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IMPACT OF SEEDBED PREPARATION CONDITION ON AGGREGATES STABILITY, YIELD, WATER PRODUCTIVITY AND FERTILIZERS USE EFFICIENCY ON MAIZE (ZEA MAYS)

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Abstract

Field experiments were conducted during the summer season of 2017 as cooperation studying between the National Research Centre and Soils, Water and Environmental Research Institute, Agricultural Research Center to evaluate the effect of soil moisture content M1, M2 and M3 (w/w %), plowing depth D1, D2 and D3 (10, 20, 30 cm) and Plowing speed S1 and S2 (1.93; 10.33 km h^{-1}) on soil structure, crop yield, water productivity and fertilizers use efficiency. Chisel plow was used for seedbed preparation. Corn (Zea Maize) seeds were seeded on clay loam soil under surface irrigation (Border strip). Data obtained could be abstracted in the following:

1-Total stable aggregates (TSA) values obtained under soil moisture content (M1, M2 and M3) were (57.74, 52.78 and 47.61%), respectively. While its values under Plowing speed S1 and S2 (1.93; 10.33 km h-1), were achieved 39.72 and 49.66 %, respectively, whereas these values under plowing depth D1, D2 and D3 were (511.91, 52.53 and 53.05 %), respectively. 2- the main effects of M, D, S on the investigated parameter could be written in the following ascending orders: M3 < M2 < M1, S1 < S2 and D1< D3 < D2, 3- the interaction: M X S X D affected all the studied parameters within significant differences, 4- the maximum values of the studied parameters were obtained in the interaction M1 X D2 X S1 whereas, the minimum ones were achieved in the interaction: M3 X D3 X S3 and 5- There are significant differences between all values of studied parameters.

Keywords: Soil, Aggregate, Moisture, Depth, Plow speed, Crop yield, Water Productivity and Fertilizers use efficiency.

Introduction

Tillage is one of the most important factor affecting soil physical and hydraulic characteristics (Lal and Shukla, 2004). According to Walters (2013) the main aim of tillage is to improve seedbed for better germination and crop growth our word today, is facing an ever-increasing challenge of wide spread food insecurity. Therefore, all the agricultural sectors must produce more crop per unit of our precious and limited resources i.e. soil, water, energy and fertilizers.

Obalum Obi (2010) states that soil physical conditions a major index of productivity is prone to changes in the field due to management practices used. They added that soil structure is perhaps the most dynamic physical property. According to Bablo and Opara Nadi (1993) this is due to its effects on soil cementing agents i.e. Calcium carbonates, organic matter, iron oxide and aluminum oxide.

Soil structure was defined as the arrangement of soil particles (single aggregated) and soil pores(large, medium and small)relative to each other into a structural pattern (Baver, 1956, Rose, 1966, Kohnke, 1968, and Baver *et al*., 1972). Soil structure is a key to soil fertility.

Conflicting results have been reported concerning the effects of soil moisture content at plowing depth, plowing speed on the hydro physical properties. Stickler (1962) mentioned on increase in crop yield reduction with increasing soil bulk density. Soil compaction has been associated with adverse effects i.e. low soil water content and nutrients availability, poor soil aeration, slow fluids movements and mechanical impedance to root growth (Al-Darby, 1989). He added that shoot and root growth of wheat crop decreased exponentially with increasing soil strength. Several researchers have dealt with the effects of soil moisture content at plowing, plowing speed and plowing depth on the hydro physical soil properties recently. Al-Ani al-Ani (2010) found that increasing of working forward speed of plowing increased total porosity of clay loam at moisture content of 22 and 19 w/w%. Dena Bayoume (2016) found that total soil porosity and the mean weight diameter increased with increasing soil moisture content from 9.5-23 % by weight. The adverse effects of soil compaction include increasing slip of the tractor wheels, fuel consumption and the micro pores on the expense of the macro ones. Whereas, they decrease the field capacity and the useful life of tractors and their wheels. (Tayel *et al*., 2016; Tayel *et al*., 2017; Tayel et al., 2018 and Dena Bayuomy *et al.,* 2018). This study aimed to evaluate the effect of some conditions for seedbed preparation i.e. soil water content at plowing, plowing depth and speed on total stable aggregates, crop yield, water use efficiency and fertilizers use efficiency.

Materials and Methods

The National Research Centre and the Soil Water and Environmental Institute, Agricultural Research Centre conducted field experiment during the summer season of 2017 to evaluate the effects of the following treatments:

(a) Soil water content M1, M2 and M3 (8.1, 17.1, 26.49, on the weight basis),

(b) Plowing depth D1, D2 and D3 (10, 20, 30 cm) and

(c) Plowing speed S1 and S2 (1.93; 10.33 kmh^{-1})

On total stable aggregates, grains yield, water use efficiency and fertilizers efficiency. The experiment design was split-split plots. Chisel plow was used for seedbed preparation as showing in Figure (1). Three replicates were used. Corn seeds (*Zea maize*) were seeded on clay loam soil under surface irrigation. Other agricultural treatments were performed according to the recommendation of ministry of agriculture and land reclamation 100 day after planting, crop was harvested, and grains yield was calculated. Soil physical and hydro physical properties were conducted according to standard methods (Klute, 1986).

Fig. 1A. : Chisel plowing device

Fig. 1 B: Tractor during tillage and seedbed preparation

Water and fertilizers use efficiency were calculated using the following equations:

$$\text{Water use efficiency} = \frac{\text{grains yield (kg)}}{\text{seasonal evapotranspiration} (m^3)} \quad ....(1)$$

$$\text{Fertilizers use efficiency} = \frac{\text{Grains yield (kg)}}{\text{Fertilizer used (kg)}} \quad ....(2)$$

After Michael (1978), Howell *et al*. (1995) and Barber (1976).

Statistical analysis: The data were subjected to analysis of variance (ANOVA) using Costat program. The split plot design according to Van Ginkel and Kroonenberg, (2014).

Results

Tables (1; 2) and Figures (2, 3, 4; 5) showed the main effects of some seedbed conditions i.e. soil moisture content M: M1, M2 and M3 (8.1, 17.1; 26.4 %) on weight basis, plowing depth D: D1, D2 and D3(10, 20; 30 cm) and plowing speed S: S1 and S2 (1.93; 10.33 Kmh^{-1}) on the total stable aggregates (T.S.A.) Grains Yield (G.Y) kg/fed., water productivity (WP), Nitrogen Use Efficiency (NUE), Potassium Use Efficiency (K2O USE) and Phosphorous use efficiency P_2O_5UE).

It is worthy to mention that M1 treatment surpassed the two treatments M2 and M3 by: (9.4; 21.3 %), (24.4; 27.7 %), (8.6; 10.0 %), (24.6; 28.6 %), (27.7; 29.0 %) and (26.0; 27.2%) in the case of T.S.A., G.Y., WUE, NUE, K2O UE and P_2O_5 UE, respectively). The main effects of M treatments could be written in the following ascending order M3<M2<M1.

D treatments could be arranged on the following ascending order: D1<D2<D3 except G.Y. and K_2O. It can be noticed that that fertilizers use efficiency could be put on the following ascending order: $N<K_2O<P_2O_5$. This could be due to : (a) corn plant need more N than both K_2O and P_2O_5, whereas the yield is constant see equation (2), N is more mobile in soil relative to K_2O and P_2O_5, and mineral N is subjected to loss by leaching due to it's mobility and by denitrification, N is lost via voltization to the air and filling to inter cell structure (Alexander, 1961). In the case of plowing speed S treatments S2 exceeded S1 by: (27.3, 10.9), (35.1, 11.9) and (9.4; 9.2%) for T.S.A., G.Y., WP, NUE, K_2OUE and P_2O% UE, respectively.

D treatments could be arranged on the following ascending order: D1<D2<D3 except G.Y. and K_2O. It can be noticed that that fertilizers use efficiency could be put on the following ascending order: $N<K_2O< P_2O_5$. This could be due to : (a) corn plant need more N than both K_2O and P_2O_5, whereas the yield is constant see equation (2), N is more mobile in soil relative to K_2O and P_2O_5, and mineral N is subjected to loss by leaching due to it's mobility and by denitrification, N is lost via voltization to the air and filling to inter cell structure (Alexander, 1961). In the case of plowing speed S treatments S2 exceeded S1 by: (27.3, 10.9), (35.1, 11.9) and (9.4; 9.2%) for T.S.A., G.Y., WP, NUE, K_2OUE and P2O% UE, respectively.

Tables (1; 2) and Figures (2, 3, 4; 5) indicated that interactions M X S X D has effects on the parameters mentioned above. It is obvious the interaction: M X S X D has effects on the values of the parameters under investigation. The maximum values were achieved in the interactionM1 X S2 X D 1, while the minimum ones were obtained in the interaction M3 X S3 X D3.

Table 1 : Main effects of M, S and D on T.S.A., G. Y., WP and FUE.

Treatments			**TSA %**	**G.Y.**	**WP**	**FUE**		
Moisture θ (%) I	**Plow S (km/h) II**	**Plow depth (cm) III**				**N**	**K_2O**	**P_2O_5**
θ1 8.1%	S1 1.9	10	57.28	3729	1.07	55.66	155.38	160.39
		20	57.31	3962	1.13	59.19	165.08	170.76
		30	60.16	2263	0.65	33.78	94.29	97.33
	S2 10.33	10	56.83	2711	0.77	40.46	112.26	116.60
		20	57.17	3724	1.06	55.85	155.17	142.97
		30	59.43	2413	0.96	36.01	100.54	103.78
θ2 17.1%	S1 1.9	10	51.52	2422	0.79	36.15	100.92	104.17
		20	52.59	2333	0.76	34.82	97.21	100.34
		30	55.95	2819	0.91	42.07	117.46	121.28
	S2 10.33	10	52.05	2301	0.75	34.34	95.88	98.98
		20	52.18	1833	0.59	27.36	76.38	78.84
		30	55.32	2305	0.75	34.40	96.04	99.14
θ3 26.4%	S1 1.9	10	46.56	2567	0.32	38.31	106.96	110.41
		20	48.33	2305	0.63	34.40	96.04	99.14
		30	48.33	2856	1.07	42.63	119.00	122.84
	S2 10.33	10	47.64	2291	0.86	34.19	95.46	98.56
		20	50.17	2891	0.86	34.19	95.46	98.56
		30	47.11	2161	0.81	32.25	90.04	92.95
LSD 0.05								
I X II			0.01	2.14	0.01	0.02	0.01	0.02
I X III			0.21	0.01	0.02	0.03	0.02	0.03
II X III			0.06	0.03	0.03	0.01	0.03	0.01
I X IIXIII			0.02	1.11	0.01	0.01	0.02	0.02

T.S.A.: total stable aggregate %, G.Y.: Grain yield kg/fed, Acre = fed = 4200 m^2, WP: kg corn grains/the seasonal transpiration (m^3), FUE: fertilizer use efficiency Kg grains / Kg fertilizers

Table 2: Main factors of seed bed preparation conditions effect on TSA, GY, WP and FUE.

Factors of Study	**TSA**	**GY**	**WP**	**FUE**		
				N	**K_2O**	**P_2O_5**
θ1	58.30a	3133.66c	0.94a	46.83a	130.45a	131.97a
θ2	53.27b	2335.50b	0.76b	34.86c	97.32c	100.46c
θ3	48.02c	2511.83a	0.76cb	36.00b	100.49b	103.74b
S1	53.11a	2806.22a	0.81b	41.89a	116.93a	120.74a
S2	51.10b	2514.44b	0.82a	36.56b	101.91b	103.38b
d1	51.98c	2670.16b	0.76c	39.85b	111.14c	114.85c
d2	52.96b	2841.33a	0.84b	40.97a	114.22a	115.10b
d3	54.38a	2469.50c	0.86a	36.86c	102.89b	106.22a
LSD 0.05	**0.42**	**1.17**	**0.01**	**0.11**	**1.02**	1.08

Discussion

The views of many authors i.e. (Marshal, 1949; Grim, 1953; Alexander, 1961; Beer, 1965; Rose, 1966 and Baver *et al.*, 1972) have to be briefly stated to facilitate result's discussions. In the following: 1-The predominant lattice of clay minerals are built up from staked layers or sheet of oxygen $(O)^{++}$ and hydroxyl $(OH)^{-}$ with metallic cation $(Si)^{++++}$ and aluminum

$(Al)^{+++}$ sheets interlinked and staked in different ways according to the common feature of the lattice clay, Silica sheet 2(Si+O+3/2O_2) has a net negative charge due to replacing the silicon by divalent cation, 2-The divalent cation mention above is not a part the unit structure, but it forms on clay platelet a double electrical charge, it can be exchanged easy with a suitable cation, 3-The charge of the Al sheet depends on isomorphous exchange and broken bonds. And 4- Forces of attraction between different charges vary directly with the charge, whereas, the repulsive ones between the similar vary inversely (with the distance between them).

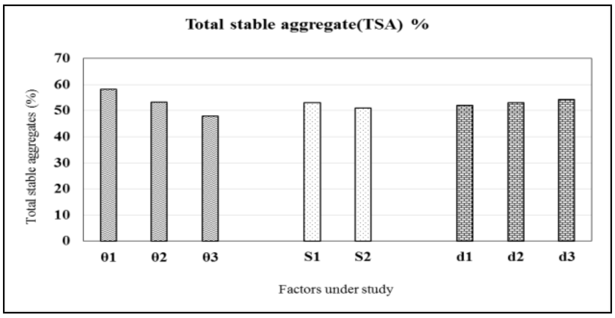

Fig. 1 : Effect of the some seedbed conditions: soil moisture content (θ), plowing speed (S) and plowing depth (d) on total stable aggregates.

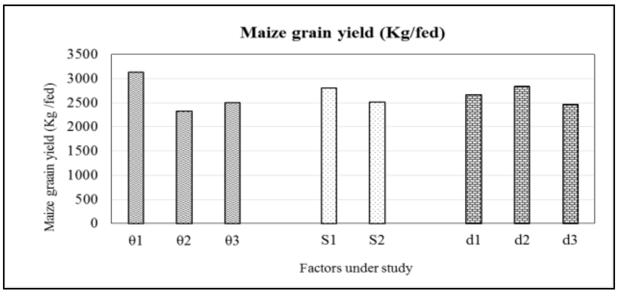

Fig. 2 : Effect of the some seedbed conditions: soil moisture content (θ), plowing speed (S) and plowing depth (d) on Maize grain yield.

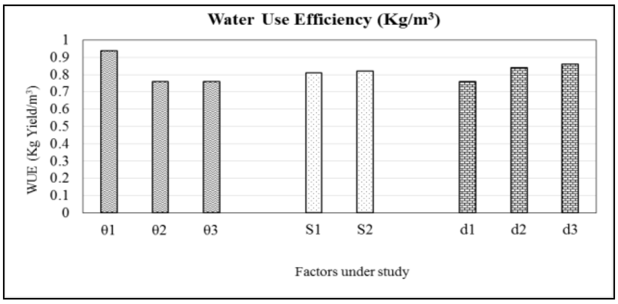

Fig. 3 : Effect of the some seedbed conditions: soil moisture content (θ), plowing speed (S) and plowing depth (d) on water use efficiency.

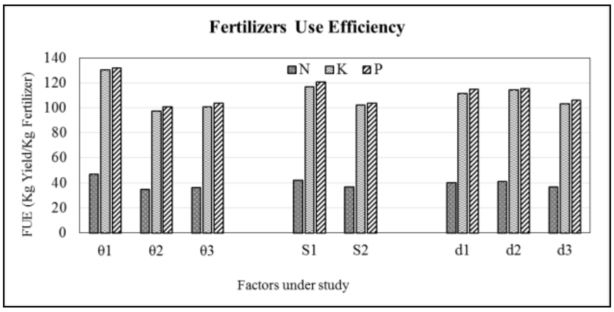

Fig. 4 : Effect of the some seedbed conditions: soil moisture content **(θ),** plowing speed (S) and plowing depth (d) on fertilizers use efficiency.

For food security all agricultural sectors have to use our precious and limited resources i.e. soil, water, energy and fertilizers efficiently, responding to the ideal is m (Wisness) saying necessity knows no. low. Plowing soil at higher soil moisture content (M2 and M3) leads to ions and clay hydration and clay swilling(Mansour, and Aljughaiman, (2012); Manour et al., (2015a,b,c) and Manour et al., (2016). Its increases the thickness of both water films surrounding soil particles and the double electrical charge and subsequently soil compaction. This compaction negatively affects all plant growth factors i.e. total porosity and pore size distribution, fluids and root movement within the soil, soil aerating biological activity and soil water content. Increasing plowing depth breaks the compacted soil layer formed below the lowed layer due to the used management practices. This assures pores continuity through the plowed layer. This improves all crop growth factors mentioned above. Increasing plowing speed from l.9 to 10.33 km h^{-1} increased soil pulverization.

Conclusion

Depending on the data obtained, one could state that:
1-soil moisture content at plowing (M), Plowing depth (D) and Plowing speed (S) and their interaction: M X D X S affected all the studied parameters total stable aggregates, grain Yield, Water and fertilizer use efficiency, 2-fertilizers use efficiency could be written in the following ascending order: N<K2O<P2O5, 3-NUSE efficiency could be taken as an index for soil compaction, 4- M2 and M3 led to the soil compaction and decreasing the efficiency of all crop growth factors,
5-the main effects of M, D; S could be written in the following ascending orders: M3<M2<M1, D1<D3<D2; S1<S2, 6-the interaction MXDXS affected all the studied parameters and 7-the maximum values of the studied parameters were obtained in the interaction M1XD2XS1, whereas, the minimum ones were achieved in the interaction:M3XD3XS3.

References

Al-Ani, A.N. and Al-Ani F.S. (2010). The relationship between tractor velocity and different moisture content on plowing soil layer. The Iraqi Journal of Agricultural Sciences, 41(1): 61-77.

Al-Darby, A.M. (1989). The effect of soil compaction at two soil water content on wheat emergence and early growth. Bulletien of the faculty of Agriculture, Cairo University.

Alexander, M. (1961). Introduction to soil microbiology, John Wiley and Sons, INC.

Babalola, O. and OpraNadi, O.A. (1999). Tillage system and soil properties in west Africa – Soil Tillage Research, 27: 149-170.

Baver, L.D. (1956). Soil physics. Third Edition. John Wiley and Sons.

Baver, L.D.; Gandener, W.H. and Gardener W.R. (1972). Soil physics. Hohn Wiley and Sons.

Chaudhary, N.R. and S.S. Prinar. (1974). Comparison of banded and broadcast fertilizer application in relation to compaction and irrigation in maize and wheat. Agron. J. 66: 560-564.

Dina Bayoume, S.I. (2016). Design of combined machine for seedbed preparation for onion. MSc. Thesis, Department of Agricultural Engineering, Faculty of Agriculture, Cairo University.

Dina, S.; Sabreen Kh. P.; Yossery, B.A.; Tayel, M.Y. and Naser, G.E. (2018). Developing a combined machine for seedbed preparation. Agric. Engin. CIGR Journal Open access, 20(1): 90-94.

Grim, R.E. (1953). Clay mineralogy. McGraw-llill, N-Y.

Howell, T.A.; Yazar, A.; Schneider, A.D.; Dusek, D.A. and Coreland, K.S. (1995). Yield and water use efficiency of corn in response to lepa irrigation. Trans. ASAE, 38(6): 1737-1747.

Joost R.; Van, G. and Pieter, M.K. (2014). Analysis of variance of multiply imputed data. Multivariate Behav Res. 49(1): 78–91.

Klute, A.A. (1986). Methods of soil analysis. Part 1. Physical and mineralogical methods 2nd Edition. American Agron., Wisconsin, USA.

Kohnke, H. (1968). Soil physics. TATA Mcgra W Hill publishing Company LTD.

Kubina, W.L. (1938). Micro pedology. Collegiate press, Ames, IOWA.

Lal, R. and M.K. Shukla. (2004) Principles of soil physics, New Yourk, NY. Marceel Dekker Inc.

Mansour, H.A., Abd El-Hady, M.,Bralts, V.F.,Engel, B.A.(2016) Performance automation controller of drip irrigation systems using saline water for wheat yield and water productivity in Egypt. Journal of Irrigation and Drainage Engineering 142 (10),05016005.

Mansour, H.A., Abdallah, E.F.,Gaballah, M.S.,Gyuricza, C. (2015a) Impact of bubbler discharge and irrigation water quantity on 1-hydraulic performance evaluation and maize biomass yield. International Journal of GEOMATE 9 (2) ,pp.1538

Mansour, H.A., Abdel-Hady, M.,Eldardiry, E.I.,Bralts, V.F.(2015b) Performance of automatic control different localized irrigation systems and lateral lengths for:1-Emitters clogging and maize (Zea mays L.) growth and yield. International Journal of GEOMATE 9 (2) ,pp.1545

Mansour, H.A., Aljughaiman, A.S. (2012) Water and fertilizers use efficiency of corn crop under closed circuits of drip irrigation system. Journal of Applied Sciences Research 8 (11) ,pp.5485

Mansour, H.A.A., El-Hady, M.A.,Gyurciza, C.S.(2015c)Water and fertilizer use efficiencies for drip irrigated maize.Closed Circuit Trickle Irrigation Design: Theory and Applications,pp.207

Marshall, C.E. (1949). The colloidal chemistry of the silicate minerals. Agron. Vol. VI, Academic press, N.Y.

Nasr, G.E.; Tayel, M.Y.; Abdalhay, Y.B.; Sabreen, kh.P. and Dena, S.B. (2016). Technical evaluation of new combined machine for seedbed preparation. International Journal of ChemTech Research, 9 (5): 193-199.

Obalum, S.E. and Obi, M.E. (2010). Physical properties of sandy loam soil Ultisol as affected by tillage-mulch management practices and cropping systems. Soil and Tillage Research, 108: 30-36.

Rose, C.W. (1966) Agricultural Physics. Pergamon press.

Strickler, F.C. (1962). Seedling depth use of press wheels as factor affecting winter barley and winter wheat in Kansas. Agron. J., 54: 492-494.

Tayel, M.Y.; Shaaban, S.M. and Mansour, H.A. (2015). Effect of plowing conditions on the tractor wheel slippage and fuel consumption in sandy soil. International Journal of ChemTech Research, 8(12): 151-159.

Tayel, M.Y.; Shaaban, S.M.; Eldardiry, E.A. and Mansour, H.A. (2018). Wheat yield versus seed bed conditions . Bioscience Research. 15(3): 1943-1951.

Tayel, M.Y.; Shaaban, S.M.; Mansour, H.A. and Abdallah, E.F. (2016). Response of Fodder Beet Plants Grown in a Sandy Soil to Different Plowing Conditions. International Journal of ChemTech Research. 9 (09): 20-27.

Walters, R.D. (2013). Soil draft and traction. Technical note 21. USA Department of Soil Science, North Carolina Sate University