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## Effects of Organic Manures and Non-chemical Weed Control on Wheat: I-Plant Growth and Grain Yield

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### ABSTRACT

Organic wheat yield is limited by climatic and agronomic factors including nutrient deficiency, weed competition and no suitable cultivars. The effects of organic manures and non-chemical weed control on grain yield of wheat were investigated during the 2006-07, 2007-08 and 2008-09 growing seasons, in Erzurum (Turkey) rain-fed conditions. The experiment contained three experimental factors in a factorial design: (1) cultivar (Doğu 88, Kırık), (2) weed control (weedy control, hand weeding, dense sowing) and (3) manure (unfertilized, mineral NP, Bio, Bio SR, Leonardit, Organic Manure, cattle manure). The modern cultivar Doğu 88 had significantly higher leaf area index, grain filling period, spikes per m<sup>2</sup>, kernels per spike, grain yield and harvest index than the local cultivar Kırık. On average of years, hand weeding and dense sowing increased grain yield by 9.2% and 7.7% compared to weedy control, respectively. Application of mineral NP resulted in the highest grain yield. Among the organic manures, the highest grain yield was obtained at cattle manure and Organic Manure, respectively. Cattle manure and Organic Manure increased grain yield of wheat by 25.6% and 23.2%, respectively, compared to unfertilized treatment. Improved performance in response to treatments was generally related to spikes per m<sup>2</sup>. Doğu 88 should be preferred to local cultivar Kırık. Dense sowing appears to be a useful method to provide the wheat a competitive advantage against weeds. As a result, cattle manure can be used for improvement of grain yield of wheat and soil fertility under rain-fed conditions.

Keywords: Organic farming; Cultivar; Weed control; Manure; Yield

## Organik Gübreler ve Kimyasal Olmayan Yabancı Ot Kontrolünün Buğday Üzerine Etkileri: I-Bitki Gelişmesi ve Tane Verimi

### ESER BİLGİSİ

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**ÖZET**

Organik buğdayın verimi iklim, uygun olmayan çeşit seçimi, besin eksikliği ve yabancı ot rekabeti tarafından sınırlanır. Organik gübreler ve kimyasal olmayan yabancı ot kontrolünün buğdayın tane verimine etkisi 2006-07, 2007-08 ve 2008-09 ürün yıllarında Erzurum sulamasız koşullarında incelenmiştir. Tesadüf bloklarında faktöriyel deneme deseninde yürütülen araştırmada iki ekmeçlik buğday çeşidi (Doğu 88 ve Kırık), üç yabancı ot kontrol yöntemi (yabancı otlu kontrol, elle yolma ve sık ekim) ve yedi gübre kaynağı (gübresiz, mineral NP, Bio, Bio SR, Leonardit, Organik Gübre ve sıgır gübresi) yer almıştır. Bir ıslah çeşidi olan Doğu 88 yerel Kırık çeşidine göre daha yüksek yaprak alanı indeksi, tane dolum süresi, m<sup>2</sup>'de başak sayısı, başakta tane sayısı, tane verimi ve hasat indeksine sahip olmuştur. Yılların ortalaması olarak, yabancı ot mücadelesinin yapılmadığı koşullar ile karşılaştırıldığında, tane verimini elle yolma %9.2, sık ekim ise %7.7 oranında artırmıştır. En yüksek tane verimi mineral NP uygulamasından elde edilmiştir. Organik gübrelerden en yüksek tane verimini sıgır gübresi sağlamış, bunu Organik Gübre izlemiştir. Gübresiz koşullara göre tane verimini sıgır gübresi %25.6, Organik Gübre ise %23.2 oranında artırmış olup, verim artışları başlıca m<sup>2</sup>'deki başak sayısı artışları ile ilgili olmuştur. Benzer ekolojik koşullarda Doğu 88 çeşidinin Kırık çeşidine tercih edilmesi gerektiği, sık ekimin buğdaya yabancı otlara karşı rekabette avantaj sağladığı, toprak verimliliği ve buğdayın tane verimini artırmak için kuru şartlarda sıgır gübresinin kullanılabileceği sonucuna varılmıştır.

Anahtar sözcükler: Organik tarım; Çeşit; Yabancı ot kontrolü; Gübre; Verim

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**1. Introduction**

Consumers' interest in organically produced foods has grown steadily in recent years prompting increased use of organic agricultural systems. Wheat occupies more than half of the area devoted to organic cereals in Europe and is subject to strong demand from millers and animal feed processors (David et al 2005). There are 109,387 ha organic cropland comprising 0.5% of the total agricultural land in Turkey. The proportion of organic wheat farming in the East Anatolia Region of Turkey, has increased considerably over the past decade (TUIK 2008). Most comparisons of organic and conventional systems show that organically grown wheat produces lower yield than conventionally grown wheat (Garcia-Martin et al 2007; Kaut et al 2008). Nonetheless, selection of suitable cultivars in organic wheat farming is very important input factor. Past researches demonstrated that modern cultivars of winter wheat generally had higher grain yield than old cultivars in fields managed organically (Poutala et al 1993; Carr et al 2006). The yield differences between wheat cultivars may be related to yield potential (Kitchen et al 2003), an ability to use nitrogen inputs (Baresel et al 2008), and an ability to compete with weeds (Berthldsson 2005; Kaut et al 2008) in organic

systems.

The use of herbicides is not permitted in organic farming so that weeds reduce crop yield and quality through competition for moisture, nutrients, sunlight and space. In the absence of herbicides, weeds are controlled primarily through agronomic practices. Many researchers reported that hand weeding had superiority in weed control (Kironmay et al 2006) and in grain yield (Abouzienna et al 2008) compared to other weed control methods. A management practice commonly used in organic wheat production is to increase seeding rates in order to provide the wheat a competitive advantage against weeds. Weiner et al (2001) found that increasing seeding rate resulted in significant decrease in weed biomass and significant increase in grain yield.

The productivity of wheat in organic farming is mainly restricted by nutrient deficiency. Supplementing the nutrient requirement of wheat through organic manures plays a key role in sustaining soil fertility and crop productivity. These also improve the soil biological properties, humus contents, cation exchange capacity, aeration, water holding capacity and water infiltration rate (Barzegar et al 2002; Gopinath et al 2008). Many researchers have reported that farmyard manure increased grain yield through

improvement of soil water holding capacity, physical and chemical conditions, and greater availability of plant nutrients (Hiltbrunner et al 2005; Olesen et al 2009). The development of organic agriculture has led to the emergence new organic amendments permitted in organic farming as a nutrient source. The use of commercial amendments has not been recommended in organic farming due to their high prices, low nutrient value, and poor agronomic performance (Rodrigues et al 2006).

Despite the increases in organic wheat farming, there has been no previous research targeting organic wheat production in these areas in Turkey. Therefore, the primary objectives of this study were to: (i) investigate the adaptation of the most popular two bread wheat cultivars to organic growing conditions; (ii) assess the effects of hand weeding and dense sowing on yield; (iii) compare the agronomic performance of cattle manure, commercial organic amendments and inorganic fertilizer.

## 2. Materials and Methods

### 2.1. Site description and experimental design

Field experiments were performed on a fallow field in last two-years of the Experimental Farm of Ataturk University in Erzurum (39°55'N and 41°16'E with an altitude of 1850 m a.s.l.), Turkey, in the 2006-07, 2007-08 and 2008-09 growing seasons. The climate is semi-arid with an average annual precipitation of 395 mm and an average annual air temperature of 4.9°C. Some properties of the experimental soils (0-20 cm) were determined in the fall prior to the cropping years (Table 1).

The experiments were carried out in a factorial design with four replications. The factors were two wheat (*T. aestivum* L.) cultivars (Kırık, Doğu 88), three weed control (weedy control, hand weeding, dense sowing) and seven manure sources (unfertilized, mineral N and P, Bio, Bio SR, Leonardit, Organic Manure, cattle manure). Kırık is an old local cultivar (awnless, white-grain, facultative), and the most common cultivar in the region. Doğu 88 is a modern cultivar (awny,

red-grain, winter), and the highest-yielding cultivar under rain-fed conditions of the region. Optimum seeding rate for winter wheat in the region is 475 seeds m<sup>-2</sup> under dryland conditions. The Zadoks growth scale (ZGS) was used to take phenological data (Zadoks et al 1974). The experiment comprised three non-chemical weed control: an weedy control (475 seeds m<sup>-2</sup>), a hand weeding-once at the beginning of stem elongation (475 seeds m<sup>-2</sup>+HW) (ZGS 30), and a dense sowing (625 seeds m<sup>-2</sup>). Cattle manure from the Research Farm of Ataturk University was prepared after cattle dung and bedding material had been composted about 90 days. The cattle manure and four commercial organic amendments (Bio Organic, Bio Organic SR, Leonardit, Organic Manure) were manually applied to plots and incorporated into the soil just before sowing in recommended doses. Application rates and important characteristics of organic manures are shown in Table 2. In mineral fertilized plots, N as ammonium sulphate (21% N) was applied of 60 kg ha<sup>-1</sup> and P as triple superphosphate (42-44 P<sub>2</sub>O<sub>5</sub>) of 50 kg ha<sup>-1</sup>. Half of N and all P were applied at sowing; second half of N was applied at the beginning of stem elongation.

### 2.2. Crop management, measurements and calculations

The fallow field was prepared by ploughing to a depth of 20 cm, which was followed by surface cultivation. Plots were sown with a six-row planter. The plots consisted of six rows spaced 20 cm apart, with a row length of 6.0 m. The sowing and harvesting dates were shown in Table 1. No chemical fungicides, herbicides or insecticides were used. No pests and diseases control were performed in the experiments.

The length of the grain filling period (GFP) was taken as the number of days from anthesis to physiological maturity. Anthesis was defined as when 50% of spikes had anthers extruding (ZGS 65), and physiological maturity defined as when 50% of the glumes had turned yellow (ZGS 92). Chlorophyll-SPAD values were determined at anthesis (ZGS 65) with a self-calibrating chlorophyll meter (Model SPAD 502, Minolta,

**Table 1-Soil properties, environmental data, sowing and harvesting dates for field experiments**  
*Çizelge 1-Deneme yerlerinin toprak özellikleri, deneme yıllarına göre iklim verileri ile ekim ve hasat tarihleri*

<i>Growing seasons</i>	<i>2006-07</i>	<i>2007-08</i>	<i>2008-09</i>
Soil texture	Clay-loam	Clay-loam	Clay-loam
Organic matter (%)	1.49-1.56	1.71-1.77	1.38-1.50
Total N (g kg <sup>-1</sup> )	0.6-0.7	0.7-0.8	0.5-0.7
Available P (mg kg <sup>-1</sup> )	11.2-14.8	9.8-12.2	9.1-12.9
Available K (mg kg <sup>-1</sup> )	699-748	602-721	762-776
pH	7.6-7.8	7.1-7.5	6.6-6.8
Precipitation (mm)			
Total (1 September-31 August)	467.0	336.7	386.7
1 September-30 November	144.6	101.9	76.9
1 December-30 April	130.0	108.0	138.4
1 May-31 August	192.4	126.8	171.4
Air temperature (°C)			
Average annual	5.3	5.0	5.2
Average of 1 September-30 November	7.5	7.4	8.4
Average of 1 December-30 April	-4.6	-5.6	-4.5
Average of 1 May-31 August	16.0	16.4	14.8
Maximum	31.0 (in July)	32.9 (in July)	32.0 (in July)
Minimum	-31.6 (in December)	-32.6 (in January)	-36.0 (in January)
Sowing date	1 September	30 August	29 August
Hand weeding date	28 May	25 May	24 May
Second half of N application date	29 May	26 May	25 May
Harvesting date	9 August	15 August	18 August
Number of weeds in hand weeding plots m <sup>-2</sup>	26-57 (average 42)	41-67 (average 55)	17-34 (average 26)
Weed biomass in hand weeding plots (g m <sup>-2</sup> )	14-177 (average 63)	74-413 (average 179)	122-297 (average 103)

**Table 2-Important characteristics and application rates of organic manures used in the experiments***Çizelge 2-Araştırmada kullanılan organik gübrelerin önemli özellikleri ve uygulama oranları*

<i>Organic manures</i>	<i>Total N (g kg<sup>-1</sup>)</i>	<i>Available P (g kg<sup>-1</sup>)</i>	<i>Organic matter (%)</i>	<i>Application rate (kg ha<sup>-1</sup>)</i>	<i>Producer company</i>
Bio-Organic (Bio)	14.8	0.52-0.83	50-55	750	Biyotar
Bio-Organic SR (Bio SR)	14.8	0.52-0.83	70-75	750	Biyotar
Leonardit	10.3	3.06	25-45	650	Bereket Organik
Organic Manure	35.0	13.10	70	1500	BioFarm
Cattle manure					
2006-07	7.7	2.62	17	10000	
2007-08	8.0	2.84	20	10000	
2008-09	8.3	2.71	21	10000	

Japan) on 20 flag leaves per plot (Badaruddin et al 1999). A 30-cm sample from the inner row of each plot was harvested at anthesis stage (ZGS 65) and leaf area determined on plants. Leaf lamina area was measured with area meter (Licor, LI-3000C Model). Leaf area index (LAI) was calculated as the sum of the areas of the leaf laminae (one side) per unit of ground surface area

(Yunusa & Sedgley 1992). Spikes per square meter were determined from 1-m row sample in the center of each plot at the hard dough stage of kernel development (ZGS 87). At maturity, ten spikes were randomly harvested from within plots for kernels per spike determination. The plots were trimmed to 5.0 m, and the four inner rows were harvested by hand at 3-4 cm above soil

surface. The plants were tied and left in respective plots for sun drying for three days. Biomass was measured after drying, and plants were threshed with a plot-combine, and the weight of cleaned grain from each plot was recorded. Thousand-kernel weight was determined from 4×100 kernel samples. Harvest index was estimated as the ratio of grain weight to the biomass.

Statistical analyses were made with the MSTAT-C software package (Freed et al 1989). The analysis of variance was made separately for each growing season, because of large growth differences in between seasons, and the main effect of year, and its interactions were significant. Duncan's multiple range test was used to separate the means when the ANOVA test indicated a significant effect of the treatment (Steel et al 1997).

### 3. Results and Discussion

#### 3.1. Weather conditions and year effects

Years differed considerably in terms of both precipitation and temperature. Total precipitation was 467.0 mm in 2006-07, 336.7 mm in 2007-08 and 386.7 mm in 2008-09 (Table 1). In 2007-08, very low blanket of snow together with severe freezes during the January resulted in approximately 50% winterkill for Kırık wheat plots. Only in 2008-09 cropping season, wheat stripe rust was observed. Plants did not lodge at any rate of seeding. The climatic conditions were more favorable in 2006-07, and spikes per m<sup>2</sup> and grain yield were higher than other years. The winterkills in Kırık plots in 2007-08 were largely responsible for the resulting low leaf area index, spikes per m<sup>2</sup> and grain yield as well as the reason for the between-year differences and the year × cultivar interactions. Severe infection of wheat stripe rust decreased kernel weight in 2008-09.

#### 3.2. Cultivar performance

There were significant differences between cultivars for all studied parameters. The modern cultivar, Doğu 88 had significantly higher leaf area index, grain filling period, spikes per m<sup>2</sup>, kernels per spike, grain yield and harvest index than the local cultivar Kırık, however, the Kırık

had higher SPAD value and 1000-kernel weight (Tables 3, 4, 5 & 6). On average of weed control methods and manure sources, Doğu 88 produced grain yield that was 44.7%, 135.0% and 63.6% higher than the Kırık in 2006-07, 2007-08 and 2008-09 growing seasons, respectively. The higher grain yield in Doğu 88 was due to larger number of spikes per m<sup>2</sup> and kernels per spike. Results of this research and previous studies by Poutala et al (1993), Kitchen et al (2003) and Carr et al (2006) do not support the hypothesis that old cultivars are better adapted to organic systems than modern cultivars if grain yield is an important selection criterion. The cultivars and their interaction with weed control methods were significant for grain yield and the other parameters studied, except leaf area index (Tables 3, 4, 5 & 6). In the growing seasons, Doğu 88 showed 8.8-10.9% and 7.7-10.8% increases in grain yield in response to hand weeding and dense sowing, and Kırık showed 4.2-14.6% and 1.5-8.3%, compared with the weedy control, respectively. Competition with weeds had a large negative effect on grain yield, and wheat cultivars may be differ in weed suppression ability (Kitchen et al 2003; Kaut et al 2008). Weed biomass per unit area was used as a measure of the weed suppression ability of wheat cultivars (Bertholdsson 2005). As averages of years, weed biomass at the beginning of stem elongation was 90.3 g m<sup>-2</sup> and 139.5 g m<sup>-2</sup> in Doğu 88 and Kırık wheat plots, respectively. Doğu 88 plants suppressed weed growth by 35% because of a denser plant canopy. Cultivars × manure source interactions were detected for all parameters. Yield increases in response to manure source were consistently greater for Doğu 88 than for Kırık. As average of years, mineral NP and cattle manure increased grain yield of wheat by 56% and 35% in Doğu 88, by 28% and 15% in Kırık, respectively, compared with unfertilized control. On the other hand, Doğu 88 (80.1 kg ha<sup>-1</sup>) had significantly higher total grain N-uptake than Kırık cultivar (48.9 kg ha<sup>-1</sup>). Possible difference between cultivars in grain yield may be depend on cultivars' adaptation ability to low N-input conditions and on their ability to use nitrogen

**Table 3-Effects of experimental variables on leaf area index and grain filling period***Cizelge 3-Deneme faktörlerinin yaprak alanı indeksi ve tane dolum süresi üzerine etkileri*

Cultivars (C)	Weed control (W)	Manures (M)	Leaf area index			Grain filling period (days)		
			2006-07	2007-08	2008-09	2006-07	2007-08	2008-09
Kırık	Weedy control	Unfertilized	1.90	0.80	1.80	38.0	35.2	38.0
		Mineral NP	2.45	1.45	3.65	39.5	36.1	41.8
		Bio	2.11	0.95	2.05	39.3	35.3	39.3
		Bio SR	2.15	0.93	2.35	38.8	36.8	40.5
		Leonardit	2.07	0.83	2.00	37.8	36.5	38.8
		Organic manure	2.37	1.23	2.85	39.0	36.0	40.3
	Cattle manure	2.41	0.95	2.83	39.3	36.0	41.8	
	Hand weeding	Unfertilized	2.50	0.80	1.85	38.5	34.9	39.3
		Mineral NP	2.65	1.73	3.90	40.5	36.4	42.5
		Bio	2.35	1.25	2.13	38.3	36.5	40.5
		Bio SR	2.89	1.23	2.10	38.3	36.5	41.0
		Leonardit	2.83	1.55	2.90	37.5	35.0	39.8
		Organic manure	2.71	1.25	3.48	39.3	36.0	41.8
	Cattle manure	2.57	1.75	3.05	38.5	35.5	41.8	
	Dense sowing	Unfertilized	2.48	1.20	2.03	36.8	34.0	39.0
		Mineral NP	2.71	1.95	3.83	38.3	36.5	41.8
		Bio	2.70	1.20	2.48	37.5	34.7	39.5
		Bio SR	2.73	1.63	2.45	37.5	34.5	39.0
Leonardit		2.54	1.48	2.88	39.0	35.2	39.5	
Organic manure		2.53	1.73	2.88	37.8	34.5	41.0	
Cattle manure	2.91	1.65	3.23	40.8	35.2	41.3		
Doğu 88	Weedy control	Unfertilized	2.37	2.25	2.43	38.5	37.0	40.3
		Mineral NP	4.41	3.35	4.60	41.3	36.0	43.3
		Bio	2.86	2.70	3.05	39.5	37.4	41.5
		Bio SR	2.71	2.55	2.83	39.3	37.8	41.5
		Leonardit	3.18	2.58	3.18	39.0	37.0	41.5
		Organic manure	3.68	2.60	4.38	40.0	37.6	42.8
	Cattle manure	3.27	2.65	3.43	40.3	37.1	42.8	
	Hand weeding	Unfertilized	2.64	2.68	2.40	40.8	38.7	42.0
		Mineral NP	4.16	3.90	4.90	42.0	37.5	44.0
		Bio	3.20	3.20	3.38	40.0	37.0	41.5
		Bio SR	3.71	3.45	3.43	41.0	37.3	41.8
		Leonardit	3.38	2.80	3.30	41.0	38.1	42.0
		Organic manure	3.12	3.30	3.93	40.3	37.3	42.5
	Cattle manure	3.90	3.68	3.70	41.5	38.8	43.3	
	Dense sowing	Unfertilized	2.87	2.55	3.03	37.5	37.1	39.8
		Mineral NP	4.31	4.05	4.75	38.5	36.7	43.0
		Bio	2.73	3.05	3.23	38.3	38.6	40.5
		Bio SR	3.27	2.93	3.38	38.5	37.7	39.5
Leonardit		3.28	2.80	3.20	39.0	36.8	39.5	
Organic manure		3.50	3.30	4.08	37.8	35.5	41.8	
Cattle manure	3.93	3.45	3.38	40.3	37.3	42.8		
Mean±SEM			2.93±0.47	2.18±0.36	3.11±0.25	39.1±0.97	36.5±1.10	41.1±0.92
Kırık			2.50 b	1.31 b	2.70 b	38.6 b	35.6 b	40.4 b
Doğu 88	Weedy control		3.35 a	3.04 a	3.52 a	39.7 a	37.4 a	41.8 a
			2.71 b	1.84 b	2.96 b	39.2 b	36.5 ab	40.9 b
			3.04 a	2.33 a	3.17 a	39.8 a	36.8 a	41.6 a
	Hand weeding		3.03 a	2.36 a	3.20 a	38.4 c	36.0 b	40.5 b
			2.46 d	1.71 d	2.25 e	38.3 b	36.2	39.7 d
			3.44 a	2.74 a	4.27 a	40.0 a	36.5	42.7 a
	Dense sowing		2.65 cd	2.06 c	2.72 d	38.8 b	36.6	40.5 c
			2.91 bc	2.12 bc	2.75 d	38.9 b	36.8	40.5 c
			2.88 bc	2.00 c	2.91 d	38.9 b	36.4	40.2 cd
			2.98 bc	2.23 bc	3.60 b	39.0 b	36.1	41.7 b
			3.16 ab	2.35 b	3.27 c	40.1 a	36.6	42.3 ab
<i>P values</i>								
C			<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
W			<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
M			<0.001	<0.001	<0.001	<0.001	0.365	<0.001
C × W			0.345	0.046	0.270	<0.001	0.041	0.009
C × M			<0.001	0.078	<0.001	0.745	0.006	0.489
W × M			0.281	0.416	0.013	<0.001	0.218	0.196
C × W × M			0.670	0.558	<0.001	0.340	0.034	0.332

a-d; For each variable, values in a column followed by the different letter are significantly different ( $P \leq 0.05$ )

**Table 4-Effects of experimental variables on SPAD value and spikes per m<sup>2</sup>***Çizelge 4-Deneme faktörlerinin SPAD değeri ve metrekaredeki başak sayısı üzerine etkileri*

Cultivars (C)	Weed control (W)	Manures (M)	SPAD value			Spikes per m <sup>2</sup>		
			2006-07	2007-08	2008-09	2006-07	2007-08	2008-09
Kırık	Weedy control	Unfertilized	43.2	45.8	46.3	410.0	210.0	410.0
		Mineral NP	49.5	47.6	51.2	452.5	237.5	480.0
		Bio	45.6	46.5	47.6	415.0	267.5	430.0
		Bio SR	46.3	45.4	46.9	420.0	232.5	425.0
		Leonardit	50.2	46.2	46.4	437.5	220.0	420.0
		Organic manure	45.0	47.1	50.3	427.5	205.0	457.5
	Cattle manure	48.2	46.5	48.6	427.5	242.5	458.8	
	Hand weeding	Unfertilized	45.3	45.2	46.5	422.5	220.0	420.0
		Mineral NP	49.6	46.5	50.5	477.5	265.0	505.0
		Bio	47.4	45.3	48.1	430.0	235.0	430.0
		Bio SR	47.5	46.6	48.2	437.5	220.0	407.5
		Leonardit	48.4	46.3	48.2	437.5	245.0	432.5
Organic manure		47.3	43.5	50.0	477.5	265.0	487.5	
Cattle manure	48.5	48.4	49.5	450.0	250.0	477.5		
Dense sowing	Unfertilized	44.8	44.7	45.9	462.5	245.0	415.0	
	Mineral NP	48.9	46.3	49.7	567.5	272.5	495.0	
	Bio	49.5	44.7	45.6	477.5	257.5	420.0	
	Bio SR	45.5	46.4	47.5	470.0	257.5	437.5	
	Leonardit	47.8	45.5	46.2	540.0	280.0	430.0	
	Organic manure	48.0	45.0	50.8	457.5	217.5	480.0	
Cattle manure	50.0	48.2	47.6	477.5	272.5	485.0		
Doğu 88	Weedy control	Unfertilized	43.7	44.0	44.9	430.0	387.5	407.5
		Mineral NP	44.6	46.2	46.6	520.0	512.5	525.0
		Bio	44.4	45.4	45.7	450.0	456.3	470.0
		Bio SR	44.9	43.4	43.5	490.0	477.5	440.0
		Leonardit	43.8	44.5	44.9	452.5	456.3	450.0
		Organic manure	43.4	44.5	48.5	442.5	450.0	500.0
	Cattle manure	44.4	46.0	45.9	477.5	475.0	497.5	
	Hand weeding	Unfertilized	45.5	44.5	42.7	445.0	445.0	425.0
		Mineral NP	47.1	45.9	46.7	537.5	550.0	542.5
		Bio	45.2	44.1	44.4	450.0	435.0	455.0
		Bio SR	45.5	46.0	46.2	477.5	480.0	435.0
		Leonardit	44.2	44.8	43.4	467.5	460.0	457.5
Organic manure		46.3	44.4	45.0	490.0	525.0	505.0	
Cattle manure	46.0	46.7	46.9	527.5	478.8	497.5		
Dense sowing	Unfertilized	44.9	43.4	43.0	480.0	463.8	472.5	
	Mineral NP	47.6	45.8	47.2	602.5	568.8	550.0	
	Bio	45.4	42.9	41.9	487.5	510.0	455.0	
	Bio SR	45.5	42.9	42.4	507.5	477.5	452.5	
	Leonardit	47.6	45.0	42.8	507.5	525.0	475.0	
	Organic manure	47.0	42.5	43.3	582.5	462.5	515.0	
Cattle manure	49.0	46.6	45.2	590.0	532.5	512.5		
Mean±SEM			46.5±0.76	45.4±0.95	46.5±0.60	477.1±33.97	363.0±48.28	463±12.87
Kırık Doğu 88	Weedy control	Unfertilized	47.4 a	46.1 a	48.1 a	456.0 b	243.7 b	447.8 b
		Mineral NP	45.5 b	44.7 b	44.8 b	498.3 a	482.3 a	478.1 a
		Bio	45.5 c	45.6 a	46.9 a	446.6 c	345.0 b	455.1 c
	Hand weeding	Unfertilized	46.7 b	45.6 a	46.9 a	466.3 b	362.4 ab	462.7 b
		Mineral NP	47.2 a	45.0 b	45.6 b	518.6 a	381.6	471.1 a
		Bio	44.5 d	44.6 c	44.6 f	441.7 c	328.5 c	425.0 d
	Dense sowing	Unfertilized	47.9 a	46.4 a	48.6 a	526.3 a	401.0 a	516.3 a
		Mineral NP	46.2 c	44.8 bc	45.5 de	451.7 c	360.2 bc	443.3 c
		Bio SR	45.9 c	45.1 bc	45.6 d	467.1 bc	357.5 bc	432.9 d
		Leonardit	47.0 b	45.4 b	45.3 ef	482.1 b	364.4 bc	444.2 c
		Organic manure	46.1 c	44.5 c	47.9 b	479.6 b	354.2 bc	490.8 b
		Cattle manure	47.6 a	47.1 a	47.3 c	491.7 b	375.2 ab	488.1 b
<i>P values</i>								
C		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
W		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
M		<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
C × W		<0.001	0.028	<0.001	0.534	0.561	<0.001	
C × M		<0.001	0.503	<0.001	0.018	0.122	0.009	
W × M		<0.001	<0.001	<0.001	0.042	0.123	<0.001	
C × W × M		<0.001	0.018	<0.001	0.094	0.985	0.008	

a-f, For each variable, values in a column followed by the different letter are significantly different ( $P \leq 0.05$ )

inputs (Baresel et al 2008). These results suggest that response to management factors in organic wheat farming may depend on choice of cultivar.

### 3. 3. Effects of weed control

The effects of weed control methods were significant for all parameters (Tables 3, 4, 5 & 6). Over the three study years, a total of 45 weed species were recorded in hand weeding plots. The major weed species were *Lactuca serriola* L., *Cephalaria sparsipilosa* Matthews, *Polygonum bellardii* All., *Descurainia sophia* L., *Adonis aestivalis* L., in this study. The results indicated that allowing weeds competing with wheat plants in weedy control plots caused a significant decrement in leaf area index, grain filling period, yield components and consequently led to a reduction in grain yield by 8.4%, compared to hand weeding treatment, as average of years. The harmful effect of weeds may be attributed to allelopathy of weeds on wheat (Oudhia 2000), number of spike bearing tillers, grains per spike, net assimilation rate (Abouzienna et al 2008), removal nutrients and moisture from soil (Bertholdsson 2005; Kaut et al 2008). Hand weeding gave the longer grain filling period, greater kernels per spike, heavier 1000-kernel weight and higher harvest index than other treatments. The increases in these parameters were related to lower competition conditions in hand weeding (Kironmay et al 2006; Abouzienna et al 2008). As average of years, cultivars and manure sources, the highest spike number per m<sup>2</sup> was obtained from dense sowing. The greater competition in dense sowing treatment compared to hand weeding treatment had a negative effect on grain filling period, kernels per spike and 1000-kernel weight (Ozturk et al 2006). When compared to the weedy control, dense sowing increased leaf area index, spikes per m<sup>2</sup> and grain yield by 14.4%, 10.0% and 7.7%, respectively. The higher grain yield in high seeding rate treatments may be related to a decreasing in weed biomass. Many researchers reported that increasing crop density resulted in reduced weed growth and increased in grain yield (Doll 1997; Weiner et al 2001).

### 3.4. Effects of manure source

The results show significant differences in measured parameters due to various manure applications (Tables 3, 4, 5 & 6). Mineral NP application resulted in significantly higher leaf area index, spikes per m<sup>2</sup>, kernels per spike and grain yield than organic manures. As averages of years, cultivars and weed control methods; cattle manure, Organic Manure, Leonardit, Bio SR and Bio applications increased spikes per m<sup>2</sup> by 13.4%, 10.8%, 8.0%, 5.2% and 5.0%; kernels per spike by 13.4%, 11.7%, 7.7%, 6.1% and 6.6%, respectively, compared with unfertilized treatment. The highest 1000-kernel weights were obtained from NP and cattle manure application. Cattle manure and Organic Manure yielded similar results and produced higher grain yield than other organic amendments (Table 6). Cattle manure and Organic Manure increased grain yield by 25.6% and 23.2%, respectively, compared to unfertilized treatment. This finding is agreed with the results from several other studies investigating the effects of various manure sources application on wheat in organically managed field experiments (Barzegar et al 2002; Garcia-Martin et al 2007; Gopinath et al 2008). The greater effect of mineral NP on grain yield may have been associated with the higher readily available NP amount in plots (Hiltbrunner et al 2005; Garcia-Martin et al 2007). On the other hand, lower availability of plant nutrients in plots applied with organic manures was expected, due to the slower release rates of organic materials (Gopinath et al 2008). The higher SPAD values may have been caused by the amount and availability of nutrients in the mineral NP. Among the organic manures, cattle manure application resulted in higher grain yields followed by Organic Manure. Chemical analyses of cattle manure indicated that it generally added more N and P than did the other organic manures (Table 2). Many works have demonstrated that farmyard manure increase grain yield of wheat through improvement of soil water holding capacity, physical and chemical conditions, and greater availability of plant nutrients (Garcia-Martin et al 2007; Olesen et al



**Table 5-Effects of experimental variables on kernels per spike and 1000 kernel weight***Çizelge 5-Deneme faktörlerinin başaktaki tane sayısı ve 1000 tane ağırlığı üzerine etkileri*

Cultivars (C)	Weed control (W)	Manures (M)	Kernel per spike			1000 kernel weight (g) <sup>2</sup>		
			2006-07	2007-08	2008-09	2006-07	2007-08	2008-09
Kırık	Weedy control	Unfertilized	16.4	16.8	16.7	38.6	38.4	35.1
		Mineral NP	20.2	22.3	19.3	39.1	39.9	39.8
		Bio	19.1	17.7	16.3	38.3	37.1	35.1
		Bio SR	19.4	18.9	18.2	37.8	37.1	36.7
		Leonardit	18.4	20.5	15.5	37.0	38.0	37.2
		Organic manure	17.1	16.7	19.9	39.0	38.2	40.4
	Cattle manure	19.1	20.1	18.0	37.7	38.3	37.8	
	Hand weeding	Unfertilized	18.8	19.4	15.6	37.8	37.0	34.5
		Mineral NP	21.5	22.2	21.3	40.3	39.0	41.3
		Bio	20.8	20.4	16.4	39.5	38.7	32.2
		Bio SR	19.5	20.6	15.0	40.2	38.0	36.7
		Leonardit	19.7	19.0	17.2	38.7	39.1	35.5
Organic manure		19.4	21.5	17.4	39.8	38.7	38.4	
Cattle manure	20.3	21.2	17.3	40.4	39.2	39.9		
Doğu 88	Weedy control	Unfertilized	16.1	18.6	15.5	36.3	36.7	35.1
		Mineral NP	20.2	21.1	20.1	37.8	38.1	38.5
		Bio	16.5	21.5	14.8	37.2	37.8	35.6
		Bio SR	16.0	20.5	16.6	37.6	38.1	36.5
		Leonardit	16.6	21.2	16.9	36.8	37.6	34.2
		Organic manure	17.0	19.7	17.9	37.3	38.6	36.9
	Cattle manure	19.5	19.3	18.1	37.6	37.9	38.3	
	Hand weeding	Unfertilized	24.1	24.1	20.4	35.2	36.4	31.0
		Mineral NP	28.6	27.8	26.6	37.7	37.3	37.8
		Bio	23.9	23.2	24.1	36.6	36.7	35.6
		Bio SR	25.5	23.2	21.1	35.9	35.7	35.7
		Leonardit	26.2	24.3	20.4	38.9	37.3	35.6
Organic manure		25.4	23.5	25.0	37.0	37.3	38.1	
Cattle manure	26.6	25.5	25.2	38.4	38.6	38.8		
Dense sowing	Unfertilized	23.7	23.9	21.2	36.8	37.1	33.5	
	Mineral NP	28.3	24.6	29.0	39.2	38.8	38.7	
	Bio	25.7	24.3	22.0	38.7	38.4	32.9	
	Bio SR	25.6	24.8	23.1	38.3	38.4	34.6	
	Leonardit	26.7	26.5	23.1	39.1	38.4	36.1	
	Organic manure	27.1	26.0	26.6	38.3	37.4	35.2	
Cattle manure	27.2	25.6	25.4	40.4	39.8	39.9		
Doğu 88	Weedy control	Unfertilized	20.2	21.1	19.6	34.7	34.9	31.9
		Mineral NP	27.0	25.9	28.8	37.0	37.7	39.7
		Bio	22.5	24.0	23.7	35.2	35.5	32.0
		Bio SR	20.8	22.5	24.1	35.3	35.8	32.4
		Leonardit	26.4	23.3	18.8	34.7	34.8	33.7
		Organic manure	23.8	23.9	25.5	35.2	36.0	39.5
	Cattle manure	23.1	24.7	23.3	36.4	36.5	38.1	
	Hand weeding	Unfertilized	23.7	23.9	21.2	36.8	37.1	33.5
		Mineral NP	28.3	24.6	29.0	39.2	38.8	38.7
		Bio	25.7	24.3	22.0	38.7	38.4	32.9
		Bio SR	25.6	24.8	23.1	38.3	38.4	34.6
		Leonardit	26.7	26.5	23.1	39.1	38.4	36.1
Organic manure		27.1	26.0	26.6	38.3	37.4	35.2	
Cattle manure	27.2	25.6	25.4	40.4	39.8	39.9		
Dense sowing	Unfertilized	20.2	21.1	19.6	34.7	34.9	31.9	
	Mineral NP	27.0	25.9	28.8	37.0	37.7	39.7	
	Bio	22.5	24.0	23.7	35.2	35.5	32.0	
	Bio SR	20.8	22.5	24.1	35.3	35.8	32.4	
	Leonardit	26.4	23.3	18.8	34.7	34.8	33.7	
	Organic manure	23.8	23.9	25.5	35.2	36.0	39.5	
Cattle manure	23.1	24.7	23.3	36.4	36.5	38.1		
Mean±SEM			21.9±1.61	22.2±1.36	20.5±1.74	37.7±0.89	37.6±0.82	36.3±1.47
Doğu 88	Weedy control	Unfertilized	18.7 b	20.0 b	17.3 b	38.3 a	38.2 a	36.9 a
		Mineral NP	25.2 a	24.4 a	23.7 a	37.1 b	37.1 b	35.8 b
		Bio	22.1 b	21.8 b	20.5	37.6 b	37.6 b	36.8 a
		Bio SR	23.2 a	22.8 a	20.7	39.1 a	38.4 a	36.4 ab
		Leonardit	20.4 c	21.9 b	20.3	36.4 c	36.9 c	35.9 b
		Organic manure	19.9 d	20.7 c	18.2 d	36.7 c	36.8 c	33.5 d
	Hand weeding	Unfertilized	24.3 a	24.0 a	24.2 a	38.5 a	38.5 a	39.3 a
		Mineral NP	21.4 bc	21.8 b	19.5 c	37.7 b	37.4 bc	33.9 d
		Bio	21.1 c	21.7 b	19.7 c	37.5 b	37.2 bc	35.4 c
		Bio SR	22.3 bc	22.5 b	18.6 cd	37.5 b	37.5 b	35.4 c
		Leonardit	21.6 bc	21.9 b	22.0 b	37.7 b	37.7 b	38.1 b
		Organic manure	22.6 b	22.7 b	21.2 b	38.5 a	38.4 a	38.8 ab
Dense sowing	Unfertilized	18.7 b	20.0 b	17.3 b	38.3 a	38.2 a	36.9 a	
	Mineral NP	25.2 a	24.4 a	23.7 a	37.1 b	37.1 b	35.8 b	
	Bio	22.1 b	21.8 b	20.5	37.6 b	37.6 b	36.8 a	
	Bio SR	23.2 a	22.8 a	20.7	39.1 a	38.4 a	36.4 ab	
	Leonardit	20.4 c	21.9 b	20.3	36.4 c	36.9 c	35.9 b	
	Organic manure	19.9 d	20.7 c	18.2 d	36.7 c	36.8 c	33.5 d	
Dense sowing	Unfertilized	24.3 a	24.0 a	24.2 a	38.5 a	38.5 a	39.3 a	
	Mineral NP	21.4 bc	21.8 b	19.5 c	37.7 b	37.4 bc	33.9 d	
	Bio	21.1 c	21.7 b	19.7 c	37.5 b	37.2 bc	35.4 c	
	Bio SR	22.3 bc	22.5 b	18.6 cd	37.5 b	37.5 b	35.4 c	
	Leonardit	21.6 bc	21.9 b	22.0 b	37.7 b	37.7 b	38.1 b	
	Organic manure	22.6 b	22.7 b	21.2 b	38.5 a	38.4 a	38.8 ab	
Dense sowing	Unfertilized	18.7 b	20.0 b	17.3 b	38.3 a	38.2 a	36.9 a	
	Mineral NP	25.2 a	24.4 a	23.7 a	37.1 b	37.1 b	35.8 b	
	Bio	22.1 b	21.8 b	20.5	37.6 b	37.6 b	36.8 a	
	Bio SR	23.2 a	22.8 a	20.7	39.1 a	38.4 a	36.4 ab	
	Leonardit	20.4 c	21.9 b	20.3	36.4 c	36.9 c	35.9 b	
	Organic manure	19.9 d	20.7 c	18.2 d	36.7 c	36.8 c	33.5 d	
Dense sowing	Unfertilized	24.3 a	24.0 a	24.2 a	38.5 a	38.5 a	39.3 a	
	Mineral NP	21.4 bc	21.8 b	19.5 c	37.7 b	37.4 bc	33.9 d	
	Bio	21.1 c	21.7 b	19.7 c	37.5 b	37.2 bc	35.4 c	
	Bio SR	22.3 bc	22.5 b	18.6 cd	37.5 b	37.5 b	35.4 c	
	Leonardit	21.6 bc	21.9 b	22.0 b	37.7 b	37.7 b	38.1 b	
	Organic manure	22.6 b	22.7 b	21.2 b	38.5 a	38.4 a	38.8 ab	
Dense sowing	Unfertilized	18.7 b	20.0 b	17.3 b	38.3 a	38.2 a	36.9 a	
	Mineral NP	25.2 a	24.4 a	23.7 a	37.1 b	37.1 b	35.8 b	
	Bio	22.1 b	21.8 b	20.5	37.6 b	37.6 b	36.8 a	
	Bio SR	23.2 a	22.8 a	20.7	39.1 a	38.4 a	36.4 ab	
	Leonardit	20.4 c	21.9 b	20.3	36.4 c	36.9 c	35.9 b	
	Organic manure	19.9 d	20.7 c	18.2 d	36.7 c	36.8 c	33.5 d	
Dense sowing	Unfertilized	24.3 a	24.0 a	24.2 a	38.5 a	38.5 a	39.3 a	
	Mineral NP	21.4 bc	21.8 b	19.5 c	37.7 b	37.4 bc	33.9 d	
	Bio	21.1 c	21.7 b	19.7 c	37.5 b	37.2 bc	35.4 c	
	Bio SR	22.3 bc	22.5 b	18.6 cd	37.5 b	37.5 b	35.4 c	
	Leonardit	21.6 bc	21.9 b	22.0 b	37.7 b	37.7 b	38.1 b	
	Organic manure	22.6 b	22.7 b	21.2 b	38.5 a	38.4 a	38.8 ab	
Dense sowing	Unfertilized	18.7 b	20.0 b	17.3 b	38.3 a	38.2 a	36.9 a	
	Mineral NP	25.2 a	24.4 a	23.7 a	37.1 b	37.1 b	35.8 b	
	Bio	22.1 b	21.8 b	20.5	37.6 b	37.6 b	36.8 a	
	Bio SR	23.2 a	22.8 a	20.7	39.1 a	38.4 a	36.4 ab	
	Leonardit	20.4 c	21.9 b	20.3	36.4 c	36.9 c	35.9 b	
	Organic manure	19.9 d	20.7 c	18.2 d	36.7 c	36.8 c	33.5 d	
Dense sowing	Unfertilized	24.3 a	24.0 a	24.2 a	38.5 a	38.5 a	39.3 a	
	Mineral NP	21.4 bc	21.8 b	19.5 c	37.7 b	37.4 bc	33.9 d	
	Bio	21.1 c	21.7 b	19.7 c	37.5 b	37.2 bc	35.4 c	
	Bio SR	22.3 bc	22.5 b	18.6 cd	37.5 b	37.5 b	35.4 c	
	Leonardit	21.6 bc	21.9 b	22.0 b	37.7 b	37.7 b	38.1 b	
	Organic manure	22.6 b	22.7 b	21.2 b	38.5 a	38.4 a	38.8 ab	
Dense sowing	Unfertilized	18.7 b	20.0 b	17.3 b	38.3 a	38.2 a	36.9 a	
	Mineral NP	25.2 a	24.4 a	23.7 a	37.1 b	37.1 b	35.8 b	
	Bio	22.1 b	21.8 b	20.5	37.6 b	37.6 b	36.8 a	
	Bio SR	23.2 a	22.8 a	20.7	39.1 a	38.4 a	36.4 ab	
	Leonardit	20.4 c	21.9 b	20.3	36.4 c	36.9 c	35.9 b	
	Organic manure	19.9 d	20.7 c	18.2 d	36.7 c	36.8 c	33.5 d	
Dense sowing	Unfertilized	24.3 a	24.0 a	24.2 a	38.5 a	38.5 a	39.3 a	
	Mineral NP	21.4 bc	21.8 b	19.5 c	37.7 b	37.4 bc	33.9 d	
	Bio	21.1 c	21.7 b	19.7 c	37.5 b	37.2 bc	35.4 c	
	Bio SR	22.3 bc	22.5 b	18.6 cd	37.5 b	37.5 b	35.4 c	
	Leonardit	21.6 bc	21.9 b	22.0 b	37.7 b	37.7 b	38.1 b	
	Organic manure	22.6 b	22.7 b	21.2 b	38.5 a	38.4 a	38.8 ab	
Dense sowing	Unfertilized	18.7 b	20.0 b	17.3 b	38.3 a	38.2 a	36.9 a	
	Mineral NP	25.2 a	24.4 a	23.7 a	37.1 b	37.1 b	35.8 b	
	Bio	22.1 b	21.8 b	20.5	37.6 b	37.6 b	36.8 a	
	Bio SR	23.2 a	22.8 a	20.7	39.1 a	38.4 a	36.4 ab	
	Leonardit	20.4 c	21.9 b	20.3	36.4 c	36.9 c	35.9 b	
	Organic manure	19.9 d	20.7 c	18.2 d	36.7 c	36.8 c	33.5 d	
Dense sowing	Unfertilized	24.3 a	24.0 a	24.2 a	38.5 a	38.5 a	39.3 a	
	Mineral NP	21.4 bc	21.8 b	19.5 c	37.7 b	37.4 bc	33.9 d	
	Bio	21.1 c	21.7 b	19.7 c	37.5 b	37.2 bc	35.4 c	
	Bio SR	22.3 bc	22.5 b	18.6 cd	37.5 b	37.5 b	35.4 c	
	Leonardit	21.6 bc	21.9 b	22.0 b	37.7 b	37.7 b	38.1 b	
	Organic manure	22.6 b	22.7 b	21.2 b	38.5 a	38.4 a	38.8 ab	
Dense sowing	Unfertilized	18.7 b	20.0 b	17.3 b	38.3 a	38.2 a	36.9 a	
	Mineral NP	25.2 a	24.4 a	23.7 a	37.1 b	37.1 b	35.8 b	
	Bio	22.1 b	21.8 b	20.5	37.6 b	37.6 b	36.8 a	
	Bio SR	23.2 a	22.8 a	20.7	39.1 a	38.4 a	36.4 ab	
	Leonardit	20.4 c	21.9 b	20.3	36.4 c	36.9 c	35.9 b	
	Organic manure							

**Table 6- Effects of experimental variables on grain yield and harvest index***Çizelge 6- Deneme faktörlerinin tane verimi ve hasat indeksi üzerine etkileri*

Cultivars (C)	Weed control (W)	Manures (M)	Grain yield (kg ha <sup>-1</sup> )			Harvest index (%)			
			2006-07	2007-08	2008-09	2006-07	2007-08	2008-09	
Kırık	Weedy control	Unfertilized	2362	1421	2026	27.4	24.1	25.5	
		Mineral NP	3452	1926	2955	30.2	27.0	25.9	
		Bio	2676	1591	2292	27.0	26.3	25.0	
		Bio SR	2742	1483	2395	27.3	24.9	28.0	
		Leonardit	2781	1516	2410	27.9	24.6	26.5	
		Organic manure	2943	1524	2103	30.1	24.8	22.6	
	Cattle manure	2819	1703	2638	27.7	25.8	27.2		
	Hand weeding	Unfertilized	2714	1715	2004	30.1	27.4	23.3	
		Mineral NP	3463	1974	3296	28.4	26.9	25.3	
		Bio	2930	1645	2416	30.4	26.7	28.8	
		Bio SR	2942	1648	2173	30.6	25.9	25.4	
		Leonardit	3091	1933	2355	30.8	24.0	27.0	
		Organic manure	2892	1881	2597	30.2	25.6	22.9	
	Cattle manure	2988	2032	2681	33.2	26.6	29.5		
	Dense sowing	Unfertilized	2682	1645	2041	26.4	23.6	24.3	
		Mineral NP	3506	1799	3350	31.3	26.3	28.6	
		Bio	2884	1817	2106	32.2	24.8	26.4	
		Bio SR	2940	1804	2081	30.5	23.7	22.8	
Leonardit		3124	1648	2216	32.3	23.7	25.7		
Organic manure		2945	1498	2996	32.3	25.2	28.9		
Cattle manure	3053	1877	2291	28.6	27.5	25.3			
Doğu 88	Weedy control	Unfertilized	3114	2955	3388	32.1	28.0	34.2	
		Mineral NP	4970	5273	4075	31.3	30.3	26.1	
		Bio	3446	3306	3220	29.6	26.9	29.3	
		Bio SR	3624	3106	3810	26.8	26.3	29.6	
		Leonardit	3988	3746	3806	30.9	26.6	30.3	
		Organic manure	4483	4397	3869	32.1	28.1	27.4	
	Cattle manure	4510	3819	4160	33.1	29.7	29.2		
	Hand weeding	Unfertilized	3687	3212	3760	32.3	25.2	30.9	
		Mineral NP	5236	5274	4310	31.8	28.5	24.1	
		Bio	3993	3679	4116	29.9	28.5	31.6	
		Bio SR	4619	3773	4025	33.6	30.3	27.5	
		Leonardit	4369	4056	3935	30.9	28.1	29.0	
		Organic manure	4555	4800	4194	31.1	28.5	28.2	
	Cattle manure	4742	4390	4310	34.9	29.3	29.5		
	Dense sowing	Unfertilized	3659	3102	3607	29.6	24.2	28.4	
		Mineral NP	5020	5427	4562	33.4	29.7	26.8	
		Bio	4206	3592	4175	31.6	26.0	30.1	
		Bio SR	4279	3725	3866	31.7	26.6	27.9	
Leonardit		4233	3848	4097	32.2	25.9	29.7		
Organic manure		4266	4369	4502	30.8	28.2	30.7		
Cattle manure	4628	4961	4360	31.3	28.5	27.9			
Mean±SEM			3608±327.6	2878±354.9	3228±313.1	30.6±1.47	26.6±1.61	27.5±3.40	
Kırık			2949 b	1718 b	2449 b	29.8 b	25.5 b	25.9 b	
Doğu 88	Weedy control		4268 a	4038 a	4007 a	31.5 a	27.8 a	29.0 a	
			3422 b	2697 b	3082 b	29.5 b	26.7 ab	27.6	
			3730 a	3001 a	3298 a	31.3 a	27.2 a	27.4	
	Hand weeding		3673 a	2937 a	3303 a	31.0 a	26.0 b	27.4	
			3036 e	2341 d	2804 d	29.6 c	25.4 d	27.8	
			4275 a	3612 a	3758 a	31.1 ab	28.1 a	26.1	
	Dense sowing		3356 d	2605 cd	3054 c	30.1 bc	26.5 cd	28.5	
			3524 cd	2590 cd	3058 c	30.1 bc	26.3 cd	26.9	
			3598 bcd	2791 c	3136 c	30.8 ab	25.5 d	28.0	
			3680 bc	3078 b	3377 b	31.1 ab	26.7 bc	26.8	
			3790 b	3130 b	3406 b	31.5 a	27.9 ab	28.1	
	<i>P values</i>								
	C			<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	W			<0.001	<0.001	<0.001	<0.001	<0.001	0.904
M			<0.001	<0.001	<0.001	<0.001	<0.001	0.166	
C × W			0.112	0.278	0.008	0.017	0.607	0.712	
C × M			<0.001	<0.001	0.020	<0.001	0.078	0.010	
W × M			0.288	0.213	0.007	<0.001	0.056	0.009	
C × W × M			0.823	0.670	0.267	0.014	0.024	0.939	

a-d, For each variable, values in a column followed by the different letter are significantly different ( $P \leq 0.05$ )

2009). Lower grain yields in the plots amended with Bio, Bio SR and Leonardit may have been associated with the less readily available nutrients. Rodrigues et al (2006) indicated that commercial organic amendments did not exhibit good performance. As average of years and cultivars, weed biomass for unfertilized, mineral NP, Bio, Bio SR, Leonardit, Organic Manure and cattle manure treatments were 142.5, 150.3, 80.7, 97.3, 93.7, 74.9 and 164.8 g m<sup>-2</sup> in hand weeding plots, respectively. These results suggest that the varying amount and availability of nutrients can affect the weed biomass (Liebman & Davis 2000). Higher weed biomass in cattle manure plots may have been associated with the potential introduction of seeds in the cattle manure.

As average of years, grain yields of organic treatment combinations ranged between 1936 kg ha<sup>-1</sup> and 4649 kg ha<sup>-1</sup>. The highest grain yields were obtained from “Doğu 88 + dense sowing + cattle manure”, followed by “Doğu 88 + hand weeding + Organic Manure”, while the lowest grain yield was recorded for “Kırık + weedy control + unfertilized) combined plots. The economic analyses were made according to local cost and organic product prices. “Doğu 88 + dense sowing + cattle manure” combination had the highest gross production value and gross profit (Birinci et al 2010).

#### 4. Conclusions

High yield potential, ability to competition with weeds and nitrogen use may be important traits adaptation to organic farming conditions. Doğu 88 should, therefore, be preferred to local cultivar Kırık. Controlling the weeds by increasing seeding rate by 30% could be more suitable, particularly in large areas. Cattle manure can be used for improvement of grain yield of wheat and soil fertility.

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