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Full Length Article

Performance of some Bread Wheat Genotypes under Organic and Conventional Production Systems

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ABSTRACT

Organic agriculture is accepted as an effective alternative solution to overcome harmful effects of excessive chemical use in conventional agriculture. Many of the crop cultivars record a reduction in yield when shifted from conventional to organic systems. Wheat is the second field crop gaining area under organic farming only after cotton in Turkey. There is dire need to look for wheat varieties that are better adapted to organic systems with little yield reduction. In this study, twelve bread wheat genotypes, which are adapted to Aegean Basin of Turkey, were grown to compare their yield and agronomic performances under organic and conventional production systems. The study was carried out during 2008-2009 and 2009-2010 growing seasons. Highest grain yield for conventional system was recorded for Sagittario (3819 kg ha^{-1}), Basribey-95 (3619 kg ha^{-1}) and Ekm4 (3505 kg ha^{-1}). Grain yield was reduced by almost 46% in organic farming as compared with conventional system. Sagittario, Esperia, Ekm6 and Ekm5 recorded relatively higher grain yield in organic system. Kernel number per spike, plant height, thousand kernel weight and total dry weight decreased in organic system. Our findings suggested that wheat yield reduction in organic system was primarily due to reduced kernel number per spike and thousand grain weight. Sagittario and Esperia, lines Ekm6 and Ekm5 were promising bread wheat genotypes for organic production systems.

Key Words: Organic agriculture; Bread wheat; Yield; Agronomic parameters

INTRODUCTION

Awareness for environmental safety and healthy food products has increased enormously during recent past in many countries of the world (Demiryürek, 2004). Organic products are highly preferred by the consumers because they are considered healthier and ecologically benign than those produced conventionally (Annicchiarico *et al.*, 2010). Organic agricultural systems are characterized by the use of organic forms of fertilizers and non chemical crop protection strategies and often involve reduction in yields as compared with conventional systems. Such lower yields are usually compensated by higher prices of the organic products (Tamis & Van den Brink, 1999). Organic agriculture is practiced in approximately 100 countries. Presently, organic land is located particularly in Oceania, Europe and Latin America and comprises less than 1% of the total agricultural land of the world but in future the growth of organic market is expected especially in industrialized countries (Shi-ming & Sauerborn, 2006).

Despite all the potential environmental benefit of organic agriculture, its productivity is often challenged (Connor, 2008). The main concern is whether the organic practices could feed the world today or in 2050 when the global population is projected to reach 9 billion and global grain demand expected to double (Tilman *et al.*, 2002). While several yield trials for organically and conventionally grown plants have shown lower yield values for organic systems (Ryan & Kirchmann, 2004), it is also reported that organic agriculture still will be better equipped to realize its full potential as a viable alternative to conventional agriculture provided that selection is made for high yielding organic cultivars with good quality characteristics (Murphy *et al.*, 2007).

Wheat has been one of the most important sources of food throughout the history of man, and organically grown wheat is becoming more attractive for the producers from different countries in recent years (Tzouvelekas *et al.*, 2002). The production area of organically grown wheat is also increasing in Turkey (Er, 2007). Studies revealed that the yield of organically grown wheat has been lower when compared with that produced under conventional production systems. Mazzoncini *et al.* (2007) reported that grain and straw yield of organic wheat was almost 50% of that realized in conventional system. In a study carried out in Turkey, the grain yield of organically grown wheat was 34% lower as compared to conventionally grown wheat (Çalışkan *et al.*, 2007).

The primary goal of present studies was to identify wheat genotypes that yield higher in organic farming

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systems and can be manipulated further to develop necessary breeding programs. Different bread wheat genotypes adapted to Aegean region were grown in both organic and conventional conditions in order to determine their agronomical performances and understand possible mechanism underlying yield reduction in organic production systems.

MATERIALS AND METHODS

A field experiment was conducted during 2008 and 2009 growing seasons of wheat in Izmir, Turkey. Eight bread wheat genotypes, Cumhuriyet-75 (Cum), Gönen-98 (Gon), Basribey-95 (Bas), Kaşifbey (Kas), Ziyabey (Zıy), Meta-2002 (Met), Esperia (Esp) and Sagittario (Sag), which are frequently grown in Aegean region and four high yielding, promising bread wheat genotypes for Aegean region, Ekm3 (Ek3), Ekm4 (Ek4), Ekm5 (Ek5) and Ekm6 (Ek6) were used as plant material for both organic (OA) and conventional (CA) conditions. The experiment was set up as randomized complete block design with a split-plot arrangement and three replications.

The seeds were autumn-sown at a density of 180 kg ha^{-1} under rainfed condition. Row space was 20 cm and the plot size was 3.6 m^2 consisting of six rows. The size of each treatment was approximately 3, 6 $m^2 \times 12$ (genotypes) × 3 (replications) ~ 130 m^2 and the total area of the experiment 130 $m^2 \times 2 \sim 260$ m^2.

On the organic area of the experiment, conventional practice was not performed during last five years. On the organic area, winter wheat followed by vetch, and on the conventional area winter wheat followed by maize as second crop was grown during last five years. Before the study, mung bean (*Vigna radiata* L.) was broadcast at seed rate of 10 kg ha^{-1} (Kay, 1979) during summer season and mixed into the soil on the flowering stage as green manure in organic agriculture treatment. This added 37000 kg ha^{-1} fresh plant material (6600 kg ha^{-1} dry matter) into the soil. Previous analyses revealed that the amount of nitrogen, phosphorus and potassium totally in the leaves and stem of mung bean are 4.96%, 0.45% and 5.4%, respectively (Algan & Çelen, 2011). Pest and diseases were not observed on the experiment field for both growing seasons.

Table I: Physical and chemical properties of experimental site after harvest

Soil characteristics	Organic	Conventional
pH	7.71	7.78
Total salt (%)	0.05	0.06
Lime (%)	18.24	17.12
Soil texture	Clay loam	Clay loam
Organic matter (%)	1.66	1.04
Total nitrogen (%)	0.11	0.11
Available phosphorus (ppm)	4.18	4.54
Available potassium (ppm)	480	417
Available calcium (ppm)	1382	1313
Available magnesium (ppm)	44	90
Available sodium (ppm)	12784	13536
Available iron (ppm)	3.50	4.50
Available zinc (ppm)	1.70	0.90
Available copper (ppm)	1.70	1.90

Conventional tillage was done with mould board plough followed by disc harrow once in the beginning of autumn and 50 kg ha^{-1} nitrogen as ammonium sulfate, 60 kg ha^{-1} phosphorus as triple super phosphate and 40 kg ha^{-1} potassium as potassium sulfate were added to the soil before planting in conventional agriculture treatment. An additional dose of 45 kg ha^{-1} nitrogen as ammonium nitrate was applied in March to maintain similar nutrient conditions of organic practices.

The crop was sown in November and harvested in June during both years. On the study, it was observed that the time to reach physiological maturity of all genotypes was almost the same for both organic and conventional systems. All plots were harvested at physiological maturity and grain yield, thousand grain weight, above ground dry matter, grain number per spike, harvest index and plant height were determined by following standard procedures.

Physical and chemical characteristics of the experimental soil for both OA and CA treatments after the termination of study are shown on Table I. The soil was clay loam with a neutral pH (7.7). Total soluble salt content of the soil was 0.05 % approximately and the lime content was 17.68% for both practices.

Data were subject to analysis of variance for each character to evaluate effects of organic and conventional agricultural systems as well as wheat genotypes. All data were analyzed by using ANOVA techniques of the computer program. The means were compared by using the LSD test described by Steel and Torrie (1980). Meteorological conditions of the growing season are given in Table II.

RESULTS AND DISCUSSION

Analysis of variance revealed statistically significant differences only in grain yield and grain numbers per spike between the two years (Table III). The grain yield was found higher in 2009 (2491.0 kg ha^{-1}) as compared with 2010 (2279.0 kg ha^{-1}). Grain numbers per spike (24.05) were also higher in 2009 ($P \leq 0.05$). The interaction of treatments and varieties was statistically significant for grain yield, grain number per spike, thousand grain weight and plant height ($P \leq 0.05$). Biomass differed significantly ($P \leq 0.05$) between conventional and organic practices while harvest indices remained unaffected (Table III). A perusal on meteorological data for both growing seasons revealed that there were non-significant differences for mean temperature, humidity and total rain, while the distribution of precipitation differed for the two years. The total rain amount for March and April, on the flowering stage of the plants, was quite higher in 2009, and could be the reason for higher grain yield, and yield parameters in this year (Table II).

Table II: Meteorological condition of the experimental site during 2008-2009 and 2010-2011 growing seasons

Months	2008-2009			2009-2010		
	Rainfall (mm)	Mean temperature (ºC)	Relative humidity (%)	Rainfall (mm)	Mean temperature (ºC)	Relative humidity (%)
November	92.6	15.7	69.1	160,3	14,6	70,8
December	101.0	11.5	65.1	151,8	13,1	70,2
January	204.1	10.5	69.1	142,3	10,6	66,7
February	165.2	10.0	69.3	301,3	12,6	67,8
March	175.7	11.7	64.4	16,1	13,3	61,6
April	83.8	16.0	64.5	20,4	17,4	55,7
May	44.3	21.4	51.5	27,1	21,8	49,8
June	9.2	26.2	45.8	76,3	25,5	51,4
Mean	109.4	15.4	62.4	115.7	16.1	61.8

Table III: Plant height, biomass and harvest index of wheat genotypes under organic (OA) and conventional (CA) systems

Genotypes	Grain yield (kg/ha)						Biomass (g/plant)			Plant height (cm)			Harvest index		
	2008-2009 OA	2009-2010 OA	Mean	2008-2009 CA	2009-2010 CA	Mean	OA	CA	Mean	OA	CA	Mean	OA	CA	Mean
SAG	2022.0	1877.6	1949.8 ABC	3952.3	3686.6	3819.5 A	10.1	16.5	13.3	75.5 DE	80.5 D	78.0 EF	0.21	0.23	0.22
ESP	1993.3	1870.0	1931.6 ABC	2305.6	2363.0	2334.3 G	9.0	13.6	11.3	69.2 FG	74.2 E	71.7 G	0.21	0.20	0.20
GON	1637.3	1564.0	1600.6 CDE	2807.0	2612.3	2709.6 F	13.0	17.6	15.3	66.8 G	83.2 CD	75.0 FG	0.15	0.17	0.16
CUM	1742.0	1258.0	1500.0 DE	2989.6	2663.3	2826.5 EF	10.8	21.5	16.1	90.0 A	97.7 A	93.8 A	0.20	0.20	0.20
ZIY	1540.3	1394.0	1467.1 DEF	3619.3	3218.6	3419.0 BCD	10.2	15.8	13.0	80.3 BCD	95.8 A	88.1 BC	0.19	0.23	0.20
MET	1400.0	1184.3	1292.1 EFG	3122.3	2986.3	3054.3 DEF	7.4	14.6	11.0	85.3 AB	92.5 AB	88.9 B	0.24	0.18	0.20
BAS	1142.0	1105.0	1123.5 GH	3873.6	336.6	3619.8 AB	6.9	16.7	11.7	79.2 CDE	86.5 C	82.8 D	0.20	0.20	0.20
KAS	1037.6	952.0	994.8 H	2993.6	2691.6	2842.6 EF	6.6	16.9	11.7	83.3 BC	97.0 A	90.2 AB	0.19	0.17	0.18
EK3	1711.6	1609.3	1660.5 BCDE	3528.0	3111.0	3319.5 BCD	8.5	14.4	11.5	79.3 CDE	86.3 C	82.8 D	0.20	0.15	0.18
EK4	1908.6	1479.0	1693.8 BCD	3655.3	3354.6	3505.0 ABC	13.5	15.5	14.5	80.8 BCD	87.3 BC	84.1 CD	0.17	0.17	0.17
EK5	2012.6	1929.5	1979.4 AB	3362.6	3003.3	3183.0 CDE	9.2	17.2	13.2	80.7 BCD	94.3 A	87.7 BC	0.19	0.14	0.16
EK6	2065.3	2159.0	2112.1 A	3366.3	3156.3	3261.3 BCD	9.7	15.5	12.6	74.0 EF	88.3 BC	81.2 DE	0.21	0.22	0.21
Mean	1684.4	1531.8	1603.5 B	3298.0	3017.8	3157.9 A	9.6 B	16.3 A	12.9	78.7	88.7	83.7	0.20	0.19	0.19
The significance of F values															
Year			*				ns			ns			ns		
Treatment			**				**			**			ns		
Genotype			*				ns			*			ns		
Year x Treatment			ns				ns			ns			ns		
Year x Genotype			ns				ns			ns			ns		
Treatment x Genotype			**				ns			*			ns		
Year x Treatment x Genotype			ns				ns			ns			Ns		
C.V.			7.83				19.35			3.44					
LSD: 0.05			37.21				42.115			5.731					

The major objectives in most wheat production systems are increasing yield and improving yield stability (Slafer & Kernich, 1996). In this study, the highest yield value for conventional agriculture treatment was obtained from the genotype Sagittario (3819.0 kg ha^{-1}), while the genotype Ekm6 had the highest yield (2112.0 kg ha^{-1}) in organic agriculture treatment (Table III). Nevertheless, if the yield of each genotype is compared for organic and conventional systems, it is seen that the lowest reduction ratio was determined for the genotype Esperia (17.0%) and the highest for the genotype Basribey (69.0%). According to these results, Ekm6 can be suggested for organic production systems with higher yield potential whereas Esperia can be used for specific breeding program for organic production systems because it's relatively lower yield reduction when shifting from conventional to organic systems. Ilker *et al.*

(2011a) stated that the genotype Basribey 95 is high yielding for Aegean Region. Besides, Basribey 95 was also identified high yielding under drought conditions (Ilker *et al.*, 2011b). However, this genotype yielded higher in present study under optimum conditions and its adaptation potential to organic conditions was lower.

Grain number per spike is often considered a good selection criterion for high yielding genotypes of cereals (Sönmez *et al.*, 1999). In CA treatment, the highest grain number per spike (31.2) was recorded for Basribey 95, which was also high yielding genotype for conventional system (Fig. 1). The highest grain number per spike (21.4) in OA treatment was found in Sagittario. Miller and Bean (1999) reported that the main three yield components of wheat are grain number per spike, spike number per m^2 and grain weight. Thousand grain weight (TGW) is an important component for yield and also quality of cereals (Yağdı, 2004). In this study the highest TGW was found in Cumhuriyet 75 in both organic and conventional agriculture treatments (Fig. 2). The highest reduction rate in thousand grain weight as a shift to organic application was observed for Ekm6, although grain yield of this genotype was more pronounced than others in organic conditions. It was imperative that TGW was not a primary parameter involved in yield reduction in wheat under organic conditions. There was also no significant variation in spike number per m^2 for both production systems and among genotypes (data not shown). Our findings indicated that grain number per spike is more important parameter than those other two primary yield components to obtain high grain yield under organic conditions. Öztürk and Akkaya (1996) also noted that grain number per spike is highly correlated with yield potential of winter wheat.

Plant height of cereals is one of the important morphological characteristics besides yield, yield components and quality (Kün, 1996). Plant height of Cumhuriyet 75 was higher than those of other genotypes for both organic (90.0 cm) and conventional (97.7 cm) conditions in present study (Table III). The genotypes Ziyabey (95.8 cm), Kaşifbey (97.0 cm) and Ekm5 (94.3 cm) showed higher plant height under conventional conditions compared to other genotypes.

Biomass of plants decreased in organic as compared with conventional system although there was no significant variation in between genotypes in both conditions (Table III). Total dry matter production was 16.3 g $plant^{-1}$ in conventional treatment while it was 9.6 g $plant^{-1}$ in organic agriculture treatment. Organic agriculture practice had no significant influence on harvest index in both systems (Table III). Although organic applications resulted in discernible changes in dry matter production of plants, partitioning of carbohydrates didn't change.

Conclusively, Ekm5 and Ekm6 were identified as high yielding genotypes for organic production systems. Basribey 95 had higher performance in conventional conditions, and it had lower capacity to adapt to organic conditions. Grain number per spike could be used for selecting high yielding genotypes under organic conditions.

Fig. 1: Mean grain number per spike values of 12 wheat genotypes under both organic (OA) and conventional (CA) systems for 2008-2009 and 2009-2010 growing seasons

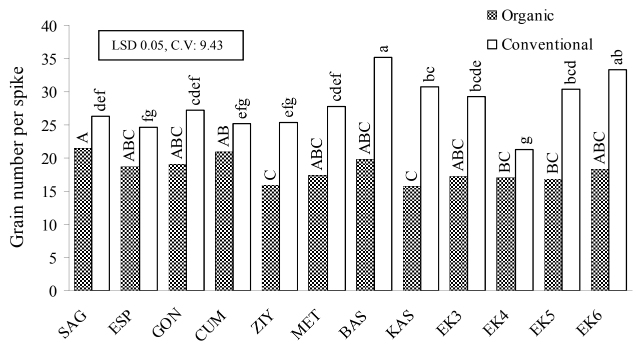
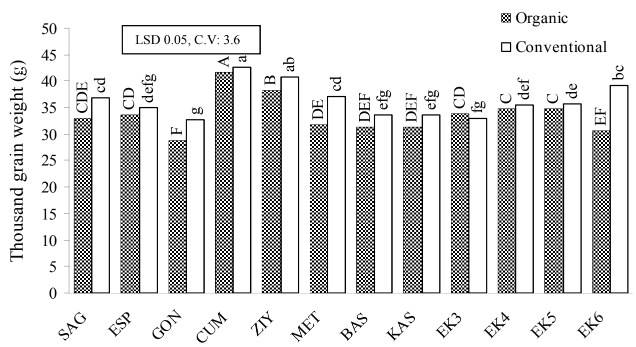


Fig. 2: Mean thousand grain weight (g) of 12 wheat genotypes under both organic (OA) and conventional (CA) systems for 2008-2009 and 2009-2010 growing seasons



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