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Quality Response of Facultative Wheat to Winter Sowing, Freezing Sowing and Spring Sowing at Different Seeding Rates

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Abstract: Researches on wheat mostly focus on growth and yield rather than quality characteristics. Beside the yield, quality parameters are also affected by genotypes, climate conditions, fertilizer applications, sowing times and sowing rates. This study was performed by using facultative Kirik wheat variety under the dryland conditions of Erzurum (Turkey) during the 2002-03 and 2003-04 seasons. Quality parameters were investigated with regard to three different sowing times [winter sowing (first week of September), freezing sowing (last week of October) and spring sowing (last week of April)] and seven different sowing rates (325, 375, 425, 475, 525, 575 and 625 seeds m^{-2}). Effects of sowing times on flour ash content were found to be significant. Although, early sowing times (winter sowing and freezing sowing) increased flour yield, the latest sowing time (spring sowing) had the highest values for the other parameters (sedimentation volume, wet gluten content and dry gluten content). Seeding rates had significant impacts on entire parameters. However, effect of sowing times and seeding rates over investigated parameters were not stable with regard to years and exhibited variations with years. While the seeding rate of 325 seeds m^{-2} was found to be suitable for flour yield, 525-625 seeds m^{-2} like dense seeding rates had better values with regard to other parameters (sedimentation volume, wet gluten content, dry gluten content and flour ash content). Grain moisture contents of different sowing times and rates observed in both years of the experiments were within the acceptable limits for storage. Falling numbers were found to be higher than desired values but almost optimum value was observed at spring sowing treatment of 2002-03. Results of this study revealed that the sowing time of spring sowing with seeding rates of 525 seeds m^{-2} or over densities was better than the other sowing periods and rates with regard to quality parameters.

Key words: Facultative wheat, sowing times, seeding rates, quality

INTRODUCTION

Cereals are the characteristic crop group of both Turkish agriculture and Northeastern Anatolia region. While the cultivated land resource of Erzurum in the region is 231.536 ha, wheat is cultivated over 103.872 ha of this land resource and the yield is 1430 kg ha^{-1} (Anonymous, 2010). Wheat yield of Erzurum province is below the country average (2200 kg ha^{-1}).

There are several factors effective in low yield levels of wheat in the region. Almost 80% of regional wheat production is consumed by producer families and the low-yield variety Kirik with weak response against fertilization and irrigation is cultivated over large part (55%) of cultivated lands (Anonymous, 1997). The case is similar in Erzurum and this variety is used >60% of wheat cultivated lands (Anonymous, 2003). The variety Kirik is commonly used in the region just because of its facultative characteristics, white grains and suitability for making traditional bread. That is why local farmers, making their own bread from their own product, prefer varieties suitable for making traditional bread against high-yield varieties. Although, several high-yield registered varieties able to be grown under dry and irrigated conditions of local ecology were developed and provided for the use of local farmers to increase the wheat yield of the region, these varieties have not been adopted enough by the local farmers and therefore have not widespread over the land resources of the region. It was mostly because the new varieties do not have the desired quality characteristics and almost all of them are winter-sown varieties and farmers are mostly not able to sow on time due to various reasons.

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In spite of common use in the region, there is a lack of scientific research on cultivation technique of the variety Kirik. Farmers have been using traditional methods for years in cultivation of this variety. High lengths, sensitivity against lodging and low tillering capacity require special attention in sowing rate. Unit area yield of wheat is closely related to sowing rate. The variety has facultative characteristic and can be sown either in winter or spring. It is winter-sown sometimes after potatoes and sugar beet like crops. In case these previous crops are not harvested late and left the field for wheat on time for winter sowing, it is sown either in late-fall as freezing (buried) or in early spring as spring sown. Yield of spring sowing is almost half of winter sowing and yield in freezing sowing is also higher than spring sowing (Kun, 1988). Excessive seed utilization and general preference for spring sowing are the two basic reasons for low yield of the variety Kirik. Therefore, both sowing rate and sowing time should together be investigated for this variety. Darwinkel *et al.* (1977) stated that sowing rate and time of wheat could not be thought separately and sowing rate x sowing time interaction was a significant issue in wheat. Moving from these facts, Ozturk *et al.* (2006) carried out a research on yield response of the bread variety Kirik of the region against different sowing times (winter, freezing and spring) and sowing densities (325, 375, 425, 475, 525, 575 and 625 seeds m^{-2}). Researchers recommended sowing rate of 525 seeds m^{-2} for winter sowing and 575 seeds m^{-2} for freezing and spring sowing and indicated higher yields for winter sowing than freezing and spring sowings.

As it was in Turkey, there is a general lack of research on quality of bread wheat in the region. Yield potential studies should also deal with quality potentials of the varieties (Sumer, 2008). In this study, impacts of different sowing times and seeding rates on quality parameters of wheat variety of Kirik were investigated. Recommendations were also made in this study for proper sowing time and seeding rate of this bread variety with regard to quality parameters.

MATERIALS AND METHODS

Location, design and treatments: A 2 years field experiment was conducted at the Experimental Farm of Ataturk University in Erzurum (29° 55'N and 41°16'E with altitude of 1850 m) Turkey during the 2002-03 and 2003-04 growing seasons under rainfed conditions. Type of soil was clayey loam with an organic matter content of 1.7-1.9% and pH of 7.7-7.8. Available P and K contents of the soil were 15.7-18.8 and 1790.1-1870.4 kg ha^{-1}, respectively.

The experiment included three sowing times: 2 September (Winter Sowing (WS)), 28 October (Freezing Sowing (FS)) and 28 April (Spring Sowing (SS)) in 2002-03: 1 September (WS), 26 October (FS) and 29 April (SS) in 2003-04. Seeding rates in all years were 325, 375, 425, 475, 525, 575 and 625 viable seeds m^{-2}. Randomized complete block design with four replicates was used with treatments arranged in a split plot, sowing times as main plots and seeding rates as sub-plots.

Crop management and measurements: The field was prepared by ploughing to a depth of 0.20 m, which was followed by surface cultivation. The facultative bread wheat cultivar Kirik (awnless, white grain) was used in the experiment. Plots were sown with a six-row planter. Sub-plots consisted of six rows spaced 20 cm apart, with a row lenght of 6.0 m. Plots were basically fertilised with 60 kg ha^{-1} N and 50 kg ha^{-} P_2O_5. In experiments, Ammonium sulphate (20.5% N) fertilizer was used as nitrogen source and Superphosphate fertilizer (18.0% P_2O_5) was used as phosphorus source. Half of N and all P were applied at sowing; the second half of N was applied at the beginning of stem elongation. Weeds were controlled by hand each season.

Quality analyses were performed at quality analysis laboratories of Ataturk University, Agricultural Faculty, Food Engineering Department. Flour yield was determined in accordance with Seckin (1975) and flour ash content in accordance with Ozkaya (1978). Dry gluten content was determined in accordance with the method specified by Ozkaya and Kahveci (1990). Whole kernels were analysed for moisture content Method 110 (International Association of Cereal Chemistry (ICC), 1986). The falling number values were determined according to ICC Standard 107 (International Association of Cereal Chemistry (ICC), 1986). Wet gluten content of flour samples was determined by International Association of Cereal Chemistry (ICC) (1986) Method 106 and expressed on a 14% moisture basis. Sedimentation volume values Method 116 (International Association of Cereal Chemistry (ICC), 1986) were tested using whole meal flour.

Years and sowing times were considered to be random while seeding rates were considered to be fixed. Analysis of variance was performed with the MSTAT-C (1991) software package. When year x treatment interactions were not significant, data were combined over years and presented as 2 years mean values.

RESULTS AND DISCUSSION

Meteorological variations of some climate factors for Erzurum Plain during years of the study and long-term averages were also shown in Table 1. The total annual rainfall was 368.2 and 501.5 mm in 2002-03 and 2003-04, respectively. Monthly rainfall for the 2002-03 season did not differ greatly from the long term averages but 2003-04 season was wetter than the average. Amount of precipitation during grain filling period of wheat in 2002-03 was more appropriate than 2003-04. Annual average temperature was recorded as 4.9°C in 2002-03 and as 5.1°C in 2003-04. While the average temperatures of experimental years were close to each other, they were lower than long-term averages (5.6°C).

Mean values and variance analysis results about the effects of experimental factors on flour yield, grain moisture content, flour ash content, falling number, dry gluten content, wet gluten content and sedimentation volume were shown in Table 2.

Flour yield (%): As an average of experimental factors, flour yield of 2003-04 (59.4%) was found to be >2002-03 (57.1%). Drier climate conditions in 2002-03 (Table 1) caused to have of weak and small grains (Ozturk *et al*., 2006) and consequently lower flour yields. Flour yield of wheat decreases with increasing rate of small grains (Shuey and Gilles, 1969). Flour yield data of this study are in compliance with the results of previous studies (Ertugay, 1981; Egesel *et al*., 2009). Impacts of sowing times over flour yield were found to be significant in both years (2002-03 and 2003-04). While the highest flour yield (59.3%) was obtained from WS treatment in 2002-03, the highest value (60.3%) was observed in FS treatment of 2002-03. A regular decrease was observed in flour yield of 2002-03 with delay in sowing time (Table 2). Longer vegetative and grain filling periods in WS and FS treatments than SS treatment have positive impacts on grain yield (Ozturk *et al*., 2006) and increasing grain yield also increases flour yield. Seleiman *et al*. (2011) carried out a research about impacts of different sowing times (November 1st, November 15th, December 1st and December 15th) on yield, technological and rheological characteristics of bread wheat and observed the highest grain and flour yield from the sowing performed at November 15th. Researchers also observed the lowest fine and coarse bran percentages for this sowing time. Flood *et al*. (1996) also observed significant effects of sowing periods on flour yield. Sowing rates had significant impacts of flour yield in both 2002-03 and 2003-04 (Table 2) and the highest flour yield was

Table 1: Total montly rainfall and average montly temperature of the long-term averages (LTA) and crop season values of Erzurum

	Rainfall (mm)			Temperature (°C)		
Months	2002-03	2003-04	LTA	2002-03	2003-04	LTA
September	18.1	19.3	34.4	13.6	13.8	14.3
October	42.9	90.9	27.9	8.9	8.8	6.2
November	25.6	35.1	20.5	1.3	-0.7	2.6
December	19.7	16.1	23.3	-12.0	-6.6	-5.1
January	17.7	14.3	17.3	-7.7	-9.0	-16.1
February	30.7	90.0	16.2	-8.2	-8.7	-3.4
March	32.9	33.7	55.6	-6.6	-1.7	-1.0
April	81.4	36.0	50.5	4.4	4.0	4.2
May	29.9	121.7	59.3	11.6	9.7	10.4
June	45.7	40.7	31.7	14.5	14.5	15.3
July	18.5	2.4	23.6	18.9	17.9	19.9
August	5.1	1.3	8.4	20.0	19.6	19.5
Total	368.2	501.5	368.7	-	-	-
Mean	-	-	-	4.9	5.1	5.6

LTA: from 53 years

Table 2: Effects of experimental variables on flour yield, grain moisture content, flour ash content, falling number, dry gluten content, wet gluten content and sedimentation volume

	Flour yield (%)		Grain moisture content (%)			Falling number (s)		Dry gluten content (%)		Wet gluten content (%)		Sedimentation volume (mL)	
Variables	2002-03	2003-04	2002-03	2003-04	Flour ash content (%)	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04
Years (Y)													
2002-03	-	-	-	-	-	0.549^{a}	-	-	-	-	-	-	-
2003-04	-	-	-	-	-	0.457^{b}	-	-	-	-	-	-	-
Mean	57.1	59.4	10.4	10.2	0.503	353.2	435.3	11.8	10.3	37.1	31.1	43.4	35.0
Sowing Times (ST)													
Winter	59.3^{a}	60.0^{b}	10.6^{a}	10.1^{b}	0.500	435.4^{a}	369.1^{c}	10.1^{c}	8.5^{c}	31.2^{c}	26.5^{c}	37.9^{b}	30.0^{b}
Freezing	56.6^{b}	60.3^{a}	10.4^{a}	10.2^{a}	0.507	365.1^{b}	457.8^{b}	11.8^{b}	9.5^{b}	36.9^{b}	29.1^{b}	37.2^{c}	33.6^{c}
Spring	55.3^{c}	57.7^{c}	10.2^{b}	10.3^{ab}	0.502	259.2^{c}	479.0^{a}	13.5^{a}	12.9^{a}	43.1^{a}	37.8^{a}	55.1^{a}	41.2^{a}
Sowing Rates (SR, seeds/m²)													
325	57.5^{a}	61.3^{a}	10.4^{abc}	10.2^{a}	0.533^{ab}	354.4^{bc}	429.3^{c}	11.7^{bc}	9.5^{e}	36.9^{cd}	29.2^{d}	39.7^{f}	31.6^{e}
375	58.8^{b}	57.8^{f}	10.5^{ab}	10.2^{a}	0.578^{a}	380.0^{a}	394.2^{d}	11.9^{b}	10.1^{cd}	37.1^{c}	31.3^{b}	40.4^{e}	32.7^{d}
425	56.9^{c}	57.1^{g}	10.3^{bc}	10.1^{b}	0.528^{ab}	340.6^{c}	444.0^{b}	11.1^{d}	9.9^{d}	34.8^{e}	30.0^{c}	40.8^{e}	36.0^{b}
475	57.3^{b}	60.9^{b}	10.6^{a}	10.1^{b}	0.489^{bcd}	369.9^{ab}	440.6^{bc}	11.8^{b}	10.9^{a}	36.4^{d}	33.8^{a}	42.2^{d}	34.6^{c}
525	57.0^{c}	58.9^{e}	10.3^{c}	10.2^{a}	0.511^{abc}	341.2^{c}	436.9^{bc}	12.4^{a}	10.4^{b}	38.7^{a}	30.2^{c}	47.1^{b}	$35.3b^{c}$
575	55.9^{e}	60.1^{c}	10.3^{c}	10.2^{a}	0.444^{cd}	334.1^{c}	456.7^{a}	12.0^{b}	10.3^{bc}	37.8^{b}	30.2^{c}	45.6^{c}	37.5^{a}
625	56.3^{d}	59.4^{d}	10.4^{abc}	10.2^{a}	0.439^{d}	352.3^{bc}	445.1^{ab}	11.5^{c}	10.9^{a}	37.8^{b}	33.3^{a}	47.9^{a}	37.1^{a}
F-values													
Y	-	-	-	-	78.2*	-	-	-	-	-	-	-	-
ST	1799.4***	1758.7***	11.2*	13.0*	0.0919	382.4***	1177.4***	287.7***	1430.3***	5889.9***	4234.8***	23624.1***	5870.1***
SR	158.5***	4312.9***	6.2**	7.4***	7.4***	7.7***	42.1***	26.4***	86.2***	49.7***	164.8***	364.1***	81.5***
Y x ST	-	-	-	-	0.0919	-	-	-	-	-	-	-	-
Y x SR	-	-	-	-	11.250	-	-	-	-	-	-	-	-
ST x SR	114.2***	1561.8***	6.9***	6.3***	0.3524	9.9***	10.3***	41.5***	72.4***	95.7***	96.6***	341.5***	42.2***
Y x ST x SR	-	-	-	-	0.2911	-	-	-	-	-	-	-	-
CV (%)	0.39	0.12	46753,0	0.53	15.45	5.11	2.12	1.98	1.58	1.44	1.32	1.24	2.08

The mean values with the same letter within variable are not significantly different (Duncan's multiple range test p<0.05), significant at *0.05, **0.01 and ***0.001 levels observed at 375 seeds m^{-2} sowing rate of 2002-03 (58.8%) and 325 seeds m^{-2} of 2003-04 (61.3%). In both years, the sowing rate of 475 seeds m^{-2} was found to be the second best sowing rate with regard to flour yield (57.3% in 2002-03 and 60.9% in 2003-04). Flour yields exhibited irregular variations with both sowing rates and experimental years. Geleta *et al*. (2002) similarly observed significant effects of sowing rates on flour yield. Xue *et al*. (2011), on the contrary to this study, observed increasing flour yields with increasing sowing rates. Geleta *et al*. (2002) studied 4 different sowing rates (16, 33, 65 and 130 kg ha^{-1}) and observed significant and regular increases in flour yield up to 65 kg ha^{-1} sowing rate.

Grain moisture content (%): Average grain moisture content was higher (10.4%) in 2002-03 than it was (10.2%) in 2003-04 (Table 2). Higher precipitations during the grain filling of the year 2002-03 (Table 1) caused to have higher grain moisture contents than the year 2003-04. Moisture content is a significant issue for wheat trade and storage. Since, higher moisture contents decrease dry matter yields, it decreases commercial value of wheat and makes the storage difficult because of initiation of germination due to bacteria and fungi activity (Elgun *et al*., 1999). Grain moisture contents of Turkish wheats are between 8-14% with an average of 9-11%. The threshold value for moisture content is 14.6% (Unal, 2002). According to these values, the moisture content values obtained in this study were within the acceptable limits and the results were in compliance with other studies carried out in different regions of Turkey (Ekinci and Unal, 2002; Tayyar, 2005) and in studies carried out under Erzurum conditions (Ozturk and Aydin, 2004). Effects of sowing times on grain moisture content were found to be significant (Table 2) in both years (2002-03 and 2003-04). Each delay in sowing time during 2002-03, with low precipitation during growing period (Table 1) and high temperatures during grain filling period, decreased the grain moisture content. Moisture contents for WS, FS and SS treatments of 2002-03 were 10.6, 10.4 and 10.2%, respectively. Contrary conditions in 2003-04 caused slight increases in grain moisture content based on the delay in sowing time. Grain moisture contents for WS, FS and SS treatments of that time were 10.1, 10.2 and 10.3%, respectively. Impacts of seeding rates over grain moisture contents were found to be significant in both 2002-03 and 2003-04. While the lowest grain moisture content (10.3%) was obtained from 425, 525 and 575 seeds m^{-2} sowing rates in 2003-04, the lowest value (10.1%) was obtained from 425 and 475 seeds m^{-2} seeding rates in 2003-04. The variation in grain moisture content with sowing rates was irregular and varied with years (Table 2).

Flour ash content (%): Ash content of is bread-making related characteristics of wheat and is closely related to flour yield (Ozturk *et al*., 2010). Average ash content of flour samples was significantly higher in 2002-03 (0.549%) than the one in 2003-04 (0.457%). Dry climate conditions (Table 1) caused to have higher ash content values in 2002-03. Ozturk and Aydin (2004) indicated increasing ash contents with increasing temperatures and water stress. Lower flour yield values in 2002-03 are in compliance with literature of Shuey and Gilles (1969) indicating increasing ash contents with decreasing flour yields. General average of ash content in this study was determined as 0.503% and this value is in compliance with the results of Ertugay and Elgun (1986). Impact of years on flour ash content due to climate conditions were also reported by Egesel *et al*. (2009). Combined analysis of years yielded insignificant impacts of sowing times on flour ash content. In this study, flour ash contents of WS, FS and SS sowing times were 0.500, 0.507 and 0.502%, respectively (Table 2). Results of combined variance analysis for ash content of flour yielded significant differences among seeding rates. While the highest value (0.578%) was obtained from 375 seeds m^{-2} seeding rate, the lowest value was observed in 625 seeds m^{-2} seeding rate (Table 2). In spite of some exceptions increase in seeding rates generally decreased the ash content of flour. Ozturk *et al*. (2010) carried out a study with Kirik and Dogu 88 bread wheat varieties and indicated significant effects of sowing rates on ash content and also reported decreasing ash contents with increasing seeding rates.

Falling number(s): Falling number is a parameter used to determine the diastatic activity of wheat and effects amount of gas produced during bread-making, bread volume (Unal, 2002), bread inside texture and bread color (Ozturk *et al*., 2010). Falling number indicates the time in seconds (s) for wheat starch to lose its viscosity due to α and β amylase enzymes of flour (Unal, 2002). A falling number between 200-250s indicates normal enzyme activity and a value over 300 indicates low enzyme activity (Elgun *et al*., 1999). The falling number in 2002-03 (353.2s) was lower than the one (435.3s) in 2003-04 (Table 2). Results of both years indicated low enzyme activities not within desired limits. Falling numbers closer to optimum falling numbers in 2002-03 were mostly due to precipitations during July of that year (Table 1). Gooding and Davies (1997) indicated decreasing falling numbers with increasing alpha amylase activity due to late period precipitations. Similarly, Erekul *et al*. (2009) obtained observed lower falling numbers during the year with higher precipitations at starch formation period of wheat. Ozturk *et al*. (2010) in a study carried out with Kirik and Dogu 88 wheat varieties indicated significant effects of crop years on falling numbers and reported higher falling numbers for dry year. Diepenbrock *et al*. (2005) reported significant increases in falling numbers with dry weather conditions during the grain filling period and also reported consequent rapid decreases in enzyme activity of flour and volume decrease in bread. Effects of sowing times on falling number were found to be significant. Among the sowing periods, the highest falling number in 2002-03 was observed in WS with 435.4s and it was followed by FS with 365.1s and SS with 259.2s. A significant decrease was observed in falling number from early sowing to late sowing. The differences among sowing times with regard to falling number were found to be significant and sowing times were placed at different groups. Optimum falling number was obtained from SS in 2002-03 (259.2s). Falling number values of WS, FS and SS in 2003-04 were found to be as 369.1, 457.8 and 479.0s, respectively (Table 2). Falling numbers were also significantly affected by seeding rates. An unstable state was observed in impacts of seeding rates on falling numbers and falling numbers varied with seeding rates and years. Since, the desired falling number should be around 250s, considering the values closest values to desired one, seeding rate of 575 seeds m^{-2} with falling number of 334.1s in 2002-03 and seeding rate of 375 seeds m^{-2} with falling number of 394.2s came into prominence (Table 2). Different results were obtained from different studies about effects of seeding rates on falling numbers. While Gooding *et al*. (2002) and Ozturk *et al*. (2010) were reporting increasing falling numbers with increasing seeding rates, Sumer (2008) reported decreasing falling numbers with increasing seeding rates. Similar to this study, Ozturk *et al*. (2010) also reported significant impacts of seeding rates on falling numbers.

Dry gluten content (%): Dry gluten is obtained by drying wet gluten. Wet gluten has a water ratio of 2/3 and dry matter ratio of 1/3. Therefore, amount of dry gluten is controlled by wet gluten. Almost 80-85% of wheat protein constitutes dry gluten and it is related to amount of protein (Unal, 2002). Dry gluten content was found to be higher in 2002-03 (11.8%) than in 2003-04 (10.3%). Dry climate conditions caused to have higher dry gluten contents in 2002-03 (Table 1 and 2). Since, starch synthesis and accumulation in grain is more sensitive to dry conditions than proteins, these dry conditions might have increased the dry gluten content. Impacts of sowing times on dry gluten content were found to be significant. Similarly, Khattak *et al*. (2007) and Seleiman *et al*. (2011) also observed regular increases in dry gluten contents with advenced sowing times in both crop years. Differences among sowing times were found to be significant and each time was placed in different group. Dry gluten contents of WS, FS and SS were found to be respectively as 10.1, 11.8 and 13.5% in 2002-03 and as 8.5, 9.5 and 12.9% in 2003-04 (Table 2). Seeding rates had significant impacts of dry gluten contents and different results were obtained based on seeding rates and years. While the highest dry gluten content (12.4%) was observed at 525 seeds m^{-2} seeding rate of 2002-03, the highest value (10.9%) was obtained from 475 and 625 seeds m^{-2} seeding rates (Table 2).

Wet gluten content (%): Wet gluten is a significant quality parameter of wheat for bread-making and it is an elastic protein indicating the suitability of dough for making bread (Ozturk and Gokkus, 2008). Wet gluten content is generally related to nitrogenous matter content of grain and it yields an idea about the amount of protein rather than the quality of protein (Elgun *et al*., 1999). Average wet gluten content was determined as 37.1% in 2002-03 and 31.1% in 2003-04 and the higher value was observed in 2002-03 (Table 2). That was mostly because of high sedimentation values observed in 2002-03 with drier climate conditions (Table 1). Ozturk and Aydin (2004) pointed out the positive relationship (r = 0.721) between wet gluten content and sedimentation volume and stated increasing wet gluten contents with water stress. Schaefer (1962) and Krejcirova *et al*. (2007) reported significant impacts of environmental conditions on wet gluten content and Ozturk and Gokkus (2008) reported that wet gluten content was varied based on years. Unal (2002), classified wet gluten contents of flours as high for >35%, good for 28-35%, medium for 20-27% and low for below 20%. Higher wet gluten contents represent better qualities for bread-making. The average values observed in this study revealed good quality of Kirik variety for making bread (Table 2). Sowing times had significant effects on wet gluten content in both 2002-03 and 2003-04. The highest gluten content was observed in SS treatment in both years and it was followed by FS and WS. Wet gluten contents were found to be as 31.2, 36.9 and 41.3%, respectively for WS, FS and SS of 2002-03 and as 26.5, 29.1 and 37.8%, respectively for WS, FS and SS of 2003-04 (Table 2). Similarly, lower gluten contents were observed in early sowings and increasing contents were seen with advenced sowing times by Kahraman (2006). Seeding rates had also significant effects on wet gluten contents. While the highest gluten content (38.7%) was observed at 525 seeds m^{-2} seeding rate in 2002-03, the highest value (33.8%) was seen at 475 seeds m^{-2} seeding rate in 2003-04. Effects of seeding rates on wet gluten contents with regard to years were unstable and varied with years (Table 2). Similar to this study, Sumer (2008) also observed significant impacts of sowing rates on wet gluten contents.

Sedimentation volume (mL): Sedimentation test is also a significant indicator of wheat quality for making bread and provides an idea about protein quality beside the amount. Flours with high gluten content and high quality gluten have also high sedimentation volume (Elgun *et al*., 1999). Higher sedimentation volumes indicate better water holding capacity of gluten and larger volume of bread made of these flours (Elgun *et al*., 2001). The difference in quality of breads made of flours with the same protein content comes from higher or lower sedimentation volumes (Kahraman, 2006). Average sedimentation volume was measured as 43.4 mL in dry year of 2002-03 and as 35.0 mL in 2003-04 with more appropriate climate conditions (Table 1 and 2). The year 2002-03 with higher gluten (wet and dry) content had higher sedimentation volume (Table 2). Ozturk and Aydin (2004) carried out a correlation analysis and pointed out the positive relationship between wet gluten content and sedimentation volume. Ozturk *et al.* (2010) observed lower sedimentation volumes in the experimental year with higher precipitations. Unal (2002) defined the Zeleny sedimentation values of bread wheat as very good for >30 mL, good for 25-30 mL, medium for 20-25 mL, weak for 15-20 mL and poor for <15 mL. According to this classification, the variety Kirik can be classified as very good (Table 2). Sowing times had significant impacts on sedimentation volume. The highest sedimentation volume was obtained from SS treatment of both years. While the value was 55.1 mL in 2002-03 for this treatment, it was 41.2 mL in 2003-04. Sedimentation volume increased with advenced sowing times (Table 2). Similarly, Kahraman (2006) observed the highest sedimentation volume for the latest sowing time and indicated significant effects of sowing time on sedimentation volume. Identical results were also reported by Flood *et al.* (1996). Seeding rates also had significant impacts on sedimentation volumes. The highest sedimentation volume (47.9 mL) was observed at 625 seeds m^{-2} sowing rate in 2002-03 and at 575 and 625 seeds m^{-2} sowing rates in 2003-04, respectively with 37.5 and 37.1 mL (Table 2). Sumer (2008) and Ozturk *et al.* (2010) observed significant impacts of seeding rates on sedimentation volume. Variations were observed in effects of seeding rates on sedimentation volumes with regard to experimental years.

The data about grain protein concentration (%) of this study were also evaluated in another study published by Ozturk *et al.* (2006). According to findings of these researchers: grain protein concentrations for the WS, FS and SS were 12.0, 12.7 and 13.4%, respectively. The FS and SS increased grain protein concentration compared with WS. High temperatures and moisture deficits during grain filling in the SS and FS treatments relative to the WS led to a reduced grain size and high protein concentration. Protein concentration was unaffected by seeding rate.

CONCLUSION

In this study, impacts of different sowing times and seeding rates on some quality parameters of facultative Kirik wheat variety were investigated and Spring Sowing (SS) had distinctive superior values with regard to most of the quality parameters. Although, quality response to seeding rates varied with years, seeding rate of 525 seeds m^{-2} or over (preferably 575 seeds m^{-2}) had positive effects on quality parameters. According to classifications with regard to sedimentation volumes and wet gluten contents this variety was classified as quality variety with superior quality characteristics. In brief, similar findings were observed in this study with the traditional cultivation practices of local people for this common variety of the region.

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