EFFECT OF PRECISION LAND LEVELING ON FABA BEAN RESPONSE TO COMPOST APPLICATION IN SANDY SOILS

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ABSTRACT

This study was carried out in Kalabsho Region, El-Dakhlia Governorate, during 2007 winter season to identify effect of precision land leveling on faba bean response to compost application in sandy soils. The experiment was designed statistically as a split plots with three replicates. The main plots were located for the precision land leveling levels of 0, 0.01, 0.02 and 0.03% slope, which were compared with the traditional land leveling (0.01% slope), and the sub plots were devoted for the compost amount levels of 1.60, 2.00 and 2.40 Mg/fed, which were compared with the bereaved of compost application. The precision land leveling slope of 0.02% under compost application of 2.40 Mg/fed achieved the lower soil bulk density value of 1.28 g/m3, the lower soil infiltration rate value of 20 mm/h and the higher concentration of soil macronutrients values of 24, 17 and 311 ppm for N, P and K, respectively. It required the lower total applied irrigation water amount of 1415 m3/fed. It achieved higher grain yield of 1.40 Mg/fed. and higher water use efficiency of 0.98 kg/m^3.

Generally, it is recommended to apply the precision land leveling under compost application to achieve higher faba bean grain yield and save more irrigation water in sandy soils.

INTRODUCTION

Egypt faces a growing imbalance between agriculture production and population increase. The horizontal expansionism should be taken into consideration to achieve the balance between the population food consumption and agricultural production. About 2.38 million feddans of sandy desert soil close to Nile Delta could be added to the cultivated area (**Ministry of Agriculture and Land Reclamation, 2006**). The sandy reclaimed soil of the coarsest texture is hard to be

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productive because of the lower water holding capacity, the higher aeration, the rapid drain, the lower content of the organic matter and the higher fertilizer leaching (**El-Banna, 1998**).

In Egypt, the irrigation water is relatively limited (55.50 mlrd m^3 yearly) and insufficient for reclamation purpose (**Semika and Rady, 1987**). So, it is essentially to apply water saving irrigation methods, as well as by improving management of available water resources. It is an important issue to depend on the precision land leveling as a wise method to manage the available water. It was concluded by **El-Behery and El-Khatib** (**2001**), **El-Raie et al.** (**2003**) and **El-Raie et al.** (**2004**) that the laser land leveling saves farm inputs like water and fertilizers, improves crop stand, encourages uniform germination.

In addition, it is necessary to improve the fertility of the newly reclaimed sandy soils. Egypt imports yearly about 1.50 million Mg of chemical fertilizers**.** On the other hand, 25 million Mg of crop wasts and 12 million of livestock wasts produced yearly. Only 18% of total amount of the agricultural wasts is used in organic fertilizer production (**Agricultural Statistics Abstract**, **2003**)**.** The amount of imported chemical fertilizers would increase with reclaiming more soils. Recently, the agricultural technology introduced the agricultural nature material as soil conditioners. Composting is defined as a biological in which organic bio-degradable residues are converted into hygienic, humus, rich or compost by the action of bacteria's (**Mathur**, **1991**). Compost plays an important role in improving soil organic matter, nitrogen content, P_2O_5 concentration and exchangeable cations. Furthermore, it decreases soil pH, which results in increasing solubility of nutrients and nutrient availability to the plants that enhance plant growth and development (**Salem**, **1988** and **Wafaa et al., 2004**).

In Egypt, faba bean is considred as the most leguminous crop. It is considred as the main dish. Faba bean can be used as a vegetable either green or dried fresh or canned. The chemical composition reveals the highly faba bean nutritional value. It is attributed to the higher protein content, which ranges from 25 to 35%. Also , it is a good source of sugars, minerals and vitamins. In addition, it contains carbohydrate, which reaches to be 50-60%, that is mainly constituted by starch (**Larralde** and **Martinez**, **1991**).

This study aimed to identify the effect of precision land leveling on faba bean response to compost application in sandy soils.

MATERIAL AND METHODS

Experimental Procedure:

1. Soil and water characteristics:

To fulfill the objective of this study, a field experiment of 1.50 fed. (105 x 60 m)was conducted at Kalabsho Region, El-Dakhlia Governorate, during 2007 winter season. As shown in tables (1) and (2), the soil was analyzed mechanically and chemically according to the standard procedures as cited by **El-Serafy and El-Ghamry** (**2006**). Also, the soil field capacity, available water, wilting point and soil infiltration rate were determined using pressure extractor with regulated air pressure as pointed out by **Garcia** (**1978**). As indicated in table (3), both irrigation and drainge water were analyzed chemically according to **El-Serafy and El-Ghamry** (**2006**).

Table (1): Soil mechanical analysis of the experimental site.

SAND, %			SILT, %	CLAY, %	SOIL TEXTURE CLASS
COARSE, %	FINE, %	TOTAL, %			
66.48	2.62	69.20	13.85	16.95	SANDY

Table (2): Some soil characteristics of the experimental site.

BULK density, g/cm^3	pH, 1:2.5 (susp.)	Available nutrients, ppm			Field capacity, Wt/wt%	Wilting point, Wt/wt%	Available water, mm	Infiltration rate, mm/h
		N	P	K				
1.58	7.33	19.31	8.50	291.40	15.10	5.93	22.91	42

Table (3): Water chemical analysis at the experimental site.

Water type	Ph, 1:2.5 (susp.)	EC_w, dS/m	Total soluble salts, ppm	SOLUBLE anions, ppm				Soluble cations, ppm				SAR
				Co_3	HCo_3	Cl	So_4	Ca	Mg	Na	K	
Irrigation	7.40	3.06	1653.99	0.03	427.15	591.36	124.27	83.05	77.53	342.34	8.26	2.11
Drainage	8.37	4.43	2296.46	0.05	549.43	956.32	227.52	85.64	122.37	344.57	10.56	3.57

3. Agricultural practices:

a. Compost preparation:

As reported by **Bunt et al.** (**1976**), a plant residues of rice straw was air dried. It was composted using accelerator chemical fertilizer for decomposition confined 20 kg ammonium sulfate, 10 kg super phosphate and 10 kg potassium sulfate per 1 Mg dry matter of rice straw. Then, the composted rice straw (30% weight) was mixed with fresh cattle manure (70% weight) under aerobic conditions. The optimal decomposition took place at 55-66 °C 1/19 C/N ratio and 50% moisture content that were supplied continuously by water spraying. The composted rice straw was inverted. Then, the compost was matured at 4 months. The compost was chemically analyzed as presented in table (4).

Table (4): Some chemical characteristics of the composted rice straw.

EC ds/m (1:10)	Ph, (1:10)	Macroelements, %					
		N	P	K	Fe	Zn	Mn
4.24	7.22	1.32	0.57	1.56	844	253	403

b. Seed bed preparation:

The seed bed was tilled using a chisel plough in two perpendicular directions at 0.20 m depth. Then, the compost was manually broadcasted and mixed with soil using a tandem disc harrow. The precision land leveling was carried out using a mounted hydraulic land leveler of 1.26 m^3 capacity (0.60 x 3.00 x 070 m). It was accompanied with a laser control equipment that consists of transmitter (Spectra-physics 1145 laserplane), control box (CB2MTD), receiver mast, receiver unit and telescoping grade rod (1084 English). A 4 WD tractor of 90 kW was used to operate the precision land leveling unit. While, the traditional leveling was performed using the same hydraulic land leveler that was operated using 2 WD tractor of 60 kW.

c. Planting:

The selected seeds of Giza 3 faba bean variety were planted using a pneumatic planter at row spacing of 0.60 m with 0.20 m hill spacing at the same row.

d. Irrigation:

As shown in figure (1), the border surface irrigation system was applied using an electric archimedean screw of 252 m^3/h discharge.

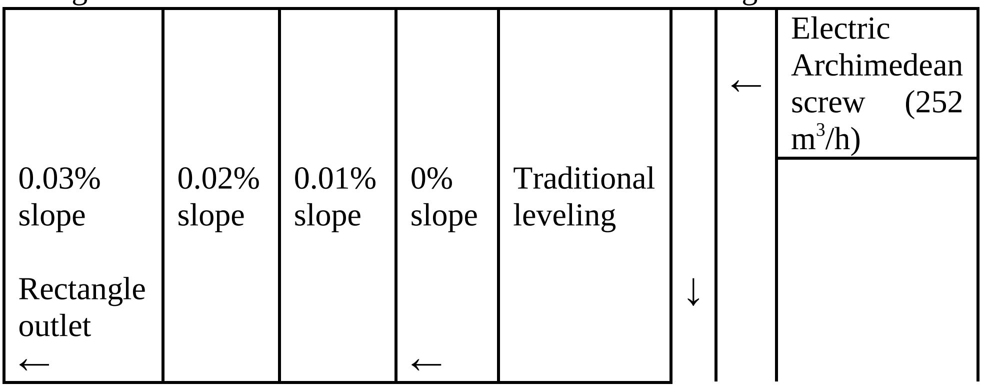

Fig. (1): Sketch diagram of the border surface irrigation system.

All other practices were done according to the recommendations of the Leguminous Crops Res. Dept., Field Crops Inst., Ag. Res. Center, Ministry of Agriculture and Land Reclamation.

4. Statistical design and treatments:

During the experiment, the following treatments were tested:

1. Precision land leveling: It included the Precision land leveling levels of 0, 0.01, 0.02 and 0.03% slope, which were compared with the traditional land leveling (0.01% slope).
2. Compost application: It included the applied cmpost amount levels of 1.60, 2.00 and 2.40 Mg/fed which were compared with the bereaved of compost application (control).

The experiment was designed statistically as a split plots with three replicates. The main plots involved the precision land leveling levels, and the sub plots involved the compost amount levels.

Measurements:

1. Soil conditions:

At harvest, the soil mean weight diameter was determined as cited by **Kepner et al. (1982)**, the soil bulk density was determined according to **ASAE** (**1992**), the soil infiltration rate was determined according to **Garcia** (**1978**) and the soil available macronutrients consantration was determined as cited by **El-Serafy and El-Ghamry** (**2006**).

2. Amount of total irrigation water:

The amount of total irrigation water (T.I.W) was determined during flowering, bud setting and maturity crop growth stages at 50, 60 and 70% of the available water, respectively as follows:

$$T.I.W = \frac{LR + CR}{\eta x a} m^3 / fed \qquad (1)$$

Where:

LR is leaching requirements, m^3/fed.

CR is crop water requirements, m^3/fed.

η is irrigation system efficiency, %.

A is irrigated area, fed.

LR is estimated as outlined by **Doorenbos and Prutt** (**1977**) as follows:

$$LR = \frac{ECi}{EC_d} \qquad (2)$$

Where:

EC_i is irrigation water electrical conductivity, dS/m.

EC_d is drainge water electrical conductivity, dS/m.

The net crop water requirements and the irrigation interval (*I.I*) are calculated according to **FAO** (**1979**) and **Israelson and Hansen** (**1962**) as follows:

$$WHC = (FC - PWP) x\, p_b \text{ x d x} 10 \text{ mm} \qquad (3)$$

$$Max.CR = \frac{MADxWHC}{100} \text{ mm} \qquad (4)$$

$$Max.CR = \frac{Max.g.w.r}{\eta} mm \qquad (5)$$

$$I.I = \frac{Max.CR}{Etcrop} day \qquad (6)$$

$$Et = Et_0 \times k_c \; mm/day \qquad (7)$$

Where:

WHC. is soil water holding capacity, mm.

FC is soil field capacity, %.

PWP is soil permanent wilting point, %.

ρ_b is soil bulk density, g/cm^3.

D is effective root zone depth, m.

MAD is management allowable deficit,mm/m.

Max. g.w.r is maximum gross water requirements, mm.

Et is net crop water requirements, mm.
Et_0 is is potential evapotranspiration, mm/day.
K_c is crop factor.
Et_0 was calculated according to the data recorded by Kafr Ssad weather station, Domiit *Governorate* which is affiliated to the Central Laboratory for Agricultural Climate, Ministry of Agriculture and Land Reclamation.
he applied irrigation water amount was measured using a rectangular shape crested weir. It was determined according to **James** (**1988**) as follows:

$$Q = kxc_dxA\sqrt{H} \quad \text{L/s} \qquad (8)$$

Where:
Q = orifice discharge ,L/s
k is discharge coefficient.
c_d is constant unit.
A is orifice area, m^2.
H is effective water head over the orifice center, m.

3. Faba bean grain yield:

At harvest, for each experimental unit, an area of 1 m^2 was taken randomly to determine the faba bean grain yield. Then, it was calculated on basis of 14% moisture content (d.b.).

4. Water use efficiency (*WUE*):

$$WUE = \frac{\text{grain yield, kg/fed.}}{\text{appllied irrigation water amount, m}^3\text{/fed.}} \quad \text{kg/m}^3 \qquad (9)$$

Statistical Analysis:

SAS computer software package was used to employ the analysis of variance and the LSD tests for faba bean grain yield data.

Regression and Correlation Analysis:

Microsoft Excel 2007 computer program was used to carry out the simple regression and correlation analysis to represent the relation between the precision land leveling slope and the faba bean grain yield.

RESULTS AND DISCUSSIONS

1. Soil Conditions:

Results presented in Figures (2), (3), (4) and (5) show the significant effect of the precision land leveling under compost application on the soil conditions, comparing with the traditional leveling. The precision land leveling slope of 0.02% under compost application of 2.40 Mg/fed achieved the lower soil bulk density value of 1.28 g/m^3, the lower soil infiltration rate value of 20 mm/h and the higher concentration of soil macronutrients values of 24, 17 and 311 ppm for N, P and K, respectively. This result may be due to the higher accuracy of the precision control equipment, for cutting and filling the soil. Hence, the precision leveling achieved the soil particles of smaller mean weight diameter by about 25% than that were resulted using the traditional leveling. The precision leveling achieved lower values of soil bulk density by about 4% than that was obtained by the traditional leveling. This finding could be explained that the precision leveling accomplished fine soil particles, which having a negligible electromagnetic charge. So, the soil free pore spaces increase per unit volume, resulting in lower soil bulk density. Moreover, the precision leveling consummated lower soil infiltration rate values by about 11% than that was obtained with the traditional leveling. It is illustrated that the irrigation water streams, detaches soil particles from the surface and pushes fine particles into surface pores, creating smaller pores offer greater resistance to gravity, where they can impede the infiltration process. In addition, the precision leveling complemented more amount of the available soil macronutrients concentration than that was obtained using the traditional leveling by about 105, 121 and 109% for available N, P and K, respectively. It is due to the finer soil particles of greater specific surface area which allow to release more amounts of the available soil macronutrients.

The figures indicate that as the leveling slope increased from 0 to 0.02%, the soil bulk density and the soil infiltration rate decreased, then, they increased at 0.03% slope. While, the concentration of available soil macronutrients related positively with the leveling slope until it reached to be 0.02%. then, this relation reversed. It is due to the impact force between the scraper edge and the soil clods, which increases with the leveling slope, resulting in the smaller soil clods of hlarger pore spaces, leading to lowering the soil mass per unit volume.

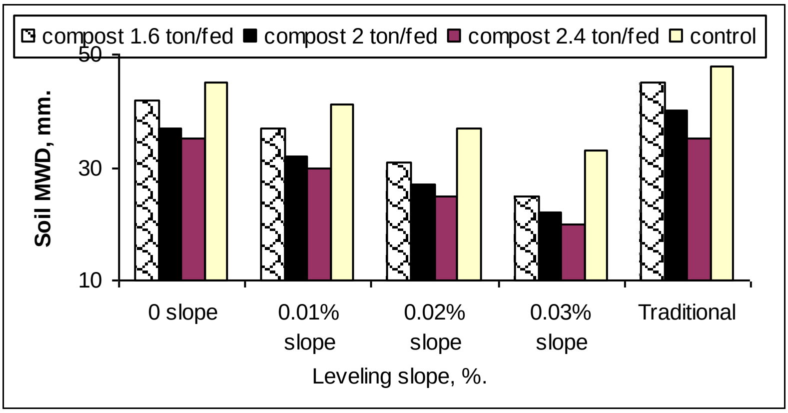

Fig. (2): Effect of precision land leveling on soil mean weight diameter (MWD) under compost application.

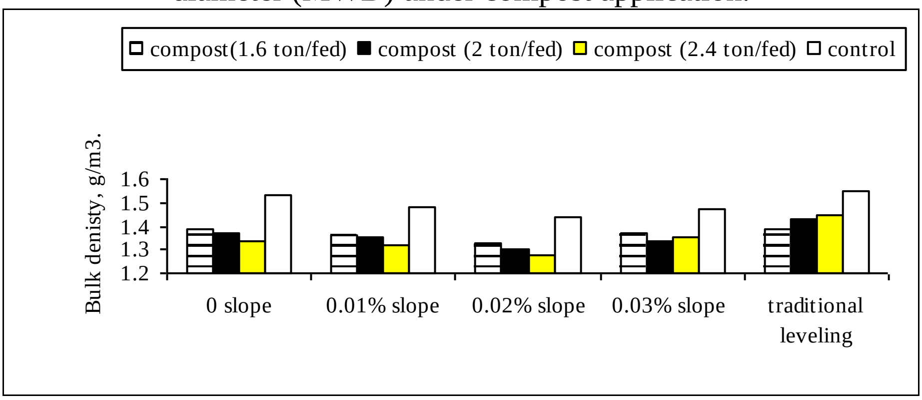

Fig. (3): Effect of precision land leveling on soil bulk density under compost application.

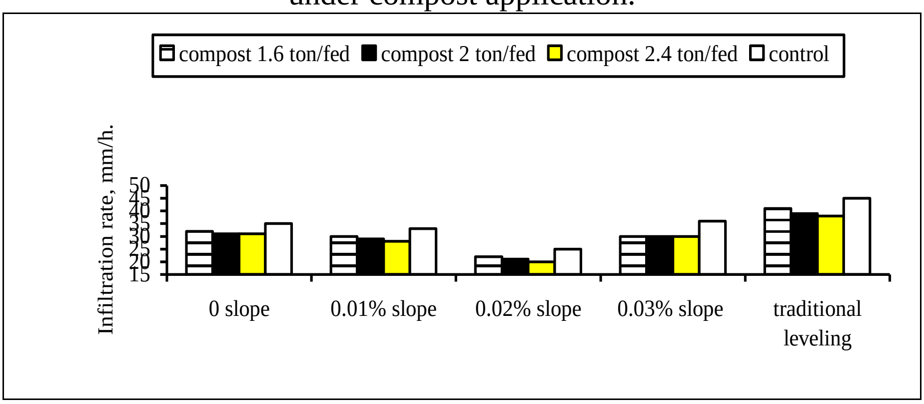

Fig. (4): Effect of precision land leveling on soil infiltration rate under compost application.

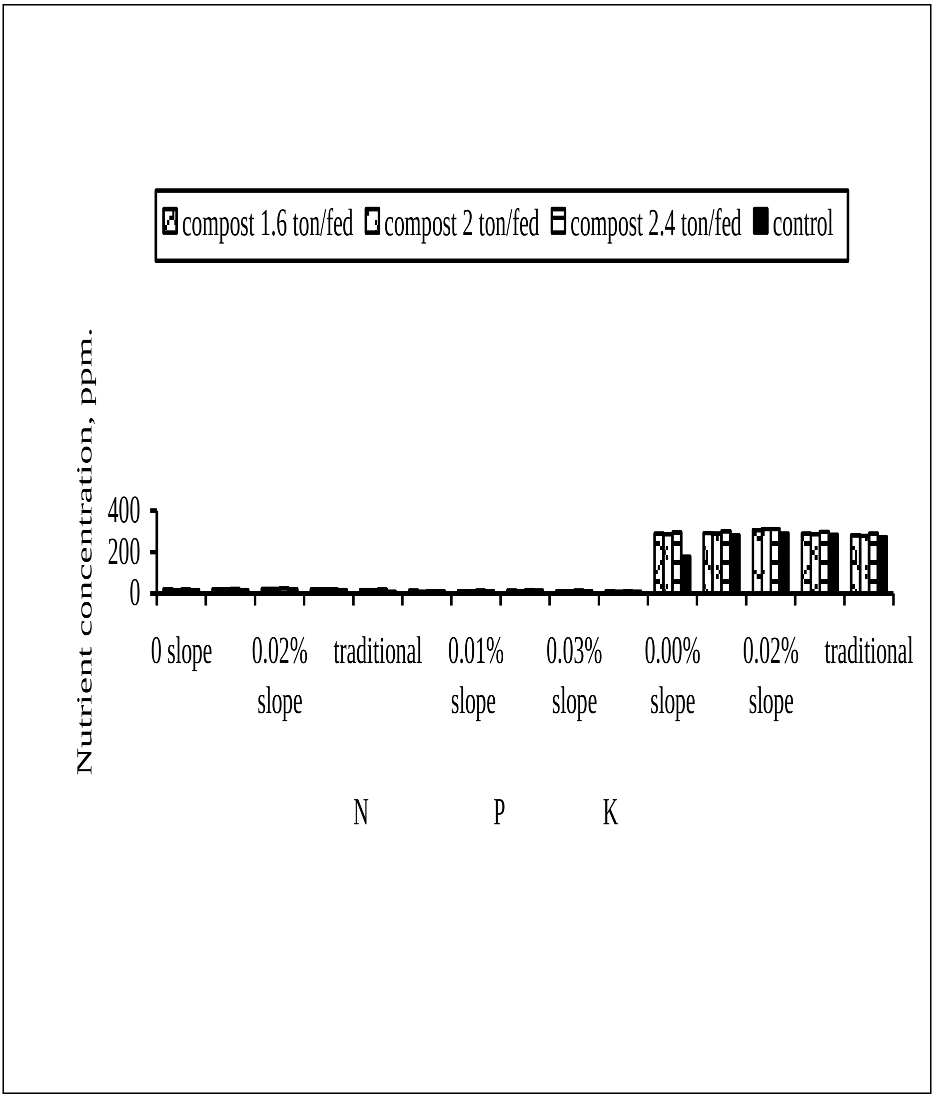

Fig. (5): Effect of precision land leveling on concentration of available soil macronutrients under compost application.

On the other hand, as the leveling slope reached to be 0.03%, the higher impact force between the scraper edge and the soil clods accomplished finer soil particles, leading to enclosing soil pore spaces that create an aggregated structure.

The figures reveal that the compost application in case of the precision leveling improved the soil conditions, comparing with the traditional leveling. It is attributed to the beneficial effect of compost which is retained in the soil in voids between the particles, sticking one to another, increasing the free pore spaces per soil volume unit, consequently, the soil conditions improve.

2. Applied Irrigation Water amount:

The obtained data revealed that faba bean plants required 4, 3 and 2 irrigations with irrigation intervals of 12, 14 and 16 days to achieve 50, 60 and 70% of the available water during flowering, bud setting and maturity growing stages, respectively. Figure (6) transposes that the precision leveling of 0.02% slope under compost application of 2.40 Mg/fed required the lower irrigation water amounts of 585, 465 and 365 m^3/fed. during flowering, bud setting and maturity growth stages, respectively. In other words, it required the lower total irrigation water amount of 1415 m^3/fed during the growing season.

The figure shows that the precision leveling saved the total irrigation water amount by about 27, 28, 36 and 32% from that was required using the traditional leveling. It is due to the high quality laser technique land leveling which decreases the water irrigation losses by deep-percolation, evaporation and run-off.

On the other hand, the compost application of 1.60, 2.00 and 2.40 Mg/fed saved the total irrigation water amount by about 2, 4 and 8%, respectively from that was required in case of the bereaved of compost application. This finding is illustrated that compost improves the soil structure, resulting in the increase of water holding capacity, the hydraulic conductivity and the water retention.

3. Faba Bean Grain Yield:

Figure (7) demonstrates that the higher faba bean grain yield of 1.40 Mg/fed was obtained using the precision land leveling under compost application of 2.40 Mg/fed. The Figure exhibits that the precision land leveling of 0, 0.01, 0.02 and 0.03% slope, increased the faba bean grain yield by about 119, 125, 175 and 127% respectively, comparing with the traditional leveling. This finding means that, the faba bean grain yield was affected significantly by the precision land leveling which improves the soil conditions, resulting in enhancing the release of more available soil nutrients. Then, the faba bean plants uptake more amount of soil nutrients. Consequently, the faba bean grain yield increases.

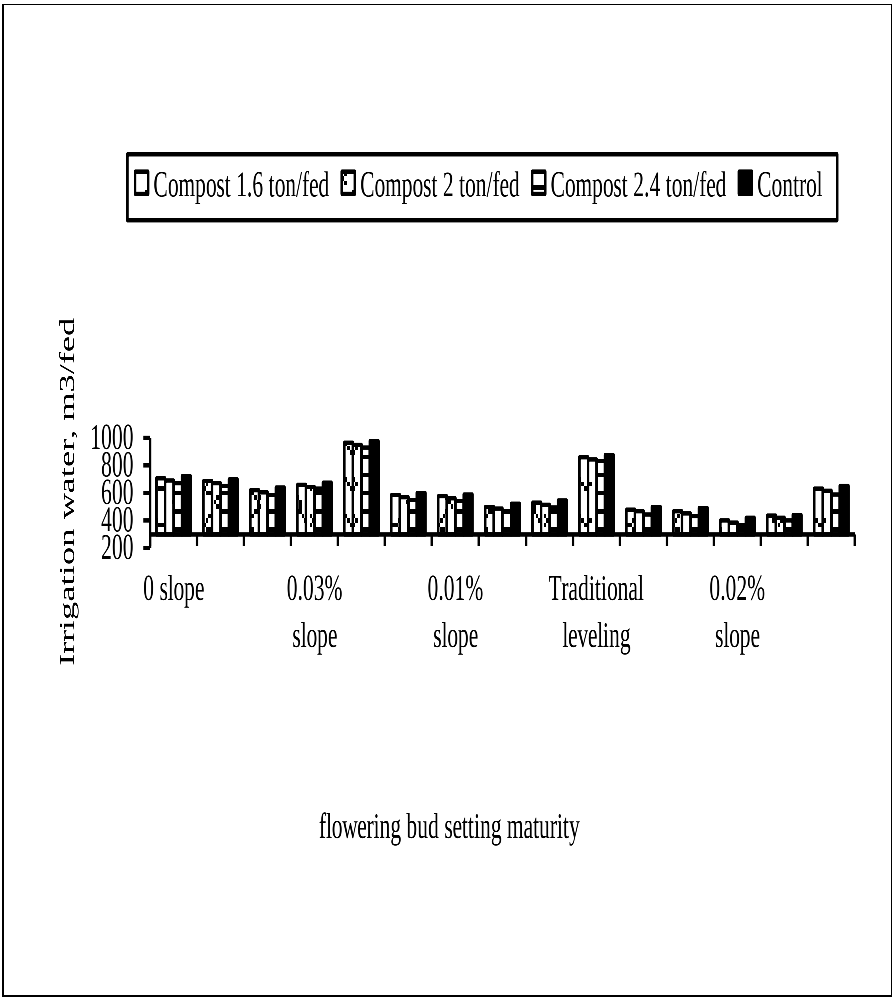

Fig. (6): Effect of precision land leveling on the applied irrigation water amount under compost application.

Therefore, faba bean grain yield was affected significantly by the compost application. The compost application of 1.60, 2,00 and 2.40 Mg/fed increased faba bean grain yield by about 105, 107, 111 and 109%, respectively comparing with the bereaved of compost application. This finding is explained that compost improves the soil conditions, leading to the increase of nutrients solubility and nutrient availability to the plants that enhance plant growth and development.

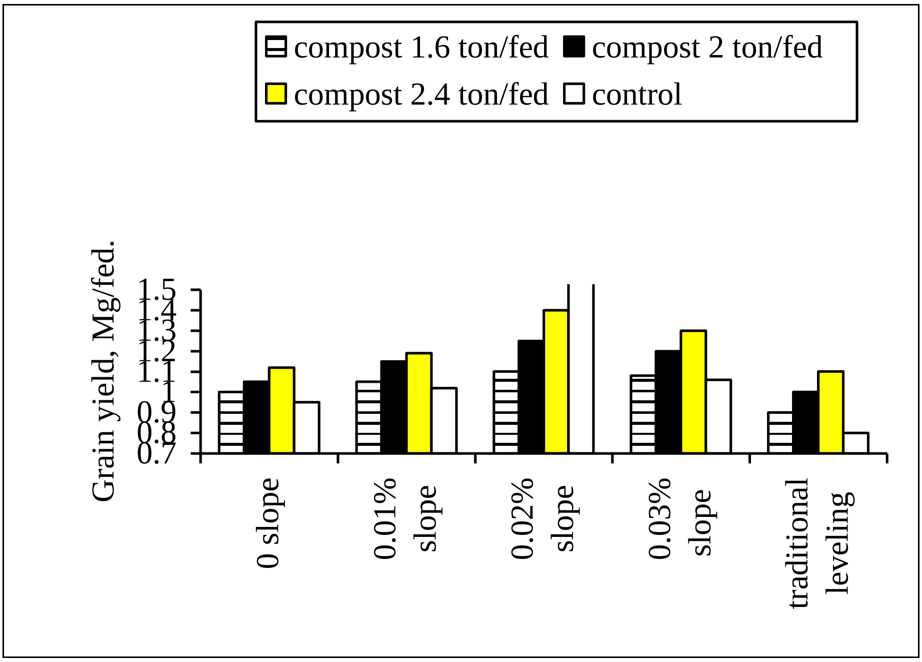

Fig. (7): Effect of precision land leveling on faba bean grain yield under compost application.

The analysis of variance test indicates that there is a highly significant difference in faba bean grain yield due to the precision land leveling and the compost application.

The L.S.D. test at 0.05 level shows that the precision land leveling slope of 0.02% under compost application of 2.40 Mg/fed achieved the highest faba bean grain yield among the other treatments.

The regression and correlation analysis reveals that the faba bean grain yield (y) correlates positively with the precision leveling slope (x) as follows:

compost 1.6 Mg/fed: $y = - 0.0379 x^2 + 0.2301 x + 0.812$ ($R^2 = 0.895$)

compost 2 Mg/fed: $y = - 0.0536 x^2 + 0.3164 x + 0.770$ ($R^2 = 0.940$)

compost 2.4 Mg/fed: $y = - 0.0607 x^2 + 0.3713 x + 0.776$ ($R^2 = 0.813$)

control : $y = - 0.0514 x^2 + 0.2826 x + 0.698$ ($R^2 = 0.886$)

4. Water Use Efficiency:

Figure (8) reveals that the higher water use efficiency value of 098 kg/m^3 was obtained using the precision land leveling of 0.02% slope under compost application of 2.4 Mg/fed. The Figure indicates that the precision land leveling of 0, 0.01, 0.02 and 0.03% slope, increased the water use efficiency by about 162, 164, 200 and 198% respectively, comparing with the traditional leveling. While, compost application of 1.60, 2.00 and 3.40 Mg/fed increased the water use efficiency by about 108, 116 and 130%, respectively comparing with the bereaved of compost application.

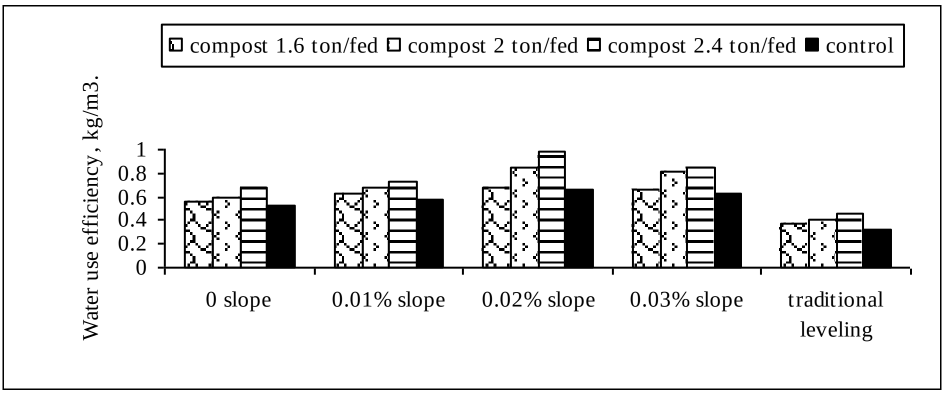

Fig. (8): Effect of precision land leveling on faba bean water use efficiency under compost application.

CONCLUSION

The obtained results of this study could be concluded as follows:

1. The PRECISION land leveling under compost application achieved the proper soil conditions.
2. The precision land leveling under compost application saved the total applied irrigation water amount.

The precision land leveling under compost application produced the higher faba bean grain yield and theFinally, It is recommended to use the precision land leveling under compost application due to the desirable soil conditions, the higher faba bean grain yield and the higher water use efficiency, comparing with the traditional land leveling.

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الملخص العربي

تأثير التسوية الدقيقة للتربة على إستجابة الفول البلدي لإستخدام سماد الكومبوست في الأراضي الرملية

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أجريت هذه الدراسة بمنطقة قلابشو بمحافظة الدقهلية خلال الموسم الشتويي ٢٠٠٧, وذلك للوقوف على تأثير التسوية الدقيقة للتربة على إستجابة الفول البلدي لإستخدام سماد الكومبوست في الأراضي الرملية, وقد تم تنفيذ وتصميم التجربة إحصائياً في قطع منشقة, وقد تضمنت القطع الرئيسة معاملة التسوية الدقيقة للتربة عند إنحدار صفر و٠,٠١ و٠,٠٢ و٠,٠٣% بالمقارنة بالتسوية التقليدية للتربة, بينما إشتملت القطع الشقية على معاملة سماد الكومبوست بمعدل ١,٦٠ و٢,٠٠ و٢,٤٠ طن/فدان بالمقارنة مع عدم التسميد بالكومبوست, وقد حققت التسوية الدقيقة للتربة عند إنحدار ٠,٠٢% مع إستخدام التسميد بالكومبوست بمعدل ٢,٤٠ طن/فدان أقل قيمة للكثافة الظاهرية للتربة (١,٢٨ جم/س^{٣}) وأقل قيمة لمعدل رشح التربة (٢٠ مم/س) وأعلى تركيز للعناصر الغذائية الميسرة بالتربة (٢٤ و١٧ و٣١١ جزء في المليون للنتروجين والفوسفور والبوتاسيوم على الترتيب), وكذلك أقل كمية مستهلكة من مياه الري (١٤١٥ م^{٣}/فدان), وكذلك أعلى إنتاج لحبوب الفول البلدي (١,٤٠ طن/فدان) وأعلى كفاءة إستفادة مياه الري (٠,٩٨) كجم/م^{٣}.

وبصفة عامة, فإنه يوصى باستخدام التسوية الدقيقة للتربة مع التسميد بالكومبوست, وذلك لتحقيق أعلى إنتاج لحبوب الفول البلدي مع توفير أكبر قدر ممكن من مياه الري.

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