SELECTION OF SUPERIOR GENOTYPES FOR SUPPLEMENTARY IRRIGATED AND RAIN FED ENVIRONMENTS FOR DURUM WHEAT (*TRITICUM TURGIDUM SSP. DURUM* DESF.) IN SOUTH-EAST TURKEY

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Abstract. This research aimed to select the best cultivars for both supplementary irrigated and rain fed conditions. A group of 17 recently released cultivars were tested employing randomized complete block design with three replications under supplementary irrigation and rain fed conditions at Sanliurfa and in Adiyaman locations in 2019-20. Grain yield with five agro-morphological and six quality traits were scored. Results indicated that entries differed for all traits under study. Index selection based on rank sums of all traits showed that durum wheat cultivars of Sümerli (1st), Artuklu (2nd), Zühre (3th), Perre (4th), and Saricanak-98 (5th) ranked at first five place for both conditions. Spearman's average rank coefficient of correlation between ranks of sums of all traits for supplementary irrigation vs. rain fed condition was 73.52%. This was only 56.8% for grain yields for supplementary irrigation vs. rain fed condition. Mean yield (7,256.26 kg. ha^{-1}) of supplementary irrigation was higher than that of (5,097.56 kg. ha^{-1}) rain fed condition by 42.34%. It was concluded that genotypes 8 (Sümerli), 7 (Artuklu), and 3 (Zühre) perform well in both environments and may be used directly in irrigated or in rain fed conditions in the studied locations. Furthermore, high performing varieties for both supplementary irrigation and rain fed conditions can be picked up better by index selection. This must be referred for better variety selection in breeding programs.
Keywords: *rank stability, index selection, dryland vs supplementary irrigation, wheat, SE Anatolia*

Introduction

Durum wheat (*Triticum turgidum ssp. durum* Desf.) world production was 37 million tons in 2018-19 and 33,9 mil tons in 2019-20, and approximately 10% of this production was generated in Turkey. An annual production of 3.5 and 3.2 mil tons was obtained from almost 1.1 mil ha in 2018-19 and 2019-20, respectively (Anonymous, 2019). Average yields were 2.74 and 2.78 t ha^{-1}, respectively. Durum wheat grains are used to make bulgur, frike (i.e. Wheat is harvested early, while the grains are still tender and green and the kernels are then parched, roasted, dried and rubbed), semolina, pasta, and various types of breads (Elias and Manthey, 2005). South-East Anatolia (SEA) located in the Fertile Crescent is one of the places of origin of einkorn and emmer wheat (Lupton, 1987). Wheat was probably first cultivated in this area (Heun et al., 1997). *T. turgidum ssp. dicoccoides* (wild emmer wheat) still grows voluntarily in Karacadag (in Diyarbakır

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Province), and the diversity shown by the species is a source of genes for improve abiotic and biotic stresses in wheat (Ozkan et al., 2002). SEA is known to be the durum wheat belt of the country (Atlı et al., 1993) and 1,023 mil ton annual productions was obtained from this region in 2019 (Anonymous, 2019). Approximately 32% of the national production comes from SEA, and the region holds about 35% of national macaroni production (Ozberk et al., 2005a). In the SEA, weighted grain yield under rain fed conditions was 1,814 kg ha^{-1} in the 1980s (Anonymous, 2001). This remained stable in the following decades. On the other hand, average yield for supplementary irrigated conditions was 6,000 kg ha^{-1} (Ozberk et al., 2005b). Wheat production in the Mediterranean region is often limited by sub-optimal moisture conditions (Arzani, 2000). Where most rain falls during autumn, winter, and early spring, the water deficit occurs in late spring starting from flowering to the grain filling period (Moraques et al., 2006; Schulthess et al., 2013). Visible syndromes of plant exposure to drought in vegetative phase are leaf wilting, and a decrease in plant height, the number, and the area of leaves (Talebi et al., 2009). Drought stress may also result in reduction in yield related traits as the number of spikes per unit area, number of grains per spike, and grain weight (Aboyami and Wright, 1999; Chmielewski and Khon, 2000; Karimizadeh et al., 2012). According to previous studies, the number of grains per spike, thousands kernel weight, and the number of tillers per unit area have direct and positive effects on durum wheat yield (Garcia del Moral et al., 1991; Simane et al., 1993; Mohammadi et al., 2011; Zarei et al., 2013). Under water deficit stress, the plant ability to survive and produce grain is called 'drought tolerance'. It can be also defined as the relative yield of a genotype compared to the other genotypes subjected to the same drought stress (Hall, 1993). Although some researchers claim opposite (Richards, 1996; Rajaram and Wan Ginkel, 2001) high potential yield under non stress conditions may not necessarily result in same achievement under stress conditions and genotypes with a high yield may not be stress tolerant (Siose Mardeh et al., 2006). Spearman's rank correlation analysis can give an idea of the correlations among traits of genotypes grown across environments. Supplementary irrigation allows the farmers to plant their crops early, to increase yield, and to alleviate terminal heat and drought stresses in semi-arid regions (Carvalho et al., 2014). Zhang and Oweis (2000) showed that yield and water use efficiency increased significantly by applying 75 to 212 mm of supplementary irrigation from beginning to the end of anthesis in Northern Syria. In durum wheat, apart for agro-morphological yield related traits, some quality traits such as semolina color, protein (%), semolina yield, sedimentation index are also important for higher marketing prices and suitability for some special end products. In durum wheat grain, the color is mainly due to two natural classes of pigments: carotenoids and anthocyanin. Carotenoids provide a yellow pigmentation of durum wheat endosperm and consequently of the semolina. This has important implications for the marketing of end products based on durum wheat (Elias et al., 2005). Some carotenoids have provitamin activity, which provides protection from some ocular diseases (Ribaya-Mercado and Blumberg, 2004). Selection of better genotypes at the stress and non-stress environments has always been argued. Several agronomic traits were subjected to the justification such as mean productivity (Rosille and Hamblin, 1981), geometric mean productivity (Fernandez, 1992), tolerance (Rosille and Hamblin, 1981), stress susceptibility index (Fisher and Maurer, 1978), stress tolerance (Fernandez, 1992). Finlay and Wilkinson (FW) and environmental variance (EV) indexes proposed by Lin and Binns (1985), and Lin et al. (1986) were also used for index selection. FW was found to be correlated with the grain yield, regression

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coefficient, and the mean square of contribution of test cultivar to genotype × season interaction (G×S). EV index did not show any significant correlation with the measure of traits. In other studies, (Majit and Aliakbar, 2011; Patel et al., 2019), tolerance index, mean productivity index, geometric mean productivity, stress susceptibility index, and stress tolerance index were placed in the same cluster indicating any of them can be used as indirect selection tool. In these perspectives, the objective of this study was to assess the possibility of selecting superior genotypes through the agro-morphological and quality traits by index selection planting same set of durum wheat genotypes under rain fed and supplementary irrigated conditions in two locations of south-east Anatolia.

Material and methods

Seventeen durum wheat genotypes (*Table 1*) were grown under rain fed (RF) and supplementary irrigated conditions (SI) in Koruklu (36,88°N, 38,92°E) in Sanliurfa and in Husnumansur (37,5°N,38,0°E) in Adiyaman locations of SE Anatolia in Turkey during 2019-20 cropping season. Fifteen of them were the recently released and well adapted cultivars (Kendal et al., 2012; Dogan and Cetiz, 2015; Tekdal and Yıldırım, 2015; Kanat, 2017; Polat, 2017) developed by national agricultural research institutes including two landraces. Field trials were laid out in a randomized complete block design with three replications. The size of the plots was 1.2 × 6 m= 7,2 m^2 at sowing and 1.2 × 5 m=6,0 m^2 at harvest with a 20 cm inter-row spacing. Plot drill were used for sowing in mid-December and plot combine harvester at harvest in mid-June, respectively (*Figures 1-4*). Adiyaman received 590,61 mm of annual rainfall during 2019-20 (from September to June), while Sanliurfa only got 590,62 mm of annual rainfall (from September to June) during the same cropping season (https://power.larc.nasa.gov/data-access-viewer/) Long term averages of those locations are 716,2 mm for Adiyaman https://www.mgm.gov.tr/veridegerlendirme/il-ve-ilceler-istatistik.aspx?k=A&m=ADIYAMAN and 446,2 mm for Şanlıurfa (https://www.mgm.gov.tr/veridegerlendirme/il-ve-ilceler-istatistik.aspx?m=ŞANLIURFA).

All necessary measures were taken for healthy and reliable experimental results. Chemical controls for rodents and weeds were managed by appropriate chemical on time (i.e. Tribenuron-methyl (12 g ha^{-1}) for broad leaves and Phenoxiprop-P-ethyl 500 cc ha^{-1}). As fertilization, 60 kg ha^{-1} of nitrogen and phosphorus were applied at sowing supplying 300 kg ha^{-1} 20-20-0 of chemical fertilizer. At the end of tillering stage, a second nitrogen application was practiced by giving another 80 kg ha^{-1} of urea. Plants were irrigated twice at milky and dough stage of grain filling giving approximately 100 mm m^{-2} of water in each irrigation. Agro-morphological traits such as number of spike m^{-2} (NS), SPAD (Konica-Minolta SPAD-502 plus chlorophyll meter), plant height (cm) (PH), number of grain $spike^{-1}$ (NGS^{-1}), grain weight $spike^{-1}$ (g) (GWS^{-1}), and grain yield (kg. ha^{-1}) (GY) were scored. Five plants were employed for scoring and the average value was considered for analysis of variance. Some quality traits of hectoliter weight (HL) (AACC 2000, method 55-10), 1000 kernel weight (TKW) (Uluoz, 1965), protein % (P) (AACC 2000 method 46-10.01, Anonymous, 2000), semolina yield (%) (SY) (AACC method no:26-30, Anonymous, 1969) Semolina color (SC) (Hunter Lab. Mini scan, AACC 2000 Method 14-50, Anonymous, 2000), and Sedimentation (S) (ICC method :116, Anonymous (1972) and Black and Bushuk (1967)), were also scored only at the Sanliurfa field trials carried out under SI and RF conditions.

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Table 1. *Entry list tested under supplementary irrigation vs rain fed conditions in Sanlıurfa and Adiyaman locations*

Entry number	Name	Pedigree	Some specifications
1	Sarı başak	STOT//ALTAR 84/ALD/3/SNITAN	Spring growing habit, Medium tolerance to drought and cold, yellow and leaf rust, tolerant to septoria,
2	Ayzer	BCRIS/BICUM//LLARETAINIA/3/DUKEM_12/2*RASCON_21	Spring growing habit, early maturing, moderate drought tolerance: and cold tolerance;
3	Zühre	SNTURK M183-84 375/NIGRİS S//TANTLO-1)	Spring growing habit, Flag leaf Rolling; very low, leaf sheet; waxy, High yellow pigmentation, vitreous kernel
4	Güney yıldızı	RASCON-39/TILD-1	Spring growing habit, : no flag leaf rolling, waxy leaf sheet, Light Brown awn color, high yellow semolina pigmentation, Vitreous kernel.,
5	Fırat-93	AA"S"/VOL"S"//FG"S"/3/SHWA'S'	Spring growing habit, not lodging, moderate resistance to cold, tolerant to drought and heat, low yellow pigmentation
6	Sarıçanak-98	DAKI 'S'	Spring type, medium-early maturing, high yellow pigmentation
7	Artuklu	LAHN//GANSO/STORK	Spring type growing habit, waxy, spike characteristics: Amber grain color, vitreous, high yellow pigmentation
8	Sümerli	No access	Spring type, semi- dwarf, leaf sheet: waxy, leaves: moderate waxy. Spike: moderate waxy, Amber grain color, vitreous, high yellow pigmentation
9	Özberk	Fg's'/Gr's'//Candea/4/ Grebe 's'/3/…..	Spring/facultative growing habit, no lodging; brown grain color:, early –medium maturing type, high 1000 KW
10	Akcakale-200	SCHE//CORM/RUFO/3/AJAIA	Spring type, medium early maturing type, tolerance to drought and heat, and yellow rust
11	Edessa	No access	Spring type, not lodging, susceptible to yellow berry, resistance to heat, moderate resistance to yellow and black rust
12	Tüten-2002	ALTAR 84/ATO/3/GS/FG//CNDO	Spring type, no lodging, high yielding ability
13	Alatay	CAM20/A-NAS//ACT/5/CORM/RUFO//RU/3/RISSO/4/CHEN 'S'/AUK	Spring growing habit, medium plant height, early maturing type
14	Perre	No access	Spring type, amber grain color, Phenology: medium tolerance to cold and drought, no lodging, early maturing type, tolerance to bund, moderate tolerance to smut, and rusts
15	Burgos	No access	Spring type growing habit, tolerance to lodging and drought, tolerance to yellow, leaf and stem rust, susceptible to Septoria. High yellow pigmentation
16	Deve disi	Land race	Facultative type, tall plant/ lodging type , hairy gluma, starchy kernel, suitable for flat bread making
17	Hacı Ali	Land race	Facultative type, tall plant/ lodging type, small-medium size spike, small-medium size grain, suitable for bulgur (Cracked wheat)

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Figure 1. *Bed planting large furrow irrigation in Koruklu*

Figure 2. *Large bed and furrow maker*

Figure 3. *Bed and furrow preparation for sup. Irrigation*

Figure 4. *Harvest for dryland experiment in Adiyaman*

Statistical analysis

Prior to combined ANOVA analysis, within family block variances of replications for both experiment was tested for homogeneity by F max test. Confirming homogeneity, a combined ANOVA for joint replications was performed for quality traits. Agro-morphological traits were scored only in first replication (=block 1) in each field trial in each location. Therefore, confirming the homogeneity of within block variance, irrigated and rain fed field trials in it selves were subjected to combined ANOVA employing two replications (i.e. Each location was considered as one replication). Entries and replications (actually locations) when found significant statistically were grouped by Tukey's mean separation test. Rank similarity of all traits scored for supplementary irrigation vs. rain fed were evaluated by Spearman's rank coefficients for correlations. Finally, an index selection for the traits scored under rain fed and supplementary irrigated conditions was performed employing sums of the ranks (Mulamba and Mock, 1978) and the lowest sums of ranks were detected as the best and the entries were also ranked by referring sums of ranks. JMP-5 statistical software was used for statistical analysis.

Results

Combined ANOVA for grain yield under SI in Sanliurfa and Adiyaman

Confirming the homogeneity of error variances for irrigated field trials in both locations, combined ANOVA was performed (not given here) and the entries (F=29,20**), locations (F=28,40**) and the entry × location interaction (F=2,00*) turned out to be significant. Replications were non-significant, and CV was 9,9%. Average grain

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yield at Sanliurfa (7637.44 kg. ha^{-1}) was higher than that of Adiyaman (6875.08 kg. ha^{-1}). Entries 8, 12, 2, 7 and 11 placed in the first five ranks giving 8839.65, 8699.70, 8371.98, 8281.90 and 8235.51 kg ha^{-1}, respectively (*Table 2*).

Table 2. *Means of grain yield and Tukey's groups of entries through the combined ANOVA*

Entry no	Means (kg ha^{-1}) for sup. irrigation	Groups	Means (kg ha^{-1}) for rain fed	Groups
1	7244,96	b-d	5772,88	a
2	8371,98	abc	5692,61	ab
3	7784,40	a-d	5776,78	a
4	7294,26	b-d	4915,78	b-d
5	7081,30	cd	5513,45	a-c
6	7561,68	a-d	5735,51	ab
7	**8281,90**	a-d	**5880,66**	a
8	8839,65	a	5402,73	a-c
9	7060,36	cd	5130,25	a-d
10	6821,21	d	4732,16	cd
11	8235,51	a-d	5314,00	a-d
12	**8699,70**	ab	**5765,65**	a
13	8093,86	a-d	5088,15	a-d
14	7688,16	a-d	5401,65	a-c
15	7631,48	a-d	4556,21	d
16	3746,20	e	3110,93	e
17	2919,81	e	2869,15	e

Combined ANOVA for grain yield under RF condition at Sanliurfa and Adiyaman

Homogeneity of error variances for individual experiments was confirmed and the combined ANOVA was performed. All sources of variation were significant giving F=5.08** for replications, F=32.18** for entries, F=52.20** for locations and F=1.93* for entry × location interaction. CV was 7,4%. Mean grain yield at Sanliurfa (5370,78 kg ha^{-1}) was higher than that at Adiyaman (4824,34 kg ha). Entries 7, 3,1,12 and 6 ranked at first five entries giving 5880.66, 5776.78, 5772.88, 5765.65 and 5735.51 kg ha^{-1}, respectively (*Table 2*). Spearman's rank coefficient of correlation for ranks of entries under supplementary irrigation *vs.* rain fed was 56.8% (*Table 3*).

Table 3. *Spearman's rank coefficients of correlations for all traits under study for both SI and RF conditions*

Traits no	Traits (SI vs. RF)	Spearman's rank coefficient of correlation (%)
1	Grain yield	56.8
2	PH	63.9
3	SPAD	52.2
4	NSm^{-2}	54.6
5	NGS^{-1}	38.7
6	GWS^{-1}	46.32
7	HL	81.8
8	TKW	70.0
9	Protein (%)	74.26
10	SY	61.02
11	SC	88.97
12	Sedimentation	71.81
	Sums of ranks	**73.52**

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Agro-morphological traits

Means of entries and Tukey's grouping for agro-morphological traits under study for SI and RF conditions were given in *Table 4a* and *Table 4b*, respectively.

Table 4a. *Means of entries and Tukey's grouping for agro-morphological traits for supplementary irrigation*

Entry No.	PH/ Groups (cm)	SPAD/Groups	NSm^{-2}/ Groups	NGS^{-1}/ Groups	GWS^{-1}/ Groups (g)
1	97,5bc	55,00a	716,0a	50,9a	2,175a
2	87bc	54,25a	765,5a	57,8a	2,320a
3	85,5bc	51,10a	776,0a	42,7a	1,875a
4	96,5bc	46,55a	645,5a	47,1a	2,190a
5	81,5c	56,35a	525,5a	36,9a	2,090a
6	89,5bc	54,45a	589,0a	55,1a	2,860a
7	99,5bc	56,20a	678,0a	61,1a	3,110a
8	93,5bc	60,45a	716,5a	46,4a	2,150a
9	90,5bc	55,75a	602,0a	40,9a	2,360a
10	91,5bc	52,35a	662,5a	58,1a	2,985a
11	91,5bc	54,95a	561,5a	52,0a	2,385a
12	99,0bc	57,5a	593,5a	64,6a	2,910a
13	94,5bc	55,20a	707,0a	58,8a	2,830a
14	92,5bc	53,50a	684,5a	64,7a	3,225a
15	93,0bc	51,00a	642,5a	38,5a	2,045a
16	128,5a	60.60a	541,0a	40,2a	3,020a
17	106,5ab	48,70a	521,0a	40,3a	1,950a
Grand mean	**95,19**	**54,34**	**642,79**	**50,35**	**2,498**

Table 4b. *Means of entries and Tukey's grouping for agro-morphological traits for rain fed conditions*

Entry no.	PH/ Groups (cm)	SPAD/Groups	NSm^{-2}/Groups	NGS^{-1}/ Groups	GWS^{-1} /Groups (g)
1	93,0bc	50,30a	676,0a	57,3a	2,085a
2	91,0bc	54,05a	693,5a	46,4a	1,300a
3	91,5bc	52,55a	765,0a	40,5a	1,390a
4	97,5bc	48,70a	607,0a	50,5a	1,380a
5	89,5b	53,40a	633,0a	41,1a	1,870a
6	90,0bc	51,00a	591,0a	58,5a	2,215a
7	104,0a-c	55,20a	663,0a	57,9a	2,435a
8	85,5c	56,70a	649,0a	57,9a	2,285a
9	86,5c	53,65a	574,5a	46,8a	2,115a
10	101,5a-c	52,35a	571,0a	50,5a	2,105a
11	93,0bc	52,75a	632,5a	52,9a	1,845a
12	99,5bc	58,20a	664,5a	58,9a	1,970a
13	93,5bc	54,60a	595,5a	47,6a	1,780a
14	86,0c	55,95a	678,5a	46,0a	1,795a
15	85,0c	44,10a	541,5a	52,3a	1,370a
16	119,5a	48,65a	507,0a	55,3a	1,955a
17	109,5ab	45,35a	637,0a	42,4a	1,150a
Grand mean	**95,05**	**52,20**	**628,20**	**50,75**	**1,826**

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Plant height under SI and RF conditions (cm)

ANOVA for plant height in SI showed that entries were statistically significant with F=6,91** and the replications were non-significant. Entries 5,3,2,6 and 9 were the shortest genotypes giving 81,5, 85,5,87,0, 89,5 and 90,5 cm, respectively.

ANOVA for same trait in RF indicated the presence of genetic variability among entries for PH giving F=7, 45**. Replications were non-significant. Entries 15, 8, 14,9 and 5 were the shortest entries giving 85, 85,5, 86, 86,5 and 89,5 cm, respectively. Rank coefficient of correlation between PH's of supplementary irrigated vs rain fed conditions was 63,9%.

SPAD for SI and RF conditions

SPAD ANOVA for SI showed that neither entries nor replications were significant. Entries 16, 8, 12, 5 and 7 gave the highest ranks giving 60,6, 60,4, 57,5, 56,35 and 56,2, respectively.

SPAD ANOVA for RF showed the absence of any significant effect. Entry numbers of 12, 8,14, 7 and 13 were highest SPAD giving entries with 58,2, 56,7, 55,95, 55,2 and 54,6 respectively. Rank coefficient of correlation between SPAD's of supplementary irrigated conditions vs rain fed conditions was 52,2%.

Number of spike m^{-2} for SI and RF condition

Entries in the ANOVA for SI was not significant whereas, replications turned out to be significant (F=67,36**). Entry numbers of 3, 2, 8, 1 and 13 placed at first five ranks giving 776, 765,5, 716,5, 716 and 707, respectively.

As given above, entries were not significant in the ANOVA for RF and the replications were significant (F=95,99**). Entry numbers of 3, 2, 14, 1 and 12 placed at first five ranks giving 765, 693,5, 678,5, 676 and 664,5. Rank coefficients of correlations between NSs of supplementary irrigation vs rain fed condition was 54,6%.

Number of grain $spike^{-1}$ for SI and RF conditions

ANOVA for SI showed that entries were significant (F=3,48**) with a non-significant replication. Tukey's mean grouping showed that entry numbers of 14, 12,7,13 and 10 placed at top five ranks giving 64,7, 64,6, 61,1, 58,8 and 58,1, respectively.

Neither source of variation turned out to be significant in the ANOVA for SI. Entry numbers of 12, 6, 7, 8 and 1 placed at first five ranks giving 58,9, 58,5, 57,9, 57,9 and 57,3 respectively. Rank coefficient of correlation between NGs of SI vs RF was 38,7%.

Grain weight $spike^{-1}$ SI and RF conditions (g)

Neither source of variation turned out to be significant in the ANOVA for SI. The accessions 14, 7, 16,10 and 12 were the highest-ranking entries giving 3,22, 3,11, 3,02, 2,98 and 2,91 g, respectively.

Replications were significant in the ANOVA for RF (F=16,95**). Varieties were non-significant. The varieties 7,8,6,9 and 10 were the highest grain weight giving entries with 2,43, 2,28, 2,21, 2,11 and 2,10 g, respectively. Rank coefficient of correlation between GWs of SI vs RF was 46,32%

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Quality traits

Means and Tukey's grouping for some quality traits under study for both SI and RF conditions in Koruklu were given at *Table 5a* and *Table 5b*, respectively.

Table 5a. *Means of entries and Tukey's grouping for some quality traits for supplementary irrigation at Sanliurfa*

Entry no.	HL/Groups (kg)	TKW/Groups (g)	P/Groups (%)	SY/Groups (%)	SC/Groups	S/Groups (mm)
1	84,00a-d	41,73cd	14,56b-e	72,33a	26,80ef	20,06b-d
2	83,20cd	35,18e	14,03e	71,00a	32,96a	19,00b-e
3	84,00a-d	42,00cd	15,13b-e	72,33a	29,23cd	21,33a-c
4	83,20cd	42,66b-d	15,73a-c	71,00a	32,03ab	21,33a-c
5	83,86a-d	54,40a	16,60a	72,66a	25,23f	17,00ef
6	86,00a	46,93b	14,53b-e	72,00a	29,63cd	15,33f
7	84,66a-c	44,53bc	14,76b-e	73,00a	28,66d	18,66c-e
8	83,60b-d	45,33bc	15,63a-d	71,66a	30,83bc	21,66ab
9	84,40a-d	53,20a	15,83a-c	73,66a	25,36f	18,00d-f
10	82,40d	42,80b-d	15,13b-e	73,00a	25,93f	20,66a-d
11	83,60b-d	42,13cd	14,23de	69,33a	29,83cd	15,33f
12	82,66cd	38,08de	14,16e	71,33a	28,86d	17,00ef
13	85,60ab	46,13bc	15,03b-e	73,33a	28,50de	19,33b-e
14	83,46b-d	42,00cd	14,50b-e	71,66a	25,66f	20,66a-d
15	83,46b-d	46,40bc	15,66a-d	72,33a	29,70cd	23,00a
16	70,00f	54,80a	14,40c-e	73,66a	26,36f	20,00b-d
17	78,66e	43,06bc	15,90ab	71,33a	20,66e	19,66b-e
Grand mean	**82,75**	**44,78**	**15,044**	**72,094**	**28,01**	**19,29**

HL: hectoliter weights, TKW: Thousand kernel weights, P: protein, SY: Semolina Yield, SC: Semolina color, S: Sedimentation

Table 5b. *Means of entries and Tukey's grouping for some quality traits for rain fed condition at Sanliurfa*

Entry no.	HL/Groups (kg)	TKW/Groups (g)	P/Groups (%)	SY/Groups (%)	SC/Groups	S/Groups (mm)
1	79,93a-c	31,20de	15,53ab	68,33a-c	27,40c-e	21,66a
2	77,86cd	26,60e	15,26ab	69,33a-c	32,90a	22,33a
3	80,53a-c	32,93c-e	15,90ab	69,33a-c	31,40a-e	25,33a
4	78,53b-d	31,86de	16,66ab	68,33a-c	32,10ab	23,33a
5	81,46ab	42,00ab	16,00ab	69,33a-c	27,60c-e	20,00a
6	82,13a	35,33b-d	14,93b	68,00bc	30,20a-d	18,66a
7	81,33b	36,00b-d	15,20ab	70,33a-c	29,10a-d	21,33a
8	78,26b-d	34,13b-c	16,23ab	69,00a-c	32,20ab	21,00a
9	81,46ab	41,06a-c	15,86ab	70,00a-c	26,20de	18,66a
10	79,60a-d	33,46c-e	14,66b	69,33a-c	27,40c-e	21,33a
11	80,00a-c	32,00de	14,86b	67,33c	30,06a-d	20,33a
12	79,60a-d	32,53de	14,50b	70,00a-c	29,73a-d	19,00a
13	80,53a-c	31,86de	16,06ab	72,00a	29,90a-d	21,66a
14	80,66a-c	35,46b-d	15,30ab	71,33ab	28,00b-d	22,66a
15	78,80b-d	32,66de	17,46a	70,33a-c	28,83a-d	24,66a
16	68,26c	49,06a	15,13ab	70,66a-c	27,40c-e	19,66a
17	76,40d	36,26b-d	16,93ab	68,00bc	23,33e	22,33a
Grand mean	**79,13**	**34,96**	**15,67**	**69,46**	**29,04**	**21,40**

HL: hectoliter weights, TKW: Thousand kernel weights, P: protein, SY: Semolina Yield, SC: Semolina color, S: Sedimentation

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Hectoliter weight for SI and RF conditions (kg/hl)

ANOVA for SI showed that entries were significant for this trait (F=74,8**), whereas replications turned out to be non-significant. Entry numbers of 6,13,7,9, and 1 placed at top five ranks giving 86, 85,6, 84,66, 84,4, and 84 kg, respectively.

ANOVA for RF indicated the presence of statistical significance for both entries (F0 28,8**) and replications (F=6,02**). Entry numbers of 6,9,5,7 and 14 gave the highest five ranks with 82,1, 81,46, 81,33, 80,66 and 80,53 kg respectively. Rank coefficient of correlation between Hl's of SI vs RF was 81,8%.

1000 kernel weights for SI and RF conditions (g)

ANOVA for SI indicated the presence of statistically significance for both entries (F=35,69**) and replications (F=5,86**). Entries 16,5,9,6, and 15 were the highest TKW giving entries with 54,8, 54,4, 53,2, 46,9 and 46,4 g, respectively.

ANOVA for RF showed the presence of statistically significance for entries (F=10.47**). Replications were non-significant. The accessions 16, 5,9,17, and 7 placed at first five ranks giving 49,06, 42, 41,06, 36,26 and 36,00 g, respectively. Rank coefficient of correlation between TKW's of SI vs RF was 70%.

Protein for SI and RF conditions (%)

ANOVA for SI showed that entries were significant (F= 7,23**) and contrary the replications were non-significant. Entries 5, 17, 9,4 and 15 were the top five ranking entries giving 16,6, 15,9, 15,8, 15,7 and 15,6%, respectively.

ANOVA for RF presented that both replications and entries were significant statistically giving F= 4,98** and F=3.14**, respectively. The accessions 15,17,4,8 and 13 were the top five ranking entries giving 17,46, 16,93, 16,61, 16,23 and 16,06%, respectively. Rank coefficient of correlation between P%'s of SI vs RF condition was 74,26%.

Semolina color for SI and RF conditions

ANOVA for SI showed that both entries and replications were significant giving F=429,1** and 4,83**, respectively. Entries 2,4,8,11, and 15 were the highest-ranking entries with 32,96, 32,03, 30,83, 29,83 and 29,70, respectively.

ANOVA for RF showed statistically significance for only entries with F=8,91**. Entry numbers of 2,8,4,3, and 16 were the top five ranking entries giving 32,9, 32,2, 32,13, 31,4 and 30,2, respectively. Rank coefficient of correlation between SCs of SI vs. RF conditions was 88,97%.

Semolina yield for SI and RF conditions (%)

ANOVA for SI indicated the absence of any statistical significance all sources of variations. However, entries were about at the significance threshold with F=1,84 ($p<0.0687$). Entry numbers of 9,16,13,10 and 7 placed at top five ranks giving 73,66, 73,66, 73,33, 73,0, 73,0%, respectively.

ANOVA for RF showed the presence of statistical significance for both entries (F=3,04**) and replications (F=6,43**). Entry numbers of 13,14,16,15 and 7 were the highest SY giving entries with 72,00, 71,33, 70,66, 70,33 and 70.0%, respectively. Rank coefficient of correlation between SY's for SI and RF was 61,02%.

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Sedimentation for SI and RF conditions (mm)

ANOVA for SI indicated that only entries were significant (F= 17,39**). Entry numbers of 15, 8,13,4, and 10 were at the top five ranks giving 23,00, 21,66, 21,33, 21,33 and 20,66, respectively.

ANOVA for RF revealed that only entries were significant (F= 2.22*). Entry numbers of 3,15,4,14 and 17 were the highest five sedimentation giving entries with 25,33, 24,66, 23,33, 22,66 and 22,33 respectively. Rank coefficient of correlation between Ss of SI vs. RF was 71,81%.

Index selection

The result of variety selection based on rank-sums for SI and RF conditions were given in *Table 6a* and *Table 6b*, respectively. Grain yield, agro-morphological and quality traits were evaluated jointly. Lower values for PH were given higher ranks. Finally, sums of ranks of all traits for SI and RF conditions were also ranked, and the durum wheat cultivars Sümerli, Alatay, Artuklu, Özberk, Zühre, Sarıcanak-98 and Perre were the top seven entries under SI conditions. However, cultivars Artuklu, Sümerli, Perre, Zühre, Sarıcanak-98, Fırat-93, and Tüten-2002 were the top seven varieties for RF environments. Sümerli, Artuklu, Zühre, Perre and Sarıcanak-98 can be grown in either condition safely. Rank coefficient of correlation for index ranking of SI vs. RF was 73,52%.

Table 6a. *Index selection through ranks and sums of ranks for all traits under study in SI conditions*

Entry no	GY (kg ha)	PH (cm)*	SPAD	NS	NGS^{-1}	GWS^{-1}	HL (kg)	TKW (g)	P (%)	SY	SC	S	Sum**s	Rank of sums/varieties ***
1	12	13	8	4	9	12	5	15	11	7	11	7	114	12
2	3	3	11	2	6	10	12	17	17	15	1	11	108	9
3	7	2	14	1	12	17	6	14	7	9	7	3	99	5 Zühre
4	11	12	17	9	10	11	13	11	4	16	2	4	120	14
5	13	1	4	16	17	14	7	2	1	6	16	15	112	11
6	10	4	10	13	7	6	1	4	12	10	6	17	100	6 S. Canak-98
7	4	15	5	7	3	2	3	8	10	5	9	12	83	3 Artuklu
8	1	10	2	3	11	13	9	7	6	12	3	2	79	1 Sümerli
9	14	5	6	11	13	9	4	3	3	1	15	13	97	4 Özberk
10	15	7	13	8	5	4	15	10	8	4	13	5	107	8
11	5	6	9	14	8	8	8	12	15	17	4	16	122	16
12	2	14	3	12	2	5	14	16	16	13	8	14	119	13
13	6	11	7	5	4	7	2	6	9	3	10	10	80	2 Alatay
14	8	8	12	6	1	1	10	13	13	11	14	6	103	7 Perre
15	9	9	15	10	16	15	11	5	5	8	5	1	109	10
16	16	17	1	15	15	3	17	1	14	2	12	8	121	15
17	17	16	16	17	14	16	16	9	2	14	17	9	157	17

*The lowest PH, the highest rank
** The lowest sums, ***the highest rank

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Table 6b. *Index selection through ranks and sums of ranks for all traits under study in RF conditions*

Entry no	GY (kg ha)	PH (cm)*	SPAD	NS	NGS^{-1}	GWS^{-1}	HL (kg)	TKW (g)	P (%)	SY	SC	S	Sum**	Rank of sums/varieties ***
1	3	10	13	4	5	6	9	16	9	13	13	7	108	10
2	6	7	6	2	13	16	15	17	11	9	1	6	109	11
3	2	8	10	1	17	13	7	10	7	10	4	1	90	4 Zühre
4	13	12	14	11	10	14	13	15	3	14	3	3	125	13
5	7	5	8	9	16	9	3	2	6	11	12	13	101	6 Fırat-93
6	5	6	12	13	2	3	1	7	14	16	5	16	100	5S.Canak-98
7	1	15	4	6	3	1	4	5	12	5	9	10	75	1Artuklu
8	8	2	2	7	4	2	14	8	4	12	2	11	76	2Sümerli
9	11	4	7	14	12	4	2	3	8	6	16	17	104	8
10	14	14	11	15	6	5	10	9	16	8	14	9	131	15
11	10	9	9	10	8	10	8	13	15	17	6	12	127	14
12	4	13	1	5	1	7	11	12	17	7	8	15	101	6 Tüten-2002
13	12	11	5	12	11	12	6	14	5	1	7	8	104	8
14	9	3	3	3	14	11	5	6	10	2	11	4	80	3 Perre
15	15	1	17	16	9	15	12	11	1	4	10	2	113	12
16	16	17	15	17	7	8	17	1	13	3	15	14	143	16
17	17	16	16	8	15	17	16	4	2	15	17	5	148	17

*The lowest PH, the highest rank
** The lowest sums, ***the highest rank

Discussion

The CV of combined ANOVA's through locations for both SI and RF experiments with less than 10% proved to be reliable. Prerequisites for the homogeneity of error variance were fulfilled. Mean yield of SI trial at Sanliurfa (7,634.4 kg. ha^{-1}) was higher than that of Adiyaman (6,875.0 kg. ha^{-1}). This was also same for rain fed field trials, in which mean yield of Sanliurfa (5,370.0 kg ha^{-1}) was higher than that of Adiyaman (4,824.3 kg ha^{-1}). Despite having adequate rainfalls in both locations nearly 600 mm, the lower mean yield of Adiyaman in RF condition might be attributed to the non-regular rain distribution during the grain filling period. In fact, in April and May, Adiyaman received relatively less rainfall than that of Koruklu. Average mean yield of SI experiments of both locations (7,256.0 kg ha^{-1}) vs. RF (5,097.0 kg ha^{-1}) was higher by 42.35%. This yield increase was 30.9% in durum wheat in float irrigation and 39.1% for furrow irrigation in Jordan (Carvallo et al., 2014). Huge yield gap was also detected between SI vs. RF in DW in Iran (Arzani, 2002). A 56,8% of Spearman's rank coefficient of correlation between SI vs. RF indicated moderate opportunity for selection of entries for grain yield in either condition. Agro-morphological traits except GWS^{-1} under study seemed to be slightly higher for SI than those of RF conditions. Average mean of all entries for GWS^{-1} for SI (2,498 g) were quite higher than that of RF (1,826 g). In similar conditions, primary

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yield related traits such as PH, NS, NGS, and GWS under RF (Garcia del Moral et al., 1991; Simane et al., 1993) were found to be lower than those for SI conditions. Agro-morphological traits under study as indicated by (Talebi et al., 2009) were either positively or negatively associated with the grain yield. Spearman's rank coefficients of correlation for agro-morphological traits ranged from 38,7% to 63,9% indicating the presence of moderate relations. HL, TKW, P%, SY, SC and S are the most referred quality criteria (Landi, 1995). Grand means of quality traits under this study pointed out that HL, TKW and SY for SI were higher than those of RF. P%, SC and S were slightly lower for SI than those of RF. Irrigation affected positively to HL, TKW and semolina yield, whereas P%, SC and S were not affected from irrigation. Spearman's rank coefficients of correlation of quality traits between SI vs. RF ranged from 61,02% to 88,97% indicating the presence of close relations for both SI and RF conditions and the heritability estimates for some quality traits with high Spearman's coefficients of correlation can be estimated accurately due to less environment influence on the trait (Colasuonno et al., 2019). Index selection based on sums of the ranks gave the equal chance to all traits under study. Grain yield, agro-morphological and quality traits were subjected to index selection and the lowest sums were also ranked for final cultivar selection for SI and RF conditions. As the only priority was given to grain yield, entries 8, 12, 2, 7, and 11 would be the first five ranking entries for SI conditions. The accessions 7, 3,1,12 and 6 would be picked up for RF conditions. Furthermore, if the priority was given to only agro-morphological traits including grain yield, the entries 2, 7, 13, 12 and 8 for SI, and 8, 7,12, 6 and 1 would be selected as first five ranking entries for RF, respectively. Considering for all traits under study, the entries 8, 13, 7,9, and 3 were selected for SI and entries 7,8,14,3 and 6 for RF conditions. The selected genotypes 8 (Sümerli), 7 (Artuklu), and 3 (Zühre) perform well in both environments and may be used directly in irrigated or in rain fed conditions in the studied locations, or in breeding programs to obtain a new cultivar for one of the two specific situations.

Conclusion

It was concluded that durum wheat varieties Sümerli, Artuklu and Zühre can be grown and recommended for farmers in the region for both SI and RF conditions. Simple index selection as indicated by Haider Shah et al. (2009) and Kılıc (2012) rather than many other complex indexes could be more practical and facile method for variety selection for stress and non-stressed environments. A 73,52% Spearman's rank coefficient of correlation between ranks of sums of SI vs. RF conditions points out that better genotypes for both SI and RF conditions can be picked up in either condition. Although entries shared common environment in this study in a single year, the results obtained from the study cannot be trusted fully. Comparisons for grain yields of entries for SI vs RF conditions must be further tested for yield stability and accurate conclusions.

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