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Effect of Tillage Systems on Chickpea (*Cicer arietinum* L.) Productivity: Seed Yield and Yield Components

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ABSRACT

This research was conducted at the experimental field of Polatli Agricultural farms to the General Directorate of Farm Enterprises (TIGEM) in 2008 and 2009 for determination the effect of four different tillage systems on yield and yield components of a chickpea (*Cicer arietinum* L.) variety under Central Anatolian conditions of Turkey. Traditional, minimum (reduced), no-till (direct seeding) and no-till + herbicide treatments were applied in the experiment. According to the results of the research tillage systems constituted significant differences for seed yield, plant height, legume number per plant, biological yield per plant, harvest index and 1000-seed weight. Average seed yield values of chickpea in the traditional, minimum, no-till and no-till + herbicide treatments were 1558.25 kg.ha^{-1}, 1240.10 kg.ha^{-1}, 1637.30 kg.ha^{-1} and 1874.85 kg.ha^{-1}, respectively. Relationships between yields' data and tillage systems were R^2=0.469** and 0.412** indicating a significant influence of tillage systems. In this way, the results revealed that direct seeding can be offered for chickpea cultivation in Central Anatolian Region.

1. Introduction

Tillage is one of the highest power-required processes of the agricultural production. Today, the high cost of energy forces farmers to find alternative economic tillage methods. No-till systems can, if not always, produce similar or higher yields compared with conventional tillage systems. As tillage operations are not required, no-till producers do not need to purchase tillage implements. This, together with the reduced labor and tractor hours, will reduce the crop production cost (Chen et al., 2004; Kurlov et al., 2013). The main purpose of direct planting is to decrease the water and wind soil erosion and to make plant production more profitable. Thus, the target is protection of soil, soil moisture, energy consumption, labor and also protection of machinery will be effective (Cociu et al., 2010; Ozkan et al., 2004; Singh, 2002; Canakci et al., 2005).

Aykas, Onal (1999) studied the effects of different tillage methods on yield and weeding for wheat. They obtained better grain and straw yield from reduced tillage (rotary-tiller) as 3500 kg.ha -1 and 3470 kg.ha -1 as compared to the conventional and zero tillage system, respectively. They recommend that proper tillage system should be carefully selected in order to achieve a better weed control.

Yalcın et al., (2005) studied tillage parameters and economic analysis of the direct seeding, minimum and the conventional tillage in wheat. The wheat yields found were 6800 kg.ha-1 and 7400 kg.ha-1 for the direct seeding and minimum tillage, fuel consumption were 8.9 l.ha-1 and 58.4 l.ha-1 for the direct seeding and the conventional tillage, respectively.

Vegetal residues on soil surface reduce water evaporation, and therefore favor water accumulation and conservation, which is very important in drought conditions (Hartfield et al., 2001). The residue cover also decreases the wind and water soil erosion (Unger et al., 1988).

This research was conducted for determination the effect of four different tillage systems on yield and yield components of a chickpea variety under Central Anatolian dry conditions of Turkey.

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2. Materials and methods

This study was conducted under dry conditions at the experimental field of Polatli Agricultural Farms of TIGEM located in the Central Anatolia (32º08′ E and 39º34′ N). The trials were conducted in 2008 and 2009 for determination the effect of four different tillage systems on yield and yield components of chikpea variety Gokce, commonly used in the Region refered.

The relief was generally flat, having the average altitude of 870 m and continental temperate climate. 2007-2008 growing season was with the higher precipitations in the autumn mounts, but with lower in the spring mounts than 2008-2009. As well, 2008-2009 growing season was more warm (average 10.0°C), but with the higher spring and total rainfalls (246.2 mm) (Table 1). Winters were generally poor in snow. The soil type is classified as sandy-clay with a pH of 7.76 (Tables 2 and 3).

Table 1
Monthly temperature and rainfall data of the experimental field.

Months	Temperature (°C)		Rainfall (mm)	
	2007-2008	2008-2009	2007-2008	2008-2009
October	12.8	11.4	10.0	30.0
November	7.8	8.2	67.5	21.0
December	1.0	0.5	37.0	0.0
January	-3.8	4.6	6.0	41.4
February	-3.2	3.6	20.0	23.9
March	9.0	4.5	22.0	22.0
April	12.9	9.5	11.5	32.7
May	14.5	14.4	17.5	48.5
June	20.9	20.3	9.0	6.0
July	23.2	23.2	0.0	20.7
Mean	9.5	10.0	-	-
Total	-	-	200.5	246.2

Table 2
Soil parameters of the pilot area

Soil parameters	Traditional	Minimum	No-till
Gravimetric moisture (%) (0–20 cm)	20,3	23.4	26.2
pH	7.73	7.76	7.77
Organic matter (%)	1.95	1.88	1.63
Lime (%)	23.68	29.45	29.67
EC (mmos.cm^{-1})	152.5	144.25	134.5
Phosphor (mg.kg^{-1})	32.64	31.24	31.84
Potassium (mg.kg^{-1})	1140.06	999.87	795.09

Table 3
Texture analysis of the soil

Sand (%)	33.5
Silt (%)	27.3
Clay (%)	39.2
Texture class	sandy-clay

The different tillage systems were applied in the plots of wheat stubble-field. The crop was sown by Randomized Complete Block Design with four replicates in the beginning of April. Each year 75 kg.ha-1 N (in two applications) and 65 kg.ha-1 P_2O_5 was applied. Row space and seeding rate was 40 cm and 150 kg.ha-1, respectively.

For the traditional tillage system, the soil was first ploughed with three bottom mold-board plough. After plowing the field was harrowed with disc harrow and leveled with float. In the reduced tillage system, soil was prepared for seeding with rotary tiller-roller and drill. For the direct seeding applications, seeding was made without tillage. Only in one of direct seeding applications before seeding, Gramoxone (Paraquat) was applied as herbicide (Fig. 1).

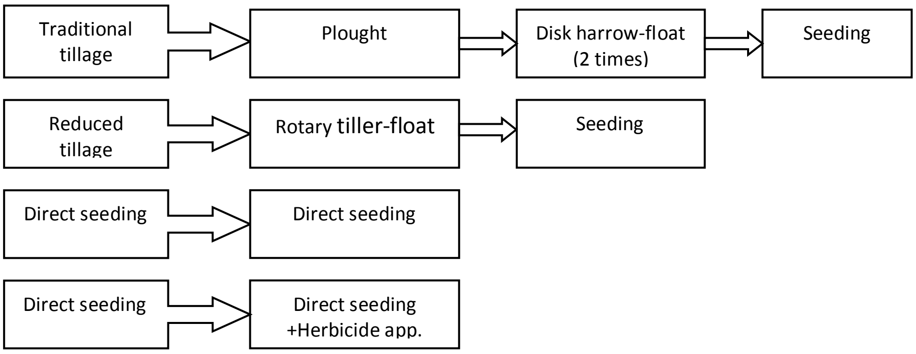

Figure 1
Tillage systems applied in the study

At maturity, plant height was measured from the soil surface to the top of the plants. A sample of 10 plants was harvested randomly from each plot to measure the yield components (Ozdemir, Karadavut, 2003; Omar, Singh, 1997; Slim, Saxena, 1993). Results were analyzed and compared using MSTAT-C statistical software and Raudonius (2017).

3. Results and Discussion

The variance analysis of results of investigated traits after applications of tillage systems are shown as F-tests in Table 4, the average values and LSD groups in Table 5 and the average values of the traits with significant year x tillage system interactions in Table 6.

Table 4
Results of the variance analysis (F- tests).

Traits	A (year)	B (tillage system)	AXB	Coefficient of variation (%)
Seed yield	**	**	**	11.80
Plant height	ns	**	*	7.24
Legume number per plant	ns	*	ns	25.21
Kernel number per plant	**	ns	ns	21.76
Kernel weight per plant	*	ns	ns	27.77
Biological yield per plant	*	*	*	20.97
Plant number per m^2	ns	ns	ns	16.26
Harvest index	ns	*	ns	11.22
1000-kernel weight	*	*	ns	6.23

Notes. ****, *-** Significant at 0.01 and 0.05 levels, respectively; **ns-** non-significant.

Table 5
Mean values of the traits and LSD groups.

Traits	1	2	3	4	LSD
Seed yield (kg.ha^{-1})	1558,25b	1240,10c	1637,30ab	1874,85a	267.90*
Plant height (cm)	34.93a	32.28ab	30.60b	35.71a	3.48**
Legume number per plant	12.97a	12.00ab	9.58b	14.38a	3.24*
Kernel number per plant	11.56	13.06	10.04	11.71	ns
Kernel weight per plant (g)	6.01	5.57	4.81	6.19	ns
Biological yield per plant (g)	13.22a	9.71b	10.63b	11.84b	2.50*
Plant number per m^2	32.07	30.15	27.74	27.71	ns
Harvest index (%)	45.13a	46.81a	39.25b	45.21a	5.20*
1000-kernel weight (g)	439.42b	450.96ab	479.31a	450.49ab	29.78*

Notes. **1-** Traditional tillage; **2-** Reduced (minimum) tillage; **3-** Direct seeding (no-till); **4-** Herbicide + no-till; ****, *-** Significant at 0.01 and 0.05 levels, respectively; **ns** - non-significant; Means within the same analyzed trait followed by different letters are significantly different at P<0.05 and 0.01, respectively.

Table 6
Mean values of the traits with significant year x tillage system interaction and LSD groups

Traits	Aplication	2008	2009	LSD
Seed yield (kg.ha^{-1})	1	1104,30de	2012,20b	267,90**
	2	976,50e	1503,70c	
	3	1096,40de	2178,20ab	
	4	1306,20cd	2443,50a	
	Mean**	1120,80	2034,40	
Plant height (cm)	1	31,29cd	38,56a	2,54*
	2	31,80bc	32,75bc	
	3	29,17d	32,04bc	
	4	34,17b	37,25a	
	Mean^{ns}	31,61	35,15	
Biological yield per plant (g)	1	7,64c	19,04a	2,50*
	2	6,66c	12,77b	
	3	7,75c	13,51b	
	4	8,64c	15,04b	
	Mean*	7,61	15,09	

Notes. 1-Traditional tillage; 2- Reduced tillage; 3-Direct seeding: 4- Direct seeding + herbicide; **, *- significant at 0,01 and 0,05 levels, respectively; ns- non-significant; Means within the same analyzed trait followed by different letters are significantly different at P<0,05 and 0,01, respectively.

The analysis of variance indicates that the seed yield and the more of other traits were significantly affected by the year conditions and tillage systems. The year x system interactions were very significant only with seed yield, plant height and biological yield per plant (Table 4).

The results presented in Tables 5 and 6 show that the most favorable treatment for this crop was direct seeding application. As well, the relationships between yields' data and tillage systems were R2=0.469** and 0.412** indicating the significant influence of tillage applications (Fig. 2).

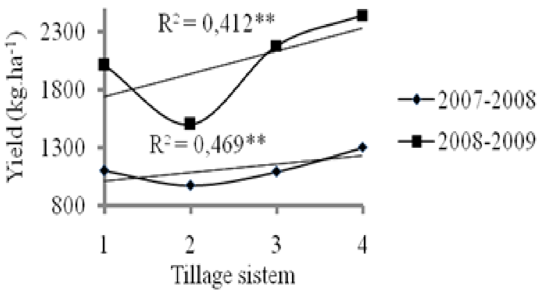

Figure 2
Relationship between yield and tillage systems (1-traditional, 2- redused, 3- no-till, 4- no-till + herbicide), m=16, **: P<0.01.

The recorded mean seed yield of no-till (1874,85 kg.ha-1) was 16.87% and 33.86% higher than those registered in traditional and reduced tillage, respectively. The higher mean seed yield was reached in the 2009 (2034,40 kg.ha-1), mainly due to the different precipitation that occurred during the yield formation period (May-June). A similar tendency can be seen in the other traits observed.

The results presented by Cociu et al. (2010), Aykas, Onal (1999) and Kurlov et al., (2013) revealed similarly, that different tillage systems have had a different effect on grain yield of plants studied, viz., the highest grain yields were obtained with the no-till variant.

The interesting results in this study are the similar and close means of traits achieved by applying the direct seeding and treated direct seeding systems. For example, the mean seed yields are 1637.30 kg.ha-1 and 1874.85 kg.ha-1, respectively, point at that the treatment with herbicide after harvest of the crop doesn't affect significantly the yield, especially under dry Central Anatolian conditions.

Environmental conditions and tillage systems, which influenced positively the chickpea seed yield, increased correspondently the other traits investigated. On the other hand, unfavorable conditions for seed yield, such as drought and high temperatures, determined lower levels of these traits (Table 6). Year x tillage system interaction (significant at P<0.01) indicated lower seed yield levels obtained with traditional tillage systems. This means, that the relationships are depended on soil water supply and climatic conditions during yield formation period.

The results of the research showed that no-till system which reduces water evaporation from soil increase the seed yield. An efficient way of decreasing water evaporation from soil is the enhancement of soil coverage with the residue from the previous crop. This residue facilitates also water infiltration and soil moisture storage (Hatfield et al., 2001; Singh et al., 2002).

4. Conclusions

Among tillage systems applied in the study, the most favorable treatment for chickpea was direct seeding application. The recorded mean seed yield in this system was 16% and 33% higher than those registered in conventional and reduced tillage, respectively. Year conditions and tillage systems had a similar influence on seed yield, plant height and biological yield per plant. These results revealed that direct seeding systems can be offered for chickpea cultivation in Central Anatolian Region.

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