Tarım Makinaları Bilimi Dergisi (Journal of Agricultural Machinery Science)
2008, 4 (2), 157 - 164

Reduced Tillage and Direct Seeding Applications on Second Crop Maize and Sunflower*

Harun YALÇIN[1], Engin ÇAKIR[1], Erdem AYKAS[1], İsmet ÖNAL[1], Ercan GÜLSOYLU[1], Bülent OKUR[2], Sezai DELİBACAK[2], Ali Rıza ONGUN[2], Yıldız NEMLİ[3], Süleyman TÜRKSEVEN[3]

[1] Ege University, Faculty of Agriculture, Agricultural Machinery Department,
[2] Ege University, Faculty of Agriculture, Soil Science Department,
[3] Ege University, Faculty of Agriculture, Plant Protection Department,
35100 Bornova, İzmir, TURKEY
harun.yalcin@ege.edu.tr

ABSTRACT

Reduced tillage practices for corn, sunflower, soybeans, cotton, and cereal grains were introduced over 50 years ago to conserve soil and water. Crops grown without tillage use water more efficiently, the water-holding capacity of the soil increases, and water losses from runoff and evaporation are reduced. In addition, soil organic matter and populations of beneficial insects are maintained, soil and nutrients are less likely to be lost from the field and less time and labor is required to prepare the field for planting.

The objective of this study was to evaluate the effect of reduced tillage and direct seeding systems on the second crop maize (*Zea mays* L.) and sunflower (*Helianthus annuus* L.) for the comparison of the conventional system in Menemen located in the west region of Turkey. In this research, conventional tillage, three systems of reduced tillage and direct seeding were applied in dry and wet soil conditions after harvesting previous crop of wheat and barley. Rotary tiller, chisel and rotary tiller combination, and heavy duty disk harrow were selected as reduced tillage systems. The effect of tillage systems on the soil physical properties such as bulk density, penetration resistance, and organic matter were examined. Plant height and yield were measured for the effectiveness of the tillage system. Conventional tillage system had more different kind of weeds comparing the other systems.

According to the results, while tillage systems were found statistically significant for bulk density, penetration resistance, and organic matter of the soil there was found no statistical difference for plant yields of corn and sunflower.

Key words: Second crop sunflower, second crop corn, conservation tillage, direct seeding, weed.

INTRODUCTION

Sustainable farming and increasing the cost of fuel in tillage operations force farmers to change the farming methods. Reduced tillage and direct seeding are some of the systems that farmers apply recently for a long-term erosion free farming with minimum fuel cost. Considering the negative effect of intensive farming in the field, direct seeding becomes more vital for farmers for establishing the nature of the soil and flora allowing natural plant growth with less plant protection problems.

Harold and Edward (1974) found that no-till systems prevent soil erosion especially after heavy rain. They found the soil loss 23 ton ha^{-1} for conventional tillage and 2.5 ton ha^{-1} for no-till systems. Direct seeding on the residue of previous crop gives advantages for reducing soil erosion, increasing infiltration and water holding capacity.

Soil degradation is responsible for making from 2 million ha to 12 million ha or 0.3–0.8% of the world's arable land, unsuitable for agricultural production every year, with wind and water erosion accounting for 84% of the soil degradation (den Biggelaar et al., 2004a).

*This research covers some parts of main project supported by research fund of Faculty of Agriculture, Ege University and carried out in the years of 2004-2007 (2004 / ZRF / 019 Numbered BAP Project,2008).

Lafond et al. (2005) worked on the effects of three tillage methods; zero, minimum and conventional methods for three four-year crop sequences in grain yield over a 12-year period under Canadian growing conditions. Their results indicated that a one-year non-cereal break crop was enough to alleviate the negative effects of consecutive cereal crops on winter wheat. Results of this study also supported the large shifts towards in conservation tillage being observed in the Canadian prairies.

Ike (1987) reported that although yield was found low for direct seeding of cotton and corn, this system allowed quite time save. Clark et al., (1991) found less soil crust problem and better water use efficiency and water storage in reduced tillage system.

Onal and Aykas (1995 and 1997) reported that chopping cotton residues and incorporating with soil gives the N,P,K 48%, 41%, and 74% back to the soil, respectively. And they said this application of chopping and incorporating with soil of cotton residues is a main key for sustainable farming. They also concluded that decomposed residue increases organic content and water holding capacity of the soil.

Yalcin (1998) studied the suitable tillage methods in second crop corn for silage. The experiment was a long term base with main plant wheat. He found that the yield for second crop silage corn was 41 Mg ha^{-1} for conventional system and 43 Mg ha^{-1} for no-till planter.

Rajan and Khera (2005) conducted the field study to estimate the effect of tillage and different modes of mulch application on soil erosion losses. Treatments comprised minimum and conventional in the main plots and five modes of straw mulch applications; mulch spread over whole plot (M_w), mulch spread on lower one-third of plot ($M_{1/3}$), mulch applied in strips (M_s), vertical mulching (M_v) and un-mulched control (M_o). Mulch spread over whole plot reduced runoff by 33%. Runoff and soil loss were 5 and 40% higher under conventional tillage conditions. Straw mulching reduced maximum soil temperature and helped in conserving soil moisture. Minimum tillage coupled with mulch spread over whole plot was highly effective in reducing soil erosion losses, decreasing soil temperature and increasing moisture content by providing maximum surface cover.

Dam et al.(2005) studied the effect of different tillage practices and corn residues on soil bulk density, corn emergence rates and crop yields over an 11-year period for corn (*Zea mays* L.). They applied no-till, reduced tillage and conventional tillage methods with corn residues and without residues. According to their findings, bulk density was 10% higher in no-till (1.37 Mg m^{-3}) than in conventional tillage (1.23 Mg m^{-3}), particularly at the 0–0.10 m depth. They found that No-till with residue (NTR) possibly had the slowest overall emergence due to the higher surface residue cover (8.5 Mg ha^{-1} in 1996) and higher bulk density (1.37 Mg m^{-3} over the 11 years). But, they observed that long-term mean dry matter corn yields were not affected by tillage and residue practices during the course of this study.

According to the research findings, fuel consumptions of different tillage methods were found as 49,4 L ha^{-1} (100%), 31,2 L ha^{-1} (63,2%), 28,3 L ha^{-1} (57,3%), 25,2 L ha^{-1} (50,9%), 13,3 Lha^{-1} (27,08%) for plough, chisel, disk harrow, ridge-tillage and direct seeding respectively. Direct seeding saved 73% fuel energy comparing the conventional method (Köller, 2003).

From the results of long-term research made by Megyes et al. (2003), it was shown that crop production technologies based on reduced/conservation tillage methods may replace conventional tillage systems and are applicable under the environmental conditions of Hungary.

The objective of this study was to evaluate the effect of reduced tillage and direct seeding systems on the second crop maize and sunflower for the comparison of the conventional system in Menemen located in the west region of Turkey. Rotary tiller, chisel and rotary tiller combination, and heavy duty disk harrow were selected as reduced tillage systems. The effect of tillage systems on the soil physical properties such as bulk density, penetration resistance, and organic matter were examined. To evaluate effectiveness of the tillage systems on plant production; plant height, head diameter, and seed yield were measured.

MATERIALS AND METHODS

The experiments were conducted in the fields of Ege University's research farm in 2006 and 2007. Research farm is located in the western part of Turkey. Sunflower was planted as a second crop in 2006 in the wheat stubble. Corn was planted as a second crop after harvesting barley in 2007. Both plants were seeded in the same field which was divided into nine sections, in each one different tillage system was applied. Applied tillage systems were given in Table 1.

Mainly conventional tillage system was compared with three different reduced tillage and direct seeding systems. Direct seeding system was applied in dry and wet soil conditions. In direct seeding system, secondary tillage tools are allowed for in-row tillage purposes to air the soil and clean up the weeds in the rows. In no-till system, no tillage was made until harvesting. So direct seeding was applied to the no-till plots without tillage and no tillage application was done until harvesting time. Dry soil was irrigated after seeding.

Each plot was 50 m long and 6 m wide with sandy loam soil having a texture of 10.12% clay, 22% silt and 67.88% sand. The soils are classified as Typic Xerofluvent in the US Soil Taxonomy.

For preparation of the soil, the baler was used to pick up the hay to cover 30% of the soil surface with residue in the field. The mean stubble height was 20 cm for corn and 17 cm for sunflower after harvesting wheat.

For conventional tillage system, two tillage systems were used. Normal traffic and controlled traffic conditions were applied in first and the second plots, respectively. In both systems, the soil was first ploughed with three-bottom moldboard general purposed plough. After plowing, the field was harrowed with disc harrow and leveled with float. For direct seeding application, seeding was made without tillage. After emergence of seedlings, the inter-row areas were harrowed and fertilized with inter-row cultivator. Inter-row cultivator with fertilizer applicator was used for furrow making before irrigation for all trials except no-till system. The specifications of the tools used in the experiment are given in Table 2.

Table 1. Applied tillage systems

No	System	Application
1	Conventional	Plough + Disk Harrow + Float +Direct Seeding Machine
2	Conventional (Controlled Traffic)	Plough + Disk Harrow + Float +Direct Seeding Machine
3	Reduced Tillage-I	Rotary Tiller + Direct Seeding Machine
4	Reduced Tillage- II	Chisel and Rotary Tiller Combination + Direct Seeding Machine
5	Reduced Tillage- III	Heavy Duty Disk Harrow + Float + Direct Seeding Machine
6	Direct Seeding, Wet Soil	Direct Seeding Machine (Secondary tillage are allowed)
7	Direct Seeding, Dry Soil	Direct Seeding Machine (Secondary tillage are allowed)
8	No-Till, Wet Soil	Direct Seeding Machine (No tillage at all)
9	No-Till, Dry Soil	Direct Seeding Machine (No tillage at all)

Table 2. The specifications of the tools used in experiment

Tool	Type	Working Depth (cm)	Working Width (m)
Plough	3-furrow	30	1,0
Disc-Harrow	32 Disks-Tandem	16	2,5
Float	-	-	2,6
Rotary Tiller	Horizontal rotary cultivator with L-shape knives	15	2,0
Rotary Tiller with chisel	With 4 legs	17	2,6
Heavy Duty Disk Harrow	20 Disks-Offset	20	2,5
Direct Seeding Machine	4 Rows	4-6	2,8

The direct seeding machine was a 4-row seeding machine designed especially for direct seeding purposes. In the experiment New Holland 80-66 (Engine Power 60 kW) tractor was used. The corn (Zea mays L.) seed used was May Agro Bora hybrid seeds for grain and The sunflower (Helianthus annuus L.) seed used was Asgrow RX-893 hybrid seeds.

Herbicides were used to clean up narrow and broad leaf weeds in direct seeding and no-till plots.

Frame with 1/4 m^2 area was used to measure weeding. Frame was placed two times in each plot and the number of weeds was counted when plant has 4-6 leaves. The number of weeds was then multiplied with 4 and averaged to calculate the weed density (number of plants/m^2). Flora of Turkey and Seed Plants Systematic reference was used to identify the weeds (Davis,1985, Seçmen et al., 1998).

Bulk density and organic matter of the soil were measured at 10 cm depth of the soil after seeding. Penetration resistance of the soil was measured at 5 cm depth of the soil after seeding. Plant height and yield were measured from samples taken from 2,1 m^2 area at harvesting time. Completely randomized experimental design with three replications was used for statistical analysis of the data. The data were analyzed using the COSTAT statistical package program for analysis of variance (Anonymous, 1988). Means were compared by Duncan tests at $P \leq 0.05$.

RESULTS AND DISCUSSION

Soil Conditions

Soil conditions changes with different tillage applications. Bulk density, penetration resistance and organic matter of the soil were found statistical significant for both corn and sunflower plants. Bulk densities of the soil were found high in reduced tillage and no-till plots in corn plots. This was due to the compaction occurred in reduced tillage because of float use. In sunflower plots, bulk densities of the soil were similar for all tillage systems although statistical significance was observed (Figure 1).

Penetration resistance of the soils for corn and sunflower plots were given in Figure 2. Due to its nature of leaving the soil without tilling, higher penetration resistance of the soil (250 N/cm^2) were measured in direct seeding and no-till plots comparing conventional and reduced tillage systems.

Organic matter of the soil was measured generally 1,5% in all plots (Figure 3). The difference for organic matter content of the soil was found low in corn plots, while it was high in sunflower plots. Generally direct seeding and reduced tillage systems provided higher organic matter content in the soil comparing conventional system in sunflower plots.

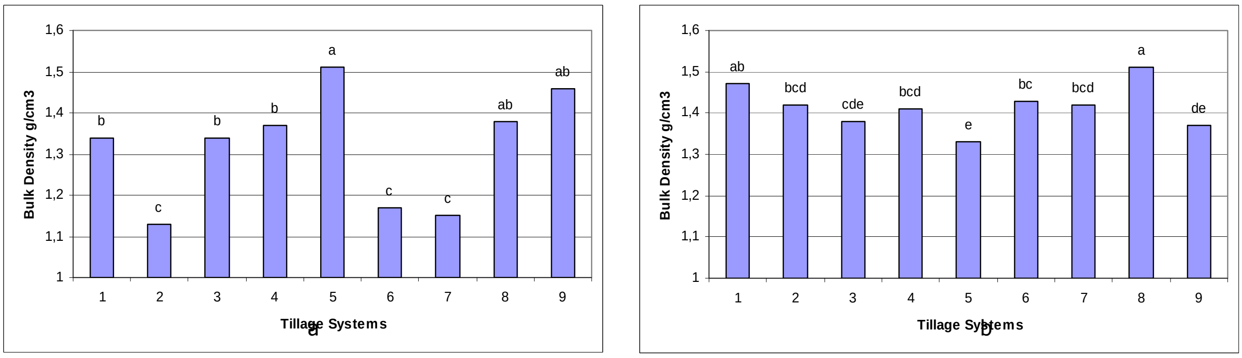
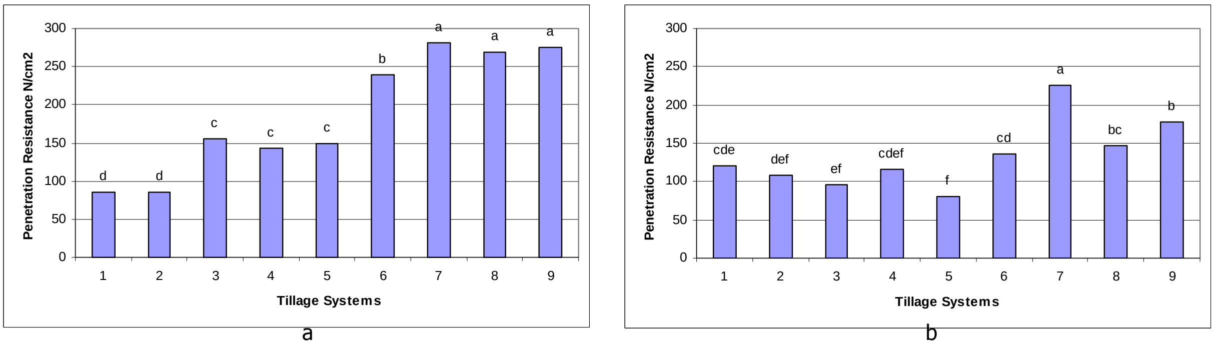
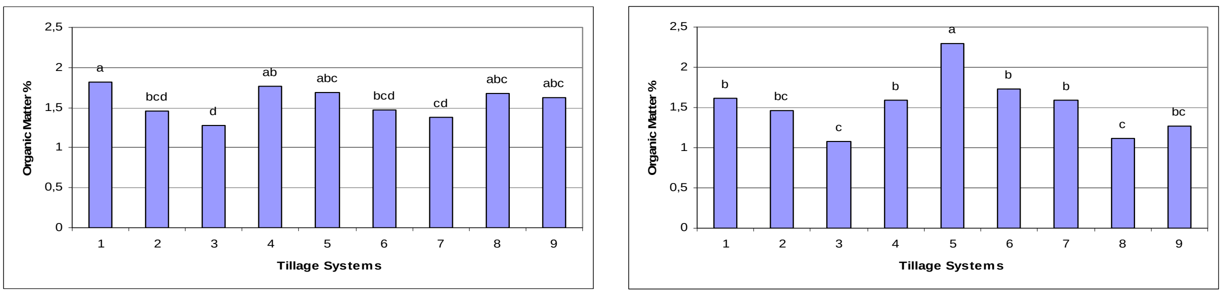


Figure 1. Bulk density of the soil as affected by tillage systems in the corn (a) and sunflower (b) fields



a b

Figure 2. Penetration resistance of the soil as affected by tillage systems in the corn (a) and sunflower (b) fields



a b

Figure 3. Organic matter of the soil as affected by tillage systems in the corn (a) and sunflower (b) fields

Weeding

Weed density (number/m^2) in tillage systems are given in Table 3. In all plots, 8 different weeds were observed. *S.halapense* was counted as the most dense weed in the plots with 49 number/m^2.

As it can be seen from Table 4, tillage systems effects were found statistical significant regarding weeding in plots. Generally direct seeding and conventional tillage systems had more weeding problems comparing the other tillage systems. The weed densities for all weed were measured as 118,5 number/m^2 and 115,5 number/m^2 for direct seeding and conventional tillage systems, respectively. Generally conventional tillage system had more different kind of weeds comparing the other systems.

Table 3. Weed density in tillage systems

SYSTEMS	***Sorghum halapense***	***Cyperus rotundus***	***Portulaca oleracea***	***Amaranthus retroflexus***	***Chenopodium album***	***Polygonum aviculare***	***Cynedon dactylon***	***Xanthium strumarium***	**TOTAL**
1	50	14		6				2	72
1	28	32	2	10	8	8	2		90
2	32	18							50
2	28	12	12					2	54
3	8	2	8						18
3	12		4						16
4	38	18							56
4	12	12							24
5	26								26
5	4	4							8
6	22	12		2					36
6	38	12	2						52
7	42	8							50
7	36	4	4						44
8	128	12							140
8	184								184
9	82	8							90
9	56	4							60
Average	**49**	**12,5**	**2,3**	**2,2**	**1,2**	**0,6**	**0,5**	**0,2**	**68,5**

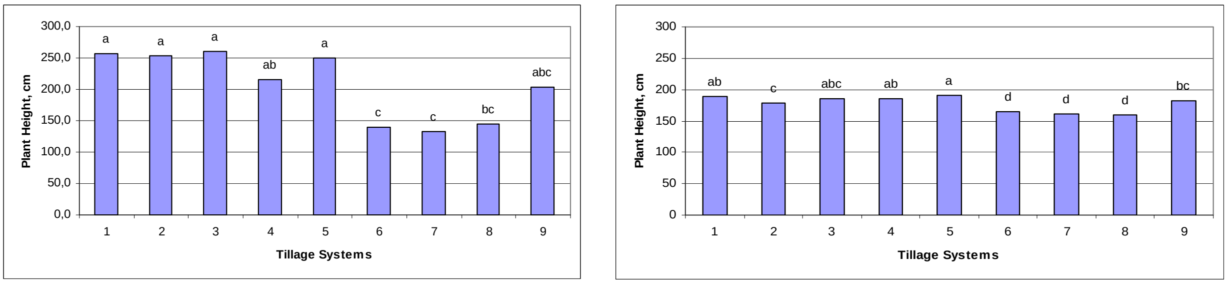
Plant heights and head diameter

Plant heights of corn and sunflower for each tillage system were given in Figure 4. Plant heights were found statistically significant for both plants. So the tillage system affects the plant height. Average 250 cm plant height was found for corn plant in conventional and reduced tillage systems while this was measured 150 cm for direct seeding and no-till systems. Although there was found statistical difference in plant height of sunflower, the difference between conventional and direct seeding systems was not so high as it was in corn plant. Generally lower plant heights were observed in direct seeding and no-till systems in both corn and sunflower fields.

The tillage system affects the head diameter of sunflower. Smaller head diameters were found in the systems of direct seeding and no-till in wet soil condition (Figure 5).

Table 4. Statistical results of weed densities of all weeds and *A.myosoroides*

Systems	***Sorgum halapense***		***All Weeds***	
	Density (number/m^2)	***Statistical Group P 0,05***	***Density (number/m^2)***	***Statistical Group P 0,05***
Conventional	58	ab	115,5	b
Rotarytiller	20	a	34,5	a
Rotarytiller +chisel	20	a	28,5	a
Heavy Duty Diskharrow	34,5	a	45,5	ab
Direct Seeding	112,5	b	118,5	b



a **b**

Figure 4. Plant height of corn (a) and sunflower (b) as affected by tillage systems

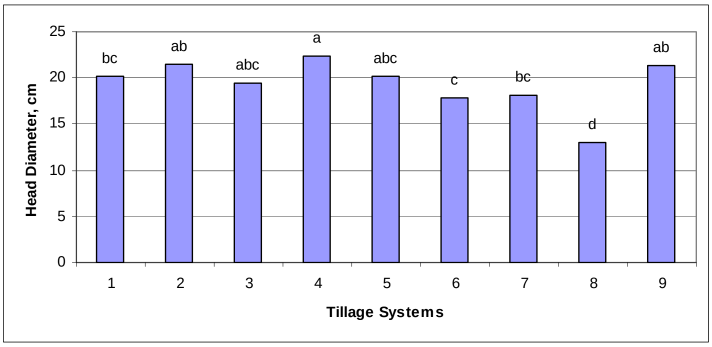


Figure 5. Head diameter of sunflower as affected by tillage systems

Yield

Corn and sunflower yields of the systems were given in Figure 6. There was found no statistical difference regarding yields for both corn and sunflower plants except direct seeding in dry soil conditions. Generally the yield results were found high in conventional and minimum tillage systems and low in the direct seeding and no-till systems. The highest yield was found in reduced tillage system I and II for both corn and sunflower plots. Yields for corn plant were measured as 1230 kg da^{-1} and 1164 kg da^{-1} for tillage system I and II, respectively. Similar high yields were found in reduced tillage system I and II as 503 kg da^{-1} and 519 kg da^{-1}, respectively for sunflower plant.

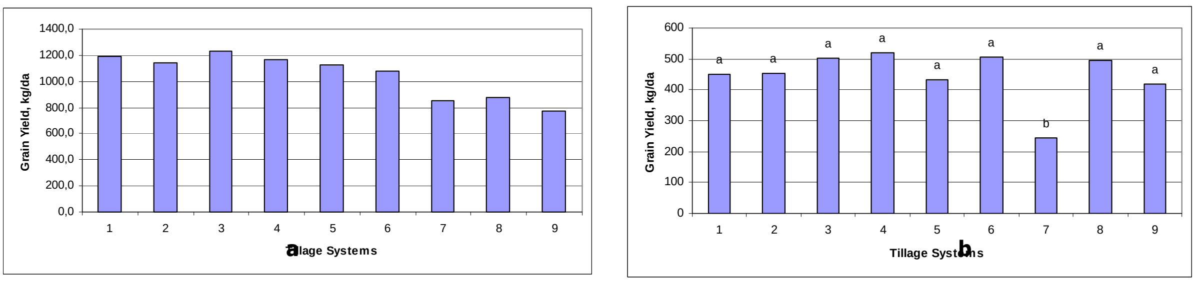


Figure 6. Yield of corn (a) and sunflower (b) as affected by tillage systems

CONCLUSIONS

According to the results, tillage systems changes soil physical properties while does not affect the yield for both corn and sunflower plants. The effects of tillage systems were found high on corn plants comparing the sunflower plants. It can be said that sunflower plant is less susceptive comparing corn. Direct seeding and No-till systems generally created higher penetration resistance and bulk density comparing conventional systems. High penetration resistance and bulk density caused the plant height and yield become low in no-till conditions comparing the other systems.

Reduced tillage systems I and II, where rotary tiller and rotary tiller with chisel used for cultivating the soil, provided generally better soil and plant conditions along with best yields for both corn and sunflower.

Tillage systems effects weed density. In all plots, 8 different weeds were observed. Generally direct seeding and conventional tillage systems had more weeding problems comparing the other tillage systems.

Knowing that application of direct seeding and no-till systems provide 8 times less fuel consumption and 6 times more field efficiency comparing the conventional system (Cakir et al., 2006), we can conclude that no-till systems preserves environment while providing similar yield for corn and sunflower. In some conditions, even, reduced tillage systems allow farmers to have better yield with time and fuel save where direct seeding and no-till tillage systems can not applied comparing conventional tillage system.

This study covers the two years' results of summer plants from the 2004 / ZRF / 019 numbered Research Project, Ege University, Izmir. According to the whole project, similar conclusions could be drawn from the final project report. The authors of this project continue working on no-till studies and target on long term effects of conservation tillage systems on soil conditions and yield of the plants.

REFERENCES

Anonymous, 1988. COSTAT Statistical Package For Analysis of Variance.

Çakır, E., H.Yalçın, E. Aykas, E.Gülsoylu, B.Okur, S.Delibacak, A.R.Ongun, 2006. The Effects of Conservation Tillage and Direct Seeding on the Yield of Second Crop Silage: First Year Results. Journal of Agricultural Machinery Science. Volume 2, Number 2, p.139-146, ISSN:1306-0007, Bornova-İZMİR.

Clark, L.E., Wiedeman, H.T., Gerard, C.J. and Martins, J.R., 1991. A Reduced Tillage System with Furrow Disking for Cotton Production, Transactions of the ASAE, 34(4):1597-1603.

Dam, R.F., B.B. Mehdi, M.S.E. Burgess, C.A. Madramootoo, G.R. Mehuys and I.R. Callum, 2005. Soil Bulk Density and Crop Yield in Eleven Consecutive Years of Corn with Different Tillage and Residue Practices in a Sandy Loam Soil in Central Canada. Soil and Tillage Research, Volume 84, Issue 1, November 2005, Pages 41-53.

Davis, P.H., 1985. Flora of Turkey, 9, Edunburg University Pres, 724 p.

den Biggelaar, C., R. Lal, K. Wiebe and V. Breneman, 2004. The Global Impact of Soil Erosion on Productivity I: Absolute and Relative Erosion-induced Yield Losses, Adv. Agron. 81(2004), pp. 1–48.

Harrold, L.L., Edward, W.M, 1974. No Tillage System Reduces Erosion from Continuous Corn Watersheds, Transactions of the ASAE, P: 414-416.

Ike, I.F., 1987. Maize and Cotton Yield Responses to Different Tillage practices, , OQ Field-Crops-Abstracts, 1989, 042-05988.

Köller, K., 2003. Conservation Tillage-technical, Ecological and Economic Aspects. Conservation Tillage and Direct Seeding Workshop, October 23-24, 2003. ISBN 975-483-601-9. Bornova-İzmir. pp. 9-34

Lafond,G.P., W.E. May, F.C. Stevenson and D.A. Derksen, 2005. Effects of Tillage Systems and Rotations on Crop Production for a thin Black Chernozem in the Canadian Prairies. Article in press, Soil & Tillage Research.

egyes, A. T. Ratonyi, J. Nagy, 2003. Effects of Tillage Systems on Soil Physical Characteristics and Corn (Zea mays L.) Production in Eastern Hungary. 16th Triennial Conference of ISTRO 13-18 July, 2003, Proceedings of ISTRO 16, Brisbane, Australia. pp. 732-736.

Onal, İ., E. Aykas, 1997. Technical Machines for Incorporating Cotton Residue After Harvest in the Soil. 17th Agr. Mech. National Congress Proceedings. Tokat.

Onal, İ., E. Aykas, 1995. Conservation Tillage Methods for Cereal and Cotton production in Ege Region. Ist Symposium on I. Gediz Basin and Environment, Salihli, Manisa.

Rajan B. and K.L. Khera, 2005. Effect of Tillage and Mode of Straw Mulch Application on Soil Erosion in the Submontaneous Tract of Punjab, India, Article in press, Soil & Tillage Research.

Seçmen, Ö., Gemici, Y., Görk, G., Bekat, L. Ve Leblebici, E., 1998. Systematic of Seed Plants. 5th Edition. Ege University Press, Bornova İzmir, 410p.

Yalcin H., 1998. A Study on Investigation of the Suitable Tillage Methods in Second Crop Maize for Silage. Ph.D. Thesis. Institute of Natural and Applied Science, Ege University, İzmir, p. 136.

Yalcin H., E.Aykas, E. Cakir, E.Gülsoylu, İ.Önal, B. Okur, Y.Nemli, A.R.Ongun, S.Delibacak, S.Türkseven, 2008. Conservation Tillage and Direct Seeding Applications on Controlled Traffic Conditions. Final Report of 2004 / ZRF / 019 Numbered BAP Project (Not Published)