Comparison of Minimum and Conventional Tillage Systems and Different Nitrogen Doses on Grain Yield of Barley (*Hordeum vulgare* L)

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Present study was conducted to evaluate the effects of minimum and conventional tillage systems on yield of barley (*Hordeum vulgare* L.) under 5 different nitrogen doses. The experiment was a split-plot design with 3 replications and was conducted in irrigated land of Cukurova district in Turkey during 2003 and 2005 growing seasons. Three different tillage systems were tested during this experiment; (1) conventional-till, (2) cultivator and (3) disc-harrow treatments. Along with these 3 tillage systems, nitrogen was added at the rates of 0, 50, 100, 150 and 200 kg N ha^{-1}. Barley variety Kaya was used in the experiment. Results show significant ($p \leq 0.01$) differences between the different tillage systems and nitrogen doses. In this study, maximum grain yield was obtained from conventional tillage systems with 200 kg ha^{-1} nitrogen dose. Results of this experiment show the positive effects from conventional tillage systems and high nitrogen doses for grain yield. It is recommended that barley growing should prefer the conventional tillage systems and 200 kg ha^{-1} nitrogen dose. It was determined as that the most tillage system were conventional tillage systems and the most nitrogen dose was 200 kg ha^{-1} for grain yield.

Key Words: Barley, Grain yield, Tillage systems, Nitrogen, N use efficiency.

INTRODUCTION

Minimum tillage was defined as a system in which both crop residues are retained or near the soil surface and a rough soil surface is maintained, to achieve control of soil erosion and to achieve good soil-water relations[1,2]. Plant-available water and soil erosion are major factors limiting agricultural production in Mediterranean environments[3,4]. Therefore, farmers need to manage crop residues and tillage to control soil erosion and effectively store and use the limited precipitation received

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for crop production[5-7]. Many reports suggested that crop residues and other forms of surface mulches are very effective in reducing soil erosion and preserving water[8,9]. In addition, soil tillage also reduces the energy and labour costs and provides weed control. Reduced tillage systems could be more profitable due to savings of fuel usage and reductions of equipment wear.

Soil tillage has a large influence on the soil environment and crop production and may influence nitrogen leaching. Stenberg[10] studied emergence of spring barley on soils without firm seedbed bottoms. This is the case for many crop establishment systems today and a rapid and uniform establishment of the crop is necessary for an efficient use of soil nitrogen available to the crop. Tillage system success depends on soil, type, climate and cultural practices. Although, little difference in soil structural characteristics has been reported among tillage systems[11], low rainfall and high temperature in arid and semiarid regions result in a lower potential of soil organic carbon accumulation[12]. Several studies have reported that the minimum tillage system in arid regions has an adverse effect on cereal yield[13].

The excessive nitrogen application could be harmful to environment. Water reservoirs could be polluted by N derivatives resulting from nitrification and denitrification or leaching and could cause, reduction of profit margins of farmers. A major goal for the design of tillage systems is to use N as efficiently as possible. In general, the use of mineral N fertilizer by cereals decreases with increasing N amounts[14]. However, high N rates at the beginning of growth increase the number of tillers and ears per square meter. Sieling *et al.*[15] reported that different cropping systems on grain yield of winter barley increased grain yield as N doses increased. High N at the beginning of growth increased the number of tillers and ear[16] per m^{-2}. Halvorson *et al.*[17] compared effect of tillage systems with different N doses on grain yields of wheat. Conventional tillage gave higher grain yield than no-till and minimum tillage and grain yield increased with increased N-doses in the all tillage systems.

The aim of the study was to determine effects of minimum and conventional tillage systems and different N-doses on grain yield of barley.

EXPERIMENTAL

Experiment site: The experiment was conducted in irrigated land of Cukurova district, Adana, in Turkey during 2003 and 2005 groving seasons. Experiment was set up as randomized complete block design with split plot arrangement with 3 replications. The tillage systems were main plots, the nitrogen doses were subplots split within main plots. The net main plot size was 6 m × 8 m and subplots size 1.2 m × 5.0 m. Barley variety Kaya was used in the study. This variety is two-rowed, awned, white seeded, with 1000 grain weight equals to 40-48 g and resistant to lodging and could be used for feeding and malting. Seeds were sown in row 15 cm × 5 cm apart with a dibbler. Seed rate used was 500 number m^{-2}.

TABLE-1
NUMBER OF SOWN SEEDS AND EMERGED SEEDLINGS

Tillage systems	Seeds sown m^{-2} 2003-05	Number of emerged seedling m^{-2}	
		2003-04	2004-05
Conventional	500	452	468
Cultivator	500	400	412
Disc-harrow	500	380	375

Nitrogen was broadcast at rates of 0, 50, 100, 150, 200 kg ha^{-1} in the form of ammonium sulphate $(NH_4)_2SO_4$. One-third of $(NH_4)_2SO_4$ was applied during sowing, one-third at the tillering stage and the rest at dressing stage. H_3PO_4 (120 kg ha^{-1}) and K_2O (100 kg ha^{-1}) were applied once with sowing.

Climatic data of crop growing seasons was shown at Table-2. Adana has a Mediterranean climate (semiarid, with rainy cold winters and dry hot summers) with an annual mean rainfall of 500 mm (80 % occurring from October to June). The long-term average temperature from November to May in Adana is 13.2°C. Precipitation is 549.9 mm for the same period. The average temperature for Adana from November to May was 12.7°C in 2003-2004, total rainfall was 466.2 mm for the same period. However the same period in 2004-2005 was warmer and drought conditions (temperature: 14 ºC, precipitation 273.0 mm) were more pronounced (Table-2).

TABLE-2
CLIMATIC DATA OF THE REGION (2003-2004 AND 2004-2005 GROWING SEASONS)

	Years	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Total/ Mean
Mean temperature (ºC)	2003/04	16.1	11.0	8.4	9.4	14.6	16.9	20.9	13.2
	2004/05	23.7	9.9	10.2	9.8	13.4	17.5	22.5	14.0
	Long term	15.5	11.1	9.4	10.4	13.1	17.2	18.6	12.7
Precipitation (mm)	2003/04	12.2	127.5	241.5	63.0	3.0	14.0	5.0	466.2
	2004/05	73.2	19.1	27.2	41.9	20.8	82.8	8.0	273.0
	Long term	73.9	124.4	109.4	88.9	65.8	52.5	35.0	549.9

Regional Meteorology Station, Adana.

Soil in a depth of 30 cm was sampled before the start of the experiment and subjected to physico-chemical analysis. Soil was medium in nitrogen (19.8 kg NH_4^+ ha^{-1}), neutral (pH 7.0), low in calcium carbonate (1.3 %) of medium in P (55.9 kg ha^{-1} P_2O_5) and in low amount of K_2O (141 kg ha^{-1}) contents. The soil of the experimental area had a variable topography ranged from almost smooth to soft slopes with clay texture.

Tillage experiment: The experiments were conducted using 3 tillage systems; conventional-till (CT), cultivator (CVT) and disc-harrow (MTD). For conventional-till the experiment soil was tilled at of depth 20-25 cm with plough pan on soils.

After, seed beds were prepared by pulling of cultivator and disc harrow on soils. For minimum tillage systems only disc-harrow and cultivator were used as devices for tilling. In study, 2,4-D amine was used as weed killer at tillering stage. The experiments were irrigated at time two as tillering and flowering stage.

In the present study, grain yield were determined. The traits studied in this research were determined in the following ways:

Grain yield was calculated as change from parcel grain yield to hectare. Data obtained was statistically analyzed by the analysis of variance techniques (ANOVA), by using SAS[18] computer package.

RESULTS AND DISCUSSION

Effects of nitrogen doses on grain yield: The effects of the nitrogen doses on the grain yield for both years were significant at the 0.01 % level of significance (Table-3). Grain yield raised with increased N level in all tillage systems. During the first and second years and the average of 2 years, maximum grain yields were obtained from 200 kg ha^{-1} N doses (3609, 3656 and 3632 kg ha^{-1}, respectively, the lowest grain yields were obtained from contol treatments (1855, 1779 and 1817 kg ha^{-1}, respectively). Grain yields were gradually declined with the amount of N fertilizers for both years and average of two years (Fig. 1).

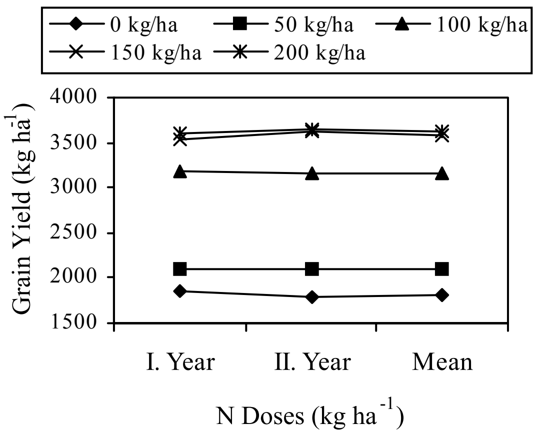

Fig. 1. Effects of nitrogen rates on grain yield

When increased N doses used, barley grain yield were significantly increased. In similar studies as reported by Halvorson *et al.*[17] and Thomsen[19] barley grain yields were increased with increased N doses compared to N controls. Poor seedling emerge may result in low nitrogen use efficiency and low grain yield. The other reason of reduction of nitrogen use efficiency may be the infiltration of excessive nitrogen applications[20]. However reported that grain yield was not increased due to infiltration of N-fertilizer applications more than necessary[20,21].

Effects of tillage systems on grain yield: Barley grain yield were significantly affected ($p \leq 0.01$) by tillage systems. The highest grain yields were obtained from conventional tillage systems (3160 kg ha^{-1}), later on followed by cultivator tillage (2892 kg ha^{-1}) and the lowest grain yields were obtained from disc-harrow treatment (2521 kg ha^{-1}) (Fig. 2). Decrease of grain yield in the minimum tillage systems may result from poor seedbed preparation and seedling emerge per square meter. Preparing good seedbed and uniform emergence is a necessity for high grain yield. When seedbed preparation was omitted, the lack of a firm seedbed bottom causes poor crop establishment under dry weather conditions[10]. Fast emerge of cereal crops could be achieved if seeds are placed on or within a firm seedbed bottom[22]. Gajri *et al.*[23] and Hajabbasi and Hemmat[24] found that grain yield were higher in conventional tillage than reduce or minimum tillage systems. Ozpinar and Cay[25] emphasized that wheat grain yield were higher in conventional tillage than disc-harrow tillage. The present results are in agreement with those of Rasmussen and Rodhe[26] who found that crop residues caused of wheat grain yield reduction.

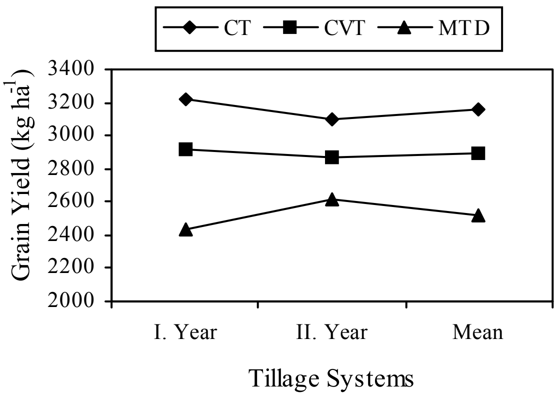

Fig. 2. Effects of tillage systems on grain yield

Effects of tillage systems × N doses interactions on grain yield: Barley grain yields were significantly affected by tillage system × N rates interactions ($p \leq 0.01$). The highest grain yields were obtained from conventional tillage systems × 200 kg N ha^{-1} interaction (4267 kg ha^{-1}) in first year (Fig. 3). In second year and average of 2 years the highest grain yield was obtained from conventional tillage systems × 150 kg N ha^{-1} interaction (4240 and 4206 kg ha^{-1}, respectively) (Figs. 4 and 5). The lowest grain yields were obtained from disc-harrow tillage systems × 50 kg N ha^{-1} interaction (1693 kg ha^{-1}) in the first year, while the lowest grain yields was determined from disc-harrow × 0 N treatments in the second years and average of two years (1763 and 1742 kg ha^{-1}, respectively) (Figs 3-5).

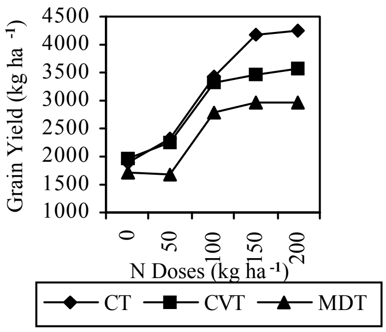

Fig. 3. Effects of tillage systems × N rates interactions on grain yield in the 2003-04

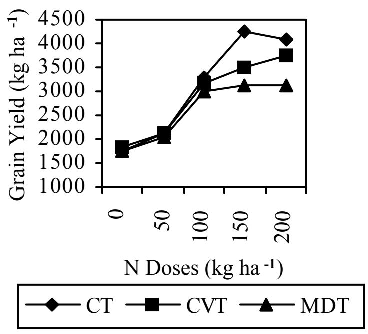

Fig. 4. Effects of tillage systems × N rates interaction on grain yield in the 2004-05

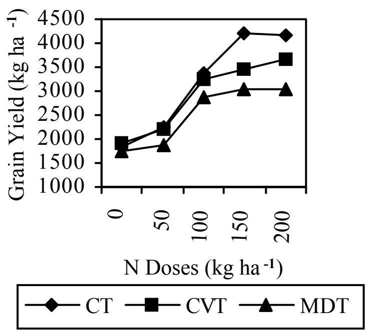

Fig. 5. Effects of tillage systems × rates interactions grain yield in the average of years (average)

As shown in the Table-3, grain yield was increased in conventional tillage systems with high N-rates. Increases in the grain yield with conventional tillage could be explained *via* high emergence of seedlings per square meter together with high N doses. Stenberg[10] emphasized that high amounts of crop residues could decrease nitrogen use and increase the risk of leaching from poor seedbed due to large amount of plant residues at the soil surface present during seed sowing. Nyborg *et al.*[27] concluded from a study in Eastern Canada on nitrogen immobilization by straw retention in reduced tillage that the effect of the straw on immobilization of nitrogen disappeared after few years. The initial size and quality of the soil organic matter and microbial biomass also influenced nitrogen immobilization. The initial conditions influenced the barley yield more than the retention of straw or the tillage method.

In present study, we did not determine amount of straw remained on the surface. Effect of remained straw on emergence of seedlings with minimum tillage systems should be studied further to determine their effects.

TABLE-3
EFFECT OF DIFFERENT TILLAGE SYSTEMS AND NITROGEN DOSES ON GRAIN YIELD (kg ha^{-1}) IN THE BARLEY

Year	Tillage system	N dose (kg ha^{-1})					Mean
		0	50	100	150	200	
2003-04	Conventional	1883 e **	2330 d	3433 b	4173 a	4266 a	3217 A**
	Cultivator	1963 e	2260 d	3313 b	3453 b	3580 b	2914 AB
	Disc-harrow	1720 e	1693 e	2783 c	2980 c	2981 c	2431 B
	Mean**	1855 C	2094 C	3176 B	3535 AB	3609 A	2854
C. V.: 3.66, LSD (**p ≤ 0.01): Means of tillage systems: 60.95, Nitrogen doses: 39.31 and N.D. × T.S. = 28.65							
2004-05	Conventional	1743 f **	2130 f	3300 de	4240 a	4100 ab	3102 A**
	Cultivator	1830 f	2126 f	3160 de	3486 cd	3747 bc	2870 AB
	Disc-harrow	1763 f	2043 f	3006 e	3120 de	3123 de	2611 B
	Mean**	1779 B	2100 B	3155 A	3615 A	3656 A	2861
C.V. = 5.22, LSD (**p ≤ 0.01): Means of tillage systems = 44.35, Nitrogen doses = 56.19 and N.D. × T.S. = 40.95							
Average	Conventional	1813 g **	2230 f	3366 c	4206 a	4183 a	3160 A**
	Cultivator	1896 g	2193 f	3236 cd	3470 bc	3663 b	2892 AB
	Disc-harrow	1742 g	1868 g	2895 e	3050 de	3052 de	2521 B
	Mean**	1817 C	2097 C	3166 B	3575 A	3632 A	
C.V. = 4.51, LSD (**p ≤ 0.01): Means of tillage systems = 44.35, Nitrogen doses = 35.34 and N.D. × T.S. = 28.25							

Means in the same columns and horizontal followed by the same letters are not significant different at p ≤ 0.01 level.

Conclusion

The highest barley grain yield was obtained from conventional tillage systems. Effect of cultivator tillage system on grain yield was moderate and the lowest grain yield was obtained from disc-harrow tillage system. Although, the highest grain yield was obtained from 200 kg N ha^{-1} N dose treatments in the research, average grain yield was not significantly different from 150 kg N ha^{-1}. According to present results, it is advised that conventional tillage systems and 150 kg N ha^{-1} in order to obtain highest barley yields.

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