Scientific Papers. Series A. Agronomy, Vol. LXI, No. 1, 2018
ISSN 2285-5785; ISSN CD-ROM 2285-5793; ISSN Online 2285-5807; ISSN-L 2285-5785

GROWTH AND GRAIN YIELD PARAMETERS OF SINGLE-PLANTED AND IN-CANOPY GROWN WHEAT (*Triticum aestivum* L.)

Uğur ÇAKALOĞULLARI, Gülden Deniz ATEŞ ATASOY, Deniz İŞTİPLİLER, Özgür TATAR

Ege University, Faculty of Agriculture, Department of Field Crops, 35100, Bornova, Izmir, Turkey

Corresponding author email: ozgur.tatar@ege.edu.tr

Abstract

Growing high-yielding wheat (Triticum aestivum L.) genotypes in dense populations under a competitive environment of field conditions is the main goal of the modern cropping systems. However, genotypic potential of yield related traits of single-planted wheat may differ with the plants grown under canopy pressure. A field experiment was conducted during two consecutive years to assess the relations between grain yield parameters of single-planted and field-grown wheat plants. The experiment was installed in a randomized complete block design with 3 replications and 8 bread wheat cultivars were used. Plant height, biomass, spike number, grain number, thousand grain weight and grain yield were determined under both conditions. Average grain yield decreased from 2.90 ton/ha in 2012 to 1.71 ton/ha 2013. Although grain weights of single-planted wheat also decreased in the second year (2.83 g/plant) comparison to first year of the experiment (4.93 g/plant), varied response were found among genotypes under single-planted and with in-canopy conditions.

Key words*: wheat, single-planted, in-canopy, grain yield.*

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops among the world with 750 million tons of production (FAO, 2016). Yield and yield related traits are important selection criteria for wheat farmers and growing high-yielding wheat genotypes in dense populations under a competitive environment of field conditions is the main goal of the modern cropping systems. Yield performance of a wheat cultivar is affected by various factors such as genetic background, environmental effects and farming practices. It is well known that plant density plays a crucial role in the formation of the yield. Numerous studies have been previously reported the effects of plant density on yield (Joseph et al., 1985), radiation use efficiency and green fraction (Whaley et al., 2000), grain weight and grain number per spike (Kazan and Doğan, 2005). Moreover, it has been also reported that the optimum plant density differs with the change in sowing dates (Spink et al., 2000). Wheat plants can compensate the reduction in plant density with their tillering capacity which depends on environmental conditions and genetic background of the plant (Jin et al., 2017). But, decrease in plant density may cause increase in weed population such as jointed goatgrass (*Aegilops cylindrica*) in wheat growing areas. Wilson and Swanson (1961) also reported a progressive decrease in grain yield as plant density dropped below 20 plants per square foot. Puckridge (1982) investigated the influence of size and distance of neighbouring plants on the development of individual plants in wheat and barley populations and at the end of the statistical analyses it has been found that there was not any direct effect of space available or the location of near neighbours on the growth of individual plants. To achieve the optimum yield of a given wheat cultivar we should know its genotypic potential as a single plant, and its performance under canopy pressure. However, relative differences between the performances of single planted and in-canopy grown wheat plants have not been clearly explained yet. The aims of this study were i) to investigate the yield and yield related traits of 8 bread wheat cultivars under two growing conditions as single-planted and in-canopy, ii) to understand the responses of measured traits to different environmental pressure conditions and iii) to identify relative performances of the cultivars

used in the experiment in terms of measured traits.

MATERIALS AND METHODS

This study was conducted in 2011/2012 and 2012/2013 growing seasons at the experimental site of Ege University, Faculty of Agriculture, Department of Field Crops, Izmir-Turkey (38°27'6", 27°13'32"E). The soil structure of experimental field was clay loam, mild alkaline and moderate calcic.

The experiment was established during two consecutive years for evaluating the relation between grain yield of single-planted and in-canopy wheat plants. The dimensions of in-canopy plots were 1 m x 0.6 m and it was conducted as three replicates in randomized complete block design. The single-planted plots were designed as four replications that sowed the single plants on corner of square which side length was 40 cm. Eight different bread wheat cultivars were used as plant materials. These were Menemen (MEN), Alibey (ALI), Basribey (BAS), Kaşifbey (KAS), Cut (CUT), Cumhuriyet (CUM), Meta (MET) and Sagittario (SAG) cultivars which are adapted to Mediterranean climate conditions.

Initially, 6 kg N and 6 kg P_2O_5 fertilizer were applied as ammonium sulphate (21%) and triple super phosphate (45%), respectively. And also 6 kg N were applied as ammonium nitrate (33%) in jointing stage of wheat.

After removing border lines, all of the plots were harvested. Plant height, biomass, spike number, grain number, thousand grain weight, and grain yield of plants were determined separately for in-canopy as well as single-planted plots.

RESULTS AND DISCUSSIONS

Yield and yield related trait values of 8 bread wheat cultivars in two growing season under two growing conditions are shown in Table 1. Bread wheat cultivar (cv.). SAG create relatively more dry weight as a single plant than other genotypes in both years (120.4 and 69.8 g). But cv. SAG was not at the first place in terms of total dry weight under canopy pressure (Table 1). Cv. BAS had the highest grain yield in first year (3509 ton/ha) while cv. MEN showed highest grain yield in second year (2465 ton/ha). For thousand grain weight, cv. CUT had the highest values for both as a single-plant (45.8 g in 2012; 28.0 g in 2013) and in-canopy (52.0 g in 2012; 33.5 g in 2013) for two growing seasons.

Table 1. Some agronomic traits of single-planted (snPL) and in-canopy-grown (inCP) 8 wheat cultivars during 2012 and 2013 growing seasons

Cultivars	Treatments	Total dry weight (g/plant)		Grain Yield (g/plant)		Grain Yield (ton/ha)		Thousand grain weight (g)		Grain number (num./spike)		Spike number (num./plant)		Plant height (cm)	
		2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
MEN	*inCP*	3.0	2.9	1.1	1.0	2787	2465	34.2	27.0	27.1	30.2	1.2	1.3	66.5	69.8
	snPL	55.0	68.4	12.9	16.8	-	-	27.7	19.8	26.5	56.8	16.8	14.5	54.4	54.8
ALI	*inCP*	3.5	2.4	1.4	0.5	3489	1217	35.8	20.3	29.5	18.4	1.4	1.4	64.5	73.0
	snPL	87.7	37.5	32.4	9.9	-	-	30.5	19.1	44.1	44.8	24.3	11.8	60.9	57.8
BAS	*inCP*	3.3	2.1	1.4	0.6	3509	1473	41.4	25.0	28.3	19.7	1.2	1.5	67.0	68.2
	snPL	61.4	29.9	12.8	7.8	-	-	22.2	18.8	25.3	55.7	22.5	7.5	58.3	57.4
KAS	*inCP*	3.2	1.5	1.3	0.4	3156	893	34.5	24.9	32.7	17.1	1.1	0.8	81.9	74.2
	snPL	49.0	48.0	12.0	10.4	-	-	26.9	22.6	23.4	52.2	19.3	9.3	52.7	60.5
CUT	*inCP*	2.8	2.3	1.0	0.7	2605	1651	52.0	33.5	20.7	19.7	1.0	1.0	78.1	85.8
	snPL	93.4	67.5	26.4	12.2	-	-	45.8	28.0	28.7	24.2	20.5	18.3	69.7	70.8
CUM	*inCP*	3.2	3.0	1.2	0.8	2890	1990	35.8	35.6	31.2	19.4	1.1	1.2	84.5	84.4
	snPL	114.0	61.2	26.7	10.2	-	-	41.2	24.4	21.5	26.7	30.3	15.5	71.2	70.2
MET	*inCP*	3.4	3.0	1.3	0.9	3226	2316	38.2	24.8	25.7	28.3	1.3	1.3	73.5	80.9
	snPL	96.7	36.8	32.4	8.8	-	-	27.1	27.4	21.8	33.0	33.5	9.8	62.7	63.8
SAG	*inCP*	2.6	2.6	0.7	0.7	1779	1690	32.5	24.8	23.6	21.8	0.9	1.3	55.6	64.6
	snPL	120.4	69.8	41.0	20.1	-	-	33.3	23.6	37.4	51.9	33.0	17.0	51.0	50.5

Cv. KAS had the highest grain number per spike in-canopy conditions in first year (32.7). But as a single-plant cv. ALI had the largest grain number per spike value in first year (44.1). In second year cv. MEN had the largest values for both as single-plant (56.8) and in-canopy (30.2) in terms of grain number per spike (Table 1). The spike number values of the genotypes were close to each other in-canopy conditions for both years (Table 1). However, the spike number values of the single-plants differed among the genotypes. The largest spike number values were observed in cv. MET (33.5) in first year. Cv. CUM had the longest plant height in-canopy and as single-plant in the first year and cv. CUT was the longest cultivar in second year (Table 1).

The mean values of measured traits under two growing conditions (in-canopy and single-planted) for both seasons were presented in Figure 1. Notable differences between the growing types and the growing seasons for all measured traits can be seen from Figure 1. Spink et al. (2000) found significant decrease in yield with the reduction in plant density. Also it has been showed that total crop dry matter increases with an increase in plant density to an optimum level (Holliday, 1960; Donald, 1963; Spink et al., 2000). In our study the yield related traits such as total dry weight, grain yield and spike number per plant decreased dramatically in canopy conditions compare to single planted plants. On the other hand the some traits such as thousand grain weight and plant height presented less variation among the growing conditions. Mosanaei et al. (2017) evaluated two different plant densities as 350 and 420 plants per m^2 for wheat and they did not find significant differences between two plant densities in terms of plant height and thousand grain weight. However, Yonggui et al. (2015) determined an increase in plant height with the increase in plant density from 250 to 500 plants per m^2. In the present study, the mean values were slightly higher in-canopy plants than those of single-planted ones in terms of thousand grain weight (Figure 1). The higher competitive conditions to reach photosynthetic radiation in canopy led wheat cultivars to become taller comparison to single planted conditions (Figure 1). For grain number per spike, single-planted wheat individuals had higher values in both years. But the gap between two growing types in terms of grain number per spike was much bigger in the second year.

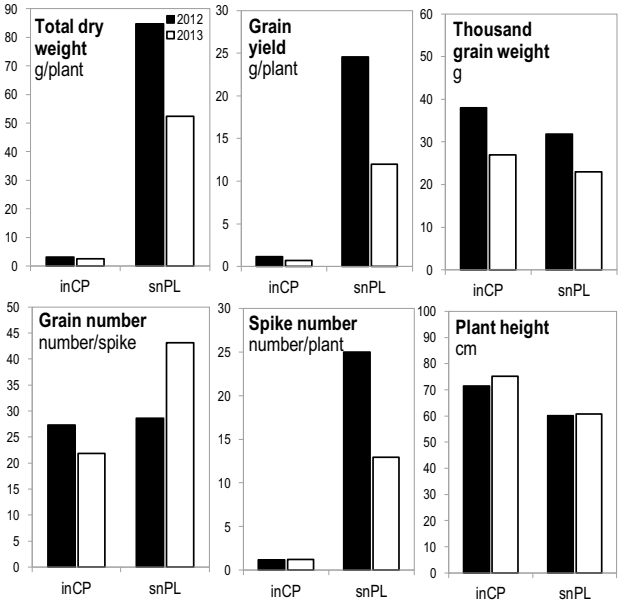

Figure 1. Some agronomic traits of single-planted (snPL) and in-canopy-grown (inCP) 8 wheat cultivars during 2012 and 2013 growing seasons

This result may be attributed to differences between the environmental conditions of two growing seasons. Mosanaei et al. (2017) found significant difference between two plant densities in first year of their research with respect to grain number per spike. When two growing season were evaluated, it can be said that there are obvious differences between two growing seasons in terms of measured traits like Mossanaei et al. (2017) found in their study. The mean values of first year measurements were relatively higher than the second year for total dry weight, grain yield per plant and thousand grain weights for both growing types in-canopy and single-planted (Figure 1). But the mean values were slightly higher in the second year for both growing types in terms of plant height (Figure 1).

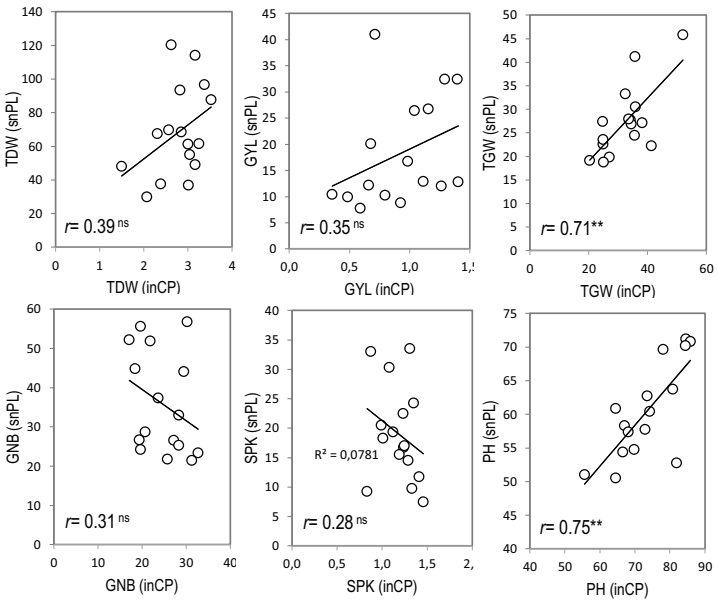

Figure 2. Correlations between some agronomic traits of single-planted (snPL) and in-canopy-grown (inCP) 8 wheat cultivars during 2012 and 2013 growing seasons. [**TDW**= Total dry weight (g/plant), **GYL**= Grain yield (g/plant), **TGW**= Thousand grain weight (g), **GNB**= Grain number (number/spike), **SPK**= Spike number (number/plant), **PH**= Plant height (cm)]

Figure 2 represents the correlations between in-canopy and single-planted values for each trait measured. Statistically significant relations were found between in-canopy and single-planted wheat plants in terms of TGW (r=0.71) and PH (r=0.75). Hence it can be said that there were close relationships between the values obtained from the single-planted and in-canopy plants in terms of plant height and grain weight. Also, these two traits were not affected by canopy density. However no significant correlation coefficient found between in-canopy and single-plant applications with respect to total dry weight per plant, grain yield per plant, grain number per spike and spike number per plant. These results indicate that the measurements obtained from single-planted individuals did not represent the measurements in-canopy with respect to these four traits.

CONCLUSIONS

The wheat cultivars did not represent their whole genotypic potential while they were in a competitive environment. The performances of single-planted wheat plants in terms of yield and yield related traits are quite different from the wheat plants grown in-canopy. Besides, the relative performances of evaluated cultivars were changed in different growing conditions. As a conclusion, although it is possible to reach the genotypic potential of a given genotype under minimum environmental pressure, this data would be not fully informative about the

relative performance of the cultivar growing in-canopy.

REFERENCES

Donald C.M., 1963. Competition among crop and pasture plants. In Advances in agronomy (Vol. 15, pp. 1-118). Academic Press.

Food and Agriculture Organization of United Nations (FAO), 2016, www.fao.org/faostat/en, Access Date: 15/02/2018.

Holliday R., 1960. Plant population and crop yield. Nature, 186 (4718), 22-4.

Jin X., Liu S., Baret F., Hemerlé M., Comar A., 2017. Estimates of plant density of wheat crops at emergence from very low altitude UAV imagery. Remote Sensing of Environment, 198, 105-114.

Joseph K. D.S.M., Alley M.M., Brann D.E., Gravelle W. D., 1985. Row spacing and seeding rate effects on yield and yield components of soft red winter wheat. Agronomy Journal, 77 (2), 211-214.

Kazan T., Doğan R., 2005. Pehlivan ekmeklik buğday (*Triticum aest*. var *aest*. L.) çeşidinde ekim zamanı ve ekim sıklığı üzerine araştırma. Uludağ ÜZF. Dergisi, 19 (1), 63-76.

Mosanaei H., Ajamnorozi H., Dadashi M.R., Faraji A., Pessarakli M., 2017. Improvement effect of nitrogen fertilizer and plant density on wheat (*Triticum aestivum* L.) seed deterioration and yield. Emirates Journal of Food and Agriculture, 29 (11), 899-910.

Puckridge D.W., 1982. The effect of density and plant arrangement on the performance of individual plants in barley and wheat crops. Australian Journal of Agricultural Research, 33 (2), 171-177.

Spink J.H., Semere T., Sparkes D.L., Whaley J.M., Foulkes M.J., Clare R.W., Scott R.K., 2000. Effect of sowing date on the optimum plant density of winter wheat. Annals of Applied Biology, 137 (2), 179-188.

Whaley J.M., Sparkes D.L., Foulkes M.J., Spink J.H., Semere T., Scott R.K., 2000. The physiological response of winter wheat to reductions in plant density. Annals of Applied Biology, 137 (2), 165-177.

Wilson J.A., Swanson A.F., 1962. Effect of Plant Spacing on the Development of Winter Wheat. Agronomy Journal, 54 (4), 327-328.

Yonggui X.I.A.O., Jianjun L.I.U., Haosheng L.I., Xinyou C.A.O., Xianchun X.I.A., Zhonghu H.E., 2015. Lodging resistance and yield potential of winter wheat: effect of planting density and genotype. Frontiers of Agricultural Science and Engineering, 2 (2), 168-178.