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Influence of Tillage Systems on Wheat Yields and Economics in Clay Loam Soil under the Mediterranean Dryland Conditions

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Abstract: In an effort to increase crop production and conserve the soil from degradation, through mechanical manipulation of the soil, field experiments were conducted in cropping season of 2001-2003 to study the effects of tillage systems on performance of winter wheat (*Triticum aestivum* L.), weed density, and tillage economics. The tillage methods evaluated were: mouldboard plough (MT), reduced tillage with rototiller (RTR) and disc (RTD). While not statistically significant, the highest wheat grain yield was recorded for RTR the least for RTD according to the average of the two of years. RTR tillage system recorded a mean increase in wheat grain yield of about 6 and 11% over MT and RTD, respectively. Weed density was significantly higher for the RTD and the least for the MT in the two year of study. Mean weed populations recorded for the tillage systems were: RTR, 44 weeds m^{-2}; MT, 39 weeds m^{-2}; RTD, 61 weeds m^{-2}. RTR resulted in the highest gross margin with the least obtained for RTD. Considering the fact that the northwest of Turkey has about 15% of country's wheat production amount, RTR system can easily be adopted for increasing and economic crop production.

Key words: Tillage, wheat, weeds density, production costs, gross margin

INTRODUCTION

Population of the world gradually increase that it will become 8.2 billion by the year 2025 according to an estimate. Feeding is becoming a problem for the fast growing population. Wheat is the most important food among cereals in Turkey so that it is inevitable to receive high yields per unit of land area due to limiting land resources. Wheat is grown on an area of 9 million ha with total production of 17 million tons, making an average yield of 1909 kg ha^{-1} which is very low as compared to some other wheat production countries such as 6454, 2975, 2608, kg ha^{-1} in France, Chine and USA, respectively[1]. In Turkey, weed competition can cause yield reductions of up to 30% in wheat grain yields[2].

There are many factors responsible for low yield. Two of the major causes of low yield are the type of tillage and the weed infestation. Cultivation is still the primary method of weed control in the most grain production regions where annual mouldboard plough is used in traditional farming methods. Although herbicides have improved the viability of farmers and helped to reduce the risk of soil erosion, the weed control with cultivation is less expensive than herbicides, which may be seen as a potential ecological hazard[3]. In Turkey, the retail cost of herbicides is estimated to account for about \$1.8 million of the annual expenditure for weed control[4] its use of which is increased cost when it is associated with the traditional farming methods of required high input for land preparation. Farmers are interested in reducing cost relations of land preparation, while use the reduced tillage in replace of traditional or conventional tillage methods. The adoption of reduced tillage production systems is increasing in the world because of savings in time and economic inputs and for soil conservation considerations. As tillage decreases, weed control can become a limiting factor in crop production[5]. Changes in tillage practices can affect weed population dynamics, including weed seed distribution and abundance in the soil seedbank[6]. The influence of soil cultivation on weeds varies not only between species but also within species in experiments situated on the same soil type close by Pollard and Cussans[7,8]. Tillage reduces weed number and species diversity but increases germination of annual weed seed in the soil seedbank[9] and breaks up the vegetative structures of perennials, thereby stimulating bud growth and depleting food reserves[10]. Moreover, the vertical seed movement is of greater consequence as different types of cultivation move seeds to different depths in the soil[11]. On the other hand, timing of tillage can play a

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crucial role in exhausting the seedbank and controlling different life-forms and species of weeds and can also control early germination annual broadleaf and grass weeds. Soil disturbance in the autumn primarily stimulates germination of winter annuals weeds, while the influence on summer annuals is limited[12]. In Turkey, autumn tillage constitutes a fundamental component in the weed management strategies, not only kills weeds but also disturbs the soil. Furthermore, it breaks the seed dormancy and stimulates some seeds to germinate and bury other seeds, which then can remain viable in the soil for many years[13]. Moreover, it was reported that reduced tillage may give more yield than autumn ploughing, especially in the years with dry early summers[14]. In contrast to autumn tillage, early tillage with plough, performed as soon as possible after crop harvest, restricts seed-shedding more than late ploughing, especially when it is followed by late autumn seedbed preparation operations. On the other hand, weed seedlings are lower in shallow tillage or no-tillage than deep tillage[15]. Although tillage initiates weed seed germination and seedling emergence, deep tillage such as plough may also initiate weed seed germination so deep in the soil that the seedlings are unable to reach soil surface. Seedling emergence from great depths is not only reduced but also slower than emergence from shallow depths[16]. Deep tillage decreases the possibilities of growth and reproduction of seeds, while shallow tillage increases the seedling emergence because of more favourable conditions for germination. Hence, deep cultivation may deplete the soil seedbank faster than shallow cultivation. However, it is also possible that tillage may move seeds deeper into the soil where germination conditions are less favourable[17]. Conservation (chisel) and no-tillage systems typically have high population of small-seeded annual weeds that remain on or near the soil surface which is the active layer in terms of germination of small seed species compared with mouldboard plough tillage whereas seeds are distributed uniformly in the top 19 cm of soil[18]. However, primary tillage operation or subsequent secondary tillage in conventional practices brings up the weed seeds previously buried to the surface and can shatter rhizome and root systems.

The objectives of this study were to determine the effects of tillage management (conventional and reduced tillage) on production costs, net economic returns, and weed density in grown winter wheat on the clay-loam soil in the Canakkale region of northwest Turkey.

MATERIALS AND METHODS

Experimental site: The field experiment was initiated in a field with a clay loam soil at the Dardanos Agricultural Research Station of Onsekiz Mart University, Canakkale (39° 30' N; 26° 8' E), a location with a mean annual rainfall of 616 mm, mean annual temperature 14.8°C according to 60 year's period. It was run for two years, during the cropping period of 2001-2002 and 2002-2003. The soil was a Eutric Vertisols according to FAO/UNESCO and Typic Haploxererts according to Soil Taxonomy with pH 7.69 and clay concentration of 304 g kg^{-1}, sand 399 g kg^{-1}, silt 298 g kg^{-1}, bulk density 1.31 Mg m^{-3}, organic carbon 7.3 g kg^{-1}, 1-2% slop at the 0-30 cm depth. The crop rotations were dominated by winter-wheat for many years. However, typically wheat is rotated sunflower, chickpea and barley. Bare fallow is seldom used on these soils, which are fertile and possess soil texture favourable for water retention. Table 1 shows monthly temperature and rainfall over the study period (2001-2003). Mediterranean climate is characterized by a high seasonal variability of with 83% of annual rainfall occurring during the months of October to June.

Tillage and cropping experiment: The design of the experiment was a randomized complete block arranged with three replications. The tillage treatments were: conventional and two reduced tillage systems that had been reapplied to the same plots during the experimental period. Conventional tillage plot was mouldboard plowed (MT) 20 cm deep in fall, disced twice and levelled prior to crop planting. Reduced tillage systems consisted of two levels of tillage and employed noninversion implements such as rototiller (RTR) and disc (RTD) for primary tillage, and thereafter one discing and levelling applied to the field of each system. The size of each tillage plot was 75 m long and 15 m wide.

The field was drilled with local winter wheat (*Triticum aestivum* L.) cultivar 'Gonen' at a depth of 4 cm at a density of 583 seeds m^{-2} (210 kg ha^{-1}) using a grain drill with a row spacing of 15 cm following the last cultivation of each treatment. Planting depth was consistent among treatments differing in residue cover and soil conditions. Seeding was completed in the period between late October and late December of each year as soon as the weather conditions permitted. Fertiliser applications were based on the regional soil test recommendations guidelines, with the same rates applied to all treatments.

Table 1: Climatological data during the experimental period

	Temperature (°C)											
	Minimum			Maximum			Rainfall (mm)			No. of rainy days>1 mm		
	2001	2002	2003	2001	2002	2003	2001	2002	2003	2001	2002	2003
October	5.8	31.0	13.3	27.5	11.0	21.2	0.0	54.9	87.6	0	8	12
November	0.0	12.0	8.7	24.0	7.0	15.0	192.5	137.9	6.9	19	10	2
December	-7.2	4.0	4.7	15.2	21.0	10.8	239.2	78.2	119.7	20	14	14
January	-0.4	2.1	5.5	17.5	14.8	11.7	60.1	58.1	55.2	12	8	10
February	-1.2	0.4	-0.3	19.0	16.4	5.5	68.7	73.6	103.4	8	9	15
March	4.5	1.0	1.1	24.2	17.8	10.2	7.7	58.4	15.4	3	7	6
April	2.1	2.8	5.9	25.2	21.0	14.7	120.2	33.5	15.9	14	9	10
May 6.4	9.8	13.3	32.1	29.4	24.7	65.3	1.5	83.2	4	2	3	
June 10.8	12.6	17.8	36.4	34.1	30.1	0.1	8.1	29.7	0	5	-	
Total							753.8	504.2	517.0	74	72	72

All other agronomic practices were kept normal and uniform for all the treatments. Farming practices performed at the research area were similar to those of the farmers in the region. Herbicide was recommended by local weed experts in terms of time and rate for annual broadleaf weeds, 2,4-D application. All wheat test plots were hand-harvested using a hand-sickle from 3 m^2 area at the third weeks of June of each year.

Plant and weed measurement: Winter wheat was harvested with a hand tool for the determination of yield. Yield was obtained from a 3 m^2 equivalent area within each treatment. Weight and moisture content of grain were determined. Wheat yields obtained from 3 m^2 area were converted to kg per hectare. Final grain yields expressed as kg ha^{-1} were corrected to 102 g kg^{-1} moisture. Weed density was counted in each growing season with 1x1 m quadrats placed randomly on each plot to quantify each weed species and then the number of weeds in 1 m^2 area was averaged. Weed density were converted to plants per unit area (m^2). Weed counts were conducted three times for each growing season before herbicide application for annual broadleaf weeds.

Data were analysed statistically using the analysis of variance (ANOVA) for each year. Means separation among treatments were obtained using the least significant difference (LSD) test at the 0.05 probability level of significance. Data from each of the two years were presented separately for weed density, but yields were presented as the average of two years.

Economic analysis: For economic analysis, data were collected on labour input for the various operations under each tillage, cost of land preparation, and other operations for each tillage system[19,20]. Cost of labour as well as the prices of wheat was also utilised. Labour was valued according to the regulations of the Turkey Ministry of Work. Wheat price was obtained from the market at the time of harvest. Costs of each type of cultivation were determined using rental prices in the area. The total labour input was calculated in mandays (Md) as the sum of labour involved in all the operations for each tillage system. Production costs for each tillage system were based on the actual sequence of operations conducted in the experiment. Costs were also taken to embody the total cost involved in land preparation and labour for all the other operations for each tillage system. Costs of all field operations during the growing season were estimated in U.S. dollars. The value of the wheat grain constituted the gross income. In arriving at the gross margins, the total cost and gross income/or net economic return was evaluated together and was calculated as treatment yield (kg ha^{-1}) X \$0.25 kg^{-1}-total cost of wheat production. All cost and income figures are presented per hectare.

RESULTS AND DISCUSSION

Weed density: The number of weed species found at tillage systems investigated ranged from 12 to 16. Weeds counted were sorted into the groups according to life history (Table 2).

Under the point of view of some weed species observed in treatments, although *A. fatua* was not significantly influenced by tillage in the first year of experiment it was found higher in both reduced tillage than in MT in each year. Similarly, it was pointed out that the density of *A. fatua* under the reduced tillage was much higher than under the MT[21]. They also expressed that the seed germination such as the species of grass weeds was reduced by up to 90% when ploughing was applied rather than reduced tillage probably due to the optimum germination depth of those species of the oat that is 5-10 cm[22]. An increase in the annual broadleaved weeds such as *M. perforate* and *S. arvensis* have also been observed in both RTR and RTD tillage than in MT, which stimulates the germination of the *S. arvensis* seeds buried by autumn plough tillage and thus the emerged seedlings get damaged due to their sensitivity to early autumn this

Table 2: Major weeds, their density during the cropping season of 2001-2003

Species scientific name		Weed density (plants/m²)							
		2002				2003			
Annuals	Common name	RTR	MT	RTD	$LSD_{0.05}$	RTR	MT	RTD	$LSD_{0.05}$
Avena fatua	Wild oats	5	2	5	NS	2	2	4	1.85
Capsella bursa-pastoris	Shepherd's-purse	3	2	2	NS	4	0	5	2.72
Centaurea cyanus	Bachelor's button	2	-	1	-	3	-	3	-
Euphorbia helioscopia	Sun spurge	2	2	5	2.45	4	1	3	2.56
Fumaria officinalis	Common fumitory	2	4	3	NS	2	5	2	NS
Lamium purpureum	Red dead nettle	4	2	5	1.99	3	1	6	2.72
Lathyrus sativus	Grass pea	2	2	5	NS	3	7	6	2.93
Matricaria perfoata	Scentless mayweed	2	2	2	NS	6	2	9	2.39
Chenopodium album	Lambsquarters	2	-	3	-	-	-	4	-
Papaver rhoeas	Common poppy	2	2	7	1.51	7	1	2	1.51
Phalaris canariensis	Reed canary grass	3	-	6	-	3	3	2	NS
Polygonum aviculare	Knotweed	3	5	2	2.07	4	6	3	2.07
Raphanus raphanistrım	Wild radish	2	4	3	1.99	2	3	2	NS
Sinapsis arvensis	Wild mustard	5	2	4	2.72	6	3	6	2.39
Perennials									
Agropyron repens	Quackgrass.	-	-	9	-	6	18	10	3.29
All weeds		36	29	56	1.60	52	49	65	6.06
Number of species		14	12	15		14	13	15	

MT: conventional tillage, RTR: conservation tillage with rototiller, RTD: conservation tillage with disc.

Table 3: Economic analysis of tillage systems*,**

Tillage system	Gross income⁺ \$ ha⁻¹	Cost of labour for land preparation and other operations⁺⁺ \$ ha⁻¹	Gross margin \$ ha⁻¹	Efficiency coefficients (output:input)
RTR	1161.29	1039.26b	122.03a	1.12
MT	1101.85	1080.00a	21.85b	1.02
RTD	1048.46	1041.48b	6.98c	1.01
$LSD_{0.05}$	NS	10.71	5.46	NS

*: The mean values in each column followed by the same letter are not significantly (P<0.05) different. ⁺: It includes only grain yield. ⁺⁺: It includes labour input, tillage, seedbed preparation, cultivation practices during the growing period and harvest operations. *: Based on following prices: wheat, 340 thousand TL kg^{-1}; wage price of labour, 25 million TL Md^{-1}; land preparation and planting charges (ha^{-1}): reduced tillage (rototiller), 272 million TL; reduced tillage (disc), 275 million TL; conventional tillage with mouldboard plough, 375 million TL. The yield income and all charges were calculated according to the SIS (1998). Turkish lira= official Turkish currency; 1 350 000 TL= 1 US\$, RTR: reduced tillage with rototiller; MT: conventional tillage with mouldboard; RTD: reduced tillage with disc.

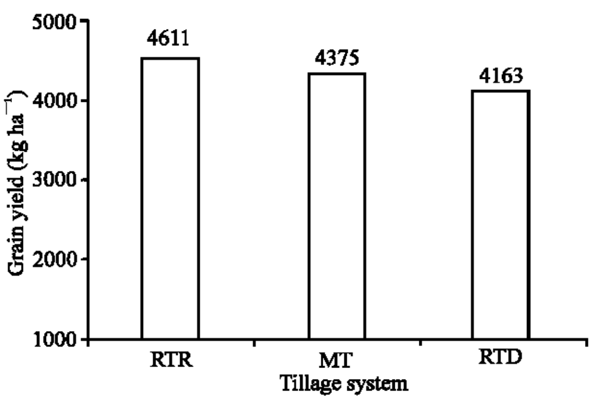

Fig. 1: The yield of wheat under three tillage systems (mean two years)

reduces the seedbank of this species in the soil. More weed density in RTR and RTD may be probably due to more wet soil condition under the reduced tillage, which includes higher residues than MT on or near the soil surface. Results similar to those reported earlier by researcher found more *S. arvensis* seedlings with disc compared with autumn plough tillage in spring wheat that it was frequently found in the treatments and significantly influenced by tillage ($p<0.05$) in this study[2]. The increase with reduced tillage in *M. perforata* is in accordance with some other studies[12,23]. Not all studies, however, have reported increased occurrence of *M. perforata* under the reduced tillage[7]. They also pointed out that the reduced tillage reduces the seedling emergence of broadleaf weeds compared with plough tillage which reduces the weed species. The reason for more density of *M. perforata* found in the last year of the experiment of this study may be probably poor stands of wheat observed in the late spring of the first year which is giving good conditions for the weed plants to develop. Thus, this is increased the seed production of *M. perforata* and probably corresponding increase in the weed seedbank and thus large infestation the next year of study. In addition, *M. perforata* has also a biennial life cycle. On the other hand, many weeds apparently favoured by autumn ploughing that were not preceded by shallow tillage. Such species were the annuals *P. aviculare*, but also the perennial *A. repens*, except the first year of study 18 weeds^{-2} in the last year that is in accordance with Bostrom and Fogelfors[12]. Conversely, it was stated that increased soil disturbance results in a decreased number of weed species and decreased species diversity[9]. Annual broadleaved weeds, however, frequently show an inconsistent response to tillage[4]. This has been found for *C. album* which was found in only RTR and RTD treatments and was not significantly influenced by tillage in both years due to no counts in MT. Similarly, it was reported that although there was no statistically difference between tillage, the highest *C. album* was observed in RTR[25]. This may be explained that the lower *C. album* than other weed species in this study is probably due to more seedling emergence in April and also due to the difference of the life cycles from winter wheat[26]. *P.canariensis*, which is an annual narrow-leaved weed, was also higher in two reduced tillage comparing with MT in the first year, while it was not statistically influenced by tillage. It was also reported that *P.canariensis* has seedling emergence of 95%[26] when it's seed remains on the near soil surface[25]. Conversely, it was obtained that an increase in tillage intensity reduced the weed growth through the growing season[27].

Some of the other annual weed species frequently found in the treatments were not significantly influenced by tillage, e.g., *C. bursa-pastoris*, *C. cyanus*, *F. officinalis*, *L. sativus*. On the other hand, the perennial grass such as *A. repens* with rhizomes or creeping roots were increased in MT than other two reduced tillage, but this density varies with tillage systems depending on the year. Contrary to our findings, some researchers stated that reduced tillage systems increased perennial weed densities and diversity more than ploughing[8,28,29].

Overall, there was a significant ($p<0.05$) tillage effect on weed density in wheat for two years when the experiment was conducted. There was a general increase in the winter annual + biennial and perennial weed species with reduced tillage as seen by some authors[9,30,31]. The density of the perennial *A. repens* also increased in the last year of the experiment in all treatments. It was also presented that more viable seeds were found in the upper than in the lower soil layer with reduced tillage while only minor differences in the lower layer was obtained between the reduced and conventional tillage[31].

In 2002, the highest weed density was recorded for RTD and the least was recorded for MT. RTD recorded a significantly higher weed density compared to other tillage systems. In 2003, RTD supported the highest weed density and MT the least. Under the point of view of the two year, MT recorded a significantly lower weed density compared to the other reduced tillage systems. Conversely, it was presented that high weed density in autumn plough decreased yield than the other tillage systems[32]. On the other hand, perennial (as *A. repens*) was most favoured in MT than in RTR and RTD, especially at last year of experiment, while it was partially controlled by the other reduced tillage treatments. It was also showed that weed density increased after one year of no-tillage and after two year of conventional tillage in a four year experiment with application of treatments to the same plot[24].

In the last year of the study, weed density in the unit area was found higher than in the previous year's in all treatments. Moreover, winter annual or biennial weeds of that year increased especially with decreased tillage. Since these species can survive during the winter, they are also larger and more difficult to control in the next growing season. In the two year study, it was not possible to find a clear tendency showing how tillage systems affect weed density (i.e., long term effects). Further information is required from more crop cycles to discover whether there is any tendency for tillage systems to influence weed density in the region.

Wheat grain yield: There were no significant statistical differences in grain yield among tillage systems in the average of two year (Fig. 1). While not statistically significant, the highest wheat grain yield for the experimental period recorded for RTR with 4611 kg ha^{-1} and the lowest for RTD with 4163 kg ha^{-1}. RTR system consistently recorded higher grain yield compared to the MT and RTD during the experimental period. The superior wheat grain yields obtained for RTR and MT systems might probably be attributed to the better weed control achieved by these tillage systems compared to disc tillage. The MT tillage system also works the soil deeper as well as RTR than disc, thereby resulting in a better weed control as reflected in the lower weed populations obtained for these tillage systems (Table 2). Hence, in addition to being a viable economic alternative for farms in the region, RTR gives higher yields than other tillage systems that gradually increased usage by farmers in this region. Furthermore, RTR probably could be prefer by local farmers because of less fuel consumption per unit area than especially mouldboard plough and then resulted lower cost relating to the land preparation pre-planting.

Economic analysis: The total labour input was obtained in all tillage systems which includes the sum of labour involved in all the operations for each tillage system. The highest labour input resulted from MT because of more operation for land preparation pre-planting than other reduced tillage systems. Total cost presented in Table 3 is included the labour input from land preparation pre-planting to the harvest. For the two year experiment, total cost for the three tillage systems were statistically different at the 0.05 significance level. MT resulted in the highest cost with 1080.00 $, while RTR resulted in the least with 1039.26 $. This is explained by the fact that more fuel per unit area is necessary in MT that charges the high rates for tillage operations, keeping in mind that all treatments receive the same amount of seed, fertiliser and chemicals, they are different in tillage systems.

The benefits are the gross margins resulting from different tillage systems. RTR was found to have the highest gross margin with the least coming from RTD which was less profitable with 6.98 $ than the other two tillage systems at the 0.05 significance level. The gross margin for RTR was the highest because the gross income is the highest with 1161.29 $ over that other two tillage systems. Moreover, cost of labour for land preparation and other operations were the lowest in RTR with 1039.26 $, while it was 1041.48 $ and 1080.00 $ in RTD and MT, respectively. Similarly it was pointed out that net economic return was lower in conventional tillage systems using blade plough with 1098.3 $/ha for barley than other reduced tillage that includes only tillage, cultivation and harvesting except other expenses such as labour, seed, fertiliser[33]. It was also reported that net economic return was higher in the reduced tillage than in conventional tillage on the heavy clay soil[34]. In contrast, some researchers reported that net economic returns were lower for reduced tillage[35]. and also expressed that this usually reflected higher production costs and little or no yield advantage for reduced tillage, just like in the results of the RTD treatment in this study. The results of this analysis showed that reduced tillage with rototiller was more profitable with 122.03 $ than other two tillage systems and was the alternative with the lowest cost of land preparation per hectare for average of two of year. Contrary to our findings some authors found that net economic returns in the conventional tillage system increased more than in reduced and no-tillage systems[36]. Hence, this comparison shows RTR with less fuel consumption to be a viable economical alternative for farms in this region, if the efficiency coefficients take into accounts which are the higher in RTR with 1.12 than other systems. In generally, two major factors caused a lower net income in MT: somewhat smaller yield and more consumption of fuel in unit area due to more soil preparation operations than RTR where a reduction in tillage intensity does not mean an increase in yield.

In this study, the RTR system gave the highest grain yields as the average of two of year and gave the highest gross margin. These results indicated that wheat production with RTR is superior to the MT and RTD. The RTR system gave best returns compared to MT and RTD when the experiment was conducted from both agronomic and economic considerations. RTR system also attracts less operational charges when compared MT operations. On the other hand, the weeds increased with less intensive tillage compared to mouldboard plough, in especially in RTD treatment. High weed density usually decreased the yield, resulting with lower yields in RTD than other tillage systems. Considering the fact that the northwest of Turkey has about 15% of country's wheat production amount, RTR system can easily be adopted with increasing use, and it can be an economic crop production because RTR is significantly more profitable than both MT and RTD.

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REFERENCES

1. SIS, 1998. Agricultural Structure (Production, price, value). State Institute of Statistics Prime Ministry Republic of Turkey. Ankara, 1998.
2. Guncan, A., 1976. Erzurum cevresinde bulunan yabanci otlar ve onemlilerinden bazilarinin yazlik Arpa ve Bugdayda mucadele imkanlari uzerine arastirmalar (Ph.D. Thesis). University of Ankara. Publication No:135.
3. Felton, W.L. and K.R. McCloy, 1992. Spot spraying. Agril. Eng., 73: 9-12.
4. Zeren, O., 1997. Turkiye'de pestisit kullanım boyutları ve cevre kirliligine etkileri. Turkiye'de Cevre Kirlenmesi Oncelikleri Sempozyumu II. Mayıs. Gebze, Kocaeli, pp: 22-23.
5. Buhler, D.D., 1992. Population dynamics and control of annual weeds in corn (*Zea mays*) as influenced by tillage systems. Weed Sci., 40: 241-248.
6. Mulugeta, D. and D.E. Stoltenberg, 1997. Weed and seedbank management with integrated methods as influenced by tillage. Weed Sci., 45: 706-715.
7. Pollard, F. and G.W. Cussans, 1976. The influence of tillage on the weed flora of four sites sown to successive crops of spring barley. Crop Protection Conf. Weeds Proc., 3: 1019-1028.
8. Pollard, F. and G.W. Cussans, 1981. The influence of tillage on the weed flora in a succession of winter cereal crops on a sandy loam soil. Weed Res., 21: 185-190.
9. Cardina, J., E. Regnier and K. Harrison, 1991. Long-term tillage effects on seed banks in three Ohio soils. Weed Sci., 39: 186-194.

10. Fryer, J.D. and S.A. Evans, 1970. Weed Control Handbook. Principles, The Newdigate Press Lmt., England, 1: 220-221.
11. Dessaint, F., G. Barralis, M.L. Caixinhas, J.P. Mayor, J. Recasens and G. Zanin, 1996. Precision of soil seedbank sampling: how many soil cores? Weed Res., 36: 143-151.
12. Boström, U. and H. Fogelfors, 1999. Type and time of autumn tillage with and without herbicides at reduced rates in southern Sweden. 2. Weed flora and diversity. Soil and Till. Res., 50: 283-293.
13. Mohler, C.L. and A.E. Galford, 1997. Weed seedling emergence and survival: seperating the effects of seed position and soil modification by tillage. Weed Res., 37: 147-155.
14. Børresen, T., 1993. Ploughing and rotary cultivation for cereal production in a long-term experiment on clay soil in southeastern Norway. 2. Yields and weed infestation. Soil and Till. Res., 28: 109-121.
15. Popay, A.I., T.I. Cox, A. Ingle and R. Kerr, 1994. Effects of soil disturbance on weed seedling emergence and its long-term decline. Weed Res., 34: 403-412.
16. Zhang, J., A.S. Hamil, I.O. Gardiner and S.E. Weaver, 1998. Dependence of weed flora on the active soil seedbank. Weed Res., 38: 143-152.
17. Egley, G.H. and R.D. Williams, 1990. Decline of weed seeds and seedling emergence over five years as affected by soil disturbances. Weed Sci., 38: 504-510.
18. Yenish, J.P., J.D. Doll and D.D. Buhler, 1992. Effects of tillage on vertical distribution and viability of weed seed in soil. Weed Sci., 40: 429-433.
19. Jungbluth, T., R.M. Peart and A. Ramdani, 1999. CIGR Handbook of Agricultural Engineering. Vol. 5. Energy and Biomass Engineering. ASAE.
20. Srivastava, A.K., C.E. Goering and R.P. Rohrbach, 1993. Engineering Principles of Agricultural Machines. ASAE.
21. Smith, G.L, R.P. Freckletn, L.G. Firbank and A.R. Watkinson, 1999. The population dynamics of *Anisantha steilis* in winter wheat: comparative demography and the role of management. J. Applied Ecol., 36: 455-471.
22. Guncan, A., 1982. Erzurum yoresinde bugday urunune karişan bazi yabanci ot tohumlarinin cimlenme biyolojisi uzerinde arastirmalar. University of Ataturk, Publ. No: 270.
23. Skuterud, R., K. Semb, J. Saur and S. Mygland, 1996. Impact of reduced tillage on the weed flora in spring cereals. Norwegian J. Agric. Sci., 10, 519-532.
24. Teasdale, J.R., C.E. Beste and W.E. Potts, 1991. Response of weeds to tillage and cover crop residue. Weed Sci., 39: 195-199.
25. Kocaturk, U., 1991. Bugdayda farkli toprak isleme yontemlerinin yabanci ot populasyonuna etkileri. Yuksek Lisans Tez Çalismasi. Bornova, Izmir.
26. Covarelli, G., 1978. Weed control. Informatore Fitopatologico., 28: 23-26.
27. Bhagat, R.M., S.I. Bhuiyan and K. Moody, 1999. Water, tillage and weed management options for wet seeded rice in the Philippines. Soil Till. Res., 52: 51-58.
28. Gill, K.S. and M.A. Arshad, 1995. Weed flora in the early growth period of spring crops under conventional, reduced, and zero tillage systems on a clay soil in northern Alberta, Canada. Soil Till. Res., 33: 65-79.
29. Feldman, S.R.C. Alzugaray, P.S. Torres and P. Lewis, 1998. Gap colonization by weeds in a wheat crop grown under different cultivation regimes. Weed Res., 38: 35-45.
30. Tørresen, K.S. and R. Skuterud, 2002. Plant protection in spring cereal production with reduced tillage. IV. Changes in the weed flora and weed seedbank. Crop Prot., 21: 179-193.
31. Tørresen, K.S., R. Skuterud, H.J. Tandsaether and B.M. Hagemo, 2003. Long-term experiments with reduced tillage in spring cereals. I. Effect on weed flora, weed seedbank and grain yield. Crop Prot., 22: 185-200.
32. Bostrom, U., 1999. Type and time of autumn tillage with and without herbicides at reduced rates in southern Sweden. Soil Till. Res., 50: 271-281.
33. Abu-Hamdeh, N.H., 2003. Effect of weed control and tillage system on net returns from bean and barley production in Jordan. Canadian Biosystems Engineering, 45: 223-228.
34. Zentner, R.P., C.A. McConkey, F.B. Campbell and F. Selles, 1996. Economics of conservation tillage in the semiarid prairie. Canadian J. Plant Sci., 76: 697-705.
35. Malhi, S.S, G. Mumey, P.A. O'Sullivan and K.N. Harker, 1988. An economic comparison of barley production under zero and conventional tillage. Soil Till. Res., 11: 159-166.
36. Hoffman, M.L., D.D. Buhler and D.K. Owen, 1999. Weed population and crop yield response to recommendations from weed control decision aid. Agron. J., 91: 386-392.