© by PSP Volume 32– No. 08/2023 pages 2918-2924 Fresenius Environmental Bulletin

THE EFFECTS OF SOWING TIMES AND SEEDING RATES ON THE FARINOGRAPH PARAMETERS AND COLOR OF FACULTATIVE KIRIK WHEAT

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ABSTRACT

This study was undertaken to evaluate the color and selected quality properties of facultative Kirik wheat variety. The effects of 3 different sowing times (winter, freezing, and spring) and 7 different seeding rates (325, 375, 425, 475, 525, 575, and 625 seeds m^{-2}) were investigated. It was observed that the sowing times and/or seeding rates changed significantly the quality parameters as well as color values. L* value of Kirik wheat during 2002-2003 season didn't show any significant differences according to the sowing times. However, a significant change on L* values was observed by changing the seeding rates. According to the seeding rates, the samples with the rate of 375 seeds m^{-2} exhibited the highest water absorption (53.9%) in 2002-2003 season. On the other hand, the samples with the rate of 325 and 625 seeds m^{-2} showed the highest water absorption (56.4%) in 2003-2004 season. While the highest softening degree was observed in spring sowing samples (67.2 BU) in 2002-2003 season, it was observed in winter sowing samples (140.0 BU) in 2003-2004 season. Based on the seeding rates, the samples with the rate of 525 seeds m^{-2} exhibited the highest dough stability as 15.3 min. All in all, treating Kirik wheat with an optimum condition by sowing times and seeding rates can be used to get a high-quality product with an enhanced farinograph parameters and color.

KEYWORDS:
Color, farinograph parameters, Kirik wheat, sowing times, seeding rates

INTRODUCTION

Wheat is an annual plant and is grown in many parts of the World because it does not vary in soil demand and has many varieties that can be grown in all climatic conditions. Wheat is one of the most planted agricultural products in terms of cultivation area in the World and in Turkiye [1]. Both the rapid increase in the World population and the continuous improvement of living standards in many countries creates more and more serious problems in the field of agriculture. For this reason, the concept of soil fertility gains importance and is updated a little more every day as an element that should be considered more seriously. There are other reasons for the prevalence of wheat cultivation all over the world. It is known that this group of plants, which includes many product species, shows a wide variety of species, varieties and ecotypes. For this reason, wheat finds wider adaptation areas compared to other cultivated plants. In addition to wheat types, species and varieties that require high humidity and fertile soil; It is also known that there are wheat species and varieties that can grow in soils with low fertility. In addition, it is known that being easy to grow and suitable for transportation, storage and keeping of the product is important for wheat to find a wide spread area on earth [1].

Wheat, which ranks first in the World and in Turkiye in terms of cultivation area and among cultivated plants used in human nutrition, is an indispensable agricultural product in terms of basic energy and protein source. Wheat plant, which is used both in human nutrition and animal nutrition, has an economic and strategic importance in the regions. It has been reported that 90% of the world wheat agriculture is made up of wheat for bread and 10% for durum wheat [2]. The purpose of the current study was to evaluate the color and selected quality properties of facultative Kirik wheat variety. The effects of 3 different sowing times (winter, freezing, and spring) and 7 different seeding rates (325, 375, 425, 475, 525, 575, and 625 seeds m^{-2}) were investigated.

MATERIALS AND METHODS

A total of 2 years field experiment was conducted at the experimental farm of Ataturk University in Erzurum, Turkiye during the 2002-2004 growing seasons at 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 content of soil were 15.7-18.8 and 1790.1-1870.4 kg ha^{-1}, respectively.

The experiment included 3 sowing times: September, 2 (Winter Sowing (WS)), October, 28 (Freezing Sowing (FS)), and April, 28 (Spring Sowing (SS)) in 2002-2003 in addition to September, 1 (WS), October, 26 (FS), and April, 29 (SS) in 2003-2004. Seeding rates in all years were: 325, 375, 425, 475, 525, 575, and 625 seeds m^{-2}. Randomized complete block design with 4 replicates was used with treatments arranged in a split plot, sowing times as main plots and rates as sub-plots.

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 was used in the experiment. Plots were sown with a six-row planter. Sub plots consisted of 6 rows spaced 20 cm apart, with a row length of 6 m. Plots were basically fertilized with 60 kg ha^{-1} N and 50 kg ha^{-1} 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 was applied at the beginning of stem elongation. Weeds were controlled by hand each season [3].

The quality analyses were determined by using the AACC method [4] with slight modifications and performed at research laboratory in Food Engineering Department of Ataturk University.

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

Color measurement. The color is one of the major quality specifications in food products, but it might change because of the environmental conditions [5,6]. The effects of sowing times (ST) and seeding rates (SR) on color values of Kirik wheat variety is demonstrated in Table 1. It was observed that the L* value of Kirik wheat during 2002-2003 season didn't show any significant differences according to the sowing times ($p \leq 0.05$). However, a significant change on L* values was observed by changing the seeding rates. The L* values were changed between 95.3 to 95.6 in 2002-2003 season. While the lowest L* value was observed for the seeding rates of 325 seeds m^{-2}, the highest L* value was observed for the seeding rates of 425, 525, 575, and 625 seeds m^{-2} as 95.6. On the other hand, in contrast to 2002-2003 season, a significant difference was found for the samples during 2003-2004 season by changing the sowing times. While the freezing (FS) and spring (SS) sowings showed the highest L* values (96.8 and 96.6, respectively), winter sowing (WS) showed the lowest L* value (96.0). A significant change in a* values was observed in samples with different sowing times. While the highest a* value was determined for WS samples (0.900), the lowest a* value was found in SS samples (0.700) in 2002-2003 season. Apart from sowing times, seeding rates showed a significant effect on a* value. While the highest a* value was observed for seeding rates of 475 (0.833), the lowest a* value was observed for the seeds m^{-2} seeding rates of 325 seeds m^{-2} (0.733). Similar to the 2002-2003 season, the highest a* value for WS samples (1.024) and the lowest a* value for SS samples (0.957) were obtained. If we look at the effect of seeding rates on a* value of Kirik wheat samples in 2003-2004 season, we saw a significant difference with different seeding rates. While the highest a* value was observed for the rate of 475, seeds m^{-2} the lowest a* value was observed for the rate of 575 seeds m^{-2} (Table 1) in 2003-2004 season. The similar trend with a* values was observed for b* values of Kirik wheat samples both in 2002-2003 and 2003-2004 seasons. While the highest b* values were determined for WS samples in 2002-2003 and 2003-2004 seasons (6.8 and 7.5; respectively), the lowest b* values were found in SS samples (6.3 and 7.4; respectively). In addition, the b* values were changed significantly according to the different seeding rates. While the lowest b* values were observed for the rates of 325 and 375 seeds m^{-2} (6.4) in 2002-2003 season, the highest b* values were observed for remaining rates (425, 475,525, 575, and 625 seeds m^{-2}). For the 2003-2004 season, the lowest b* values were observed for the rates of 525, 575, and 625 seeds m^{-2} (7.2). In addition, the highest b* values were observed for the rates of 375 seeds m^{-2} (7.8). Compared to the 2002-2003 season in terms of all color values (L*, a*, and b* values), the 2003-2004 season showed higher color values (Table 1). All in all, comparison of color values of wheat samples treated with different sowing times and seeding rates don't show any certain pattern. Similarly, it was observed that the different wheat types indicate no clear pattern on color parameters in the work of Punia et al. (2019) [7]. Singh and Singh (2010) figured out that the hunter color parameters (L∗, a∗ and b∗ values) of the wheat in the range from 56.4 to 63.8, 6.9 to 7.8 and 18.4 to 23.2, respectively [8]. As mentioned above, the freezing (FS) and spring (SS) sowings showed the highest L* values, indicating the light color as compared to winter sowing (WS) samples. WS samples showed the darkest color in appearance. On the other hand, WS samples were found more red compared to FS and SS wheat samples because of their higher a* values. Moreover, WS samples demonstrated more yellow color compared to the FS and SS samples. The yellowish color of wheat is due

to a carotenoid pigment called lutein, which can be oxidized to a colorless form by enzymes present in the grain. The most important carotenoids found in wheat are lutein and lutein-fatty acid esters from xanthophy and ß-carotene from carotenes [9].

Water absorption. The amount of water required to be added to the flour in order to obtain a dough with a certain viscosity is the water absorption value of that flour. The water absorption value of flour is constant and is approximately 2.8 times the amount of dry gluten [10]. Hard wheat flours show high water absorption, resistance, high kneading energy and more elastic structure. Soft wheat flours, on the other hand, have low water absorption, low resistance, low energy and more viscous properties [11]. The water absorption values (WAV) were tabulated in Table 1. SS samples showed the highest WAV in both 2002-2003 and 2003-2004 seasons. On the other hand, it was observed that the lowest WAV belong to WS samples (Table 1). According to the seeding rates, the samples with the rate of 375 seeds exhibited highest WAV (53.9%) in 2002-2003 season. On the other hand, the samples with the rate of 325 and 625 seeds m^{-2} showed the highest WAV (56.4%) in 2003-2004 season. Keceli et al. (2017) determined that the average value of farinograph water absorption in bread wheat genotypes varied between 46.6-66.8% [12]. According to Koksel et al. (2000), the moisture content of the flour plays an important role in the water absorption of bread flour. This situation is generally negatively proportional. In addition, wet gluten rate and quality affect water absorption [13]. According to Seckin (1970), the high water absorption rate of flour increases the amount of bread obtained from unit flour [14]. In a study of Sahin et al. (2013), a positive and significant correlation was found between bread volume and water absorption. Water absorption is the amount of water required to be added to the flour in order to obtain a dough of a certain consistency, and it is desired that the amount of water to be used in bread making is high [15]. In the study of Kruger (1996), about bread production, the gluten values of flours with high water absorption were found to be high, and water absorption was stated as an important factor for bread production [16].

Development time. The development time value is the rate at which the dough takes in water to reach the point where kneading is most effective. If the development period is short, it shows that water absorption occurs very quickly. On the other hand, if it is long, it shows that the water is taken up by the flour much slower [17]. The development time values were exhibited in Table 2. SS samples showed the highest development time in both 2002-2003 and 2003-2004 seasons (4.4 and 3.6 min, respectively). On the other hand, it was observed that the lowest development time belongs to WS samples (Table 2) in both seasons. According to the seeding rates, the samples with the rate of 525 seeds m^{-2} exhibited highest development time (4.6 min) in 2002-2003 season. On the other hand, the samples with the rate of 475 and 625 seeds m^{-2} showed the highest development time (2.6 min) in 2003-2004 season. The development times have been reported as less than 2 minutes for weak flours, 2-3 minutes for medium strength flours, 3-5 minutes for strong flours, and 5-12 minutes in very strong flours [18]. Aydogan et al. (2018), determined that the farinograph development time was changed from 5.0 to 15.1 min in addition to 4.0 to 11.1 min in aqueous conditions [19]. Dough development time increases as protein content increases [20]. A long development time indicates that the kneading time will be long, and it also shows that the amount and quality of the extract is high [21]. It has been stated that the low development time will cause the bread volume to decrease and the pore structure to deteriorate [22]. The length of the development period indicates the length of the kneading period and the high amount and quality of the core [23].

Mixing tolerance index (MTI). Mixing tolerance index is a measure of the decrease in resistance to kneading during dough kneading, 5 minutes after the peak value is reached. MTI value gives an idea about dough stability [24]. While the MTI value for good quality flours is around 20 BU, it is around 100 BU for weak flours [25]. The mixing tolerance index values were exhibited in Table 2. SS samples showed the lowest MTI in both 2002-2003 and 2003-2004 seasons (63.6 BU, and 77.1 BU, respectively). On the other hand, it was observed that the highest MTI belongs to WS samples (79.3 BU) in 2002-2003 season and (150.7 BU) in 2003-2004 season. According to the seeding rates, the samples with the rate of 375 seeds m^{-2} exhibited highest MTI (81.7 BU) in 2002-2003 season. The same sample showed the highest development time (123.3 BU) in also 2003-2004 season. The lowest MTI values were obtained for the samples with the rates of 475, 575, and 625 seeds m^{-2} (69.2 BU, 70.0 BU, and 65.0 BU, respectively) in 2002-2003 season. In addition, the lowest MTI values were obtained for the samples with the rates of 525 (98.3 BU) and 575 seeds m^{-2} (98.3 BU) in 2003-2004 season. Ozer et al. (2003), revealed in their study that the mixing tolerance index varies between 27 BU and 168 BU [26]. In current study, MTI varied between 69.2 BU and 81.7 BU, with an average of 72.1 BU in 2002-2003 season. In addition, MTI changed between 98.3 BU and 150.7 BU, with an average of 108.6 BU in 2003-2004 season. It is desired that the development stability period is long and the mixing tolerance index and softening degree values are low for the flour with high bread quality. The longer the increase time (development time) of the resistance indicates that the mixing time will be long, and it indicates that the amount of extract is

high and the quality is high. If the degree of softening is high, it indicates that the flour has less tolerance to processing and the fermentation period should be short [20].

Softening degree. The softening degree is the distance to the 500 consistency line after 12 minutes from the apex of the farinograph graph curve. It is generally known as the time when the dough starts to soften. The softening degree values were exhibited in Table 2. While the highest softening degree was observed in SS samples (67.2 BU) in 2002-2003 season, it was observed in WS samples (140.0 BU) in 2003-2004 season. On the other hand, WS samples showed the lowest softening degree (61.1 BU) in 2002-2003 season. For 2003-2004 season, the lowest softening degree was obtained for SS samples (65.7 BU). Based on the seeding rates, the samples with the rate of 375 seeds m^{-2} exhibited highest softening degree (73.4 BU) in 2002-2003 season. The same sample showed the highest softening degree (118.3 BU) in also 2003-2004 season. The lowest softening degree values were obtained for the samples with the rate of 575 seeds m^{-2} (55.3 BU) in 2002-2003 season. In addition, the lowest softening degree values were obtained for the samples with the rates of 525 (98.3 BU) and 575 seeds m^{-2} (98.3 BU) in 2003-2004 season. The degree of softening is low in bread flours with high protein amount and quality. A high degree of softening indicates the weakness of gluten proteins, less tolerance to flour processing, low bread quality, and a short fermentation time [20]. It is desired that the degree of softening is low in bread flours and high in biscuit flours [27].

Dough stability. Stability is the value that shows the resistance of the dough to processing. The dough should maintain its consistency during processing and should not be softened under any circumstances. If the stability is short, the processing ability of the dough is reduced and the fermentation time is shortened. The dough stability values were exhibited in Table 2. While the highest dough stability values were observed in WS samples (14.9 min) and FS samples (15 min) in 2002-2003 season, it was observed in SS samples (14.6 min) in 2003-2004 season. On the other hand, SS samples showed the

TABLE 1
Effects of experimental variables on color and water absorption

Variables	Color measurements						Water absorption (%)	
	L		*a*		*b*			
Years	**2002-03**	**2003-04**	**2002-03**	**2003-04**	**2002-03**	**2003-04**	**2002-03**	**2003-04**
2002-03	95.5	-	0.790	-	6.5	-	53.6	-
2003-04	-	96.5	-	1.000	-	7.4	-	55.8
Mean	96.0		0.895		6.95		54.7	
Sowing times (ST)								
Winter	95.3	96.0 b	0.900 a	1.024 a	6.8 a	7.5 a	52.6 c	52.9 c
Freezing	95.5	96.8 a	0.771 b	1.019 a	6.4 b	7.4 b	53.6 b	55.7 b
Spring	95.6	96.8 a	0.700 c	0.957 b	6.3 c	7.4 b	54.7 a	58.7 a
Seeding rates (SR, seeds m^{-2})								
325	95.3 c	96.3 ab	0.733 d	0.967 cd	6.4 b	7.5 b	53.7 ab	56.4 a
375	95.5 ab	97.0 b	0.811 ab	1.022 ab	6.4 b	7.8 a	53.9 a	56.1 b
425	95.6 a	96.0 a	0.756 cd	1.000 bc	6.5 a	7.6 b	53.5 b	55.3 d
475	95.4 bc	97.0 a	0.833 a	1.056 a	6.6 a	7.6 b	53.6 b	55.7 c
525	95.6 a	96.7 ab	0.800 ab	1.011 b	6.5 a	7.0 c	53.5 b	55.2 d
575	95.6 a	96.2 b	0.811 ab	0.944 d	6.5 a	7.2 c	53.5 b	55.2 d
625	95.6 a	96.4 ab	0.789 bc	1.000 bc	6.5 a	7.2 c	53.7 ab	56.4 a
Sources of variance								
F- values								
ST	6.2	7.1*	453.0***	24.4**	236.4***	152.0***	1226.9***	2701.3***
SR	9.4***	3.9**	10.6***	8.8***	5.5***	37.1***	3.9**	44.4***
ST x SR	12.1***	4.1**	4.6**	18.4***	12.2***	58.2***	7.3***	67.1***
Lsd range								
ST		0.6865	0.04493	0.04493	0.1101	0.4493	0.1906	0.3566
SR	0.1767	0.7206	0.04050	0.04054	0.1216	0.1767	0.3061	0.3218
CV (%)	0.14	0.58	4.06	3.67	1.48	1.87	0.45	0.45

[a-d] Means superscript with different letters in the same column alter significantly ($P \leq 0.05$).

TABLE 2
Effects of experimental variables on development time, MTI, softening degree and dough stability

Variables	Development time **(min)		Mixing tolerance index (MTI) *(BU)		Softening degree *(BU)		Dough stability **(min)	
Years	**2002-03**	**2003-04**	**2002-03**	**2003-04**	**2002-03**	**2003-04**	**2002-03**	**2003-04**
2002-03	4.17	-	72.1	-	64.4	-	14.9	-
2003-04	-	2.40	-	108.6	-	104.1	-	12.0
Mean	3.25		90.4		84.2		13.5	
Sowing times (ST)								
Winter	4.0 b	1.6 c	79.3 a	150.7 a	61.1 b	140.0 a	14.9 a	9.2 c
Freezing	4.1 b	2.0 b	73.2 a	98.0 b	64.9 ab	106.4 b	15.0 a	12.1 b
Spring	4.4 a	3.6 a	63.6 b	77.1 b	67.2 a	65.7 c	14.7 b	14.6 a
Seeding rates (SR, seeds m^{-2})								
325	4.2 b	2.2 c	73.3 ab	120.0 ab	66.8 ab	111.7 b	14.8 b	11.5 f
375	4.2 b	2.5 a	81.7 a	123.3 a	73.4 a	118.3 a	14.8 b	11.1 f
425	4.1 b	2.3 c	71.8 ab	108.3 abc	65.9 ab	91.7 e	14.7 b	13.3 a
475	3.9 b	2.6 a	69.2 b	102.0 bc	65.1 b	103.3 cd	14.8 b	12.4 b
525	4.6 a	2.3 bc	73.3 ab	98.3 c	65.1 b	98.3 d	15.3 a	12.3 c
575	4.0 b	2.4 ab	70.0 b	98.3 c	55.3 c	98.3 d	14.9 b	11.6 d
625	4.0 b	2.6 a	65.0 b	110.0 abc	59.2 bc	106.7 bc	14.7 b	11.7 d
Sources of variance								
F- values								
ST	64.1***	512.8***	39.7**	138.9***	26.6**	2034.3***	39.8**	82229.4***
SR	6.6***	12.8***	3.7**	4.2**	8.4***	46.1***	4.7**	2019.5***
ST x SR	6.5***	8.9***	8.9***	4.7***	7.8***	48.7***	4.6***	2983.1***
Lsd range								
ST	0.1681	0.3113	8.168	20.94	3.858	5.370	0.1348	0.06354
SR	0.3440	0.1720	10.25	18.90	7.636	5.108	0.4013	0.05733
CV (%)	6.50	5.61	11.10	13.57	9.25	3.83	2.11	0.41

[a-f] Means superscript with different letters in the same column alter significantly ($P \leq 0.05$)
* BU: Brabender Unit; **min:Minute

lowest dough stability (14.7 min) in 2002-2003 season. For 2003-2004 season, the lowest dough stability was obtained for WS samples (9.2 min). Based on the seeding rates, the samples with the rate of 525 seeds m^{-2} exhibited highest dough stability as 15.3 min in 2002-2003 season. On the other hand, the sample with the rate of 425 seeds m^{-2} showed the highest dough stability (13.3 min) in 2003-2004 season. A stronger dough is formed as the stability value increases. The stability value decreases in transitions from strong flour to weak flour. In the study of Aydogan et al. (2012), the relationships between rheological properties in bread wheat were examined. The water absorption varied between 56.40 and 64.20%. In addition, dough stability was found between 1.40 and 4.65 minutes, and finally development time was found as 2.15-4.25 minutes. They found significant correlations between rheological properties [28]. In addition, Sahin et al. (2013), found a high correlation between dough stability value and the amount of protein and wet gluten in their study [15]. According to Aydogan et al. (2012), if the stability value is low, the processing ability of the dough decreases accordingly and the fermentation time becomes shorter. In general, it is desired that the stability value of flours with high bread quality should be long and the degree of softening should be low. The longer the stability period, the greater the elasticity of the dough and its suitability for processing, and the larger volume of bread to be made from these flours [28].

CONCLUSION

In current study, the impact of different sowing times and seeding rates on the color and selected quality properties of facultative Kirik wheat variety were explored. The sowing times and/or seeding rates changed significantly the quality parameters as well as color values of wheat samples. While the L* value of Kirik wheat during 2002-2003 season didn't show any significant differences according to the sowing times, a significant change on L* values was observed by changing the seeding rates. In addition, the samples with the rate of 375 seeds m^{-2} exhibited the highest water absorption (53.9%) in 2002-2003 season. Based on the seeding rates, the samples with the rate of 525 seeds m^{-2} exhibited the highest dough stability. All in all, treating Kirik wheat with an optimum condition by sowing times and seeding rates can be used to get a high-quality product with an enhanced farinograph parameters and color.

ACKNOWLEDGEMENTS

We are thankful to Experimental Farm of Ataturk University in Erzurum, Turkiye.

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Received: **05.07.2023**
Accepted: **29.07.2023**

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