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DETERMINATION OF THE FIELD PERFORMANCES OF DIFFERENT TYPES OF CHISEL LEGS

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Abstract

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The objective of this study was to determine the working parameters of conventional chisel (Chisel C) and two new designed and manufactured chisel models (Chisels A and B) as an alternative to the conventional chisel. For this purpose; fuel consumptions, work efficiency and draft of 7 shank chisels were determined at 17 cm and 27 cm working depths and 5 km h^{-1} and 6 km h^{-1} theoretical working speeds in field conditions. In addition to working parameters, soil penetration resistance and dry bulk volume of weight were measured before and after the tillage to examine the effects of chisels on the physical parameters of the soil. According to the results, conventional model chisel C had the lowest performance with high draft of 16.25 kN, the lowest working capacity of 6.83 ha h^{-1} and the highest fuel consumption of 19.23 L ha^{-1} at 27 cm depth and 5 km h^{-1} forward speed conditions. Among all tools, new designed chisel A was found to have the best performance with 13.83 kN, 8.31 ha h^{-1}, and 14.23 L ha^{-1} for draft, work efficiency and fuel consumption, respectively.

*Key words***:** tillage, chisel, legs, dry bulk

Introduction

Tillage takes the first place in the farm operations and it aims to prepare the best conditions for the plants to grow. Different tillage practices affect the some of the soil physical properties such as particules size distribution, porosity, dry bulk density and penetration resistance.

Conservation tillage is described as a tillage method, which aims to lessen the erosion by leaving 30% of the residue on the field surface after the tillage and reducing the energy consumptions and time requirements by minimizing the number of tillage operations. It is well known that chisel which is a primer tillage tool causes less moisture lose in the soil and reduces the effects of the erosion due to the leaving residues on the soil surface. Recently, the Importance of conservation tillage increased and chisel use is getting more common in our country.

Chisel is a tillage tool, which tills the soil without inververting less pulverizes and more roughens, ups the soil. Chisel, generally has odd number of shanks such like 5, 7, 9 and connected on two rows in the frame. The geometrical shape and dimensions of the chisel changes its effect on the soil and affects the fuel consumption.

Turkey has 34.4% erosion sensitive steep slope areas in the agricultural land. According to the researches, 150 ton ha^{-1} soil lose due to erosion occurs every year in the world (Anonym, 2004).

It is very important that erosion preventive tillage systems should be adapted in Turkey. For this reason, “Conservation tillage” systems are gaining an importance and chisel is substituted with plough (Onal and Aykas, 1992).

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Megyes et al. (2003) proved that conventional tillage could be replaced by conservation tillage methos in Hungary conditions.

Plant residues form a mulch layer on the soil surface in the course of time in not inverted soil. This layer protects the soil from physical effects of rain and wind and meantime it keeps the moisture and temperature of the soil at top (Onal, 1995).

Pidgeon (1983), recommends chisel as an alternative to the plough for the soils where minimum tillage and no-till can not be used. According to the researches, chisel leaves 36% plant residue, which is good enough to control the erosion. Previous year left plant residue reduces run off and increases the inflitration of the soil (Erbach et al., 1992; Korucu et al., 1998).

Draft requirements of tillage tools increases or decreases with the shape of the tool, soil conditions and speed. Increasing working speed, generally, affects negatively under heavy soil conditions. Determination of draft versus working speed relation is very important for evaluation of tillage tools performance (Kushwaha and Linke, 1996; Manuwa, 2009). Besides, it is well known fact that leg penetration angle which depends on the shape of the tool, working width, and forward speed have direct affect on the performance of the tool (Tong and Moayad, 2006; Manuwa 2009; Stafford and Tanner, 1983).

The objective of this study was to determine the working parameters of conventional chisel (Chisel C) and two new designed and manufactured chisel models (Chisels A and B) as an alternative to the conventional chisel and to examine their effects on the physical parameters of the soil.

Materials and Method

The experiments were conducted in the research fields of Faculty of Agriculture at Ege University. The soil was loamy clay with 44.96% sand, 23.28% mil and 31.76% clay.

Fiat 80-66 DT 4 WD tractor was used in the experiments. Some technical parameters of the tractor are given in Table 1.

Draft measurement system, which consists of Fuel consumption mesurement unit, data collection system, and a frame on which load cells were placed mounted on the experiment tractor (Figure 1).

Three chisels with different shape and materials were used at experiments (Figure 2). Chisels A and B were made of steel with 25 thickness and cut from platina whereas chisel C was steel casted with thickness of minimum 15 mm. The model of chisel C is a model used widely by local manufacturers. C type chisel represents basically conventional type of chisel. Chisel B is a chisel patented by a local manufacturer. The other chisel model is a chisel, A which was developed at department of Agricultural Machinery, Faculty of Agriculture, Ege University. Some technical parameters are

Table 1
Some technical parameters of Fiat 80-66 experiment tractor

Technical Parameters	Values
Engine Type	Diesel, 4 Cycles
Number of Cylinder	4
Volume of Cylinder	3908 cm^3
Engine Power	62.6 kW
Total mass (with additional weights)	4050 kg
Distance between axes	2255 mm
Theoretical forward speed at [slow 2] gear and 2000 min^{-1} engine cycle	5 km h^{-1}
Theoretical forward speed at [slow 3] gear and 2000 min^{-1} engine cycle	6 km h^{-1}
Front tire dimensions	12.4 - 24
Rear tire dimensions	18.4 - 30
Front tire pressure	1 bar
Rear tire pressure	0.8 bar
Categhory of three-point-hitch system	Categhory - II

Fig. 1. Tractor with draft measurement unite

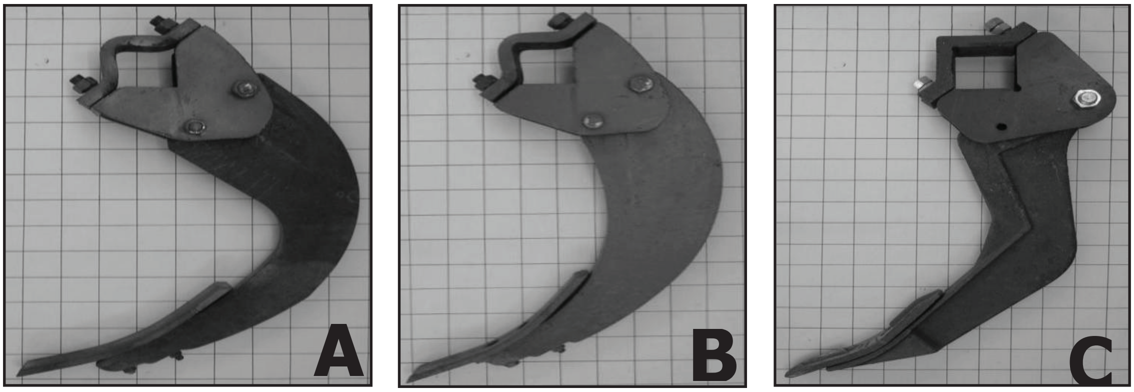
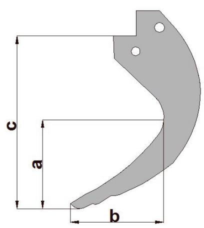
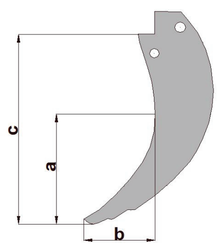
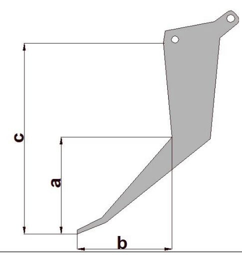


Fig. 2. Types of chisel leg used in the experiment

Table 2
Some technical parameters of chisel legs

	Types of chisel leg		
	A (New design)	B (New design)	C (Conventional)
Material of Leg	Steel	Steel	Cast steel
Thickness of Leg	25 mm	25 mm	Min 15 mm
Vertical distance of concave point and tip of the leg (a)	285 mm	350 mm	310 mm
Horizontal distance of concave point and tip of the leg (a) (b)	345 mm	290 mm	320 mm
Vertical distance of lower point of of frame and tip of the leg (c)	540 mm	540 mm	635 mm
Leg geometrical shapes and dimensions			

given in Table 2. Each chisel has 7 legs arranged in two rows as 3 legs front and 4 legs rear.

In the experiments, three chisel models were examined by using two forward speeds and two depths with three replications. During experiment, tractor was run with two gear selections; "Slow 2" and "Slow 3" with constant engine cycle of 2000 min^{-1}. The theoretical speeds of the tractor were 5 kmh^{-1} (Speed I) and 6 kmh^{-1} (Speed 2) for "Slow 2" and "Slow 3" gears, respectively. Upper gear of "Fast 1" was selected at the tractor but this was not used in the experiment due to all chisels were unable to till the soil at this speed because of heavy soil condition.

Two working depths were used; 17cm and 27cm which were set by depth adjustment Wheels mounted both sides of the frame of the chisel (Figure 3). Experiments plots were 3 m wide and 40 m long. Necessary empty spots at the beginning and at the end of the plots were left for tractor to reach its optimum speed. Randomized plot design was used as a statistical anaylsis and experiments were conducted in total 36 plots. Results were examined according to the ANOVA test by using Costat statistical package program.

In this study, draft measurement system, which was developed by Evcim et al (1997) in Ege University Scientific Research Project. Measurement system consists

Fig. 3. Depth adjustment wheel of the chisel

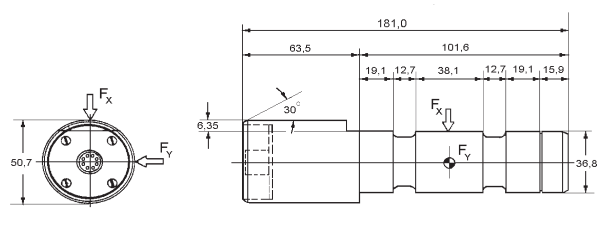
of three load cells (Biaxial clevis pin), frame and data acquasition unite with computer. The technical parameters of load celss are given in Table 3.

ADAM-5000/485 data acquasition system was used to process the signals coming from load cells. The data was gathered and processed by VISIDAQ program. Data, then transported to the excel program to determine the force values with the help of calibration curves. Total horizontal forces determined draft of a chisel.

Fuel consumptions of the chisels were measured by fuel consumption measurement container, which was used as a fuel tank. For this purpose, fuel tank of the tractor was canceled and fuel container with capacity of 1000 mL was placed at the same level with tractor fuel tank. Connections from and to the container was made by pipes and fuel return line was mounted to the container to regain the unused fuel.

Table 3
Technical parameters of load cells

Name	Biaxial Clevis Pin
Model no	CP-BAF Q9449
Measurement Capacity	33.36 kN
Bridge resistance	350 ±3.5 ohm
Input voltage	10 AC veya DC
Output voltage	0,75 mV/V
Overloading	% 150
Weight	1.5 kg



Standard push type penetrometer was used to measure the penetration resistance of the soil. The measurement range of the penetrometer was 0-7 MPa with maximum measurement depth of 45 cm.

Undisturbed soil samples from 0-10, 10-20 and 20-30 cm soil depths before and after the tillage were collected by using 100 cm^3 sample containers to determine the bulk density of the soil in the experimental field. Samples were later oven dried to determine the dry bulk volume of weight of the soil.

Results and Discussion

To determine the effects of chisels on the physical parameters of the soil, penetration resistance and bulk densities were measured. The penetration resistances of the soil, which had 19.2% moisture content before and after tillage, are given in Figures 4 and 5.

The effects of Chisels on the penetration resistances of the soil were found statistical significant with level of $\alpha=0.05$ comparing to before tillage. After tillage, no significant difference was found among chisels. Chisels lowered the high penetration resistance of 2 MPa at which roots development stops to the level of 1 MPa.

One of the important parameter of the soil, which affects the root development, is of bulk volume weight of the soil. Bulk volumes of weights of the soil before and after tillage are given in Tables 4 and 5. Chisels lowered the bulk volume weight of the soil from 1.3 g cm^{-3} to the desired level of ≤ 1.1 g cm^{-3}. Bulk volume of weight values after tillage were found statistical significant comparing the values measured before the tillage at $P<0.05$. Bulk volume of weight values below the tillage depths did not change and its effect was found not significant.

Average field performance values of the chisels are given in Table 6. Only chisel C could not work at speed II due to heavy soil condition. For this reason chisel, II was not examined statistically at speed II. Statistical analyses were made for all chisels at speed I. For statistical analysis of the speed effect, only chisels A and B were evaluated at two speeds and soil depths.

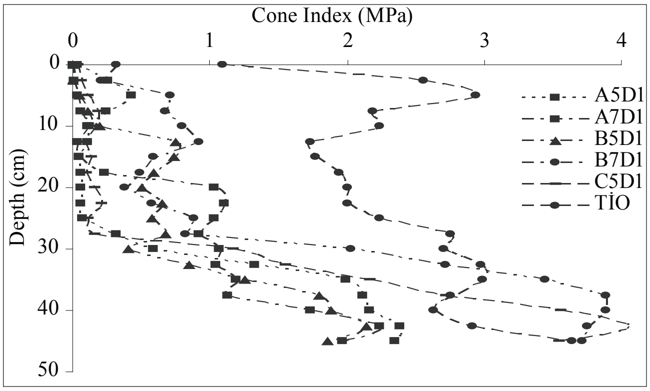


Fig. 4. Penetration resistances of the soil after tillage at 17 cm depth

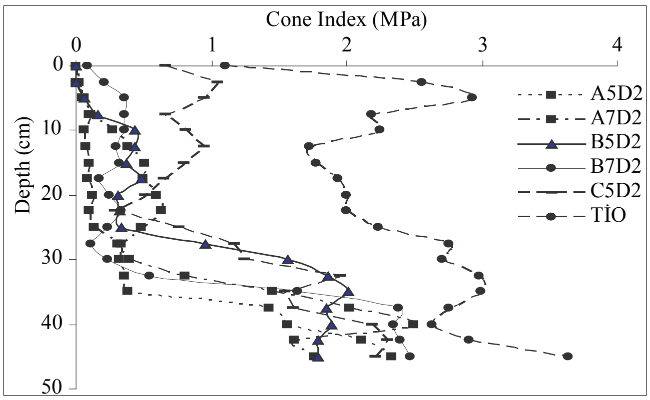


Fig. 5. Penetration resistances of the soil after tillage at 27 cm depth

Fuel Consumption

Fuel consumptions of the chisels worked at different speed and tillage depth are given in Figure 6.

Fuel consumptions increased in all chisels with increasing tiilage depth. Fuel consumption of chisel A at speed I increase from 13.85 L ha^{-1} to 14.23 L ha^{-1} when tillage depth increased from 17 cm to 27 cm. The effects of tillage depth on fuel consumption were found statically significant at $P<0.05$. Depth increased the fuel consumption 3.25 %.

According to the results, increasing speed reduced the fuel consumptions. Increasing speeds for chisels A and B reduced the fuel consumptions as seen in Figure 6. The effects of speed on the fuel consumptions of the chisels were also found statistical significant at $P<0.05$.

If we compare chisels at speed I and 17 cm depth, the lowest fuel consumption was found on Chisel A as 13.85 Lha^{-1} , while chisel C required the highest value of 18.08 Lha^{-1} and the differences among the chisels were found statistical significant.

Table 4
Soil bulk densities at 17 cm working depth, g cm^{-3}

	Soil depth, cm		
	0-10	10-20	20-30
Before Tillage	1.32^{a}	1.25^{a}	1.32^{a}
A -Speed I	1.05^{b}	1.16^{b}	1.29^{ab}
A -Speed II	1.09^{b}	1.22^{ab}	1.25^{abc}
B -Speed I	1.07^{b}	1.22^{ab}	1.19^{c}
B -Speed II	1.08^{b}	1.20^{ab}	1.26^{abc}
C -Speed I	1.04^{b}	1.20^{ab}	1.22^{bc}

Table 5
Soil bulk densities at 27 cm working depth, g cm^{-3}

	Soil depth, cm		
	0-10	10-20	20-30
Before Tillage	1.32^{a}	1.25^{a}	1.29^{a}
A -Speed I	1.13^{bc}	1.16^{c}	1.22^{ab}
A -Speed II	1.09^{c}	1.17^{c}	1.17^{ab}
B -Speed I	1.00^{d}	1.19^{bc}	1.14^{b}
B -Speed II	1.18^{b}	1.17^{c}	1.14^{b}
C -Speed I	1.05^{cd}	1.20^{b}	1.24^{ab}

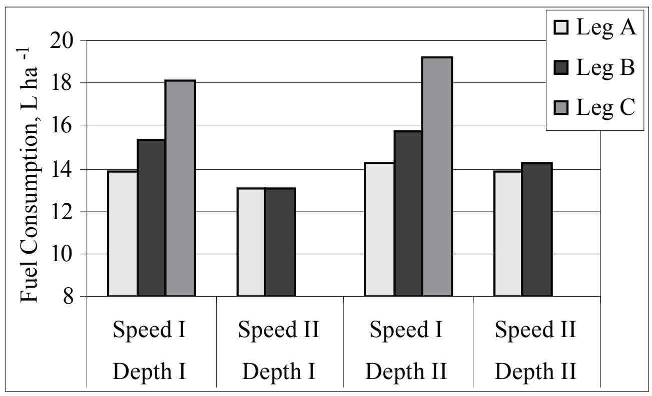


Fig. 6. Fuel consumptions of the chisels as affected by tillage speed and depth

Working Efficiency

Working efficiencies of chisels as affected by tillage speed and tillage depth are given in Figure 7. Increasing tillage depth reduced the working efficiency. On the other hand, incrasing speed increased the working efficiency. Working efficeincies of chisel A at speed I were measured as 8.73 ha h^{-1} and 8.31 ha h^{-1} for tillage depths of 17 cm and 27 cm, respectively. When the tillage speed was increased, working efficiencies of chisel A increased to 10.54 ha h^{-1} and 9.82 ha h^{-1} values for tillage depths of 17 cm and 27 cm, respectively.

When all chisels compared for working efficiencies, differences were found statistically significant. The highest and lowest working efficiencies were found as 10.54 ha h^{-1} and 6.83 ha h^{-1} for chisels A and C, respectively.

Draft

Draft requirements of chisels worked at different speed and tillage depth are given in Figure 8. Draft requirements for all chisels increased with increasing tillage speed and depth.

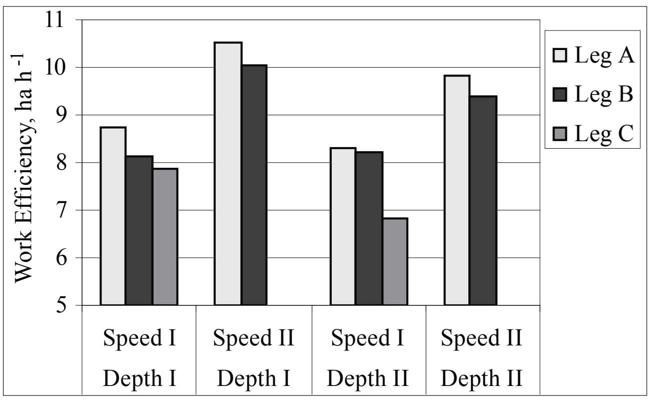


Fig. 7. Working efficiencies of chisels as affected by tillage speed and depth

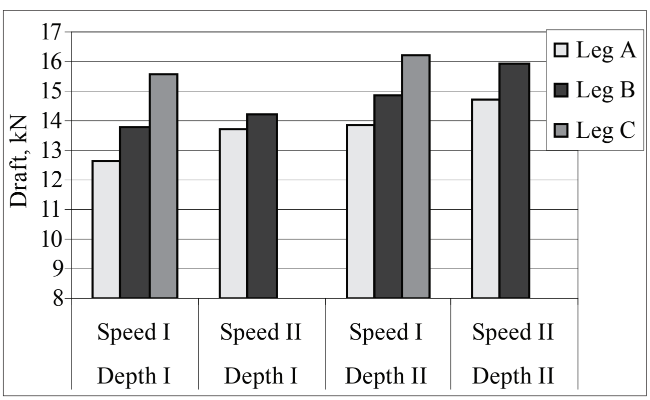


Fig. 8. Draft requirements of chisels as affected by tillage speed and depth

Chisel C could not work at speed II due to the soil conditions and constant engine cyle of the tractor. Draft of chisel A increased from 12.65 kN to 13.83 kN by increasing tillage depth from 17 cm to 27 cm at speed I. Draft requirement of chisel A also increased with increasing speed at tillage depth of 17 cm from 12.65 kN to 13.70 kN.

Draft requirements of chisels were found statistically significant. The minimum draft was found on chisel A as 12.65 kN at speed I and tillage depth of 17 cm, folllowed by chisel B and Chisel C as 13.79 kN and 15.55 kN, respectively.

Conclusion

This study was conducted for more economic and environmental friendly tillage purposes in which working parameters of conventional chisel (Chisel C) and two new designed and manufactured chisel models (Chisels A and B) as an alternative to the conventional chisel were determined and their effects on the physical parameters of the soil were examined.

The effect of tillage depth on drafts, fuel consumptions and working efficiencies of the chisel were found statistically significant. Generally, increasing tillage depth increased the draft and fuel consumption and decreased the working efficiency.

Similarly, the tillage depth, effect of speed on drafts, fuel consumptions and working efficiencies of the chisel were also found statistically significant. Since chisel C could not pulled at speed II, speed effect was examined only on chisels A and B. Increasing speed increased the draft requirements and working efficiencies but decreased the fuel consumptions of the chisels. It was observed that soil particules could flow much easier dynamically when the speed was increased which caused comfortable tillage, reduced slip and fuel consumption on chisels A and B.

When we compare the all chisels, Chisel C provided the least efficiency values. Chisel C required the highest draft value of 16.25 kN with the lowest working efficiency of 6.83 ha h^{-1} while needing the highest fuel consumption of and 19.23 L ha^{-1} among other chisels.

In all measurements, chisel A had the best values as for draft requirements, fuel consumption and working

Table 6
Average performance values of chisels at different speed and working depths

Leg type	Working depth, cm	Forward speed km h^{-1}	Slip, %	Draft, kN	Fuel consumption, L ha^{-1}	Work efficiency, ha h^{-1}
A	17	4.36	12.73	12.65	13.85	8.73
		5.27	12.20	13.70	13.08	10.54
	27	4.15	16.92	13.83	14.23	8.31
		4.91	18.18	14.75	13.85	9.82
B	17	4.08	18.49	13.79	15.38	8.15
		5.02	16.28	14.21	13.08	10.05
	27	4.11	17.71	14.84	15.69	8.23
		4.70	21.74	15.92	14.23	9.39
C	17	3.93	21.45	15.55	18.08	7.85
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	27	3.42	31.70	16.25	19.23	6.83
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** At this speed chisel could not work

efficiency. Chisel B was in the middle for comparison the others. Chisel B was beter than chisel C but falling behind the chisel A.

In conclusion, Chisel A was found the best chisel among the other chisels for its performances in the experimental conditions.

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References

Anonymous, 2004. What is conservation agriculture? http://www.fao.org/ag

Erbach, D. C., J. G. Benjamin, R. M. Cruse, M. A. Elamin, S. Mukhtar and C. H. Choi, 1992. Soil and Corn Response to Tillage with Paraplaw. *Transaction of the ASAE*, **35** (5): 1347-1354.

Evcim, U., G. Kececioglu and E. Gulsoylu, 1997. Traktör-Alet Tarla Performansının Belirlenmesinde Kullanılan Çeki Kuvveti Ölçme Seti Üzerine Bir Araştırma, Proje No: 1993 ZRF-017, Ege Üniversitesi Araştırma Fonu Kesin Sonuç Raporu. Izmir.

Korucu, T., V. Kirisci and S. Gorucu, 1998. Korumalı Toprak Isleme ve Turkiye'deki Uygulamalari Tarımsal Mekanizasyon 18, Ulusal Kongresi 17-18 Eylül 1998 Tekirdağ.

Kushwaha, R. L. and C. Linke, 1996. Draft-Speed Relationship of Simple Tillage Tools at High Operating Speeds. *Soil & Tillage Research*, **39:** 61-73.

Manuwa, S. I., 2009. Performance Evaluation of Tillage Tines Operating Under Different Depths in a Sandy Clay Loam Soil. *Soil & Tillage Research*, pp. 55–64.

Megyes, A., T. Rotonyl and J. Nagy, 2003. Effect of Tillage Systems on Soil Physical Characteristics and Corn (*Zea mays* L.) Production in Eastern Hungary. 16th Triennial Conferance of ISTRO 13-18 July, 2003. Proceedings of ISTRO 16, Barisbane, Australia, pp. 732-736.

Onal. I., 1995. Ekim, Bakım ve Gübreleme Makineleri. Ege Üniversitesi Ziraat Fakültesi Yayınları No: 490 pp. 52-65.

Onal, I. and E. Aykas, 1992. Tahılda Koruyucu Toprak İşlemeye Uygun Ekim Teknikleri. Tarımsal Mekanizasyon 14. Ulusal Kongresi. Pp. 74-89.

Pidgeon, J. D., 1983. Paraplow-A New Approach to Soil Management. *ASAE Paper* No: 83-2136. St. Joseph, MI. ASAE.

Stafford, J. V. and D. W. Tanner, 1983. Effect of Rate on Soil Shear Strength and Soil-metal Friction; II. Soil-Metal Friction. *Soil Tillage Res.,* **3:** 321-330.

Tong, J. and B. Z. Moayad, 2006. Effects of Rake Angle of Chisel Plough on Soil Cutting Factors and Power Requirements: A Computer Simulation. *Soil&Tillage Research,* **88:** 55–64.

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