

## **EFFECT OF PRECISION LAND LEVELING, PLANTING METHOD AND BIOFERTILIZER APPLICATION ON RICE GRAIN YIELD IN SANDY SOILS**

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### **ABSTRACT**

This study was carried out at Kaibsho Region, El-Dakhlia Governorate, during 2006 summer season to find out the effect of precision land leveling and planting method on rice grain yield under biofertilizer application in the sandy soils. The experiment was established and designed statistically as a split split plots with three replicates. The main plots were located for the precision land leveling treatment levels of 0, 0.01, 0.02 and 0.03% slope, comparing with the traditional leveling, the sub plots were devoted for the rice planting methods of manual broadcasting, manual transplanting and mechanical drilling and the sub sub plots were involved the biofertilizer treatment using the Blue green Algae, comparing with the bereaved of biofertilizer.

**The obtained results could be summarized as follows:**

1. The laser control equipment achieved the higher field capacity of 30.45 m<sup>3</sup>/h at 2.65 km/h forward speed and 0.03% leveling slope, while, the traditional scraper achieved the higher field capacity of 17.68 m<sup>3</sup>/h at 2.56 km/h forward speed.
2. Applying the precision land leveling under the biofertilization conditions achieve lower values of soil bulk density and soil penetration resistance than the traditional leveling by about 7 and 2 %, respectively.
3. Applying the precision land leveling under the biofertilization conditions achieved higher concentration of the available soil N, P and K than the traditional leveling by about 6, 20 and 8%, respectively.
4. Applying the precision land leveling of 0.02% slope and adobting the mechanical drilling under the biofertilization conditions achieved the higher rice grain yield of 4.18 ton/fed.

Finally, it is recommended to apply the precision land leveling and adobt the mechanical drilling under the biofertilization conditions to achieve higher rice grain yield in the sandy soils.

### **INTRODUCTION**

Rice is considered as the staple food for the largest number of the Egyptian people. Increasing the rice production is an important target for facing the tremendous need for more food due to the Egyptian population pressure. On the other hand, the agricultural policy has adopted a strategy for future planning based upon some factors. One of them is rationalization of water use. This could be done through reducing the cultivated area with higher irrigation water demand crops such as rice. So, the agricultural policy has looked for increasing the rice production in both the horizontal and the vertical expansionism. Meanwhile, a long-term plan is being implemented at present to increase the cultivated area. About 2.38 million feddans of sandy desert soil close to Nile Delta and Nile Valley could be added to the cultivated area (Khader *et al.*, 2004). Rice unlike other cereals, has a remarkable adaptation to a wide range of hydrological conditions. It is the most common crop in the newly reclaimed soils where the high salinity prevents the

successful growth of many other crops (Mourad *et al.*, 2003). So, reclaiming of the newly sandy soils may share in increasing rice production.

In Egypt, rice is cultivated as a fully irrigated crop with standing water. Maintaining standing water in the rice field depends on some factors such as the soil type and the land surface conditions. The sandy reclaimed soils of the coarsest texture is hard to be 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). So, the precision land leveling must be applied to cause some useful changes in the sandy soil properties to reduce the water percolation during the subsequent irrigation.

Rice yield depends to a great extent on the planting method. So, it is necessary to apply the appropriate planting method to obtain maximum rice yield and minimum production cost. Afify *et al.* (2000), Bahnas *et al.* (2003) and Zein El-Din *et al.* (2008) found that the drilling method gave the highest rice grain yield among the other methods. On the other hand, the highest grain yield obtained using rice transplanting as indicated by Aref (1990). While, Badr *et al.* (2007) showed that rice broadcasting reached the higher rice grain yield than the other methods. So, it is declared that there is no clear image about the effect of planting method on rice yield could be drawn. The conflict in these results may be attributed to the different conditions of these studies.

Recently, the agricultural technology has introduced the biofertilizers as soil conditioners, which could improve the soil structure, the water holding capacity, the hydraulic conductivity and the water retention. So, it would reduce leaching, water losses due to percolation and evaporation protect the plant against the hydric stress and increase both the nutrients and the water supply to the roots (Yanni, 1992). Moreover, El-Kholy and Omar (2004) found that the biofertilizer increased rice plant Nitrogen content at booting stage, plant height and effective tillers at maturity.

The main objective of this study is identifying the effect of the precision land leveling and the planting method on rice grain yield under the biofertilization conditions in the sandy soils.

## MATERIALS AND METHODS

### Experimental procedure:

#### 1. Experimental site and soil conditions:

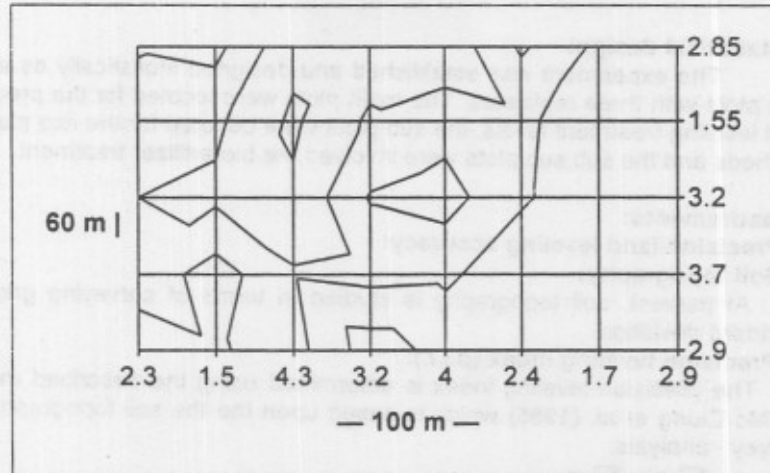
During 2006 summer season, a field experiment of 1.50 fed. area (100 x 60 m) was conducted at Kalabsho Region, El-Dakhliya Governorate. according to the standard procedures as cited by El-Serafy and El-Ghamry (2006), the soil mechanical analysis and some soil characteristics were determined and presented in Tables (1) and (2), respectively. According to Mc Clung *et al.* (1985), soil topography is studied in terms of surveying grid. The experimental field survey was determined and shown in Figure (1).

**Table (1): Soil mechanical analysis of the experimental field at Kalabsho Region, El-Dakhliya Governorate.**

Sand, %			Silt, %	Clay, %	Soil texture class
Coarse, %	Fine, %	Total, %			
70.48	3.72	74.20	9.85	15.95	Sandy

**Table (2): Some soil characteristics of the experimental field at Kalabsho Region, El-Dakhliya Governorate.**

Moisture content, % (d.b.)	Bulk density, g/cm <sup>3</sup>	Penetration resistance, MPa	pH, 1:2.5 (susp.)	Available nutrients, ppm		
				N	P	K
19.25	1.60	1.21	7.33	19.31	8.50	291.40



**Fig. (1): Schematic diagram of the experimental field grid survey at Kalabsho Region, El-Dakhliya Governorate.**

**2. Treatments:**

The following treatments were tested for the duration of the experiment:

1. precision land leveling: The precision land leveling at 0, 0.01, 0.02 and 0.03% slope was performed using a mounted hydraulic land leveler of 1.26 m<sup>3</sup> capacity (0.60 x 3.00 x 0.70 m) which 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. This treatment was compared with the traditional leveling which was performed using the same hydraulic land leveler that was operated using 2 WD tractor of 60 kW.
2. planting method: The selected seeds of Giza 178 rice variety were planted as follows:
  - a. Manual broadcasting: The seeds were manually broadcasted with a rate of 80 kg/fed.
  - b. Manual transplanting: The seeds were planted in the nursery with a rate of 70 kg/fed. After thirty days, the seedling were transplanted in the field by a team of ten labors using a marked rope (0.20 x 0.20 m).
  - c. Mechanical drilling: The seeds were drilled with a rate of 60 kg/fed. using a mounted seed drill of 21 rows with 0.15 m row spacing.

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3. **Biofertilizer:** The biofertilizer in the form of Blue green Algae powder with the rate of 0.50 kg/fed. was applied, at the tenth day after sowing, it was mixed with a suitable quantity of softy soil. The mixture was manually broadcasted above the irrigation water surface. This treatment was compared with the bereaved of biofertilization.

**3. Statistical design:**

The experiment was established and designed statistically as a split split plots with three replicates. The main plots were located for the precision land leveling treatment levels, the sub plots were devoted for the rice planting methods and the sub sub plots were involved the biofertilizer treatment.

**Measurements:**

**1. Precision land leveling accuracy:**

**a. Soil topography:**

At harvest, soil topography is studied in terms of surveying grid and standard deviation.

**b. Precision leveling index (p.l.i.):**

The precision leveling index is determined using the described method by Mc Clung *et al.* (1985) which is based upon the the soil topography grid survey analysis:

$$p.l.i. = \frac{\sum C + \sum F}{n} \text{ cm} \quad (1)$$

Where:

**C** is cut required at grid point, cm.

**F** is fill required at grid point, cm.

**N** is number of points.

**2. Machinery actual field capacity (AFC)**

The leveling machinery field capacity was evaluated at forward speed levels of 1.85, 2.25, 2.65 and 3.05 km/h at 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> slow gears, respectively of full throttle (around 75-80% engine speed of the used tractors.

$$AFC = \frac{Ve}{ATT} \text{ m}^3/\text{h} \quad (2)$$

Where:

**ATT** is the actual time required for moving 1 m<sup>3</sup> of earth work, hrs.

The volume of erth work (Ve) is calculated on the bases of the four points method as cited by Jensen (1980) as follows:

$$Ve = \frac{L^2 \sum (c)^2}{K \sum (c + f)} \text{ m}^3 \quad (3)$$

Where:

**L** is grid spacing, m.

**C** is cut required at grid point, m.

**F** is fill required at grid point, m.

**K** is dimensional constant 0.50 < K < 1.00.

### **3. Soil conditions:**

At harvest, the soil mean weight diameter (*MWD*) is determined as cited by Kepner *et al.* (1982), the soil moisture content (d.b.), the soil bulk density and the soil penetration resistance are determined according to ASAE (1992) and the soil available macronutrients concentration is determined as cited by El-Serafy and El-Ghamry (2006).

### **4. Rice grain yield:**

At harvest, for each treatment, an area of 1 m<sup>2</sup> was taken randomly to determine the rice grain yield. This procedure was replicated three times, the mean value was calculated on basis of 14% moisture content (d.b.).

### **Statistical Analysis:**

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

### **Regression and Correlation Analysis:**

Microsoft Excel 2007 computer software was used to carry out the simple regression and correlation analysis to represent the effect of the precision land leveling on the rice grain yield for the tested planting methods under the biofertilization conditions.

## **RESULTS AND DISCUSSION**

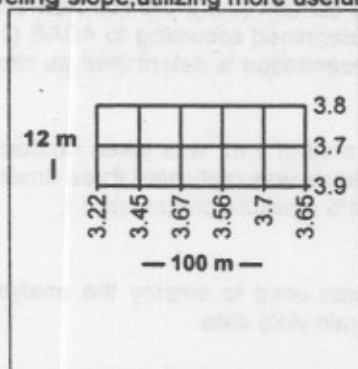
### **1. Precision Land Leveling Accuracy:**

Figure (2) shows that the precision land leveling at 0, 0.01, 0.02, 0.03% slope recorded a difference between the highest and the lowest spots of 0.20, 0.25, 0.27 and 0.29 m, with an average level for the total spot readings of 3.87, 2.59, 1.53 and 0.87 m and a standard deviation of  $\pm 0.21$ ,  $\pm 0.20$ ,  $\pm 0.16$  and  $\pm 0.16$ , respectively. Also, the previous precision leveling slope levels recorded the precision index of 0.61, 0.59, 0.56 and 0.52 cm with the same respect. While, the traditional leveling recorded a difference between the highest and the lowest spots of 0.28 m, with an average level for the total spot readings of 4.12 m and a standard deviation of  $\pm 0.22$ . Meanwhile, the recorded precision leveling index was 1.01 cm.

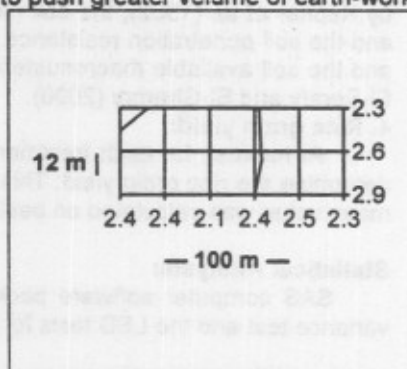
### **2. Machinery Actual Field Capacity:**

Figure (3) clarifies that the machinery field capacity increased with the forward speed from 1.85 to 2.65 km/h. This trend is illustrated that the machine moved more volume of earth-work at the time unit, utilizing shorter operating time with the increase of forward speed. Whilst, the machinery forward speed increased up to 2.65 km/h the field capacity decreased slightly. This finding may be attributed to the swelling of the moved earth-work which increases the impact force between the scraper blade and the soil, resulting in the higher soil resistance against the scraper blade. Then, the tractor wheel slip increases, leading to the lost operating time. Also, the machine field capacity is proportional to the leveling slope due to the reversible relation between the leveling slope and the rolling resistance

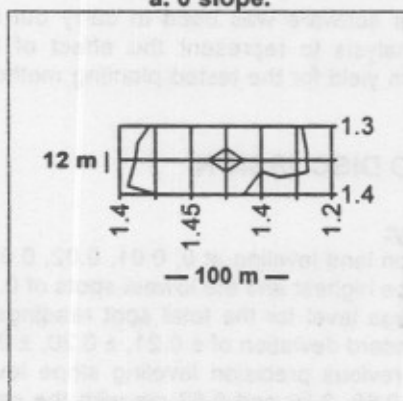
against the tractor wheels. So, the tractor wheel slip decreases with the leveling slope,utilizing more useful time to push greater volume of earth-work.



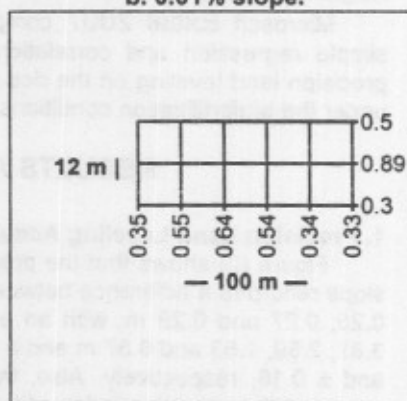
a. 0 slope.



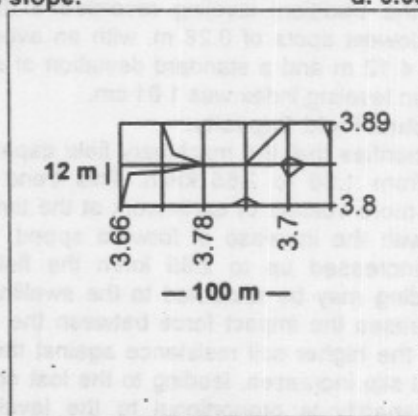
b. 0.01% slope.



c. 0.02% slope.



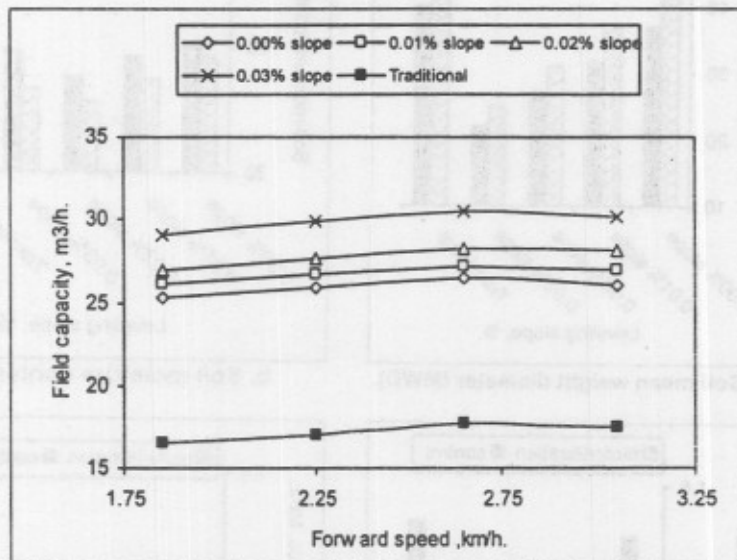
d. 0.03% slope.



e. Traditional leveling.

Fig. (2): Schematic diagram of the experimental field grid survey at harvest.

It is clear that the laser control equipment achieved the higher field capacity of 30.45 m<sup>3</sup>/h at 2.65 km/h forward speed and 0.03% leveling slope. While, the traditional scraper fulfilled the higher field capacity of 17.68 m<sup>3</sup>/h at 2.65 km/h. This finding may be attributed to the higher accuracy of the laser control equipment, for cutting and filling the soil, resulting in accomplishing the unit area in lower time.



**Fig.(3):** Effect of laser control equipment forward speed on field capacity.

**3. Soil Conditions:**

Figure (4) shows that the precision leveling achieved more desirable soil conditions than that were obtained using the traditional leveling. This result may be due to the higher accuracy of the laser control equipment, for cutting and filling the soil. Hence, the precision leveling achieved the soil particles of smaller pore spaces with grater free pore spaces per unit of soil volume. This phenomenon leads to lowering the mechanical connections between the soil particles. So, the soil resistance to the moisture deffusion decreases. Then, the soil bulk density and the soil penetration resistance decreases.

Also, the figure indicates that as the leveling slope increased from 0 to 0.02%, the soil bulk density and the soil penetration resistance decreased by about 7 and 2%, respectively. 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 pore spaces between the soil clods, leading to lowering the soil mass per unit volume. On the other hand, as the leveling slope reached to be 0.03%, the soil bulk density and the soil penetration resistance increased by about 4 and 1%, respectively. It may be due to the higher impact force between the scraper edge and the soil clods which

enclosed soil pore spaces that create an aggregated structure of the higher values of soil bulk density and soil penetration resistance.

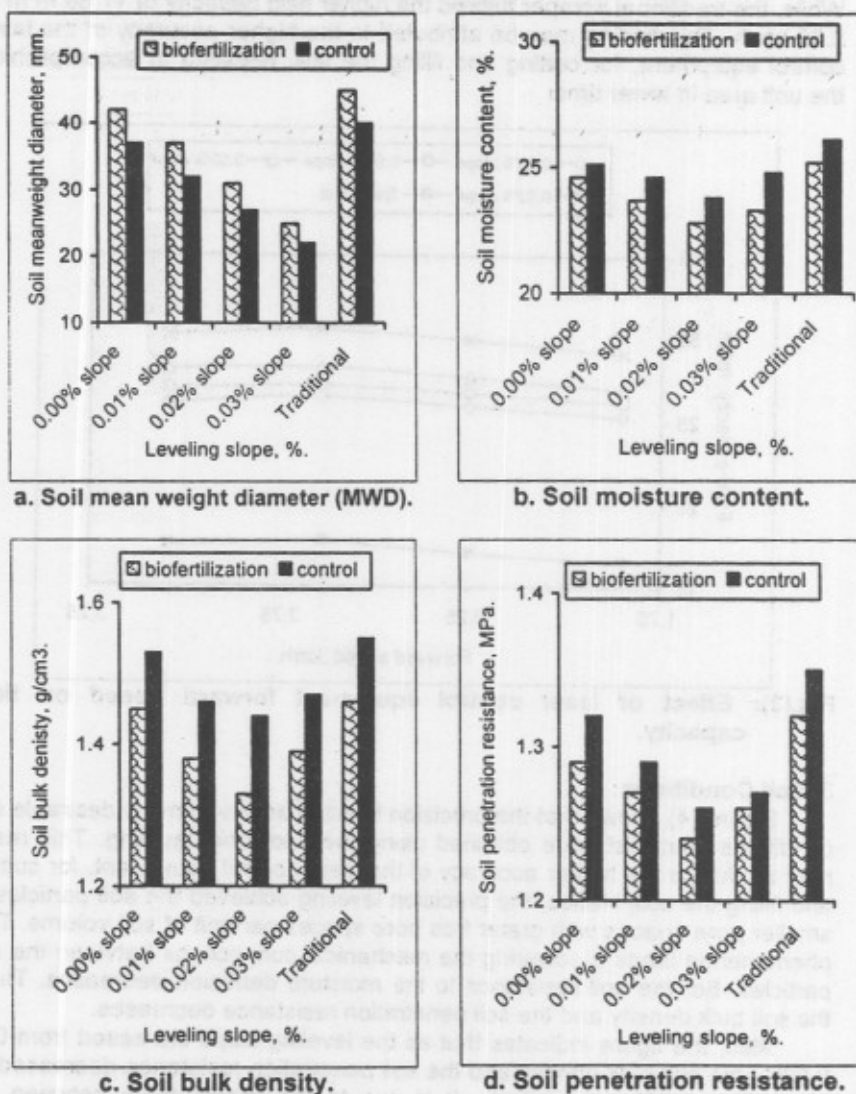
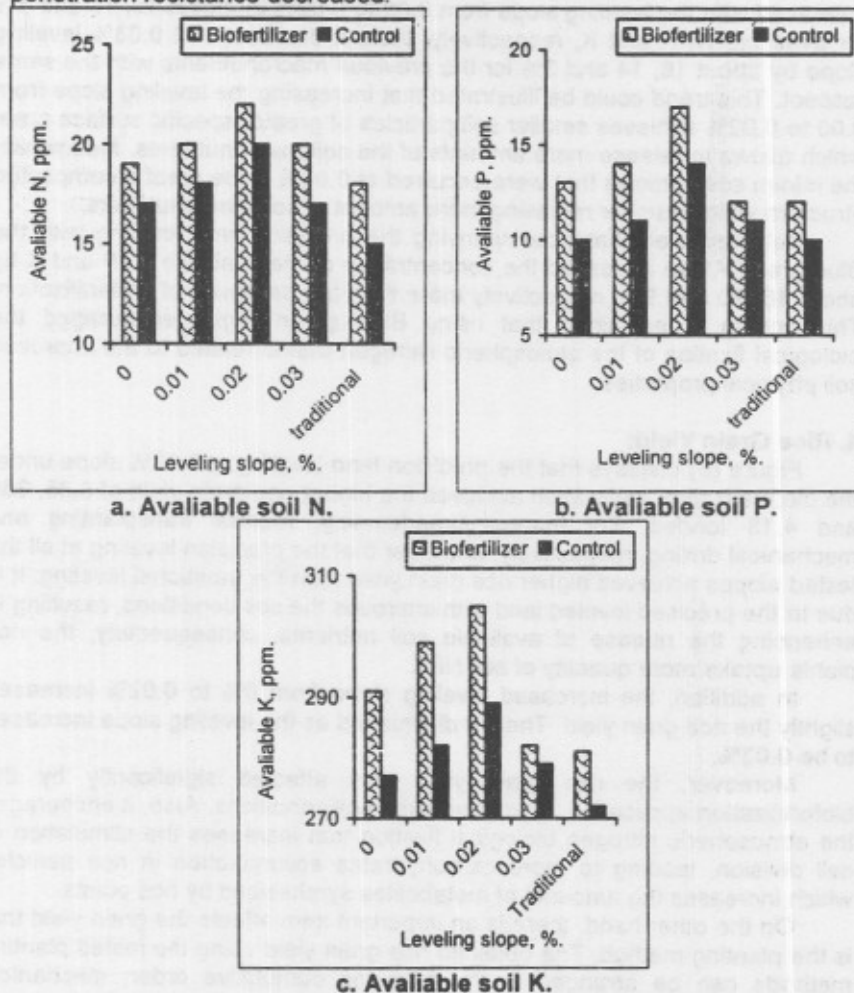


Fig. (4): Effect of precision land leveling and biofertilization application on some soil conditions.

In addition, the application of biofertilizer in case of the precision leveling diminished the soil bulk density and the soil penetration resistance by 5 and 4%, respectively, comparing with the traditional leveling. It is attributed to the



beneficial effect of the microorganisms which were 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 bulk density and the soil penetration resistance decreased.



**Fig. (5): Effect of precision land leveling and biofertilization application on available soil macronutrients concentration.**

As shown in Figure (5), the precision land leveling achieved more amount of the available soil macronutrients concentration than the traditional leveling by about 6, 20 and 8% for available N, P and K, respectively. It could be explained that the precision land leveling accomplished smaller soil particles, which having a negligible electromagnetic charge. So, the soil nutrients release increases. On the other hand, the traditional leveling

achieved larger soil particles, which having higher surface tension that increases the soil bonding forces, leading to pore spaces increment, consequently, the soil nutrients release diminishes.

The Figure shows that the available soil macronutrients concentration increased with the leveling slope from 0.00 to 0.02% by about 19, 17 and 4% for available N, P and K, respectively, then, it decreased at 0.03% leveling slope by about 16, 14 and 3% for the previous macronutrients with the same respect. This trend could be illustrated that increasing the leveling slope from 0.00 to 0.02% achieves smaller soil particles of greater specific surface area, which allows to release more amounts of the soil macronutrients. Meanwhile, the minim soil particles that were occurred at 0.03% slope creat a compacted structure which cumber releasing more amount of soil macronutrients.

Data revealed that accompanying the precision land leveling with the Blue green Algae increased the concentration of the available N, P and K by about 16, 20 and 9%, respectively more than the bereaved of biofertilization. This finding is explained that using Blue green Algae encouraged the biological fixation of the atmospheric Nitrogen that is related to the improved soil physical properties.

#### **4. Rice Grain Yield:**

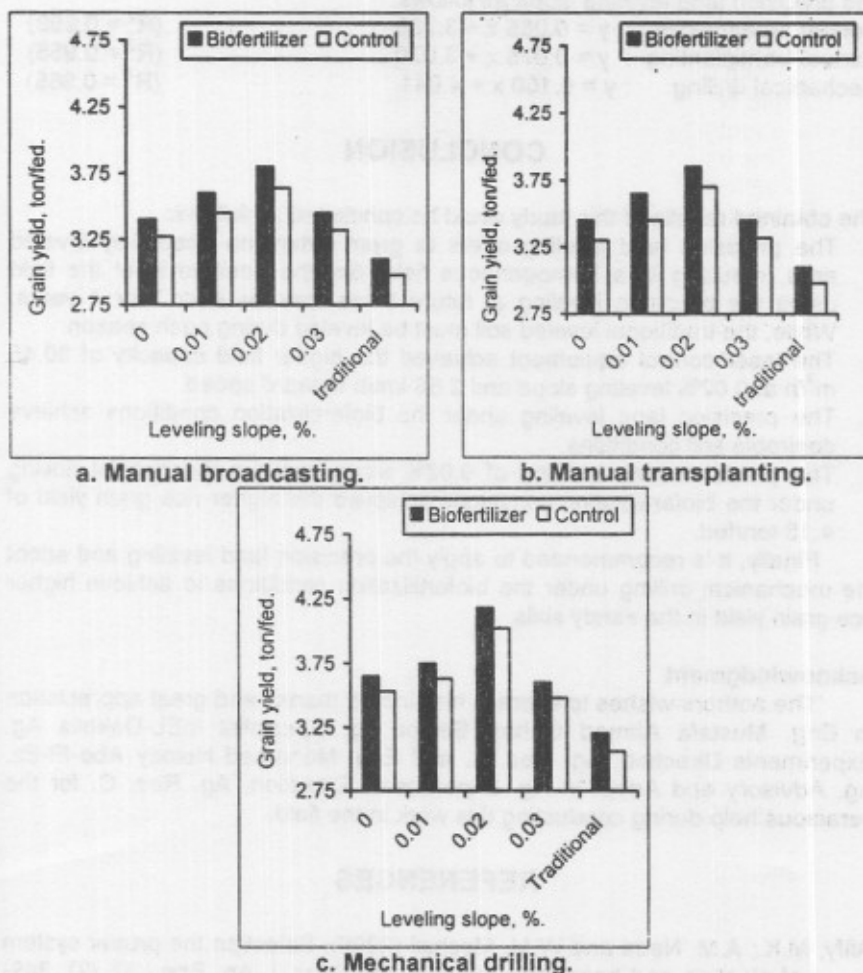
Figure (6) displays that the precision land leveling at 0.02% slope under the biofertilization application achieved the higher rice grain yield of 3.85, 380 and 4.18 ton/fed. For manual broadcasting, manual transplanting and mechanical drilling, respectively. It is clear that the precision leveling at all the tested slopes achieved higher rice grain yield than the traditional leveling. It is due to the précised leveled land with improves the soil conditions, resulting in enhancing the release of available soil nutrients, consequently, the rice plants uptake more quantity of soil NPK.

In addition, the increased leveling slope from 0% to 0.02% increased slightly the rice grain yield. Then, it diminished as the leveling slope increased to be 0.03%.

Moreover, the rice grain yield was affected significantly by the biofertilization application. It improves the soil conditions. Also, it encourages the atmospheric nitrogen biological fixation that increases the stimulation of cell division, leading to more carbohydrates accumulation in rice panicles which increases the amounts of metabolites synthesized by rice plants.

On the other hand, there is an important item affects the grain yield that is the planting method. The obtained rice grain yield using the tested planting methods can be arranged to the following cumulative order: mechanical drilling> manual transplanting> manual broadcasting. The higher rice grain yield that was obtained using the mechanical drilling is may be due to the regular plant distribution which increases the root volume, providing more water and nutrients to the plants, causing more plant anchorages. Meanwhile, the lowest rice grain yield which was obtained using the manual broadcasting is attributed to the irregularity of the plants distribution, resulting in more plant competing which lowers the nutrients uptake by rice plants. While, the lower relative rice grain yield which was obtained using the manual transplanting

may be due to the more time which was needed to recover the root seedlings after planting in the permanent land.



**Fig.(6): Effect of precision land leveling, planting method and biofertilizer application on rice grain yield.**

The analysis of variance test indicates that there was high significant difference in rice grain yield due to the precision leveling slope, the rice planting method and the biofertilization. L. S. D. test shows that applying the precision land leveling at 0.02% slope and adopting the mechanical drilling under the biofertilization conditions achieved the higher rice grain yield among the other treatments.

The obtained data of the regression and correlation analysis reveal that there was a highly significant positive correlation between rice grain yield ( $y$ ) and precision land leveling slope as follows:

manual broadcasting	: $y = 0.085 x + 3.765$	( $R^2 = 0.999$ )
Manual transplanting	: $y = 0.075 x + 3.070$	( $R^2 = 0.958$ )
Mechanical drilling	: $y = 0.100 x + 4.041$	( $R^2 = 0.965$ )

## CONCLUSION

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

1. The precision land leveling offers to great extent an absolutely leveled area, resulting in a homogeneous field. So, the need to level the field using the precision leveling at future times may be after 3 or 4 years. While, the traditional leveled soil must be leveled during each season.
2. The laser control equipment achieved the higher field capacity of 30.45  $m^3/h$  at 0.02% leveling slope and 2.65 km/h forward speed.
3. The precision land leveling under the biofertilization conditions achieve desirable soil conditions.
4. The precision land leveling of 0.02% slope and the mechanical drilling under the biofertilization conditions achieved the higher rice grain yield of 4.18 ton/fed.

Finally, it is recommended to apply the precision land leveling and adopt the mechanical drilling under the biofertilization conditions to achieve higher rice grain yield in the sandy soils.

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### تأثير التسوية الدقيقة للتربة وطريقة الزراعة والتخصيب الحيوي على إنتاج حبوب الأرز في الأراضي الرملية

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معهد بحوث الهندسة الزراعية - مركز البحوث الزراعية.

أجريت هذه الدراسة بمنطقة قلابشو بمحافظة الدقهلية خلال الموسم الصيفي ٢٠٠٦، وذلك للوقوف على تأثير التسوية الدقيقة للتربة وطريقة الزراعة تحت ظروف التخصيب الحيوي على إنتاج حبوب الأرز في الأراضي الرملية. وقد تم تصميم التجربة إحصائياً وتنفيذها في قطع تحست منشقة في ثلاث مكررات، حيث أن القطع الرئيسية تضمنت معاملة التسوية الدقيقة للتربة (إتحدار ٠٠،٠٠، ٠٠،٠١، ٠٠،٠٢، ٠٠،٠٣%) بالمقارنة مع التسوية التقليدية للتربة، وقد إشملت القطع الشقية على معاملة طريقة الزراعة (نثر يدوي، شتل يدوي، تسطير الي)، بينما إشملت القطع تحت الشقية على معاملة التخصيب الحيوي (طحالب خضراء مزرقة)، بالمقارنة مع عدم التخصيب الحيوي.

ويمكن تلخيص أهم النتائج كما يلي:

1. حققت آلة التسموية الدقيقة للتربة أعلى سعة حقليّة بمقدار ٣٠,٤٥ م<sup>٣</sup>/س عند السرعة الأمامية ٢,٥٦ كم/س ومستوى إنحدار للتربة ٠,٠٢%، بينما حققت آلة التسموية التقليدية للتربة أعلى سعة حقليّة بمقدار ١٧,٦٨ م<sup>٣</sup>/س عند السرعة الأمامية ٢,٥٦ كم/س.
٢. أدى استخدام التسموية الدقيقة للتربة تحت ظروف التخصيب الحيوي إلى إنخفاض قيمة الكثافة الظاهرية للتربة وقيمة مقاومة التربة للإختراق بحوالي ٧ و ٢% على الترتيب بالمقارنة مع التسموية التقليدية للتربة.
٣. أدى استخدام التسموية الدقيقة للتربة تحت ظروف التخصيب الحيوي إلى زيادة تركيز العناصر الغذائية الميسرة بالتربة بحوالي ٦,٢٠، ٨، ٦، ٢٠% للنيتروجين والفوسفور والبوتاسيوم على الترتيب، بالمقارنة مع التسموية التقليدية للتربة.
٤. أدى استخدام التسموية الدقيقة للتربة عند إنحدار ٠,٠٢% مع معاملة التخصيب الحيوي (طحالب خضراء مزرقة) إلى تحقيق أعلى إنتاج لحبوب الأرز بمقدار ٤,١٨ طن/فدان. ولذا فإنه يوصى باستخدام التسموية الدقيقة للتربة مع طريقة الزراعة بالتسطير الآلي تحت ظروف التخصيب الحيوي، الأمر الذي يؤدي إلى الحصول على إنتاج أعلى لحبوب الأرز.