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Maize Yield as Influenced by Some Plowing Practices and Fertilization

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Abstract: A field experiment was conducted for two consecutive years at El Nubaria station to study the effect of two plowing methods (chisel and moldboard) and fertilization on yield of maize crop and its irrigation water requirements under calcareous soil. The obtained data showed a significant effect of deep tillage on seed yield of maize. Highest yield was noted with moldboard plough compared to chisel plough. Also, seed yield of maize crop was influenced by the fertilizer treatments in both investigated seasons. Data indicated that seed yield of maize crop was increased with increasing the application rates of nitrogen, phosphorous and potassium in both seasons. Concerning, the water use efficiency (W.U.E), the highest value of W.U.E was obtained under the highest level of N fertilizers under using moldboard plow in the both seasons.

Key words: Crop water requirements · Chisel Moldboard · Maize crop

INTRODUCTION

For thousands of years, humankind has tillage the soil in order to increase the production of food [1]. In general, soil tillage is one of the fundamental agro-technical operations in agriculture because of its influence on soil properties and crop production. To assure normal plant growth, the soil must be prepared in such conditions that roots can have enough air, water and nutrients. Structure of the Ap horizon is largely influenced by soil tillage system and the implements used for tillage [2, 3]. Tillage plays an important role in controlling weeds and managing crop residues, but the primary purpose of tillage is to change the soil structure [4]. The first tillage after the last harvest and usually the most aggressive one is called primary tillage. Primary tillage of soil is mainly used to cut and loose soil to a depth of 15 to 90 cm [1]. The moldboard plow is the most common primary tillage tool in the world and has the capacity to break up many types of soil. It has the ability to turn over and cover sods, crop residues and weeds [1, 5, 6]. Chisel plow and disk plow are other common primary tillage systems [7]. The chisel plow is a soil tillage system that shatters the soil without complete burial or mixing of surface materials. Optimum tillage to achieve maximum crop yields with minimum energy consumption should be the aim of seedbed preparation. A good seedbed is generally considered to imply finer particles and greater firmness in the vicinity of seeds. The depth up to which tillage operations disturb the soil can classify the operation as shallow, medium or deep. The depth of tillage depends on the crop and soil characteristics and also on the source of power or energy available.

Deep tillage is an energy-expensive operation but may be justified only if there is a greater production and the effect is sustainable. The effect of deep tillage on moisture conservation and rain fed wheat is erratic varying with soil and rain received [8]. The earlier work done on deep tillage in the area hypothesized that gain in agronomic yield due to better root growth, greater uptake of nutrients and water under deep tillage [9, 10].

Karlen and Gooden [11] found that the average grain yield of wheat was significantly higher (0.4 Mg ha^{-1}) with moldboard plowing than with disking in four of five studies, but it was significantly higher than chisel plowing (3.09 vs. 2.48 Mg ha^{-1}) only once. No-till yield was significantly lower (0.5 Mg ha^{-1}) than yield with disking in two of four studies. Nitrogen response was significant in five of six studies. Head number and weight were increased by plowing or higher N rates.

Studying N fertilizer rates in conjunction with tillage systems is important because soil microbial populations in no-till and tilled soils are significantly different [12]. Those population differences are caused by changes in soil water content, residue distribution and soil aeration, but more importantly, they significantly change N cycling when compared to conventional tillage practices. Another factor that must be evaluated as tillage systems are changed is cultivar selection [13].

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The objective of this research was to evaluate the effect of two plough systems and N, P and K fertilizers rates on the yield of maize crop cultivated in the calcareous soil.

MATERIALS AND METHODS

Two experiments were conducted at the Agricultural Experimental Station, El Nubaria station, Behera Governorate, during two successive summer seasons of 2009 and 2010. The experimental area was divided into 48 equal experimental plots each has an area of 32 m^2 (4 X 8m). These plots were separated from each other by a belt (2 m width) to avoid lateral movement of irrigation water. A split plot design with three replicates was adopted in the experimental area, whereas plowing treatments were assigned to the main plots and fertilizers treatments in the sub-plots as following:

Main Plots: (plowing treatments)

- Chisel plough
- Moldboard plough

Sub-Plots: (fertilizers treatments)

- Two rates of Nitrogen fertilizers [250 Kg/fed (N1) and 500 Kg/fed (N2) as Ammonium Nitrate]·
- Two rates of phosphorous fertilizers [100 Kg/fed (P1)and 200 Kg/fed (P2) as super phosphate]·
- Two rates of potassium fertilizers [25 Kg/fed (K1) and 50 Kg/fed (K2) as potassium sulphate].

Undisturbed and disturbed surface (0-20 cm) and subsurface (20-40 cm) soil samples were collected to determine some physical and chemical characteristics of the investigated soil according to the methods described by Page *et al.* [14] and Klute [15]. Table 1 showed some soil physical and chemical characteristics of the experimental site.

After the preparation of the seedbed using chisel and moldboard plough, the maize seeds (variety S.C 10) were sown in furrows, at 30 cm distance between hills and 70 cm distance between furrows, on the first of June in both seasons (2009-2010). After seed emergence (one month from sowing), thinning was done into one plant per hill (recommended planting method) to get 20.000 plants/fed [16].

Table 1: Some soil physical and chemical characteristics of the experimental site

	Soil depths (cm)	
Soil characteristics	Surface layer	Subsurface layer
Particle size distribution%		
C.sand	2.2	3.5
F.sand	59.8	68.1
Silt	19.3	14.9
Clay	18.7	13.5
Texture class	Sandy loam	Sandy loam
Bulk density (g/cm^3)	1.53	1.59
Field capacity (θv%)	23.8	18.1
Wilting point (θv%)	11.5	8.2
Available water (θv%)	12.3	9.9
$CaCO_3$%	18.6	17.63
Organic matter%	0.62	0.38
pH (1:2.5 extract)	8.17	8.06
ECe (1:2.5 extract)	1.03	1.25

The values of actual evapotranspiration were calculated according to Israelsen and Hansen [17]. Irrigation water was added to each plot by gated pipe in order to control and calculate the amount of water added to each plot. A gate was established on the irrigation channel to achieve a constant head of water during irrigation applications. The amount of irrigation water was controlled through daily measurements of the soil moisture content in the surface and subsurface layers gravimetrically.

Water use efficiency was calculated according to Giriappa [18] using the following equation:

$$WUE = \frac{Yield(Kg\ /\ fed)}{ETa\ (m3\ /\ fed)}$$

At the end of the experiment (on 23 septemper in both seasons), seed yield was measured for each treatment, the concentration of N, P, K, Fe, Mn, and Zn were determined in the seeds.

All the data were analyzed statistically using Costat program in which plowing treatments represented main plot while fertilizers treatments represented sub- plots. The differences between the mean values were compared by Duncan's multiple range test. Statistical significances were evaluated at $P \leq 0.05$.

RESULTS AND DISCUSSION

Total and Monthly Actual Evapotranspiration (ETa) of Maize Crop: The data presented in Fig. 1 indicate that the actual evapotranspiration varied from month to another throughout the two growing seasons. These variations

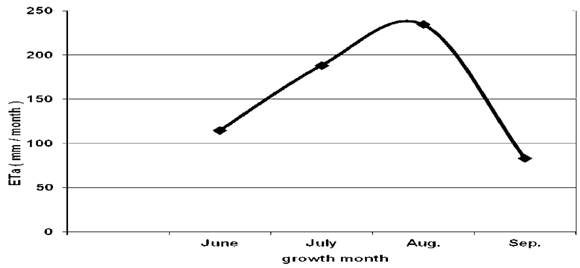

Fig. 1: Monthly actual evapotransplration of malze crop.

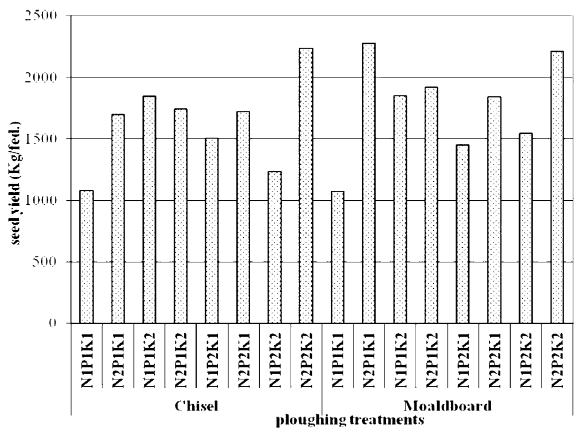

Fig. 2: Effect of ploughing and fertilizers treatments on seed yield of maize crop.

are low at the beginning of the growing season, because of the slow plant growth and so the high loss of moisture mostly by evaporation from the surface soil. As the plants develop, a gradual increase is observed in water consumption. The actual evapotranspiration (ETa) reaches the peak in August where the maize crop was at flowering stage and seed filling in this month, then the ETa decrease in September at late stage under all plowing and fertilizers treatments. On the other hand, Results indicated that the mean of total evapotranspiration of maize crop through the two studied seasons under chisel and moldboard plow was 620 mm/fed.

Effect of Tillage Practice on Bulk Density: Different tillage operations decreased soil bulk density to their titling depth specifically in the surface horizon 0 to 20 cm depth, moldboard resulted in the lowest bulk density compared with chisel plow, where it decreased from 1.53 gm/cm^3 to 1.43 gm/cm^3 in moldboard, while it decreased to 1.48 gm/cm^3 in chisel plow in the surface layer. On the other hand the changes in subsoil layer were lower than the surface where it changed from 1.59 to 1.53 gm/cm^3 in moldboard and to 1.56 gm/cm^3 in chisel plow.

The Response of Maize Seed Yield to Plowing Practices and Fertilizers Treatments: Data of seed yield of maize crop as affected by plowing and fertilizers treatments are presented in Fig. 2. The obtained results indicate that the yield of maize crop increased after moldboard plow compared to chisel plow. Under using moldboard in some fertilizers treatments seed yield were significantly greater than with using chisel. Accordingly, the seeds yield increased by 34.1, 10.3, 6.6 and 25.5% with using moldboard plow over chisel plow under the following treatments; N2P1K1, N2P1K2, N2P2K1 and N1P2K2, respectively. A significant increase in maize grain using moldboard plow as compared to chisel may be due to the deep tillage occurs by moldboard plow which provide a good aeration in rooting zone, as well as, a little condense of weed after deep tillage. Campbell and Akhtar [10] speculated that there was enhanced root growth due to moldboard and in turn shoot growth was due to increase water and nutrient uptake. Gill *et al.* [19] found that moldboard tillage resulted greater bio-mass and seed yield than conventional cultivator.

Seed yield of maize crop is influenced by the fertilizers treatments in both investigated seasons. Therefore, data presented in Fig. 2 indicate that seed yield of maize crop is increased with increasing the application rates of nitrogen, phosphorous and potassium at both seasons.

Data presented in Table 2, showed the content of some macro and micronutrients in the seed yield of maize. The results showed that the content of N, P and K under moldboard are higher than those using chisel plow. The same trend is observed for Fe, Mn and Zn. Similar increases in the macro and micronutrients contents as a result of raising the fertilization rates are observed except for Zn. Content of Zn decreased with increasing the rate of phosphate fertilizer. This result is in agreement with the finding of Reddy *et al.* [20].

Water Use Efficiency (W.U.E): Data illustrated in Fig. 3 indicate the effect of plowing and fertilizers treatments on the WUE values. The data clearly show that the values of water use efficiency (W.U.E) decreased with decreasing the rate of N fertilizers. Consequently, the highest value of W.U.E was obtained under the highest level of N fertilizers under moldboard plow in the both seasons. This may be explained by the efficient root distribution of maize crop in the root zone under moldboard plow which consume sufficient amounts of water and produce a higher seed production as compared with chisel plow.

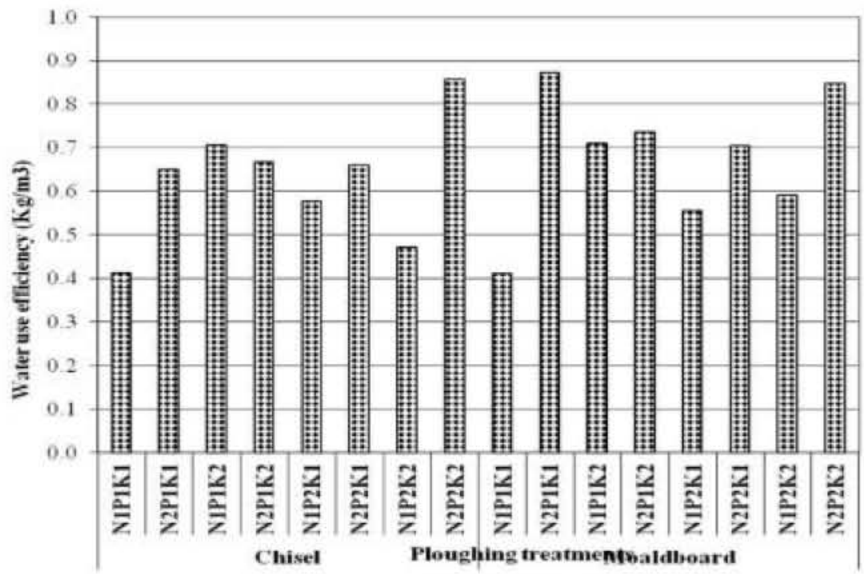

Fig. 3: Effect of ploughing and fertilizers treatments on water use efficiency of maize crop.

Table 2: Total contents of some macro and micronutrients in the seed yield of maize

Fertilizer	N	P	K	Fe	Mn	Zn
Treatments	---------Kg.fed^{-1}----------			-------------g.fed^{-1}--------------		
			Chisel			
N1P1K1	16.79	1.03	3.77	53.63	24.13	41.61
N2P1K1	29.80	1.79	6.77	107.01	31.79	46.98
N1P1K2	27.27	1.63	7.19	108.50	30.51	47.26
N2P1K2	29.04	1.87	6.96	121.14	26.86	57.09
N1P2K1	23.46	1.60	5.87	143.64	16.68	45.12
N2P2K1	31.17	1.84	6.54	114.08	24.42	56.40
N1P2K2	19.80	1.87	6.92	113.95	18.99	68.45
N2P2K2	41.08	2.37	9.38	125.38	27.60	140.77
			Moldboard			
N1P1K1	17.05	1.36	4.61	72.81	65.38	40.75
N2P1K1	41.33	1.93	7.31	130.17	54.18	83.56
N1P1K2	28.29	1.98	7.58	110.79	70.63	47.71
N2P1K2	32.81	2.25	7.51	129.20	54.19	68.70
N1P2K1	23.21	1.78	6.53	150.74	46.63	56.56
N2P2K1	33.79	1.96	6.90	202.90	50.80	127.06
N1P2K2	25.00	1.84	7.78	117.33	36.48	85.44
N2P2K2	41.06	3.25	9.61	247.61	58.45	175.00

CONCLUSION

The conclusions drawn from this study are:

- Deep plowing by moldboard plough significantly increased the seed yield of maize crop compared with chisel plough.
- Increasing the application rate of nitrogen, phosphorous and potassium fertilizers resulted in increasing the seed yield and water use efficiency of seed yield of maize.

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