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

Ali ÖZTÜRK[a], Sancar BULUT[b], Nesrin YILDIZ[c], Mehmet Murat KARAOĞLU[d]

[a] *Atatürk University, Faculty of Agriculture, Department of Field Crops, Erzurum, TURKEY*
[b] *Erciyes University, Faculty of Agriculture, Department of Field Crops, Kayseri, TURKEY*
[c] *Atatürk University, Faculty of Agriculture, Department of Soil Science, Erzurum, TURKEY*
[d] *Atatürk University, Faculty of Agriculture, Department of Food Engineering, Erzurum, TURKEY*

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Corresponding author: Ali ÖZTÜRK, e-mail: aozturk@atauni.edu.tr, Tel: +90(442) 231 25 42
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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, Kırik), (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^2, kernels per spike, grain yield and harvest index than the local cultivar Kırik. 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^2. Doğu 88 should be preferred to local cultivar Kırik. 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
Araştırma Makalesi — Bitkisel Üretim
Sorumlu Yazar: Ali ÖZTÜRK, e-posta: aozturk@atauni.edu.tr, Tel: +90(442) 231 25 42
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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 ekmeklik buğday çeşidi (Doğu 88 ve Kırik), 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 sığır gübresi) yer almıştır. Bir ıslah çeşidi olan Doğu 88 yerel Kırik çeşidine göre daha yüksek yaprak alanı indeksi, tane dolum süresi, m^2'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 sığır gübresi sağlamış, bunu Organik Gübre izlemiştir. Gübresiz koşullara göre tane verimini sığır gübresi %25.6, Organik Gübre ise %23.2 oranında artırmış olup, verim artışları başlıca m^2'deki başak sayısı artışları ile ilgili olmuştur. Benzer ekolojik koşullarda Doğu 88 çeşidinin Kırik çeşidine tercih edilmesi gerektiği, sık ekimin buğdaya yabancı otlara karşı rekabette avantaj sağladığı, toprak verimliliği ve buğdayın tane verimini artırmak için kuru şartlarda sığır gübresinin kullanılabileceği sonucuna varılmıştır.

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

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 (Abouziena 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 (39º55′N and 41º16′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 4.9ºC. 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 (Kırik, 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). Kırik 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^{-2} 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^{-2}), a hand weeding-once at the beginning of stem elongation (475 seeds m^{-2}+HW) (ZGS 30), and a dense sowing (625 seeds m^{-2}). 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^{-1} and P as triple superphosphate (42-44 P_2O_5) of 50 kg ha^{-1}. 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 -Deneme yerlerinin toprak özellikleri, deneme yıllarına göre iklim verileri ile ekim ve hasat tarihleri

Growing seasons	*2006-07*	*2007-08*	*2008-09*
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^{-1})	0.6-0.7	0.7-0.8	0.5-0.7
Available P (mg kg^{-1})	11.2-14.8	9.8-12.2	9.1-12.9
Available K (mg kg^{-1})	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^{-2}	26-57 (average 42)	41-67 (average 55)	17-34 (average 26)
Weed biomass in hand weeding plots (g m^{-2})	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

Organic manures	*Total N (g kg^{-1})*	*Available P (g kg^{-1})*	*Organic matter (%)*	*Application rate (kg ha^{-1})*	*Producer company*
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 Kırik 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^2 and grain yield were higher than other years. The winterkills in Kırik plots in 2007-08 were largely responsible for the resulting low leaf area index, spikes per m^2 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^2, kernels per spike, grain yield and harvest index than the local cultivar Kırik, however, the Kırik 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 Kırik 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^2 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 Kırik 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^{-2} and 139.5 g m^{-2} in Doğu 88 and Kırik 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 Kırik. 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 Kırik, respectively, compared with unfertilized control. On the other hand, Doğu 88 (80.1 kg ha^{-1}) had significantly higher total grain N-uptake than Kırik cultivar (48.9 kg ha^{-1}). 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

Çizelge 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*
Kırik	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
Kırik			2.50 b	1.31 b	2.70 b	38.6 b	35.6 b	40.4 b
Doğu 88			3.35 a	3.04 a	3.52 a	39.7 a	37.4 a	41.8 a
	Weedy control		2.71 b	1.84 b	2.96 b	39.2 b	36.5 ab	40.9 b
	Hand weeding		3.04 a	2.33 a	3.17 a	39.8 a	36.8 a	41.6 a
	Dense sowing		3.03 a	2.36 a	3.20 a	38.4 c	36.0 b	40.5 b
		Unfertilized	2.46 d	1.71 d	2.25 e	38.3 b	36.2	39.7 d
		Mineral NP	3.44 a	2.74 a	4.27 a	40.0 a	36.5	42.7 a
		Bio	2.65 cd	2.06 c	2.72 d	38.8 b	36.6	40.5 c
		Bio SR	2.91 bc	2.12 bc	2.75 d	38.9 b	36.8	40.5 c
		Leonardit	2.88 bc	2.00 c	2.91 d	38.9 b	36.4	40.2 cd
		Organic manure	2.98 bc	2.23 bc	3.60 b	39.0 b	36.1	41.7 b
		Cattle manure	3.16 ab	2.35 b	3.27 c	40.1 a	36.6	42.3 ab
P values								
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^2

Çizelge 4-Deneme faktörlerinin SPAD değeri ve metrekaredeki başak sayısı üzerine etkileri

Cultivars	*Weed control*	*Manures*	*SPAD value*			*Spikes per m^2*		
(C)	*(W)*	*(M)*	*2006-07*	*2007-08*	*2008-09*	*2006-07*	*2007-08*	*2008-09*
		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
	Weedy control	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
		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
Kırik	Hand weeding	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
		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
	Dense sowing	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
		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
	Weedy control	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
		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
Doğu 88	Hand weeding	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
		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
	Dense sowing	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
Kırik			47.4 a	46.1 a	48.1 a	456.0 b	243.7 b	447.8 b
Doğu 88			45.5 b	44.7 b	44.8 b	498.3 a	482.3 a	478.1 a
	Weedy control		45.5 c	45.6 a	46.9 a	446.6 c	345.0 b	455.1 c
	Hand weeding		46.7 b	45.6 a	46.9 a	466.3 b	362.4 ab	462.7 b
	Dense sowing		47.2 a	45.0 b	45.6 b	518.6 a	381.6	471.1 a
		Unfertilized	44.5 d	44.6 c	44.6 f	441.7 c	328.5 c	425.0 d
		Mineral NP	47.9 a	46.4 a	48.6 a	526.3 a	401.0 a	516.3 a
		Bio	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
P values								
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 (Abouziena 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; Abouziena et al 2008). As average of years, cultivars and manure sources, the highest spike number per m^2 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^2 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^2, 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^2 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* 2006-07	2007-08	2008-09	*1000 kernel weight (g)*[2] 2006-07	2007-08	2008-09
Kırik	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
	Dense sowing	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
Doğu 88	Weedy control	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
	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
Kırik			18.7 b	20.0 b	17.3 b	38.3 a	38.2 a	36.9 a
Doğu 88			25.2 a	24.4 a	23.7 a	37.1 b	37.1 b	35.8 b
	Weedy control		22.1 b	21.8 b	20.5	37.6 b	37.6 b	36.8 a
	Hand weeding		23.2 a	22.8 a	20.7	39.1 a	38.4 a	36.4 ab
	Dense sowing		20.4 c	21.9 b	20.3	36.4 c	36.9 c	35.9 b
		Unfertilized	19.9 d	20.7 c	18.2 d	36.7 c	36.8 c	33.5 d
		Mineral NP	24.3 a	24.0 a	24.2 a	38.5 a	38.5 a	39.3 a
		Bio	21.4 bc	21.8 b	19.5 c	37.7 b	37.4 bc	33.9 d
		Bio SR	21.1 c	21.7 b	19.7 c	37.5 b	37.2 bc	35.4 c
		Leonardit	22.3 bc	22.5 b	18.6 cd	37.5 b	37.5 b	35.4 c
		Organic manure	21.6 bc	21.9 b	22.0 b	37.7 b	37.7 b	38.1 b
		Cattle manure	22.6 b	22.7 b	21.2 b	38.5 a	38.4 a	38.8 ab
P values								
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			0.114	<0.001	0.056	0.033	<0.001	0.860
C × M			0.005	0.309	<0.001	<0.001	0.091	0.007
W × M			0.149	<0.001	0.060	0.031	<0.001	<0.001
C × W × M			0.268	0.003	0.019	0.007	0.014	<0.001

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

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^{-1})*			*Harvest index (%)*		
			2006-07	*2007-08*	*2008-09*	*2006-07*	*2007-08*	*2008-09*
		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
	Weedy control	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
		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
Kırik	Hand weeding	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
		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
	Dense sowing	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
		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
	Weedy control	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
		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
Doğu 88	Hand weeding	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
		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
	Dense sowing	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
Kırik			2949 b	1718 b	2449 b	29.8 b	25.5 b	25.9 b
Doğu 88			4268 a	4038 a	4007 a	31.5 a	27.8 a	29.0 a
	Weedy control		3422 b	2697 b	3082 b	29.5 b	26.7 ab	27.6
	Hand weeding		3730 a	3001 a	3298 a	31.3 a	27.2 a	27.4
	Dense sowing		3673 a	2937 a	3303 a	31.0 a	26.0 b	27.4
		Unfertilized	3036 e	2341 d	2804 d	29.6 c	25.4 d	27.8
		Mineral NP	4275 a	3612 a	3758 a	31.1 ab	28.1 a	26.1
		Bio	3356 d	2605 cd	3054 c	30.1 bc	26.5 cd	28.5
		Bio SR	3524 cd	2590 cd	3058 c	30.1 bc	26.3 cd	26.9
		Leonardit	3598 bcd	2791 c	3136 c	30.8 ab	25.5 d	28.0
		Organic manure	3680 bc	3078 b	3377 b	31.1 ab	26.7 bc	26.8
		Cattle manure	3790 b	3130 b	3406 b	31.5 a	27.9 ab	28.1
P values								
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^{-2} 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^{-1} and 4649 kg ha^{-1}. 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 ‘‘Kırik + 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 Kırik. 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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References

Abouziena H F, Faida A A S & El-Doseki E R (2008). Efficacy of cultivar and weed control treatments on wheat yield and associated weeds in sandy soils. *World Journal of Agricultural Sciences* **4** (3): 384-389

Badaruddin M, Reynolds M P & Ageeb O A A (1999). Wheat management in warm environments: Effect of organic and inorganic fertilizers, irrigation frequency, and mulching. *Agronomy Journal* **91** (6): 975-983.

Baresel J P, Zimmermann E G & Reents E H J (2008). Effects of genotype and environment on N uptake and N partition in organically grown winter wheat (*Triticum aestivum* L.) in Germany. *Euphytica* **163** (3): 347–354

Barzegar A R, Yousefi A & Daryashenas A (2002). The effect of addition of different amounts and types of organic materials on soil physical properties and yield of wheat. *Plant and Soil* **247** (2): 295-301

Bertholdsson N O (2005). Early vigour and allelopathy–two useful traits for enhanced barley and wheat competitiveness against weeds. *Weed Research* **45** (2): 94-102

Birinci A, Ozturk A, Bulut S & Ikikat Tumer E (2010). Farklı Gübre Kaynakları ve Yabancı Ot Kontrol Yöntemlerinin Organik Buğdayda Gayri Safi Üretim Değeri ve Brüt Kâr Üzerine Etkisi. Türkiye IV. Organik Tarım Sempozyumu. Bildiri Kitabı: 114-118. 28 Haziran – 1 Temmuz 2010, Erzurum

Carr P M, Kandel H J, Porter P M, Horsley R D & Zwinger S F (2006). Wheat cultivar performance on certified organic fields in Minnesota and North Dakota. *Crop Science* **46** (5): 1963-1971

David C, Jeuffroy M H, Henning J & Meynard J M (2005). Yield variation in organic winter wheat: a diagnostic study in the Southeast of France. *Agronomy for Sustainable Development* **25** (2): 213-223

Doll H (1997). The ability of barley to compete with weeds. *Biological Agriculture and Horticulture* **14** (1): 43-51

Freed R, Einensmith S P, Guetz S, Reicosky D, Smail V W & Wolberg P (1989). User’s Guide to MSTAT-C Analysis of Agronomic Research Experiments. Michigan State University, East Lansing, MI, USA

Garcia-Martin A, Lopez-Bellido R J & Coleto J M (2007). Fertilization and weed control effects on yield and weeds in durum wheat grown under rain-fed conditions in a Mediterranean climate. *Weed*

Research **47** (2): 140-148

Gopinath K A, Saha S, Mina B L, Pande H, Kundu S & Gupta H S (2008). Influence of organic amendments on growth, yield and quality of wheat and on soil properties during transition to organic production. *Nutrient Cycling in Agroecosystems* **82** (1): 51-60

Hiltbrunner J, Liedgens M, Stamp P & Streit B (2005). Effects of row spacing and liquid manure on directly drilled winter wheat in organic farming. *Europen Journal of Agronomy* **22** (4): 441-447

Kaut A H E E, Mason H E, Navabi A, Donovan J T O & Spaner D (2008). Organic and conventional management of mixtures of wheat and spring cereals. *Agronomy for Sustainable Development* **28** (3): 363-371

Kironmay B, Amaresh K, Ghosh S K, Pritma G & Dipali M (2006). Bio-efficacy of some new herbicides for ecosafe weed management in wheat (*Triticum aestivum* L.). *Journal of Crop and Weed* **2** (1): 9-12

Kitchen J L, McDonald G K, Shepherd K W, Lorimer M F & Graham RD (2003). Comparing wheat grown in South Australian organic and conventional farming systems. I. Growth and grain yield. *Australian Journal of Agricultural Research* **54** (9): 889-901

Liebman M & Davis AS (2000). Integration of soil, crop and weed management in low-external-input farming system. *Weed Research* **40** (1): 27-47

Olesen J E, Askegaard M & Rasmussen I A (2009). Winter cereal yields as affected by animal manure and green manure in organic arable farming. *European Journal of Agronomy* **30** (2): 119-128

Oudhia P (2000). Allelopathic effects of *Parthenium hysterophorus* and *Ageratum conyzoides* on wheat var. Sujata. *Crop Research* **20** (3): 563-566

Ozturk A, Caglar O & Bulut S (2006). Growth and yield response of facultative wheat to winter sowing, freezing sowing and spring sowing at different seeding rates. *Journal of Agronomy and Crop Science* **192** (1): 10-16

Poutala R T, Korva J & Varis E (1993). Spring wheat cultivars performance in ecological and conventional cropping systems. *Journal of Sustainable Agriculture* **3** (3): 63-68

Rodrigues M A, Pereira A, Cabanas J E, Dias L, Pires J & Arrobas M (2006). Crop use-efficiency of nitrogen from manures permitted in organic farming. *European Journal of Agronomy* **25** (4): 328-335

Steel R G, Torrie J H & Dickey D A (1997). Principles and Procedure of Statistics: A Biometrical Approach. McGraw-Hill, New York

TUIK (2008). Turkish Statistical Institute: Agriculture, Crop Production Statistics. Available: http://www.tuik.gov.tr

Weiner J, Griepentrog H W & Kristensen L (2001). Suppression of weeds by spring wheat *Triticum aestivum* increases with crop density and spatial uniformity. *Journal of Applied Ecology* **38** (4): 784-790

Yunusa I A M & Sedgley R H (1992). Reduced tillering spring wheats for heavy textured soils in a semi-arid Mediterranean environment. *Journal of Agronomy and Crop Science* **168** (3): 159-168

Zadoks J C, Chang T T & Konzak C F (1974). A decimal code for the growth stages of cereals. *Weed Research* **14** (6): 415-421