Integration Between Bio, Organic and Mineral Nitrogen Fertilization and its Effect on Growth, Fruit Yield and Quality of Tomato *(Solanum lycopersicon* L.*)*

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Abstract

Two field experiment were carried out in the Experimental Farm of Sids Horticulture Research Station Beni-Sueif Governorate in summer seasons of 2011 and 2012 to study the response of tomato plants cv. (strain B) to microbein inoculation treatments, i.e. without , one dose at the time of transplanting or two doses at the time of transplanting and 20 days later and nitrogen fertilizer at the rates of 60, 80, 100 and 120Kg N/ fed combined with organic manure as compost at the rate of 4, 6, 8 and 10 t / fed. The obtained results showed that inoculation with microbein at two doses improved plant height, number of branches, plant dry weight, total chlorophyll, N, P and K contents of leaves, total fruit yield and its components, fruit dry matter percentage, fruit length and diameter, fruit thickness and TSS% in the two growing seasons, and also it increased Vit. C in the first season, as compared to one dose or control treatments.

Nitrogen application at the rate of 100Kg N/ fed combined with compost at the rate of 8 t /fed gave the highest values of all studied characters in the two seasons. The interaction between biofertilization and nitrogen fertilizer combined with compost treatments showed that inoculation with microbein at two doses and nitrogen at the rate of 100 Kg N/ fed + compost at the rate of 8 t /fed increased the values of all the studied characters in the two seasons.

Accordingly, inoculation of tomato cv. "strain B" seedlings with microbein with two doses as just before transplanting and 20 days from transplanting and fertilizing with nitrogen at the rate of 100 Kg N/ fed combined with compost at the rate of 8 t / fed could be recommended to obtain the best results.

Keywords: Tomato (Solanum *lycopersicon* L.), bio, organic and nitrogen fertilizer

Introduction

Tomato (*Solanum lycopersicon* L.) is one of the most important vegetable crops grown in large areas in Egypt through out the year for local markets, processing and exportation. Increasing tomato production is a wide aim that can be attained throughout many pathways as favorable fertilizer requirements. Nitrogenous mineral fertilizer is commonly used, but with application of such fertilizer to the soil, some problems could be arise, e.g., some nitrogen could be lost via nitrate reduction, denitrification and /or ammonia volatilization. In addition, some nitrogen can be evaporated from soil surface and leached through under ground water, causing environmental pollution (Hewedy, 1999). Recently the use of biofertilizers is of particular interest to avoid the previously mentioned problems. Moreover, microorganisms which are used as a biofertilizers induce stimulative effect on plant growth and production by fixing atmospheric nitrogen in a free living state, biofertilizers as Azotobacter and Azospirillum produce a product free from the residual of some chemical compounds, biofertilizers also secreting growth promoting factors, e.g, gibberellin, cytokinine like substances and auxin, (Saber, 1996). El- Haddad *et al* (1993) mentioned that using biofertilizers , is considered promising alternative for chemical fertilizers in the Egyptian soils. Nowadays, attention was focused on the use of organic manure instead of chemical fertilizers to produce healthy and clean vegetables crops. Moreover, organic fertilizers could improve the soil texture and this in-turn can encourage a good root development through improving the aeration of the soil. Such improving conditions of the soil could lead to higher yield and good quality.

Many investigators reported the importance of biofertilizers in increasing growth of tomatoes (Terry *et al*, 2002; Bhart and Prasad (2004) and Alfanso et al, 2005). Moreover, Sethi and Adhikary (2009) mentioned that inoculation with Azotobacter strains gave the highest biomass, plant height, leaf and flower numbers of tomato, eggplant and pepper seedlings over the control.

Concerning biofertilization, it was reported that chemical composition was increased positively with biofertilizers inoculation of tomato plants (El-Zeny, 2007)

The effect of inoculation with biofertilizers on tomato fruit yield and its components was studied by Tanaka *et al* (2003) who reported that foliar application with biofertilizer combined with micronutrients produced higher number of fruits per plant of tomato plants. Abou – Aly (2005) stated that foliar application with yeast either alone or with Azospirillum Lipoferum and Bacillus megaterium recorded the maximum fruit yield of tomatoes. Anter *et al* (2011) indicated that highest fruit yield was obtained by inoculating tomato seedlings with Dactylaria brochopaga + (Pseudomonas spp + Bacillus megatherium), Bacillus megatherium, Bacillus vercalane and green alga.

Some researchers reported that biofertilizers enhanced fruit quality of tomato plants [Terry *et al*. (2005) and Mohan (2011)].

Some studies were carried out on the effect of nitrogen fertilization on vegetative growth parameters of tomatoes, Olasantan (2000); Scholberg *et al* (2000) and Ahmed and Morsy (2005) mentioned that applying N at the rate of 200 Kg N/fed increased plant

height, number of branches and leaf area index of tomato plants.

The best results in chemical composition as well as improving tomatoes were obtained by using nitrogen fertilizer (Csemi *et al.*, 2008 and Tang Ming Yao *et al.*, 2010).

Several works have been attracted by the effect of nitrogen chemical fertilizer on tomato fruit yield and its components. Khalil *et al.* (2001) found that application of ammonium sulfate at the rate of 150 Kg/ ha + 100 Kg P_2O_5 /ha + 50 Kg K_2O / ha increased fruit weight, weight of total fruits per plant and fruit yield /ha of tomato plants. Singh (2005) showed that the highest fruit yield was obtained by nitrogen application at the rate of 250 kg N/fed combined with plant spacing 75x50 cm of tomatoes. Abdel- Aziz (2008) and Tibebu Tesfay *et al.* (2011) concluded that clay pot irrigation plus N application produced greater fruit yield and marketable yield of tomatoes.

Application of nitrogen fertilizer is traditionally used by some investigators for increasing fruit quality of tomatoes (Ahmed and Morsy, 2005; Min and Shiwei Ming, 2009 and Jiang- Hui Min et al, 2010).

Some investigators found that there were significant differences among the tested organic manures on tomato for plant growth (El-Araby and Feleafel, 2003 and Diaz- Perez *et al.*, 2008).

With respect to plant chemical contents, Parrary *et al.* (2007) and Rao and Sankar (2007) they mentioned that organic manures improved chlorophyll , carotenoide, N, P and K uptake by tomato plants.

There are many reports on tomatoes showing the important effect of organic manures which increased fruit yield and its components of tomato plants, Lin ChumHua (2000); Prabakaran (2008) and YangLi Juan *et al.* (2010) stated that applied food waste compost produced higher fruit diameter and total yield. Positive results on fruit quality were obtained by Parrary *et al.* (2007) and Yang Li Juan (2010) they indicated that applying organic manures increased fruit quality of tomato plants.

Regarding the interaction effect of biofertilizers, nitrogen fertilization and organic manures on fruit yield, Selim *et al.* (2007) and Singh *et al.* (2008) found that inoculation with biofertilizers plus adding NPK in presence of organic manures increased fruit yield of tomatoes. Chanada *et al.* (2011) showed that applied of vermicompost supplemented with N.P.K. improved greater fruit yield of tomato plants.

This study was conducted to investigate the response of tomato cv. "Strain B" to inoculation with microbien and in combination between nitrogen fertilization and organic manure "compost" under Sids Horticulture Research Station condition.

Materials and Methods

This work was carried out at Sids Horticulture Research Station Farm, Beni- Sueif Governorate, Horticulture Research Institute during the two successive summer seasons of 2011and 2012 to investigate the effect of inoculation with the biofertilizer "microbein", mineral nitrogen fertilization combined with organic manure "compost" on growth, chemical composition, productivity and quality of tomato cv. "Strain B". The chemical and physical properties were determined in soil according to Wilde et al (1985) as shown in Table (1).

Table(1): The physical and chemical characteristics of the soil experimental site.

Physical properties	Values	
	First season	Second season
Sand %	16.72	18.10
Silt %	26.36	23.88
Clay %	56.92	58.02
Texture grade	Clay loam	Clay loam
Chemical analysis :		
PH (1: 2.5 soil-water)	7.8	8.1
E.C (m. mhos/cm at 25°c)	0.61	0.67
Organic matter %	1.80	2.00
Available N ppm	22.50	24.20
Available P ppm	15.49	12.80
Available K ppm	310.70	322.12
Ca Co_3 %	1.8	2.1

The chemical analysis of Nile compost used in this experiment is shown in Table (2).

Table (2): Chemical analysis of the used Nile compost.

Characters		Values
M^3 weight (kg)		450
Moisture	**%**	25
pH(1:10 extract)		8.2
EC ds/m (extract)		5.5
Total nitrogen	**%**	1.6
O.M.	**%**	44
Organic carbon	**%**	25.5
C/N ratio		16.5:1
Total phophorus	**%**	0.60
Total potassium	**%**	1.6
Available Fe	**ppm**	1750
Available Cu	**ppm**	200
Available Mn	**ppm**	125
Available Zn	**ppm**	60

Tomato seeds were sown on February 15th and 17th in nursery in the two growing seasons respectively. Transplanting was carried out 45 days after seed sowing. Transplants were set 30 cm apart in one side of ridges.

The experiment included 12 treatments of inoculation with microbien and nitrogen fertilization combined with compost as follows:

1- Inoculation with microbien ,i.e., with out, one dose and two doses.
2- Nitrogen fertilization at the rates of 60 ,80 ,100 and 120 Kg N/fed. combined with compost at the rates of 4 ,6, 8 and 10 t/ fed.

Nitrogen was applied in the form of ammonium nitrate (33.5% N).The nitrogen at the rate of 120 Kg N/fed (full amount of recommended dose) was considered as the control treatment.

The efficiency of microbien in peat growth media containing 28-32× 10^8 cells/100 gm peat were obtained from Microbiology Dept., Agriculture Research Center, Ministry of Agriculture. The bacteria growth media was used at a rate of 500 gm/fed

dissolved in 3 litter water with 100 g Arabic gum and the tomato root seedlings were dipped in this suspension 5 minutes before transplanting. Microbien was applied once just before transplanting and /or twice, i.e., just before transplanting and 20 days later.

Nitrogen fertilizer was added in two equal doses at 20 and 45 days after transplanting. Compost was applied during the soil preparation.

The treatments of the experiment were arranged in a split plot design with four replications. Inoculation with microbien treatments were distributed in the main plot. Whereas, nitrogen fertilization combined with compost treatments were assigned at random in the sub - plots. The experimental plot area was (12 m^2) which included 3 ridges each ridge was 1 m width and 4 m length. All cultural operations were similar to those practiced in commercial field production as recommended by Ministry of Agriculture , Egypt.

The following data were recorded:

A- **Plant growth characteristics:**

Random sample of five plants from each sub plot was taken at 65 days after transplanting (at flowering stage) to determined the follow:

1- Plant height (cm).
2- Number of branches.
3- Dry weight of plant (including stems and leaves only) was recorded at the end of growing season. The dry weight was measured after drying the samples at 70 ˚C in forced air oven.

B- **Leaves chemical content**:

1- Chlorophyll a and b contents were determined in the 5th leaf from the top of five plants were taken at random from each experimental plot, at 65 days after transplanting by a spectrocolorimeter according to Monje and Bugbee (1992).

2- Mineral nutrients content in tomato plants:

Total nitrogen, phosphorus and potassium concentrations in tomato leaves were determined at 65 days after transplanting. Nitrogen content was determined by the modified macro-Kjeldahl method (king, 1951).

Phosphorus was determined colorimetrically as described by King (1951). While potassium was determined as method mentioned by Jackson (1965).

C- **Fruit yield and its components** :

Mature fruits from each plot were harvested weekly at full - ripe maturity stage to determined the following characters:

1-Early yield "ton/fed" (the weight of first two pickings).
2- Total fruit yield "ton/fed" (the weight of all pickings).
3- Average fruit weight "g" (ten fruits were randomly taken from each plot to determine average fruit weight).

D- **Fruit quality** : Ten fruits were randomly chosen at the third picking from each plot to determine the following data:

1- Fruit dry matter percentage .
2- Fruit length (cm).
3- Fruit diameter (cm).
4- Fruit flesh wall thickness (cm).

5-Total soluble solids (TSS%) using Zeiss laboratory refractometer

6-Ascorbic acid (mg /100g fresh weight) using 2, 6 dichlorophenol indophenol dye (A.O.A.C., 1990).

Statistical analysis:

The obtained data were statistically analyzed according to Duncan's (1955).

Results and Discussion

A- Plant growth characters :

Data reported in Table (3) indicated that microbien inoculation improved plant growth characters , i.e., "plant height, number of branches and plant dry weight" as compared to the control in both seasons. Data also indicated that using two doses inoculation with microbien showed an increment in plant growth characters than that of one dose application. The simulative effect of these micro organisms might be attributed to its ability to supply the grown plants with fixed nitrogen and produced phytohormones which could stimulate absorption of nutrients and photosynthesis process and subsequently high plant growth could be achieved. Similar results were reported by Terry *et al.* (2002); Bhat and Prasad (2004); Alfonso *et al*. (2005); Sethi and Adhikary (2009) and Zare *et al*. (2011) on tomato using biofertilizers application. Moreover, N fertilizer at the rate of 100 kg/fed plus compost at the rate of 8 /fed markedly increased plant height, number of branches and plant dry weight in both seasons. These findings were supported by previous workers as, Olasamtan (2000); Scholberg *et al.* (2000) and Ahmed and Morsy (2005) on tomato plants. Also, El- Araby and Feleafel (2003); Youssef (2007) and Diaz - Perez *et al*. (2008) they found that organic fertilization markedly affected plant growth of tomato plants. Data in Table (3) showed that the effect of biofertilizer inoculation and nitrogen fertilizer plus organic manure interactions on plant growth were significant in both seasons. The highest mean values were obtained from microbien inoculation at two doses and nitrogen fertilizer at the rate of 100 kg/fed + compost at the rate of 8t /fed.

B- Chemical contents in tomato leaves:

The presented data in Table (4) showed that chlorophyll a and b, nitrogen, phosphorus and potassium percentages in leaves were significantly affected by microbien inoculation in both seasons. Inoculated plants produced markedly higher levels of the previous contents in tomato leaves as compared to the uninoculated plants. The two doses application overcame the one dose treatment for all chemical contents. These results are in agreement with those reported by El- Zeiny (2007) and Mohan *et al*.(2011) who reported that cyanobacteria inoculation significantly increased the Ca, K, Mg and P contents of tomatoes. Results in Table (4) showed that nitrogen fertilization rates significantly affected all the previously mentioned contents, i.e. chlorophyll a and b, nitrogen, phosphorus and potassium percentages of leaves in the two seasons. Adding nitrogen fertilizer at the rate of 100 kg /fed in the presence of compost at the rate of 8t /fed increased chlorophyll a and b, nitrogen %, phosphorus % and potassium %. Ahmed and Morsy (2005); Csemi *et al*. (2008) and Tang Ming Yao (2010) obtained similar results on tomato plants by nitrogen application. Also, El- Araby and Feleafel (2003); Parrary *et al* (2007) and Rao and Sankar (2007) found that application of clay mineral at 8 t / ha plus farmyard manure at 10 t/ha increased leaf N of tomato plants.

Table (3) : Integration between bio, organic and mineral nitrogen fertilizers and its effect on growth characters of tomato plants during 2011 and 2012 seasons.

Treatments		Plant height (cm)		Number of braches		Dry weight of plant (g)	
Bio "A"	Mineral + Organic "B"	2011 season	2012 season	2011 season	2012 season	2011 season	2012 season
Without	N_1C_1	55.15 g	59.43 f	5.19 e	5.01 g	174.86 f	189.70 d
	N_2C_2	57.32 fg	61.54 ef	5.31 e	5.65 efg	181.77 ef	210.32 cd
	N_3C_3	60.90 def	63.20 def	5.69 cde	6.22bcdef	203.58cdef	217.77 c
	N_4C_4	62.20 def	66.06 cde	5.81 bcde	6.38 bcde	212.74 bcd	224.41 bc
Mean		58.89 C	62.56 C	5.50 C	5.84 B	193.24 B	210.55 C
One dose	N_1C_1	58.75 efg	63.59 def	5.36 de	5.52 fg	180.40 ef	213.75 cd
	N_2C_2	61.28 def	65.01cdef	5.67 cde	6.00cdef	189.17 def	225.87 bc
	N_3C_3	69.88 ab	70.82 bc	6.54 b	6.88 b	241.30 ab	251.58 ab
	N_4C_4	63.78 cde	66.59 cde	6.06 bcd	6.49 bcd	220.07 bc	232.34 bc
Mean		63.42 B	66.54 B	5.91 B	6.22 B	207.74 AB	230.89 B
Tow doses	N_1C_1	64.60 cd	68.58 bcd	5.52 de	5.86 def	183.76 def	218.92 c
	N_2C_2	65.80 bcd	69.14 bcd	6.30 bc	6.69 bc	205.37 cde	233.10 bc
	N_3C_3	74.48 a	78.91 a	7.45 a	7.82 a	249.50 a	265.29 a
	N_4C_4	68.54 bc	73.35 ab	6.46 b	6.95 b	228.84 abc	249.62 ab
Mean		68.36 A	72.50 A	6.43 A	6.83 A	216.87 A	241.73 A
All over means for "B":							
	N_1C_1	59.50 *C*	63.87 *C*	5.36 *D*	5.49 *D*	179.67 *B*	207.46 *C*
	N_2C_2	61.47 *BC*	65.23 *C*	5.75 *C*	6.12 *C*	192.11 *B*	223.10 *B*
	N_3C_3	68.42 *A*	70.98 *A*	6.56 *A*	6.97 *A*	231.46 *A*	244.88 *A*
	N_4C_4	64.84 *B*	68.72 *B*	6.11 *B*	6.61 *B*	220.55 *A*	235.46 *AB*

Biofertilization : microbien
N_1C_1 : 60 kg N + 4t/fed compost
N_2C_2 : 80 kg N + 6t/fed compost
N_3C_3 : 100 kg N + 8t/fed compost
N_4C_4 : 120 kg N + 10t/fed compost

Means followed by the same letters within each column do not differ significantly according to Duncan's Multiple Range Test at the 5 % level .

Data in the same table revealed that the interactions between microbien inoculation and nitrogen fertilizer combined with compost showed significant affect on chlorophyll a and b, nitrogen % , phosphorus % and potassium % in the two seasons. The highest mean values were obtained from plants inoculated with microbien at two doses and fertilized with nitrogen at the rate of 100 kg/fed plus compost at 8t /fed.

C- Fruit yield and its components :

The effect of microbien inoculation and nitrogen fertilizer application combined with compost on average fruit weight, early yield and total fruit yield (ton/fed) are shown in Table (5). Data showed that the microbien inoculated plants significantly affected total fruit yield and its components in both seasons. The highest mean values were recorded in plants which received microbien at two doses application as compared to one dose and control. The significant increment in total fruit yield by using microbien inoculation might be attributed to the enhancing effect of this treatment on the growth parameters, average fruit weight and early yield. These results are nearly similar to those reported by Tanaka *et al.* (2003); Abou- Aly (2005); Satesh Kumar and Sharma (2006); Simonovich and Kazadaev (2007); Kdoglu *et al*. (2009); Anter *et al.* (2011) and Hernandez- Suarez *et al*. (2011), they mentioned that inoculation with Bacillus subtillus strains markedly increased fruit yield of tomato plants.

Concerning the nitrogen fertilizer combined with compost, data in Table (5) declared that fertilized plants with nitrogen fertilizer at 100 kg/fed + compost at the rate of 8t /fed produced higher values of average fruit weight, early yield as well as total fruit yield ton /fed in both seasons. These results were in agreement with data obtained by Khalil (2001); Singh (2005); Abedl-Aziz (2008); Min and Shiwei Ming (2009); Tiang- Hui Min *et al*. (2010) and Tibebu Tesfay *et al.* (2011) point out that using caly pot irrigation combined with N fertilizer increased fruit yield and marketable yield of tomato plants. Also, [Lin ChumHu (2000); Rao and Sankar (2007); Prabakaran (2008) and Yang Li Juan *et al.* (2010)] using organic manure on tomato plants which recorded highest tomato fruit yield by fertilizing the plants with organic manure. The data showed that interactions between biofertilizer and nitrogen fertilizer plus organic manure significantly affected total fruit yield and its components in both seasons. Microbien inoculation at two doses and N fertilizer at the rate of 100 kg/fed + compost at the rate of 8t /fed gave the best total fruit yield and its components. This conclusion agrees with those obtained by Selim *et al.* (2007); Singh *et al.* (2008) and Chanada *et al.* (2011).

E- Fruit quality:

Data of the fruit quality parameters are illustrated in Tables (5 and 6) the results showed that dry matter percentage, fruit length and diameter, flesh wall thickness and TSS % content were significantly affected by inoculation with microbien in both seasons, and Vit.C in the first season only. Plants inoculated with microbien at two doses application gave the highest fruit quality parameters. Similar results were reported by Terry *et al*. (2005) and Mohan *et al* (2011) on tomato plants using various bacterial fertilizer application.

Data in the same tables indicated that nitrogen fertilizer in presence of organic manure significantly increased fruit quality characters in both seasons. Highest values were obtained from N at the rate of 100 kg/fed combined with compost at 8t /fed . In this regard Ahmed and Morsy (2005); Pascal *et al.* (2006); Min and Shiwei Ming (2009) and Jiang *et al.* (2010). Moreover, Ahmed and Morsy (2005) reported that N application at 150 kg/ fed increased TSS%, Vit. C and titratable acidity of tomato plants. Also, Parrary *et al*. (2007); Rao and Sanker (2007) and Yang Li Juan *et al* (2010) found the same when applying organic manure on tomatoes. Parrary *et al*. (2007) reported that application of FYM at 12 quintal + neemcake at 10 kg / ha significantly increased phenol, chlorophyll , protein, ascorbic acid, oxalic acid, lycopen and carotenoide contents of tomato fruits. The effect of microbien inoculation × N fertilizer + organic manure on fruit quality was significant in both seasons. Highest mean values were obtained from inoculation with microbien at two doses application and N fertilizer at the rate of 100 kg/fed + compost at the rate of 8 t /fed.

Generally, it could be recommended that treating tomato plants cv. "Strain B" with microbien inoculation at two doses application at the time of transplanting and 20 days after transplanting and adding nitrogen fertilizer at the rate of 100 kg/fed combined with compost at the rate of 8 t /fed well produce higher fruit yield with best quality.

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التكامل بين التسميد الحيوى والنيتروجين العضوى والمعدنى وأثر ذلك على النمو والمحصول والجودة فى الطماطم.

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أجريت تجربتان حقليان بمزرعة محطة بحوث البساتين بسدس – بنى سويف – معهد بحوث البساتين خلال الموسمى الصيفي لعام 2011 ، 2012 وذلك لدراسة استجابة نباتات الطماطم صنف " استرين بى " للتلقيح بالميكروبين (غير معامل ، معامل مرة ، معامل مرتين) الأولى عند الشتل والثانية بعد 20 يوم من الزراعة والتسميد النتيروجينى بالمعدلات 60 ، 80 ، 100، 120 كجم نيتروجين / الفدان مع التسميد العضوى بالكمبوست بالمعدلات 4 ، 6 ، 8 ،10 طن/الفدان على النمو والمحصول وجودتة . وقد أوضحت نتائج الدراسة ان التلقيح بالميكروبين مرتين أدي إلى تحسين صفات النمو الخضري ومحتوي الأوراق من الكلورفيل والنيتروجين والفوسفور والبوتاسيوم ومحصول الثمار و النسبة المئوية للمادة الجافة للثمار وطول وقطر الثمرة وسمك لحم الثمرة والمادة الصلبة الذائبة الكلية خلال موسمي الزراعة وكذلك زادت معنوية فيتامين ج خلال الموسم الاول مقارنة بالنباتات التى لقحت مرة واحدة أو التى لم تلقح. كما أدى التسميد النيتروجينى بالمعدل 100كجم نيتروجين / الفدان مع التسميد العضوي بسماد الكمبوست بالمعدل 8 طن/الفدان إلى زيادة معنوية فى جميع الصفات التى درست خلال موسمي الزراعة . واعطى التداخل بين التلقيح بالميكروبين ومعدلات التسميد أفضل النتائج لجميع الصفات السابقة خلال موسمي الزراعة .

بناءًا على ما سبق يمكن التوصية بتلقيح شتلات الطماطم صنف "استرين بى" بالميكروبين على دفعتين الأولى قبل الشتل مباشرة والثانية بعد الشتل بحوالي 20 يوم والتسميد النيتروجينى بالمعدل 100كجم نيتروجين/ الفدان مع التسميد العضوي بسماد الكمبوست بالمعدل 8 طن/الفدان وذلك للحصول على أفضل النتائج.