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The Effect of Different Tillage Management and Working Depth on Maize Production

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Abstract This research was conducted to study the effect of different tillage management systems (TMS) and working depth on maize production. The TMS used in experiment 1 were moldboard + disc harrow (MB + DH), chisel (CH), disc harrow twice (DH_2), rotovator (RT) and no-tillage (NT) as a control. This experiment was conducted on a sandy loam soil. The results showed highly significant differences between treatments. The chisel (CH) significantly influenced maize growth parameters, reduced soil bulk density, soil tillage resistance, increased soil moisture at all depths and finally gave higher maize yield and yield components parameters while the no-tillage (NT) treatment gave the lowest performance. Experiment 2 was conducted on a clay soil with two treatments, no deep loosening (NDL) 20 cm depth and deep loosening (DL) 40 cm depth using tine. The results showed that the deep loosening significantly increased soil moisture, reduced soil bulk density, soil tillage resistance and finally increased maize production.

Key words maize production; tillage; soil management systems

Soil tillage is one of the most intensive processes in crop production, and is defined as any form of soil movement in crop production phase. This movement may be natural e.g.: no-tillage (NT) or artificial by using of implements (Spoor, 1975; Oni, 1991).

Maize productivity has been shown to vary with the type of tillage management used, crop rotation, climatical conditions and soil type. Yield increases with different TMS have been reported (Chuadhary et al, 1997). On the other hand it has been noted that an increase soil water in the root zone was a primary factor that causing yield increases when compared with no tillage systems (AL-Darby et al, 1986).

It is evident that tillage has a significant effect on reducing soil bulk density and soil tillage resistance . Breaking the plow sole by deep tillage and chiseling increased maize grain yield and soil infiltration rate by about 3 to 8 folds (Megh, 1982).

Research results showed that maize root penetration was greater in conventionally tilled soil than in no-tillage soil and the root exploration in NT was concentrated more than in conventionally tilled soil (Hilfiker et al, 1988). Others reported that yield and yield component from no-tillage were significantly less than that of conventional tillage (Sharma et al, 1988).

Thus the objectives of this research were to study and compare the effect of different tillage management and working depth on the performance of maize in terms of growth, yield and yield components in two soil types.

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1 MATERIALS AND METHODS

This study was conducted during 1998 Autumn season at the university farm site. Experiment 1 has five tillage treatments: moldboard 20 cm + disc harrow (MB + DH), chisel 20 cm (CH), disc harrow 15 cm twice (DH_2), rotovator 15 cm (RT) and no-tillage (NT) as control. The soil was classified as a sandy loam soil. The treatments were arranged in 4 blocks, each block was 4 m × 5 m. Starter fertilizer of P and K was applied to the soil at plowing time. Before and after plowing soil samples for bulk density were taken from depth of 5, 15, 25, 35 cm respectively. The cone index of penetrometer was also taken from the same depths after plowing and at harvest time as the characteristics of soil tillage resistance. The head of cone penetrometer was 30° with 3.2 cm^2 base area. Maize seeds was used as a test crop and sown by hand 30 cm between rows and 35 cm between holes. A mixed doze of 4:3:3 NPK was applied at the 5 ~ 7-leaf stage at a rate of 200 kg/hm^2. Soil moisture samples were taken in 2, 5, and 8 weeks after plowing from depth of 5, 15, 25, 35 cm respectively. Samples for plant height (m) were taken at 4, 6 and 10 weeks after sowing, 5 plants/plot and then averaged. Root length (m), dry matters accumulation and final emergence count plants/hm^2 were taken at 4 weeks after sowing. At harvest time sample of soil cubes 30 cm × 30 cm × 30 cm were taken from the plant base to determine root length density (5 samples/plot). Dry matter accumulation/plant was also determined. Finally 2 m × 5 m area was selected from each plot to determine yield and yield component parameters. Experiment 2 was conducted on a clay soil with two treatments. No deep loosening (NDL) using (MB + DH) and deep loosening (DL) using (MB + DH) + tine 40 cm depth. The treatments were arranged in 4 blocks. There were 8 plots, each was 5 m × 14 m. Seeds used in the test was the same as experiment 1, starter fertilizer was applied before plowing and a mixed doze of 4:3:3 NPK at the 5 ~ 7 leaf stage. Soil samples were taken before and after plowing from depth of 10, 20, 30, 40, 50 cm for bulk density determination. The cone index was taken from the same depth (as above) before and after plowing and at harvesting time. The experiment was sown by hand 30 cm between rows and 35 cm between holes. Soil moisture samples were taken in 2, 5, 8 weeks after plowing from depth of 10, 20, 30, 40, 50 cm respectively. The rest of the data were taken and measured as in experiment 1 above.

2 RESULTS AND ANALYSIS

2.1 EXPERIMENT 1

Final emergence count: The tillage management systems did not show any significant differences when tested at $P \leqslant 0.05$ level as shown in Table 1.

Plant height : Significant differences were obtained at $P \leqslant 0.05$ and $P \leqslant 0.01$ levels when plant height were checked at 4, 6 weeks and at harvest time, the CH, MB + DH and DH_2 produced taller plants while NT was significantly shorter as shown in Table 1.

Root length and root length density: The treatment showed highly significant differences at $P \leqslant 0.05$ and $P \leqslant 0.01$ levels, CH and MB + DH were the best while NT was the lowest as shown in Table 1.

Soil moisture: Tillage treatment showed highly significant difference at $P \leqslant 0.05$ and $P \leqslant 0.01$ levels, the CH, proved better storage of soil moisture in most cases, the NT was the lowest.

Table 1　Mean effect of tillage management on maize growth parameters[1)]

Parameters measured	Tillage management					Significance level	LSD	SE(±)
	MB + DH	CH	DH_2	RT	NT			
Final emergence count 4 weeks after sowing /(plant·hm^{-2})	57 450	57 500	53 650	60 300	52 900	Ns	–	–
Average plant height 4 weeks after planting/cm	80.50	86.75	82.50	79.50	67.00	0.05	8.80	4.94
Average total root length 4 weeks after planting/m	1.62	1.93	1.72	1.86	1.50	0.05	0.3	0.14
Average plant height 6 weeks after planting/cm	162	183	174	161	158	0.05	13	7.36
Average plant height at harvest time/cm	212	242	204	208	184	0.01	23	8.66
Average root length density at harvest time/(cm·cm^{-3})	0.84	1.10	0.64	0.52	0.40	0.01	0.1	0.04

1) MB + DH = Moldboard + Discharrow; CH = Chisel; DH_2 = Disc, Harrow twice; RT = Rotavator; NT = No Tillage; LSD = Least Significance Difference; SE = Standard Error

Bulk density and cone index: Results showed that soil bulk density and cone index increased with depth, and was significantly influenced by tillage management as shown in Fig. 1 and Fig. 2. Lowering soil dry bulk density increases soil water infiltration, root exploration and crop growth.

Yield and yield components: The treatments showed a highly significant difference at $P \leqslant 0.01$ level as shown in Table 2. The CH was the best one followed by MB + DH and lastly NT. Tilling the soil resulted in a considerable increase of yield and yield components and probably because of higher soil moisture stored with these systems.

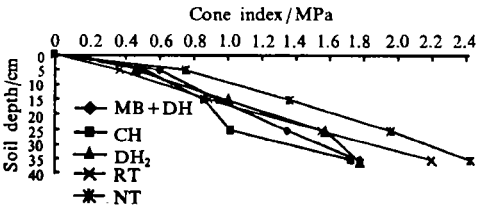

Fig 1　Mean Effect of Tillage Management on Cone Index after Plowing

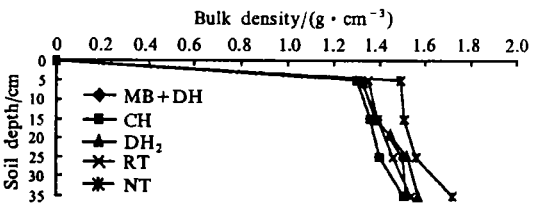

Fig 2　Mean Effect of Tillage Management on Soil Bulk Density after Plowing

Table 2 Mean effect of tillage management on yield and yield components parameters

Parameters measured	Tillage management					Significance level	LSD	SE(±)
	MB+DH	CH	DH_2	RT	NT			
Average green ears yield /(kg·hm^{-2})	10 280	12 090	9 530	8 840	7 650	0.01	1 520	570
Average No. of harvest ears/hm^2	41 125	48 375	38 125	35 375	30 625	0.01	6 110	2 280
Average ear length/cm	19.50	23.50	18.00	19.00	16.75	0.01	2.05	0.77
Average No. of raws/ear	12.75	14.25	12.50	12.75	11.75	0.01	1.29	0.48
Average No. of seeds/ear	507	586	448	442	399	0.01	22.78	8.5
Average dry matter accumulation /(g·plant^{-1})	191.75	218.75	181.25	176.30	160.00	0.01	25.9	9.06
Average ear dry mass/g	82	96	76	70	61	0.01	12.22	4.56

2.2 Experiment 2

As shown in Table 3, the accumulated dry matter showed a significant difference at $P \leqslant 0.05$ level 4 weeks after sowing, the treatment showed a significant difference at $P \leqslant 0.05$ level when final plant height and root length density were examined, the DL treatment increased plant height by 27% and root length density by 58%.

Table 3 Mean effect of working depth(Deep loosening) on maize growth parameters

Parameters measured	Working depth		Significance level	LSD	SE(±)
	NDL(20 cm)	DL(40 cm)			
Final emergence count 4 weeks after planting/(plant·hm^{-2})	66 125	66 625	Ns	–	–
Average plant height 4 weeks after planting/cm	70.0	75.5	Ns	–	–
Average root length 4 weeks after planting/m	2.51	2.82	Ns	–	–
Accumulated dry mass(g·plant^{-1})4 weeks after planting	13.25	21.25	0.05	5.84	2.48
Average plant height 6 weeks after planting/cm	166	181	Ns	–	–
Average final plant height at harvest time/cm	194.5	248.0	0.05	25.2	10.71
Average root length density at harvest/(cm·cm^{-3})	0.75	1.19	0.05	0.209	0.089

Soil moisture: The treatment showed highly significant difference at $P \leqslant 0.05$ and $P \leqslant 0.01$ levels. The use of tine significantly increased water storage throughout the season at all depths.

Soil dry bulk density and cone index: The use of tine to 40 cm depth significantly reduced soil dry bulk density and cone index as shown in Fig. 3 and Fig. 4 and this increased plant root expansion and crop growth.

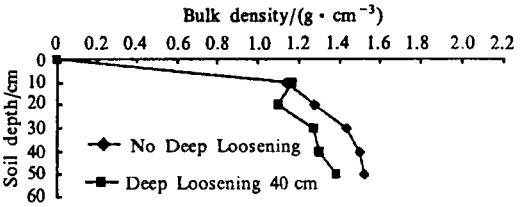

Fig 3 Mean Effect of Deep Loosening on Soil Bulk Density after Plowing

Yield and yield components: The result showed a highly significant difference between treatments at $P \leqslant 0.01$ level when yield was tested, the DL increased yield by 32% and No. of ears/hm^2 by 12% and ears length by 26% when compared with NDL treatment. Final dry matter per plant and ear dry weight showed a significant difference when tested at $P \leqslant 0.05$ level as shown in Table 4.

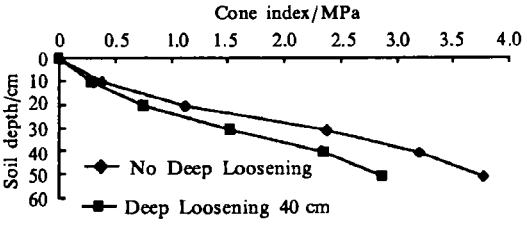

Fig 4　Mean Effect of Deep Loosening on Cone Index after Plowing

Table 4　Mean effect of working depth(Deep loosening) on yield & yield components parameters

Parameters measured	Working depth		Significance level	LSD	SE(±)
	NDL(20 cm)	DL(40 cm)			
Average green ears yield/($kg \cdot hm^{-2}$)	10 200	13 475	0.01	1 770	390
Average No. of ears/hm^2	50 460	56 640	0.05	3 950	1.68
Average ear length/cm	18.25	23.00	0.05	2.1	0.89
Average No. of rows/ear	12.5	15.0	Ns	-	-
Average No. of seeds/ear	480	570	Ns	-	-
Average accumulated dry matter/($g \cdot plant^{-1}$)	148	185	0.05	16.1	6.88
Average ear dry mass/g	66.25	96.25	0.05	14.4	6.12

3　Conclusion

The research work reported in this study is composed of two experiments mainly to assess the production of maize under different tillage management systems (TMS). Results showed that tilling the soil when compared with no-tillage (NT) and using deep loosening by tine could significantly reduce soil bulk density, reduce soil tillage resistance, increase soil water storage, promote root growth-development and finally whole plant growth and yield. In experiment 1 plant height was increased by 31%, 15%, 13%, 11%, root length density increased by 161%, 100%, 52%, 24%, for CH, MB + DH, DH_2 and RT respectively while compared with NT. In experiment 2 the use of tine could significantly increase soil moisture storage, reduce bulk density and soil tillage resistance, and finally increase plant height by 27%, root length density by 58%, yield by 32%, dry matter by 25%. More research work is needed for extra investigation and better evaluation.

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不同耕作方式和工作深度对玉米生产的影响

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摘要 为了比较不同耕作方式和工作深度对玉米生产的影响,在华南农业大学农场进行了两组对比试验,试验土壤为沙壤土和粘壤土,试验作物为玉米。第一组试验中安排了5种耕作方式,分别为犁耕加圆盘耙(MB + DH),凿形耕(CH),圆盘耙两次(DH_2),旋耕(RT)和不耕(NT),第二组试验中安排了2种耕作方式,犁耕加圆盘耙(NDL)和犁耕、圆盘耙加深松(NL)。试验结果表明,不同的耕作方式和工作深度对土壤容重、土壤耕作阻力、土壤含水量、玉米生长情况和产量均有不同影响。在第一组试验中,凿形耕(CH)效果最好,在第二组试验中,深松(NL)比不深松(NDL)好。本研究表明,应根据不同作物、不同土壤采取不同耕作方式,以增加作物产量。

关键词 玉米生产; 耕作方式; 耕作深度

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