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# INVESTIGATIONS ON THE RELATIONSHIPS BETWEEN SOME QUALITY CHARACTERISTICS IN A WINTER WHEAT POPULATION

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**ABSTRACT**

**This research was conducted to estimate the relationships between various quality traits of winter wheat. The field trial was carried out in the Research and Application Center of Faculty of Agriculture, Uludag University (Bursa / Turkey) during the 2012-2013-2014 seasons. Twenty-six different winter wheat genotypes were used as genetic material. Certain quality traits such as protein content, zeleny sedimentation volume, delayed sedimentation volume, falling number, gluten, gluten index and hectoliter were measured. The results for the individual years and the combined data for all three years revealed that there were positive and significant correlation between protein content with delayed sedimentation and gluten index indicates. The negative and significant correlation between gluten and gluten index was determined in the study and gluten index decreased while gluten content increased. A positive and significant correlation was found between hectoliter with delayed sedimentation and falling number. Thus, the relationships between these traits are considered as criterion that can be used in selection for quality. (SBx15-4)-5, (Gx22-1) and (Gx22-1)-6 and Bezostaja, Flamura genotypes were found to be good for breadmaking flour quality according to their superiority with respect to at least three and more quality criteria for all three years.**

**Keywords: Correlation, flour quality, *Triticum aestivum L*, winter wheat.**

## INTRODUCTION

Bread wheat (*Triticum aestivum L.*) is widely grown and the most consumed food crops all over the world. It is also a major field crop in Turkey (Akcura et al., 2016). Compared with other cereals, it provides food for human with more calories and proteins in the daily diet, a considerable amount of trade throughout the world, and a lot of other products (Bushuk, 1985; Branlard et al., 2001; Yıldırım et al., 2011). The need for quality wheat is increasing day by day. For this reason, the need for high-yield, high-quality, and disease-resistant varieties to achieve the desired yield potential demonstrates continuity (Kurt Polat et al., 2015). The developments of high breadmaking quality wheat responding respond to improved agricultural practices are the main achievements for bread wheat breeding programmes. In the last few decades, efforts taken by wheat breeders have resulted in successful development of bread wheat varieties possessing better quality parameters (Tayyar, 2010). Nowadays breeding of wheat (*Triticum aestivum L.*) concentrates largely on the improvement of wheat flour quality due to the importance of quality flour in bread making, end-product quality, nutritional value, and economic impact. To predict the quality of flour a number of physical, chemical and rheological characteristics must be determined. There are numerous tests to determine wheat quality for making different food products. Among them, protein content, falling number, zeleny sedimentation volume, delayed sedimentation volume, hectoliter, gluten and gluten index was been measured.

The purpose of the research was to compare the variation of the quality traits of bread wheat genotypes and also to estimate the correlations coefficients between quality traits.

## MATERIALS AND METHODS

This study was carried out in the Research and Application Center of the Faculty of Agriculture, Uludag University (Bursa / Turkey) during the 2012, 2013 and 2014 growing seasons. Twenty-six different winter wheat genotypes were used as genetic material. Twenty-two advanced lines which were obtained through the hybridisation of six different parents and four cultivars, namely, Gönen, Pehlivan, Bezostaja and Flamura in these genotypes. The field experiment was conducted in the Randomized Complete Block Design in three replications using 6 $m^2$ plots. Seeding rate was 550 seeds $m^2$ in all experiments. The field trials were planted between 1 and 15 November in each year, which is the optimal sowing time in the region. Total rainfall values during the growth period ( November-July) in the years 2012, 2013 and 2014 were recorded as 647.8 mm, 592.9 mm and 500.8 mm, respectively (TSMS, 2015). The soils of the center were mostly heavy textured, in alkaline pH and in low salt concentration. Contents of organic matter, nitrogen, phosphorus, potassium, calcium, magnessium, iron, copper and manganese were quite higher than the required level (Ozguven & Katkat, 1997). 60 kg $P_2O_5$ ha-1 and 50 kg N ha-1 were applied at sowing and additional 100 kg N ha-1 was applied in the early spring. Weeds were chemically controlled in the spring. During the experimental years, there were no incidences of diseases or pests in the experimental plots. After maturity the plants in the plots were individually harvested with plot combine was carried out when grain moisture had declined to about 13% in the July.

Flour protein content (%, Kjeldahl method), zeleny and delayed sedimentation (ml, ICC standard methods 116/ 118), gluten (%, ICC standard method 137), gluten index (%, ICC,1994), falling number (sec, ICC standard method 107) and hectoliter (test weight) (kg, AACC, 2000) were determined as quality criteria in the study.

An analysis of variance was performed for each trait for each individual year and for the combined data from all three years. The simple correlation coefficients among all of the studied traits were calculated according to the method given by Singh and Chaudhary (1979).

## RESULTS

The mean values and statistical differences of the observed traits among the twenty-six wheat genotypes are presented in Table 1. Three experimental years were evaluated separately in the research. In addition, significant differences were found among the genotypes for every trait in all experimental years. The mean values of the examined genotypes revealed that the zeleny sedimentation volume (25- 38.7 ml), delayed sedimentation volume (24-52 ml), falling number (152-628 sec.), gluten (29-49 %), gluten index (45-66 %), protein content (9.4-12.3 %), hectoliter (78.5-89.2 kg) respectively, in 2012. However, in 2013, the ranges for the same traits were 26-39 ml, 20-40.3 ml, 226-510 sec, 29-40 %, 49-78 %, 10.1-12.4 % and 79.6-83.1 kg respectively. In 2014 the ranges for the same traits were, 27.3-38.3 ml, 19-37.6 ml, 224-510.6 sec., 28-38 %, 43.3-78 %, 10.2-11.8 % and 72-79.2 kg, respectively (Table 1).

The correlation coefficients between the zeleny sedimentation volume and delayed sedimentation volume ($r=0.324$; $p<0.01$) falling number ($r=0,236$; $p<0.01$) were positive and significant for the three-year combined data. The correlation coefficients between the delayed sedimentation and falling number ($r=0,420$; $p<0.01$) protein content ($r=0,176$; $p<0.05$) and hectoliter ($r=0,249$; $p<0.01$) were positive and significant for the three-year combined data . The falling number correlation coefficients between gluten and hectoliter ($r=0,279$; $p<0.01$, $r=0,199$; $p<0.05$), were positive and significant but gluten index ($r= -0,260$; $p<0.01$) was negative and significant for the three-year combined data. The correlation coefficients between gluten and gluten index ($r=-0,273$; $p<0.01$) was negative and significant and gluten index had only one positive and significant correlation coefficients relation that is protein content ( $r= 0,193$; $p<0.05$) (Table 2). Other correlations among the traits studied in the research were statistically non-significant.

## DISCUSSION

Zeleny sedimentation volume range from about less than 20 ml for very weak wheat up to about 60 ml for the strongest wheat. Sedimentation values of 60 ml and over mean; this wheat consist almost entirely of strong wheat and of superior gluten quality. It is suitable for the mixing with weaker wheat for the production of bread flour. Sedimentation values of 40-59 ml; this wheat consist almost entirely of strong wheat and is of the type most widely used for production of bread flour. Sedimentation values of 20-39 ml; this wheat consist largely of low protein content wheat. Wheat in this range is best suited to the production of cookies flour and others types of flour or for use in mixing stronger wheat for the production of wheat flour. Cookie quality is associated with soft wheat flour of low protein content (Yao et al., 2014). Sedimentation values of less then 20 ml; this wheat consist almost entirely of soft wheat. This used primarily for the production of cake, pastry, cookie and cracker flours (Unal, 2002; Kurt and Yagdı, 2013). In general, the average sedimentation values were found to be moderate to low in all three years. However, the results from this study indicated that the genotypes, (SBx15-4)-1, (SBx15-4)-5, (Gx22-1)-6 and (Gx22-1) which were the highest results was the sedimentation values of 35.3-39 ml. For this reason these are suitable for production of cookies flour and others types of flour or for use in mixing stronger wheat for the production of wheat flour.

**Table 1.** Means of the quality traits studied

| Genotypes | ZSD (ml) | DSD (ml) | FN (sec) | GL (%) | GLI (%) | PC (%) | HL (kg) |
|---|---|---|---|---|---|---|---|
| | | | **2012** | | | | |
| **(SBxK)-1** | 25.0 k | 35.0 g-j | 152 ı | 33 f-ı | 51 g-ı | 11.9 b-d | 82.2 f |
| **(SBxK)-2** | 34.0 c-f | 38.0 d-g | 543 d | 40 b-d | 58 c-f | 9.8 j | 84.5 cd |
| **(SBx15-4)-1** | 38.7 a | 52.0 a | 533 d | 39 b-d | 55 e-g | 10.2 ı | 83.2 ef |
| **(SBx15-4)-3** | 31.0 ı | 33.0 ı-l | 569 c | 41 bc | 60 b-d | 11.2 g | 78.5 g |
| **(SBx15-4)-5** | 37.0 ab | 42.0 bc | 568 c | 43 b | 49 ı-k | 11.6 de | 83.4 de |
| **(Kx15-4)-1** | 28.7 ı-j | 34.0 h-k | 564 c | 35 d-h | 54 f-h | 11.1 g | 82.2 f |
| **(Kx15-4)-2** | 31.0 g-ı | 31.0 k-m | 588 b | 38 b-f | 45 k | 9.9 j | 88.1 b |
| **(A-12x15-4)-4** | 32.0 e-g | 30.0 l-m | 541 d | 29 ı | 51 g-ı | 9.4 k | 88.5 ab |
| **(Gx22-1)-2** | 34.7 b-e | 37.0 e-h | 617 a | 38 b-e | 48 ı-k | 10.2 ı | 83.3 e |
| **(Gx22-1)-4** | 33.0 d-g | 39.0 c-f | 628 a | 49 a | 46 jk | 11.6 de | 83.1 ef |
| **(Gx22-1)-6** | 37.3 ab | 49.0 a | 533 d | 39 b-d | 55 e-g | 11.9 b-d | 82.2 f |
| **(Gx22-1)-7** | 34.0 c-f | 31.0 k-m | 575 c | 36 c-g | 50 h-j | 11 g | 82.1 f |
| **(GxK)-2** | 32.0 e-g | 32.0 j-l | 480 f | 35 d-h | 48.3 ı-k | 11.6 e | 83.6 de |
| **(GxK)-3** | 34.0 c-f | 37.0 e-h | 423 h | 31 g-ı | 51 g-ı | 11.2 g | 83.3 e |
| **(15-4x22-1)-4** | 36.0 a-c | 45.3 b | 536 d | 36 c-g | 57 d-f | 11.8 c-e | 88.1 b |
| **(KxG)** | 29.0 h-j | 24.0 n | 467 g | 31 g-ı | 62 a-c | 11.5 e-f | 84.2 c-e |
| **(SBxK)** | 27.0 k | 28.0 m | 428 h | 42 b | 55 e-g | 11.8 c-e | 83.5 de |
| **(22-1xK)** | 36.0 a-c | 40.0 c-e | 521 e | 34 e-ı | 50 h-j | 11.9 b-d | 83.5 de |
| **(A-12xK)** | 34.0 c-f | 36.0 f-ı | 520 e | 34 e-ı | 51 g-ı | 11.3 f-g | 83.2 ef |
| **(G x K)** | 36.0 a-c | 36.0 f-ı | 514 e | 35 d-h | 59 c-e | 11.7 de | 83.6 de |
| **(GxSB)** | 35.7 b-d | 42.0 bc | 568 c | 34 e-ı | 52 g-ı | 9.4 k | 83.3 e |
| **(Gx22-1)** | 37.0 ab | 49.0 a | 486 f | 35 d-h | 61 b-d | 10.5 h | 85.2 c |
| **Pehlivan** | 34.0 c-f | 34.0 h-k | 520 e | 30 hı | 62 bc | 11.8 c-e | 88.9 ab |
| **Gönen** | 31.7 f-h | 36.6 e-h | 533 d | 31 g-ı | 64 ab | 12.1 ab | 89.0 ab |
| **Bezostaja** | 34.7 b-e | 41.3 cd | 627 a | 32 g-ı | 66 a | 12 bc | 89.2 a |
| **Flamura** | 33.3 c-g | 37.6 e-g | 540 d | 31 g-ı | 64 ab | 12.3 a | 88.8 ab |
| | | | **2013** | | | | |
| **(SBxK)-1** | 27.3 f | 30.0 f-ı | 226 q | 32 f-ı | 59 f-g | 11.4 gh | 81.6 d |
| **(SBxK)-2** | 34.0 a-d | 36.0 a-d | 473 g-h | 38 a-c | 71 cd | 10.5 o | 82.3 bc |
| **(SBx15-4)-1** | 39.0 a | 40.3 a | 481 de | 37 a-d | 68 cd | 11.5 ef | 81.5 de |
| **(SBx15-4)-3** | 31.0 c-f | 29.0 g-ı | 420 o | 36 b-e | 63 ef | 11.2 ı-j | 80.1 ı |
| **(SBx15-4)-5** | 39.0 a | 40.0 a | 510 a | 40 a | 63 ef | 11.6 e | 81.3 ef |
| **(Kx15-4)-1** | 28.0 ef | 28.0 hı | 496 b | 34 d-g | 57 g | 11.5 ef | 79.6 j |
| **(Kx15-4)-2** | 34.0 a-d | 29.0 g-ı | 476 fg | 37 a-d | 55 g | 10.9 m | 82.1 c |
| **(A-12x15-4)-4** | 31.3 c-f | 31.0 e-ı | 498 b | 30 g-ı | 57 g | 10.1 q | 82.1 c |
| **(Gx22-1)-2** | 34.0 a-d | 33.0 d-g | 421 o | 38 a-c | 49 h | 11.4 fg | 81.4 de |
| **(Gx22-1)-4** | 33.0 b-e | 27.0 ı | 498 b | 39 ab | 63 ef | 11.3 hı | 80.6 g |
| **(Gx22-1)-6** | 37.0 ab | 39.0 ab | 490 c | 37 a-d | 57 g | 11.1 kl | 81.4 d-f |
| **(Gx22-1)-7** | 37.0 ab | 33.0 d-g | 484 d | 36 b-e | 70 cd | 10.5 o | 82.2 bc |
| **(GxK)-2** | 30.0 d-f | 29.0 g-ı | 478 ef | 33 e-h | 68 cd | 11.0 l | 80.4 gh |
| **(GxK)-3** | 35.0 a-d | 33.0 d-g | 468 ı-j | 32 f-ı | 67 de | 10.1 q | 80.3 hı |
| **(15-4x22-1)-4** | 35.3 a-c | 36.0 a-d | 458 k | 35 c-f | 71 cd | 10.1 q | 82.2 bc |
| **(KxG)** | 30.0 d-f | 20.0 j | 464 j | 29 ı | 68 cd | 10.9 m | 82.1 bc |
| **(SBxK)** | 33.0 b-e | 28.0 hı | 466 ı-j | 38 a-c | 63 ef | 10.7 n | 82.2 bc |
| **(22-1xK)** | 35.0 a-d | 35.0 b-e | 498 b | 32 f-ı | 56 g | 10.3 p | 82.3 b |
| **(A-12xK)** | 33.0 b-e | 31.0 e-ı | 445 m | 32 f-ı | 62 f | 11.1 j-l | 79.6 j |
| **(G x K)** | 35.0 d | 35.0 b-e | 452 l | 31 g-ı | 78 a | 11.9 cd | 81.2 f |
| **(GxSB)** | 35.0 a-d | 39.0 ab | 436 n | 33 e-h | 72 bc | 11.8 d | 82.3 bc |
| **(Gx22-1)** | 38.0 ab | 38.0 a-c | 358 p | 34 d-g | 77 a | 11.2 ı-k | 82.3 bc |
| **Pehlivan** | 34.7 a-d | 31.6 d-h | 480 d-f | 29 hı | 76 ab | 12.0 c | 83.1 a |
| **Gönen** | 33.0 b-e | 34.0 c-f | 469 hı | 30 g-ı | 72 bc | 12.4 a | 81.4 ef |
| **Bezostaja** | 33.7 b-d | 33.3 d-g | 508 a | 31 g-ı | 76 ab | 12.2 b | 83.2 a |
| **Flamura** | 26.0 b-e | 33.3 d-g | 480 d-f | 31 g-ı | 76 ab | 12.0 c | 82.2 bc |

**Table 1.** Continued

| | | | | 2014 | | | |
|---|---|---|---|---|---|---|---|
| **Genotypes** | **ZSD (ml)** | **DSD (ml)** | **FN (sec)** | **GL (%)** | **GLI (%)** | **PC (%)** | **HL (kg)** |
| **(SBxK)-1** | 27.3 ı | 28.6 h | 224 l | 28 ı | 61 g-h | 10.6 h-k | 78.1 cd |
| **(SBxK)-2** | 34.7 c-e | 31.6 fg | 446 ef | 33 d-g | 70 e | 10.6 ı-l | 77.3 de |
| **(SBx15-4)-1** | 38.7 a | 37.6 a | 424 gh | 35 a-d | 70 e | 11.1 c-f | 76.4 fg |
| **(SBx15-4)-3** | 31.7 h | 27.6 hı | 375 ı | 34 c-f | 61 gh | 11.2 c-e | 78.0 cd |
| **(SBx15-4)-5** | 38.3 a | 37.3 ab | 465 cd | 37 ab | 62 g | 11.6 ab | 79.2 a |
| **(Kx15-4)-1** | 28.0 ı | 27.3 hı | 454 de | 33 c-g | 55 k | 11.1 c-f | 74.9 h |
| **(Kx15-4)-2** | 35.0 c-e | 28.0 h | 454 de | 36 a-c | 54 k | 10.2 m | 78.0 cd |
| **(A-12x15-4)-4** | 32.2 f-h | 31.0 g | 413 h | 30 hı | 59 hı | 10.3 l-m | 76.5 ef |
| **(Gx22-1)-2** | 34.7 c-e | 28.0 h | 473 c | 37 ab | 43 l | 10.6 h-k | 74.9 h |
| **(Gx22-1)-4** | 32.3 f-h | 25.3 j | 475 bc | 38 a | 62 g | 11.1 d-f | 75.2 h |
| **(Gx22-1)-6** | 37.3 ab | 33.3 d-f | 476 bc | 36 a-c | 57 ı-j | 11.1 d-f | 78.0 cd |
| **(Gx22-1)-7** | 33.7 d-g | 32.6 e-g | 444 fg | 35 b-e | 66 f | 11.6 ab | 78.1 cd |
| **(GxK)-2** | 28.3 ı | 22.0 k | 375 ı | 32 e-h | 62 g | 10.5 j-m | 76.4 ef |
| **(GxK)-3** | 35.7 bc | 27.0 h-j | 351 j | 32 f-h | 71 de | 10.2 m | 77.2 d-f |
| **(15-4x22-1)-4** | 35.0 c-e | 35.6 bc | 443 e-f | 33 c-g | 71 de | 10.4 k-m | 78.3 bc |
| **(KxG)** | 32.3 f-h | 19.0 l | 319 k | 28 ı | 66 f | 10.9 e-ı | 79.2 ab |
| **(SBxK)** | 34.3 c-e | 26.0 ı-j | 415 h | 38 a | 62 g | 11.3 b-d | 72.0 j |
| **(22-1xK)** | 35.0 c-e | 33.0 d-f | 422 gh | 33 d-g | 55 jk | 10.8 f-ı | 77.2 d-f |
| **(A-12xK)** | 31.7 h | 27.3 hı | 453 de | 31 f-h | 61 g | 11.6 ab | 74.6 hı |
| **(G x K)** | 34.0 c-f | 32.3 e-g | 471 c | 33 d-g | 78 a | 11.0 e-g | 73.7 ı |
| **(GxSB)** | 33.3 e-h | 33.0 d-f | 419 gh | 32 f-h | 75 c | 11.4 bc | 75.1 h |
| **(Gx22-1)** | 35.3 cd | 34.0 c-e | 352 j | 31 f-h | 77 ab | 10.9 e-h | 76.8 e-f |
| **Pehlivan** | 35.3 cd | 34.6 cd | 467 cd | 30 hı | 71 de | 10.7 g-j | 76.1 g |
| **Gönen** | 35.7 bc | 33.0 d-f | 465 cd | 31 g-ı | 70e | 11.3 b-d | 78.7 a-c |
| **Bezostaja** | 34.7 c-e | 34.0 c-e | 511 a | 32 e-h | 73 cd | 11.8 a | 78.4 bc |
| **Flamura** | 32.0 g-h | 34.6 cd | 491 b | 33 d-g | 75 bc | 11.8 a | 78.7 a-c |

ZSD: Zeleny sedimentation volume, DSD: Delayed sedimentation volume, FN: Falling number, GL: Gluten, GLI: Gluten index, PC: Protein contnent, HL: Hectoliter

Delayed sedimentation volume of the genotypes, which allows us to understand the insect damage of *Eurygaster spp*. and *Aelia spp*. and the increasing insect damage results in decreased delayed sedimentation values as well as flour quality (Tayyar and Gül, 2008). Delayed sedimentation volume results generally showed no decline in the first and second years except for the third year. Nevertheless, the decline in the third year has not occurred in all genotypes. (SBx15-4)-1, (SBx15-4)-5, (Gx22-1)-6 and (Gx22-1) which were the most promising lines was the delayed zeleny sedimentation values range of 33-52 ml, so it can be said that the this genotypes in the experiment are suitable for flour making. Hagberg (1960, 1961) and Perten (1964) developed the falling number method as a simple and rapid technique for determining a-amylase activity using wheat meal as the native substrate. Subsequently, this method has become the international standard that is used widely in grain classification, quality control and marketing. Grain with a low falling number due to high a-amylase activity causes substantial economic losses to growers, significant processing and storage problems and is generally reflected in poorer quality end-products (Derera, 1989; Edwards et al., 1989). falling number values above 250, 300 sec or in some cases 350 sec are required for inclusion of delivered grain in high-quality grades depending on the receival standards set by the wheat industries in different countries (Gale et al., 1987; Mares and Mrva, 1993; Kettlewell et al., 1996). The a, v genotypes The (SBx15-4)-1, (SBx15-4)-3, (SBx15-4)-5, (Kx15-4)-1, (Kx15-4)-2, (Gx22-1)-6,(Gx 22-1)-4 and Bezostaja genotypes were noted with their falling number values over 500 sec according to the average of the three year values. Thus, these genotypes belogs to a high quality class for the bread flour production. Gluten the main protein of wheat and gluten values of 20-27 %; this wheat consist largely of low gluten and protein content wheat. Gluten is the major protein within wheat flour, making up 47% of the total protein content. Gluten is responsible for the strength and elasticity of dough. Breadmaking qualities are largely dependent on the number and composition of gluten subunits. Gluten values of less then 20 %; this wheat consist almost entirely of soft wheat and not suitable for the flour (Schofield, 1994; Branlard et al., 2001; Kurt and Yagdi, 2013). In this study 3 years avarege results indicate that the genotypes which were the most promising lines belogs to the gluten values of 35 % and over classification for this reasons this genotypes can be used production of wheat flour. Generally accepted the values of the gluten index range 60-90% in trade for breadmaking. If its value is high, its strength is high as well (Elgün et al., 2002). The values of 3 years avarage of the gluten index as measurement of the genotypes which were the best genotypes (SBx15-4)-1, (SBx15-4)-5,(Gx22-1), Bezostaya and Flamura gluten strength were from 58% to 70%. The result of the 3 years avarage indicate that these genotypes suitable for the bread wheat production. Grain protein-content was largely influenced by environmental conditions such as soil fertility, rainfall or temperature. Many authors (Bhullar and Jenner, 1985; Wardlaw and Wrigley, 1994; Daniel and Triboï, 2000) have shown that temperature and nitrogen nutrition influence grain protein content and many reports have been published on the relationship between wheat protein content and breadmaking quality too. In general, high grain protein content has been associated with good breadmaking quality (Horvat et al., 2015). Previous studies also pointed out that the protein content of wheat was mainly dependent upon genotype which was reflected in this study too. There was a large variation in bread volume during the investigated years in the wheats used in this study. Unal (2002), reported that good protein content changed between 10-15% in bread wheat. The results from this study indicated that the average protein content of the Gönen, Bezostaja and Flamura cultivars which is used in the experiment as a control was found to be 12% and the genotypes, (SBx15-4)-5 and (GxK) which were the most promising lines had 11.5 % protein content accordin to avarege of three years. For this reason these are suitable for production of bread flour. In the study, the hectoliter weight was found to be over 80 kg in the first and second years and range of 72.03-79.23 kg in the third year. As a result of avarege of hectoliter values that all genotypes are suitable for the production of high quality flour.

**Table 2.** Correlation coefficient among the quality traits

| | **Delayed Sedimentation Volume** | **Falling Number** | **Gluten** | **Gluten İndex** | **Protein Content** | **Hectoliter** |
|---|---|---|---|---|---|---|
| **Zeleny Sedimentation Volume** | | | | | | |
| 2012 | 0.676** | 0.476** | 0.089 | 0.023 | -0.139 | 0.093 |
| 2013 | 0.578** | 0.234* | 0.180 | 0.181 | -0.019 | 0.237* |
| 2014 | 0.587** | 0.421** | 0.341** | 0.200 | 0.045 | 0.091 |
| 3-yr average | 0.324** | 0.236** | 0.166 | 0.072 | -0.051 | -0.108 |
| **Delayed Sedimentation Volume** | | | | | | |
| 2012 | - | 0.158 | 0.177 | 0.083 | -0.031 | -0.009 |
| 2013 | - | 0.043 | 0.203 | 0.206 | 0.126 | 0.182 |
| 2014 | - | 0.413** | 0.103 | 0.374** | 0.256* | 0.134 |
| 3-yr average | - | 0.420** | -0.00 | -0.022 | 0.176* | 0.249** |
| **Falling Number** | | | | | | |
| 2012 | - | - | 0.249* | 0.012 | -0.238* | 0.178 |
| 2013 | - | - | 0.097 | 0.047 | -0.066 | 0.026 |
| 2014 | - | - | 0.455** | 0.018 | 0.353** | 0.091 |
| 3-yr average | - | - | 0.279** | -0.260** | 0.110 | 0.199* |
| **Gluten** | | | | | | |
| 2012 | - | - | - | -0.334** | -0.048 | -0.450** |
| 2013 | - | - | - | -0.336** | -0.172 | -0.155 |
| 2014 | - | - | - | -0.301** | 0.182 | -0.122 |
| 3-yr average | - | - | - | -0.273** | -0.042 | -0.019 |
| **Gluten Index** | | | | | | |
| 2012 | - | - | - | - | 0.332** | 0.357** |
| 2013 | - | - | - | - | 0.342** | 0.338** |
| 2014 | - | - | - | - | 0.218 | 0.096 |
| 3-yr average | - | - | - | - | 0.193* | -0.076 |
| **Protein Content** | | | | | | |
| 2012 | - | - | - | - | - | 0.069 |
| 2013 | - | - | - | - | - | 0.034 |
| 2014 | - | - | - | - | - | -0.031 |
| 3-yr average | - | - | - | - | - | 0.084 |

Note: *: significant at p=0.05 probability level; **: significant at p=0.01 probability level

## CONCLUSION

The results from this study indicated that differential results were obtained for quality of the winter wheat varieties evaluated. (SBx15-4)-5, (Gx22-1) and (Gx22-1)-6 and Bezostaja, Flamura genotypes were found to be suitable for breadmaking flour quality according to their superiority with respect to at least three and more quality criteria for all three years. These lines were the most promising genotypes that could compete with Bezostaja and Flamura for a majority of the studied traits. It has been accepted that significant correlations between protein content, delayed sedimentation value, falling number and hectoliter could be used in the studies conducted for quality breeding in wheat.

## LITERATURE CITED


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