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Significance of nutrient and water sustainability: Effect of land leveling, cut off irrigation and N- fertilization on maize yield

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Abstract

A wide variety of soil, nutrient, and irrigation management practices are available to farmers, most of them concerned with the basic building block of agriculture, the soil. Soil management practices include the tillage and cropping systems and crop rotations used on a farm. Therefore, sustainable crop production should be managed to enhance soil ecosystems, improving soil health and fertility and reversing degradation and pollution of land. As well as, it should be contributed to maintaining and improving, and efficiently utilizing, water resources (quantity, access, stability and quality), especially promoting practices that minimize risks of water pollution from agrochemicals and save water. It is well documented that fertilizer N is the most costly input in maize production and its effective management is a major challenge for improving productivity and environmental sustainability. In present study, the effect of land leveling, cut off irrigation and N- fertilizer on yield and yield components of maize have been studied. The results showed that the highest yield of grain and straw of maize was obtained with using N-fertilization rate 288 kg N ha^{-1}, land levelling rate 0.01 % of surface slope and cut off stream of irrigation rate 75%. The results of this study suggest that, irrigation application efficiency (%) increased from 71 % (for control) to 80 % for cut off 75 % of stream irrigation and land leveling with 0.01 % slope. Thus, about 20 % from the applied water for irrigation is saved by the previous treatments.

Key words: *Maize, nitrogen, irrigation application efficiency, cut off irrigation*

I. Introduction

It is well documented that, soil management practices including the tillage, cropping systems and crop rotations can be used on a farm scale. Furthermore, tillage practices, through their impact on soil and its chemical movement are major determinants of agriculture's impact on the agroecosystem. Cropping patterns and rotations affect the amounts of chemical or non-chemical fertilizers that are needed. The levels of chemical inputs used in maize production were similar across different tillage systems (***Christensen, 2002***).

It could be summarized the maize farmers' nutrient management decisions, which influence the amounts and form of nutrients used as follows: the timing of fertilizer application and the method of application. The mix of these choices influences how much of a nutrient is used by maize, how much is stored as a residual in the soil, and how much becomes available as a potential water and air pollutant. Two recommended nutrient management practices, maize-legume rotations (primarily with soybeans) and soil incorporation of nitrogen fertilizer (either through injection application or broadcasting with incorporation), were used on nearly 60 % of the maize acreage (***Christensen, 2002***). **Ma *et al*. (1999)** suggested that fertilizer N is the most costly input in maize production and its effective management is a major challenge for improving productivity and environmental sustainability. Therefore, the objective of the present study was to evaluate the yield and water productivity indices response of maize to the combined effects of land leveling and applied N fertilizer. The results of this study can be helpful in policy planning regarding irrigation management for maximizing net financial returns from limited land and water resources. It could be hypothesized that a systematic effort on integrated technologies (precision laser leveling, cut off irrigation and N – fertilizer management) would improving resources use efficiency under arid climatic conditions of Egypt.

II. Materials and Methods

Field experiment was carried out at the experimental farm, Sakha agriculture Research, Kafr El Sheikh (6 m altitude, 31° 07- latitude and 30° 52- longitude). During 2012 season, the effect of land leveling, cut off irrigation and N-fertilization on grain and straw yields of maize, weight of 1000 grain, ear weight and plant height were considered. This experiment was conducted in split – split plot design, with three replicates. The main plots were assigned to land leveling (L1, L2 and L3), sub plots (cut off irrigation: I1, I2, and I3), and sub – sub plots (N fertilizer levels: N1, N2, and N3). The plot area was 10.5 m^2. The previous cultivated crop was wheat. **Table 1** shows the experimental design.

Maize (*Zea mays* L.) was sown on 15th July 2012. The N was applied as urea (46.5 % N). The other required cultural practices for growing maize were followed properly as recommended for the region. The following data were recorded: grain and straw yield (Mg ha^{-1}), 1000 grain weight (g), ear weight (g), and plant height (cm). All data calculated and converted on dry matter basis (15.5 %). Soil samples from the surface layers (0-20) and (20-40) were taken from the experimental sites before planting and prepared for physical and chemical analysis. Soil salinity and pH were 1.82 dS m^{-1} and 7.9, respectively for surface layer (0-20 cm). Plant samples were taken randomly at harvest to estimate the yield and its components. Soil samples were air-dried crushed and passed through 2.0 mm sieve for the chemical analyses according to **Page et al. (1982)**. The soil texture was clayey. The results were analyzed statistically by a General Linear Model procedure and 2 way analysis of variance (ANOVA) using Cohort computer program according to the method of **Gomez and Gomez (1984)**. All calculations were made on a dry weight basis.

III. Results and Discussion

As shown in **Table 2**, application of nitrogen significantly increased grain and straw yields of maize as well as 1000 grain weight, ear weight, and plant height. Maximum grain and straw yields (9.17 and 9.07 Mg ha^{-1}, respectively), whereas 1000 grain weight (44.3 g), ear weight (339 g), plant height (321 cm), were found with the application of 288 kg N ha^{-1}. All previous parameters significantly increased with increasing of N- fertilizer level from 180 to 288 kg N ha^{-1}. As well as, land leveling (0.01% ground surface slope) and cut off irrigation (75% of irrigation run) were represented the maximum values for all previous maize yield and yield components.

There are numerous studies on the interaction effects of irrigation and fertilizer N on maize. Furthermore, when water is limiting, the sum of optimum applied nitrogen and soil residual nitrogen is constant similar to that obtained when land is limiting. The optimum N- application was mainly influenced by soil residual nitrogen, but not by the water or land limiting conditions. Nitrogen plays a key role in plant nutrition and it is the mineral element required in the greatest quantity by cereal crop plant as well as it is the nutrient most often deficient. As a result of its critical roles and low supply, the management of nitrogen resources is an extremely important aspect of crop production (***Montazar and Mohseni, 2011***).

Applied and stored water decreased from traditional land leveling to 0.01 % slope, whereas both saved water and irrigation efficiency was increased for previous treatments as shown in **Fig. 1**.

It could be observed that, great efforts has been made on saving water in agriculture, especially in optimizing irrigation method, and several effective patterns were achieved, such as limited irrigation (**Kang et al. 2002**), regulate deficit irrigation (**Fabeiro et al. 2002**), surge flow irrigation (**Horst et al. 2007**), cut off irrigation (**El-Ramady et al. 2012**) and so on (**Yang et al. 2011**). From this study, the cut off irrigation can be used successively to save irrigation water amount. It could be saved till 20 % from applied irrigation water by using land leveling (0.01% ground surface slope). Therefore, it could be recommended that, optimizing irrigation strategies for high crop production and water use efficiency should be followed to conserve water resource in water limited regions.

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Table1: The experimental design

Treatments	
Land leveling	
L1	Traditional land leveling farmer's practices
L2	Dead level (0.0%) slope
L3	0.01% ground surface slope
Cut off irrigation	
I1	0 % cut off stream of irrigation or irrigation tail furrow
I2	15 % cut off stream of irrigation (85% of irrigation run)
I3	25 % cut off stream of irrigation (75% of irrigation run)
N – fertilizer levels	
N1	180 kg ha^{-1} (75 kg N fed^{-1})
N2	240 kg ha^{-1} (100 kg N fed^{-1})
N3	288 kg ha^{-1} (120 kg N fed^{-1})

Table 2: Effect of land leveling, cut off irrigation, mineral N levels on **maize** yield and its components

Treatments	**Grain yield (Mg ha^{-1})**	**Straw yield (Mg ha^{-1})**	**1000 grain weight (g)**	**Ear weight (g)**	**Plant height (cm)**
Land Leveling					
L1	6.77 c	5.93 c	42.5 c	285 c	283 c
L2	9.09 b	9.12 b	44.1 b	352 b	295 b
L3	10.32 a	10.34 a	45.6 a	356 a	309 a
Cut off irrigation					
I1	8.54 c	7.92 c	43.6 c	307 c	291 c
I2	8.71 b	8.47 b	44.1 b	321 b	296 b
I3	8.93 a	9.00 a	44.5 a	335 a	299 a
N-Level					
N1	8.33 c	7.82 c	43.8 c	297 c	272 c
N2	8.69 b	8.49 b	44.0 b	327 b	293 b
N3	9.17 a	9.07 a	44.3 a	339 a	321 a

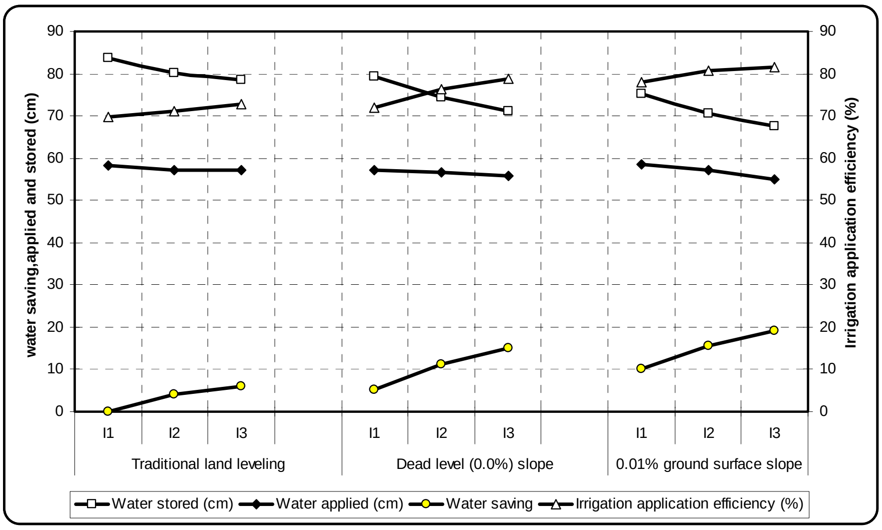

Fig. 1: Amount of water applied to **maize**, water stored, irrigation application efficiency (%) and water saving under different treatments