

The interaction between farmyard manure rates and plant densities on all studied traits was significant in both seasons. Sowing sugar beat plant at the highest plant density (56000 plant/fad) and fertilized by farmyard manure at the rate of 30 $m^3$/fad gave the highest values of top yield/fad (27.57 and 34.20 tons), root yield/fad (35.30 and 34.69 tons) and sugar yield/fad (6.30 and 6.12 tons) in 2008/2009 and 2009/2010 seasons, respectively. On the other hand, the heaviest root (1061.67 and 983.42 g) was recorded with planting sugar beet at the lowest plant density (33600 plant/fad) and fertilized by 30$m^3$/fad farmyard manure but, the slight root (464.08 and 452.33 g) was found with plants unfertilized and planting at the highest plant density (56000

plant/fad) in 2008/2009 and 2009/2010 seasons, respectively. The highest values of sucrose % (20.75 and 20.44 ) as well as purity % (85.51 and 84.53) were recorded with planting sugar beet at the highest plant density (56000 plant/fad) and wasn't fertilized with farmyard manure in 2008/2009 and 2009/2010 seasons, respectively.

The interaction between farmyard manure rates and biofertilizer treatments had a significant effect on all studied characters in both seasons. Plants grown without received any farmyard manure and biofertilization (control) gave the highest sucrose % (21.26 and 20.90) as well as purity % (87.23 and 87.08), on the other hand the lowest values of sucrose % (17.32 and 17.16) as well as purity % (80.48 and 80.33) were recorded with plants fertilized with farmyard manure at the rate of 30 $m^3$/fad and 90kg /fad in 2008/2009 and 2009/2010 seasons, respectively. The highest values of root fresh weight (1036.11 and 949.33 g), top yield/fad (28.33 and 34.08 tons), root yield/fad (36.89 and 33.96 tons) as well as sugar yield/fad 6.39 and 5.83 tons were found when applied farmyard manure at the rate of 30 m3/fad and applied mineral nitrogen at the rate of 90 kg/fad in 2008/2009 and 2009/2010 seasons, respectively. On the contrary, the lowest values in the same respect were found with plants grown without received farmyard manure and didn't fertilized with any fertilization treatments in both seasons.

The interaction between plant densities and biofertilizer treatments significantly affected all studied traits in both seasons. Planting sugar beet with the highest plant density 56000 plant/fad and received nitrogen fertilizer at a rate of 90 kg /fad gave the highest values of top yield (30.97 and 33.34 tons), root yield/fad (32.21 and 31.47 tons) as well as sugar yield/fad (5.95 and 5.79 tons), while the heaviest root (946.76 and 913.08 g) recorded with the lowest plant density (33600 plant/fad) and 90 kg/fad in 2008/2009 and 2009/2010 seasons, respectively. The highest sucrose % (19.89 and 19.42) as well as purity % (85.08 and 84.47) were found with the highest plant density (56000 plant/fad) and wasn't applied any fertilization compared to all other this interaction treatments in 2008/2009 and 2009/2010 seasons, respectively .

The interaction effect among farmyard manure, plant density and biofertilizer treatments were significant on all studied characters in both seasons. Applied farmyard manure at the rate of 30 $m^3$/fad at the lowest plant density 33600 and fertilized by 90 kg/fad gave the heaviest root (1185.00 and 1085.33 g), but plants received 30 $m^3$/fad farmyard manure at the highest plant density 56000 plant/fad and fertilized by 90 kg/fad gave the highest top yield (33.65 and 39.28 tons), root yield/fad (40.76 and 39.20 tons) as well as sugar yield (7.11 and 6.75 tons) as compared to all other this interaction treatments in 2008/2009 and 2009/2010 seasons, respectively. On the contrary, planting sugar beet plant at the highest plant density (56000 plant/fad) and didn't receive farmyard manure and any fertilization treatments gave the highest sucrose % (21.55 and 20.86) as well as purity % (88.14 and 87.15) as compared to all other treatments in 2008/2009 and 2009/2010 seasons, respectively.

Generally, it could be recommended that applied farmyard manure at the rate of 30 $m^3$/fad for sugar beet plants sown at plant density of 56000

plant/fad and fertilized by 90 kg/fad gave the highest root and sugar yield/fad at North Delta, Damietta Governorate, Egypt.

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## تأثير السماد البلدي والكثافة النباتية والسماد الحيوي على نمو ومحصول بنجر السكر

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أجريت تجربتان حقليتان بمحطة البحوث الزراعية بالسرو بمحافظة دمياط خلال الموسمين الزراعيين 2009/2008 و2010/2009م لدراسة تأثير أربعة معدلات من السماد البلدي (بدون إضافة ،10 ، 20 ، 30 م$^3$/فدان) وثلاث كثافات نباتية ( 56000 ، 42000 ، 33600 نبات/فدان) وأربعة معاملات تسميد حيوي (بدون ، سيريالين ، نتروبين ، 90 كجم ن/فدان كسماد معدني) وكذلك دراسة التفاعل بين هذه المعاملات على نمو ومحصول بنجر السكر. تم استخدام تصميم القطع المنشقة مرتين.وتتلخص أهم النتائج المتحصل عليها فيما يلي:

أوضحت النتائج أن السماد البلدي أثر معنوياً على كل الصفات مثل الوزن الغض للجذر والنسبة المئوية للسكروز والنسبة المئوية للنقاوة ومحصول الجذور للفدان وكذلك محصول السكر للفدان فى كلا الموسمين. وقد أوضحت الدراسة أن زيادة معدل التسميد البلدي أدى إلى زيادة الوزن الغض للجذر ومحصول العرش ومحصول الجذور ومحصول السكر للفدان ، وعلى العكس من ذلك زادت النسبة المئوية للسكروز والنسبة المئوية للنقاوة فى المعاملة بدون تسميد بلدي فى كلا الموسمين.

أوضحت النتائج أن الكثافة النباتية أثرت معنوياً على كل الصفات المدروسة فى كلا الموسمين. أعطت الكثافة النباتية 56000 نبات/فدان أعلى قيم للنسبة المئوية للسكروز والنسبة المئوية للنقاوة ومحصول العرش والجذور والسكر للفدان فى حين أعطت أقل وزن للجذر الغض ، وعلى العكس من ذلك فقد سجلأعلى وزن غض للجذر عند اقل كثافة نباتية 33600 نبات/فدان مقارنة بالكثافات الأخرى فى كلا الموسمين.

أوضحت معاملات التسميد تأثيراً معنوياً على كل الصفات المدروسة فى كلا الموسمين ، أعطي إضافة النيتروجين بمعدل 90 كجم ن/فدان أعلى وزن غض للجذر ومحصول العرش ومحصول الجذور ومحصول السكر للفدان مقارنة بمعاملات التسميد الأخرى فى كلا الموسمين كما أظهرت النتائج أن السماد الحيوي سيريالين تلى السماد المعدني فى كل الصفات المدروسة.

وقد كان للتفاعل بين كل عوامل الدراسة تأثيراً معنوياً على كل الصفات المدروسة فى كلا الموسمين. أعطت إضافة 30 م$^3$ سماد بلدي للفدان مع كثافة نباتية 56000 نبات/فدان والتسميد بـ 90 كجم ن/فدان أعلى محصول عرش للفدان 33.65 و 39.28 طن ، ومحصول جذور للفدان 40.76 و 39.20 طن وكذلك محصول سكر/فدان 7.11 و 6.75 طن مقارنة بكل المعاملات الأخرى فى الموسمين 2009/2008 و 2010/2009 على التوالي.

وعموماً توصى الدراسة أن إضافة سماد بلدي بمعدل 30 م$^3$ للفدان مع كثافة نباتية 56000 نبات/فدان مع إضافة 90 كجم ن للفدان أعطت أعلى محصول جذور ومحصول سكر للفدان من بنجر السكر فى منطقة شمال الدلتا - محافظة دمياط.

**قام بتحكيم البحث**

| | |
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**Table 3: Average of root fresh weight (g) of sugar beet as affected by farmyard manure, plant density, biofertilizer treatments and their interaction in 2008/2009 and 2009/2010 seasons.**

| Farmyard manure ($m^3$/fad) (A) | Plant density (B) | 2008/2009 Season | | | | Mean | 2009/2010 Season | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Biofertilizer treatments (C) | | | | | Biofertilizer treatments (C) | | | | |
| | | Zero | Cer. | Net. | 90kg /fad | | Zero | Cer. | Net. | 90kg/fad | |
| (0) without | 56000 | 378.33 | 481.67 | 440.00 | 557.00 | 464.08 | 379.33 | 481.67 | 440.00 | 508.33 | 452.33 |
| | 42000 | 480.00 | 591.67 | 540.00 | 651.67 | 565.67 | 453.33 | 610.00 | 537.00 | 661.67 | 565.50 |
| | 33600 | 646.66 | 725.33 | 686.33 | 783.67 | 710.50 | 598.33 | 718.33 | 683.33 | 753.33 | 688.33 |
| | Mean | 501.66 | 599.56 | 555.44 | 783.33 | 610.00 | 473.10 | 603.33 | 553.44 | 641.00 | 567.72 |
| 10 | 56000 | 462.67 | 554.00 | 523.33 | 664.0 | 551.00 | 471.00 | 540.66 | 525.00 | 589.33 | 531.50 |
| | 42000 | 577.00 | 675.00 | 640.00 | 653.33 | 636.33 | 583.33 | 672.33 | 639.67 | 750.00 | 661.33 |
| | 33600 | 745.00 | 837.33 | 817.67 | 746.67 | 786.67 | 691.67 | 782.67 | 750.00 | 841.00 | 766.33 |
| | Mean | 594.89 | 688.78 | 660.33 | 961.66 | 726.41 | 582.00 | 665.22 | 638.22 | 726.78 | 636.05 |
| 20 | 56000 | 615.00 | 678.00 | 648.33 | 787.22 | 682.13 | 615.00 | 677.33 | 655.00 | 759.67 | 676.75 |
| | 42000 | 753.67 | 773.00 | 756.67 | 784.67 | 767.00 | 680.00 | 792.67 | 746.00 | 849.66 | 767.08 |
| | 33600 | 880.00 | 943.00 | 926.67 | 1071.67 | 955.33 | 834.00 | 888.00 | 876.67 | 973.00 | 892.92 |
| | Mean | 749.56 | 798.00 | 777.22 | 935.34 | 815.03 | 709.67 | 786.00 | 759.22 | 860.78 | 778.92 |
| 30 | 56000 | 686.67 | 737.67 | 728.33 | 873.33 | 756.50 | 676.67 | 736.00 | 711.67 | 840.00 | 741.08 |
| | 42000 | 800.00 | 850.00 | 826.67 | 1050.00 | 881.67 | 763.33 | 820.00 | 794.67 | 922.67 | 825.17 |
| | 33600 | 961.67 | 1070.00 | 1030.00 | 1185.00 | 1061.67 | 933.33 | 973.33 | 941.67 | 1085.33 | 983.42 |
| | Mean | 816.11 | 885.89 | 861.67 | 1036.11 | 899.95 | 761.11 | 843.11 | 816.00 | 949.33 | 812.39 |
| General means of plant density | 56000 | 535.67 | 612.83 | 585.00 | 717.08 | 612.64 | 535.50 | 608.91 | 582.92 | 674.33 | 600.41 |
| | 42000 | 652.67 | 722.42 | 690.83 | 849.50 | 728.85 | 620.00 | 723.75 | 679.33 | 796.00 | 704.77 |
| | 33600 | 808.33 | 893.91 | 865.17 | 946.76 | 812.58 | 762.08 | 840.58 | 812.92 | 913.08 | 832.16 |
| General means | | 665.56 | 743.05 | 713.67 | 837.75 | 743.44 | 639.19 | 724.41 | 691.72 | 794.47 | 676.84 |

| L S D at 5 % for: | | | |
|---|---|---|---|
| Farmyard manure | (A) | 10.74 | 7.07 |
| Plant density | (B) | 6.74 | 7.64 |
| Biofertilizer treatments | (C) | 8.35 | 6.79 |
| | (AxB) | 13.49 | 15.28 |
| | (AxC) | 16.70 | 13.57 |
| | (BxC) | 10.33 | 11.76 |
| | (AxBxC) | 28.39 | 23.51 |

**Table 4: Average sucrose percentage of sugar beet as affected by farmyard manure, plant density, biofertilizer treatments and their interaction in 2008/2009 and 2009/2010 seasons.**

| Farmyard manure ($m^3$/fad) (A) | Plant density (B) | 2008/2009 Season | | | | Mean | 2009/2010 Season | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Biofertilizer treatments (C) | | | | | Biofertilizer treatments (C) | | | | |
| | | Zero | Cer. | Net. | 90kg /fad | | Zero | Cer. | Net. | 90kg/fad | |
| (0) without | 56000 | 21.55 | 20.65 | 21.11 | 19.70 | 20.75 | 20.86 | 20.47 | 20.83 | 19.61 | 20.44 |
| | 42000 | 21.30 | 20.35 | 20.66 | 19.40 | 20.43 | 20.81 | 2.30 | 20.65 | 19.35 | 20.29 |
| | 33600 | 20.93 | 20.19 | 20.50 | 19.25 | 20.22 | 20.70 | 20.18 | 20.50 | 19.22 | 20.21 |
| | Mean | 21.26 | 20.40 | 20.76 | 19.45 | 20.47 | 20.90 | 20.32 | 20.66 | 19.39 | 20.32 |
| 10 | 56000 | 20.00 | 19.70 | 20.06 | 18.98 | 19.68 | 19.83 | 19.33 | 19.50 | 18.84 | 19.37 |
| | 42000 | 19.83 | 19.31 | 19.73 | 18.85 | 19.43 | 19.75 | 19.18 | 19.38 | 18.70 | 19.25 |
| | 33600 | 19.70 | 19.22 | 19.55 | 18.70 | 19.19 | 19.61 | 19.08 | 19.30 | 18.60 | 19.15 |
| | Mean | 19.84 | 19.41 | 19.75 | 18.84 | 19.44 | 19.73 | 19.20 | 19.39 | 18.71 | 19.26 |
| 20 | 56000 | 19.00 | 18.93 | 19.09 | 18.45 | 18.87 | 18.90 | 18.69 | 18.89 | 18.38 | 18.71 |
| | 42000 | 18.90 | 18.80 | 18.98 | 18.11 | 18.70 | 18.89 | 18.58 | 18.77 | 18.18 | 18.60 |
| | 33600 | 18.82 | 18.71 | 18.90 | 18.02 | 18.61 | 18.83 | 18.40 | 18.67 | 18.01 | 18.48 |
| | Mean | 18.91 | 18.81 | 18.99 | 18.19 | 18.72 | 18.94 | 18.55 | 18.76 | 18.19 | 18.61 |
| 30 | 56000 | 18.18 | 17.81 | 18.00 | 17.45 | 17.83 | 18.10 | 17.50 | 17.90 | 17.23 | 17.68 |
| | 42000 | 17.96 | 17.60 | 17.95 | 17.30 | 17.69 | 17.95 | 17.30 | 17.81 | 17.15 | 17.55 |
| | 33600 | 17.82 | 17.41 | 17.88 | 17.22 | 17.53 | 17.85 | 17.18 | 17.70 | 17.10 | 17.61 |
| | Mean | 18.00 | 17.61 | 17.94 | 17.32 | 17.68 | 17.97 | 17.33 | 17.80 | 17.16 | 17.56 |
| General means of plant density | 56000 | 19.89 | 19.27 | 19.56 | 18.64 | 19.34 | 19.42 | 19.00 | 19.28 | 18.51 | 19.05 |
| | 42000 | 19.49 | 19.01 | 19.33 | 18.41 | 19.06 | 19.37 | 18.91 | 19.15 | 18.34 | 18.94 |
| | 33600 | 19.32 | 18.87 | 19.21 | 18.30 | 18.92 | 19.31 | 18.71 | 19.04 | 18.23 | 18.82 |
| General means | | 19.57 | 19.05 | 19.37 | 18.45 | 19.11 | 19.37 | 18.87 | 19.16 | 18.36 | 18.94 |

| L S D at 5 % for: | | | |
|---|---|---|---|
| Farmyard manure | (A) | 0.03 | 0.02 |
| Plant density | (B) | 0.02 | 0.01 |
| Biofertilizer treatments | (C) | 0.03 | 0.03 |
| | (AxB) | 0.05 | 0.02 |
| | (AxC) | 0.05 | 0.03 |
| | (BxC) | 0.05 | 0.03 |
| | (AxBxC) | 0.09 | 0.06 |

**Table 5: Average purity percentage of sugar beet as affected by farmyard manure, plant density, biofertilizer treatments and their interaction in 2008/2009 and 2009/2010 seasons.**

| Farmyard manure ($m^3$/fad) (A) | Plant density (B) | 2008/2009 Season | | | | Mean | 2009/2010 Season | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Biofertilizer treatments (C) | | | | | Biofertilizer treatments (C) | | | | |
| | | Zero | Cer. | Net. | 90kg /fad | | Zero | Cer. | Net. | 90kg/ fad | |
| (0) without | 56000 | 88.14 | 84.95 | 85.20 | 83.77 | 85.51 | 87.15 | 83.78 | 84.71 | 82.48 | 84.53 |
| | 42000 | 87.29 | 84.40 | 84.61 | 82.60 | 84.72 | 87.09 | 83.60 | 84.40 | 82.30 | 84.35 |
| | 33600 | 86.27 | 83.50 | 83.69 | 82.20 | 83.91 | 87.01 | 83.42 | 84.15 | 82.11 | 84.17 |
| | Mean | 87.23 | 84.28 | 84.50 | 82.68 | 84.72 | 87.08 | 83.60 | 84.42 | 82.30 | 84.35 |
| 10 | 56000 | 85.90 | 84.11 | 84.98 | 82.85 | 84.46 | 84.81 | 84.18 | 84.29 | 82.20 | 83.87 |
| | 42000 | 85.18 | 83.75 | 84.30 | 82.29 | 83.88 | 84.43 | 83.70 | 84.13 | 82.09 | 83.59 |
| | 33600 | 85.04 | 83.20 | 83.91 | 82.08 | 83.56 | 84.30 | 83.19 | 84.03 | 81.97 | 83.37 |
| | Mean | 85.37 | 83.69 | 84.40 | 82.41 | 83.97 | 84.51 | 83.69 | 84.15 | 82.09 | 83.61 |
| 20 | 56000 | 85.09 | 82.20 | 82.87 | 81.12 | 82.54 | 83.63 | 81.80 | 82.28 | 80.65 | 82.09 |
| | 42000 | 83.70 | 82.04 | 82.70 | 80.93 | 82.34 | 83.41 | 81.61 | 82.17 | 80.41 | 81.90 |
| | 33600 | 83.11 | 81.98 | 82.40 | 80.78 | 82.07 | 83.23 | 81.48 | 82.08 | 80.23 | 81.75 |
| | Mean | 83.59 | 82.07 | 82.66 | 80.94 | 82.31 | 83.42 | 81.63 | 82.18 | 80.43 | 81.91 |
| 30 | 56000 | 82.31 | 81.41 | 81.89 | 80.71 | 81.58 | 82.28 | 81.19 | 81.80 | 80.50 | 81.44 |
| | 42000 | 82.16 | 81.12 | 81.65 | 80.44 | 81.34 | 82.12 | 81.07 | 81.63 | 80.33 | 81.29 |
| | 33600 | 82.06 | 81.02 | 81.48 | 80.28 | 81.21 | 82.01 | 81.00 | 81.40 | 80.16 | 81.14 |
| | Mean | 82.18 | 81.18 | 81.67 | 80.48 | 81.38 | 82.14 | 81.09 | 81.61 | 80.33 | 81.29 |
| General means of plant density | 56000 | 85.08 | 83.17 | 83.73 | 82.11 | 83.52 | 84.47 | 82.74 | 83.27 | 81.46 | 82.98 |
| | 42000 | 84.58 | 82.83 | 83.31 | 81.56 | 83.07 | 84.26 | 82.49 | 83.08 | 81.28 | 82.78 |
| | 33600 | 84.12 | 82.42 | 82.87 | 81.33 | 82.68 | 84.14 | 82.27 | 82.91 | 81.12 | 82.61 |
| General means | | 84.59 | 82.81 | 83.30 | 81.67 | 83.09 | 84.29 | 82.50 | 83.09 | 81.29 | 82.79 |

| L S D at 5 % for: | | | |
|---|---|---|---|
| Farmyard manure | (A) | 0.023 | 0.18 |
| Plant density | (B) | 0.18 | 1.08 |
| Biofertilizer treatments | (C) | 0.20 | 0.1 |
| | (AxB) | 0.035 | 2.17 |
| | (AxC) | 0.40 | 2.35 |
| | (BxC) | 0.35 | 0.30 |
| | (AxBxC) | 0.69 | 4.07 |

**Table 6: Average top yield per faddan (ton) of sugar beet as affected by farmyard manure, plant density, biofertilizer treatments and their interaction in 2008/2009 and 2009/2010 seasons.**

| Farmyard manure ($m^3$/fad)(A) | Plant density (B) | 2008/2009 Season | | | | Mean | 2009/2010 Season | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Biofertilizer treatments (C) | | | | | Biofertilizer treatments (C) | | | | |
| | | Zero | Cer. | Net. | 90kg /fad | | Zero | Cer. | Net. | 90kg/fad | |
| (0) without | 56000 | 13.49 | 19.94 | 18.90 | 27.63 | 19.99 | 16.88 | 21.78 | 19.41 | 27.92 | 21.50 |
| | 42000 | 11.64 | 16.72 | 15.85 | 22.22 | 16.61 | 14.82 | 19.89 | .17.85 | 23.92 | 19.12 |
| | 33600 | 11.44 | 15.10 | 13.93 | 18.40 | 14.72 | 12.20 | 17.90 | 17.17 | 20.77 | 17.01 |
| | Mean | 12.19 | 17.25 | 16.23 | 22.75 | 17.11 | 14.63 | 19.86 | 18.14 | 24.20 | 19.21 |
| 10 | 56000 | 18.53 | 24.30 | 23.77 | 30.75 | 24.34 | 20.42 | 27.25 | 25.82 | 30.64 | 26.03 |
| | 42000 | 16.72 | 21.48 | 20.93 | 24.42 | 20.89 | 17.20 | 25.02 | 23.78 | 27.81 | 23.45 |
| | 33600 | 12.70 | 16.34 | 15.72 | 19.56 | 16.08 | 15.26 | 19.91 | 18.88 | 22.77 | 19.20 |
| | Mean | 15.98 | 20.71 | 20.14 | 24.91 | 20.43 | 17.63 | 24.06 | 22.83 | 27.07 | 22.90 |
| 20 | 56000 | 22.98 | 26.60 | 25.70 | 31.86 | 26.78 | 23.02 | 31.42 | 29.87 | 35.51 | 29.95 |
| | 42000 | 17.80 | 22.88 | 22.08 | 25.23 | 22.00 | 20.00 | 27.30 | 25.55 | 31.28 | 26.03 |
| | 33600 | 14.85 | 18.99 | 18.41 | 22.07 | 18.58 | 17.22 | 22.96 | 22.12 | 25.53 | 21.96 |
| | Mean | 18.54 | 22.82 | 22.07 | 26.39 | 22.45 | 20.08 | 27.23 | 25.85 | 30.77 | 25.98 |
| 30 | 56000 | 22.15 | 27.63 | 26.85 | 33.65 | 27.57 | 26.83 | 36.09 | 34.61 | 39.28 | 34.20 |
| | 42000 | 19.51 | 24.63 | 24.25 | 27.82 | 24.05 | 21.23 | 30.33 | 28.76 | 33.48 | 24.45 |
| | 33600 | 16.26 | 19.46 | 19.32 | 23.54 | 19.64 | 17.57 | 26.46 | 25.26 | 29.49 | 23.20 |
| | Mean | 19.31 | 23.90 | 23.47 | 28.33 | 23.76 | 21.88 | 30.96 | 29.54 | 34.08 | 29.12 |
| General means of plant density | 56000 | 19.28 | 24.62 | 23.80 | 30.97 | 24.67 | 21.79 | 29.13 | 24.43 | 33.34 | 27.20 |
| | 42000 | 16.42 | 21.42 | 20.78 | 24.92 | 20.89 | 18.32 | 25.64 | 23.98 | 29.12 | 24.26 |
| | 33600 | 13.81 | 17.47 | 16.85 | 20.89 | 17.26 | 16.48 | 22.77 | 20.86 | 24.64 | 21.19 |
| General means | | 16.50 | 21.17 | 20.48 | 25.59 | 20.94 | 18.86 | 25.85 | 23.09 | 29.03 | 24.21 |

| L S D at 5 % for: | | | |
|---|---|---|---|
| Farmyard manure | (A) | 0.31 | 0.06 |
| Plant density | (B) | 0.13 | 0.26 |
| Biofertilizer treatments | (C) | 0.14 | 0.23 |
| | (AxB) | 0.27 | 0.51 |
| | (AxC) | 0.29 | 0.48 |
| | (BxC) | 0.25 | 0.41 |
| | (AxBxC) | 0.50 | 0.83 |

**Table 7: Average root yield per faddan (ton) of sugar beet as affected by farmyard manure, plant density, biofertilizer treatments and their interaction in 2008/2009 and 2009/2010 seasons.**

| Farmyard manure ($m^3$/fad) (A) | Plant density (B) | 2008/2009 Season | | | | Mean | 2009/2010 Season | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Biofertilizer treatments (C) | | | | | Biofertilizer treatments (C) | | | | |
| | | Zero | Cer. | Net. | 90kg/ fad | | Zero | Cer. | Net. | 90kg/fad | |
| (0) without | 56000 | 17.66 | 22.34 | 20.81 | 23.99 | 21.20 | 17.70 | 22.48 | 20.93 | 23.92 | 21.11 |
| | 42000 | 16.800 | 20.708 | 19.14 | 23.57 | 20.31 | 16.83 | 21.35 | 18.98 | 23.49 | 19.80 |
| | 33600 | 16.31 | 20.31 | 18.70 | 23.33 | 19.66 | 16.47 | 20.09 | 18.56 | 23.33 | 19.26 |
| | Mean | 16.92 | 21.45 | 19.55 | 23.50 | 20.36 | 17.00 | 21.30 | 19.49 | 23.58 | 20.05 |
| 10 | 56000 | 21.59 | 25.89 | 24.42 | 27.49 | 24.85 | 21.98 | 25.23 | 24.50 | 27.50 | 24.80 |
| | 42000 | 21.00 | 23.62 | 22.91 | 26.13 | 23.42 | 20.42 | 23.53 | 22.39 | 27.25 | 23.40 |
| | 33600 | 20.66 | 23.44 | 22.89 | 23.43 | 22.61 | 19.37 | 21.92 | 21.00 | 23.55 | 21.47 |
| | Mean | 21.08 | 24.32 | 23.41 | 25.68 | 24.08 | 20.59 | 23.56 | 22.63 | 26.10 | 22.97 |
| 20 | 56000 | 28.70 | 31.64 | 30.11 | 36.62 | 31.77 | 28.70 | 31.61 | 30.57 | 35.45 | 31.58 |
| | 42000 | 24.74 | 27.05 | 26.48 | 33.24 | 27.88 | 23.80 | 27.73 | 26.11 | 29.74 | 26.85 |
| | 33600 | 24.64 | 26.40 | 25.95 | 30.00 | 26.75 | 23.35 | 24.86 | 24.55 | 27.24 | 25.00 |
| | Mean | 26.03 | 28.37 | 27.51 | 33.29 | 28.80 | 25.28 | 28.07 | 27.07 | 30.81 | 27.81 |
| 30 | 56000 | 32.04 | 34.42 | 33.99 | 40.76 | 35.30 | 31.58 | 34.77 | 33.21 | 39.20 | 34.69 |
| | 42000 | 28.00 | 29.75 | 28.93 | 36.75 | 30.86 | 26.72 | 29.050 | 27.81 | 32.29 | 28.97 |
| | 33600 | 26.93 | 29.96 | 28.84 | 33.18 | 29.73 | 26.13 | 27.25 | 26.37 | 30.39 | 27.53 |
| | Mean | 28.98 | 31.29 | 30.59 | 36.89 | 31.96 | 28.14 | 30.36 | 29.13 | 33.96 | 30.35 |
| General means of plant density | 56000 | 25.00 | 28.57 | 27.26 | 32.21 | 28.26 | 24.99 | 28.52 | 27.20 | 31.47 | 28.05 |
| | 42000 | 22.63 | 25.28 | 24.31 | 29.67 | 25.47 | 21.70 | 25.42 | 23.78 | 28.11 | 24.75 |
| | 33600 | 22.58 | 25.03 | 24.22 | 27.49 | 24.83 | 21.40 | 23.53 | 22.76 | 18.75 | 21.61 |
| General means | | 23.40 | 26.29 | 25.26 | 29.79 | 20.19 | 22.70 | 25.82 | 24.58 | 26.02 | 24.31 |

| L S D at 5 % for: | | | |
|---|---|---|---|
| Farmyard manure | (A) | 0.24 | 0.33 |
| Plant density | (B) | 0.21 | 0.36 |
| Biofertilizer treatments | (C) | 0.32 | 0.31 |
| | (AxB) | 0.42 | 0.71 |
| | (AxC) | 0.64 | 0.63 |
| | (BxC) | 0.55 | 0.54 |
| | (AxBxC) | 1.11 | 0.58 |

**Table 8: Average sugar yield per faddan (ton) of sugar beet as affected by farmyard manure, plant density, biofertilizer treatments and their interaction in 2008/2009 and 2009/2010 seasons.**

| Farmyard manure ($m^3$/fad) (A) | Plant density (B) | 2008/2009 Season | | | | Mean | 2009/2010 Season | | | | Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Biofertilizer treatments (C) | | | | | Biofertilizer treatments (C) | | | | |
| | | Zero | Cer. | Net. | 90kg /fad | | Zero | Cer. | Net. | 90kg/fad | |
| (0) without | 56000 | 3.80 | 4.61 | 4.39 | 4.73 | 4.38 | 3.69 | 4.60 | 4.36 | 4.69 | 4.34 |
| | 42000 | 3.72 | 4.42 | 3.95 | 4.57 | 4.17 | 3.50 | 4.33 | 3.92 | 4.54 | 4.07 |
| | 33600 | 3.41 | 4.10 | 3.83 | 4.49 | 3.96 | 3.41 | 4.05 | 3.81 | 4.48 | 3.94 |
| | Mean | 3.64 | 4.38 | 4.06 | 4.60 | 4.17 | 3.53 | 4.32 | 4.12 | 4.57 | 4.14 |
| 10 | 56000 | 4.32 | 5.10 | 4.90 | 5.22 | 4.88 | 4.36 | 4.88 | 4.78 | 5.18 | 4.80 |
| | 42000 | 4.16 | 4.56 | 4.52 | 4.93 | 4.54 | 4.03 | 4.51 | 4.34 | 5.09 | 4.50 |
| | 33600 | 4.07 | 4.51 | 4.48 | 4.59 | 4.41 | 3.80 | 4.18 | 4.05 | 4.38 | 4.10 |
| | Mean | 4.18 | 4.72 | 4.63 | 4.91 | 4.61 | 4.06 | 4.52 | 4.39 | 4.89 | 4.47 |
| 20 | 56000 | 5.45 | 6.00 | 5.75 | 6.76 | 5.99 | 5.42 | 5.97 | 5.77 | 6.52 | 5.92 |
| | 42000 | 4.92 | 5.08 | 5.03 | 6.02 | 5.26 | 4.49 | 5.15 | 4.90 | 5.41 | 4.99 |
| | 33600 | 4.64 | 4.94 | 4.91 | 5.41 | 4.97 | 4.42 | 4.65 | 4.58 | 4.91 | 4.64 |
| | Mean | 5.00 | 5.34 | 5.23 | 6.06 | 5.41 | 4.78 | 5.26 | 5.09 | 5.61 | 5.18 |
| 30 | 56000 | 5.82 | 6.13 | 6.12 | 7.11 | 6.30 | 5.71 | 6.08 | 5.94 | 6.75 | 6.12 |
| | 42000 | 4.95 | 5.24 | 5.19 | 6.36 | 5.43 | 4.80 | 5.03 | 4.95 | 5.54 | 5.08 |
| | 33600 | 4.80 | 5.22 | 5.16 | 5.71 | 5.22 | 4.66 | 4.68 | 4.67 | 5.20 | 4.80 |
| | Mean | 5.19 | 5.53 | 5.49 | 6.39 | 5.65 | 5.06 | 5.26 | 5.19 | 5.83 | 5.33 |
| General means of plant density | 56000 | 4.85 | 5.46 | 5.29 | 5.95 | 5.39 | 4.80 | 5.38 | 5.21 | 5.79 | 5.29 |
| | 42000 | 4.44 | 4.82 | 4.67 | 5.47 | 4.85 | 4.21 | 4.76 | 4.53 | 5.15 | 4.66 |
| | 33600 | 3.21 | 4.69 | 4.59 | 5.05 | 4.39 | 4.07 | 4.39 | 4.28 | 4.74 | 4.37 |
| General means | | 4.17 | 5.08 | 4.85 | 5.49 | 4.90 | 4.36 | 4.84 | 4.67 | 5.22 | 4.77 |

| L S D at 5 % for: | | | |
|---|---|---|---|
| Farmyard manure | (A) | 0.07 | 0.26 |
| Plant density | (B) | 0.04 | 0.20 |
| Biofertilizer treatments | (C) | 0.06 | 0.20 |
| | (AxB) | 0.08 | 0.40 |
| | (AxC) | 0.12 | 0.40 |
| | (BxC) | 0.11 | 0.30 |
| | (AxBxC) | 0.21 | 0.25 |