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A STUDY TO INCORPORATE HIGH PROTEIN CONTENT FROM TETRAPLOID WHEAT (*T. turgidum dicoccoides*) TO HEXAPLOID WHEAT (*T. aestivum vulgare*)

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ABSTRACT

Grain protein content of wheat is important for bread making and pasta quality. Wild tetraploid wheat (*Triticum turgidum* L. var. *dicoccoides*) has some genes for high protein content as a promising source. Three winter wheat cultivars of Colorado (Halt, Yuma, Akron) and one experimental line (CO99508) and one accession of *T. dicoccoides* were crossed to obtain backcrosses. The objective of this study was to determine higher protein content, SDS-sedimentation and hardiness values in backcrosses *T. aestivum* x *T. dicoccoides.*

Analysis of variance showed that highly significant differences were found among parents and backcrosses. The minimum and maximum values of grain protein content of all backcross populations changed from low protein parents (bread wheat cultivars) to high protein parent (*T. dicoccoides*). This increase in grain protein content of backcrosses is most likely due to the transferring of the high protein genes from the *T. dicoccoides* to the hexaploid cultivars. Although *T. dicoccoides* has high grain protein content, bread making quality of *T. dicoccoides* has lower than bread wheat cultivars. This situation has also been observed in all backcross populations. However, based on the results of this study, it could be concluded that high protein genes in the wild tetraploid wheat (*T. dicoccoides*) could possibly be transferred to the bread wheat cultivars.

Key words: Quality, bread wheat, protein content, wild emmer wheat

INTRODUCTION

Grain protein content of wheat is important for bread making and pasta quality. In spite of its importance, progress in breeding for high grain protein content has been slow and difficult. The first limitation is that genetic variation for protein content is small as compared with variation for environments. The second limitation is that there is a strong negative correlation between grain protein content and grain yield; cultivars with high grain protein content tend to be lower yield (Khan et al., 2000; Gonzalez-Hernandez et al., 2004). However, Zanetti et al. (2001) reported the results for high grain protein content and yield components obtained in the same population. Chee et al. (2001) explained that a weak negative correlation between yield and grain protein content was observed in substitution line (LDN(DIC)-6B) populations. Moreover, Groos et al. (2003), who found no strong negative pleiotropic effect, suggested that it would be possible to use these two economically important traits in the same breeding scheme. Also, several researchers have reported little or no significant correlation between grain protein content and grain yield (Steiger et al., 1996; Joppa et al., 1997).

Some accessions of the wild tetraploid wheat (*Triticum turgidum* L. var. *dicoccoides*) have genes for high protein content as a promising source (Avivi, 1978). A complete set of Langdon-*dicoccoides* chromosome substitution lines that provided an opportunity to study the genetics of this high protein and develop new durum cultivars with higher grain protein content is developed and showed that a gene for high protein content was present on chromosome 6B (Joppa and Cantrell, 1990). The high protein content gene from *T. dicoccoides* has also been transferred to hexaploid wheat. Hexaploid wheat cultivar Glupro ('Columbus'/*T. turgidum* var. *dicoccoides*//'Len') having high protein gene was developed from *T. dicoccoides* (Khan et al., 2000). However, the unique milling and baking properties of common bread wheat are not found among the diploid and tetraploid wheat like *T. dicoccoides*. Since only the hexaploid group possesses the D set of chromosomes, derived from *T. tauschii*, desirable quality characteristics of bread wheat have been attributed preponderantly to the presence of this third genomic component (Belderok, 2000).

The objective of this study was to find possibilities for transferring some quality traits and to determine high protein content, SDS-sedimentation and hardiness values in backcrosses of *T. aestivum* x *T. dicoccoides*.

MATERIALS AND METHODS

Three winter wheat cultivars of Colorado (Halt, Yuma, Akron) and one experimental line (CO99508) and one accession of *T. dicoccoides* supplied from the Gene Bank in the Agricultural Research Institute in Menemen, İzmir, Turkey were used in the study. Spring and winter bread cultivars were crossed with *T. dicoccoides* in the greenhouse conditions in 2002. Then hybrid F_1 plants were grown and backcrossed with bread wheat cultivars in the greenhouse. Backcrosses with winter bread wheats and parents were

planted in a Randomized Complete Block Design with three replications under field conditions at Colorado Research Station, Ardech, Fort Collins, Colorado in March 2003. Backcross combinations as follows; (Halt x *T. dicoccoides*) x Halt (BC_H), (Yuma x *T. dicoccoides*) x Yuma (BC_Y), (Akron x *T. dicoccoides*) x Akron (BC_A) and (CO99508 x *T. dicoccoides*) x CO99508 (BC_C). Each plot was harvested and threshed separately. Grain samples were milled into whole meal by a UDY Cyclone (UDY Corp., Fort Collins, Colorado). Grain hardiness and grain protein content of grain samples were determined using Infrared Reflectance Analyzer in the Quality Laboratory of Soil and Crop Science Department of Colorado State University (CSU). The SDS-sedimentation tests were performed on flour samples (1 g). Sedimentation volumes were measured the height of the dark part of solution as a milliliter and then converted to centiliter. Analysis of variance (Steel and Torrie, 1980) was applied for protein content, SDS-sedimentation, hardiness of recurrent parents and backcrosses. The means were statistically compared using the least significant difference (LSD) at p = 0.05.

RESULTS AND DISCUSSION

Analysis of variance (Table 1) revealed that there were highly significant differences among the genotypes for all characteristics, indicating the presence of the genetic variability in this genetic material.

Table 1. Mean squares for the three quality characteristics

Sources	d.f.	Protein content	SDS sedimentation	Hardiness
Replications	2	0.09	4.27	10.98
Genotypes	8	18.50**	966.61**	366.17**
Error	16	6.96	34.15	4.76
CV (%)		3.74	8.08	4.06

**: Significant at the $p \leq 0.01$ probability level

The mean, the minimum and maximum values of parents and their backcrosses for all the three characteristics and their LSD groups were presented in Table 2.

Grain Protein Content

Grain protein content in wheat varies between 8 and 17 percent depending on genetic make-up on external factors associated with the crop (Pena, 2002). Protein content of BC_Y was statistically equal to the protein content of *T. dicoccoides,* but other backcrosses had lower values than that of *T. dicoccoides*. At the same time, the protein content of all backcrosses was higher than all recurrent cultivars. Although protein content of BC_A had the lowest value among the backcross combinations, its mean value was still higher than that of the bread wheat cultivars used in this study. This increase in grain protein content in backcrosses is most likely due largely to the transfer of the high protein genes from the *T. dicoccoides* to the hexaploid cultivars. Kushnir and Halloran (1984) were observed high protein content in certain F_3 lines derived from *T. dicoccoides* x *T. aestivum* and thus they showed that high protein content could be transferred from tetraploid to hexaploid wheat. In addition, Zanetti et al. (2001) found high grain protein content in *T. aestivum* x *T. dicoccoides* cross population.

SDS-sedimentation

The sedimentation test has gained wide acceptance as a useful, small-scale test in bread wheat breeding programs to predict gluten strength and baking quality. The minimum, maximum and average values of SDS-sedimentation of parents and backcross populations were presented in Table 2. The mean value of SDS-sedimentation of *T. dicoccoides* was lower than those of bread wheat cultivars in this study (Table 2). Although *T. dicoccoides* has high grain protein content, its low SDS-sedimentation value indicated that bread making quality of *T. dicoccoides* has lower than other bread wheat cultivars (Pena, 2002). Since all backcrosses had lower SDS-sedimentation values than other bread wheat cultivars, it is expected that the bread making quality of the backcrosses could be possibly similar to quality of *T. dicoccoides*. However, when both protein content and SDS-sedimentation values of BC_C which are higher than those of recurrent parent are considered, it could be selected as a promising backcross combination. Except BC_C, mean SDS-sedimentation values of other backcross populations showed lower values than those of their parents. Nevertheless, the maximum SDS-sedimentation values of backcross populations showed that it could be possible to genotypes having high protein content and high SDS-sedimentation values in acceptable level to bread making. Ruiz and Carrillo (1995) found strong correlation between SDS-sedimentation volume and mixograph mixing time (r=0.78 to 0.85) and mixograph peak height (r=0.70 to 0.77), but not with protein content. Graybosch (2000) also suggested that the introgression of Glu-D1HMW glutenin subunits from *T. dicoccoides* (TDHMW) did little to improve the SDS-sedimentation volumes of the bread wheat lines carrying either 1AL, 1RS or 1BL, 1RS.

Hardiness

Grain hardness is determined by the way components are packed in the endosperm cells and refers to the resistance the grain opposes to being fractured and to being reduced to fine whole meal flour or to fine endosperm particles. Grain hardness is a grain quality trait associated with the milling properties of wheat and with the baking quality of the resulting milling products and milling energy requirements are affected by grain hardness. Hard wheat require longer milling times and more milling energy (Pena, 2002). The minimum, maximum and average hardiness values of parents and backcross populations were presented in Table 2. The hardiness values of bread wheat cultivars were lower than *T. dicoccoides*. The hardiness values of backcross populations were close to the bread wheat cultivars except for BC_A. It appeared that the degree of success in incorporating high hardiness from *T. dicoccoides* into hexaploid wheat may change by bread wheat varieties. Since variation in grain hardness is mainly controlled by the *Ha* locus on the short arm of chromosome 5D in hexaploid wheat and softness (*Ha*) is dominant to hardness (*ha*) (Law et al., 1978; Kunert et al., 2007). It was postulated that Akron possesses a more complex genetic system governing for hardiness. The hardiness values of BC_Y and BC_A backcrosses were statistically found similar.

Table 2. The minimum, maximum and mean values of the parents and their backcrosses

Parent/Backcross	Protein content (%)			SDS-sedimentation (cl)			Hardiness		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
T. dicoccoides	21.42 a	20.5	22.7	5.27 cd	4.4	6.7	72.14 a	57	92
Halt	15.50 de	14.0	17.4	9.42 a	8.2	10.2	52.22 c	28	83
Yuma	16.50 cd	15.2	17.8	9.45 a	8.7	10.0	61.89 b	45	76
Akron	15.04 e	13.3	17.4	8.27 b	6.3	10.0	35.61 e	27	43
CO99508	14.86 e	13.8	22.1	7.89 b	7.0	8.5	60.11 b	48	71
BC_H	18.95 b	17.7	20.2	5.83 c	3.0	9.5	59.80 b	41	81
BC_Y	20.90 a	20.0	22.3	4.59 d	3.0	7.2	51.31 c	46	59
BC_A	16.82 c	14.0	21.5	6.24 c	4.0	8.5	48.53 c	25	69
BC_C	18.98 b	17.3	22.1	8.08 b	7.0	8.5	42.33 d	27	54
LSD (%5)	1.14			1.01			3.79		

As a result of this study, it could be concluded that high protein genes in the wild tetraploid wheat (*T. dicoccoides*) could be transferred to the hexaploid bread wheat cultivars. In our study, BC_C was appeared to be a promising backcross. In addition to this, since the bread making quality properties of wheat arise from the D genome, both quality characteristics and chromosome number of promising genotypes should be determined to select genotypes with hexaploid level.

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LITERATURE CITED

Avivi, L., 1978. High grain protein content in wild tetraploid wheat *Triticum dicoccoides* Korn. In: Ramanujan S. (ed.), 5th Int. Wheat Genet. Symp., pp. 372-380. New Delhi, India.

Belderok, B., 2000. Developments in bread-making processes. In: Belderok, B., Mesdag, J., Donner D.A. (eds), Bread Making Quality of Wheat: A Century of Breeding in Europe. ISBN 0-7923-6383-3. Kluwer Academic Publishers, Netherlands.

Chee, P.W., E.M. Elias, J.A. Anderson, S.F. Kianian, 2001. Evaluation of a high protein QTL from *Triticum turgidum* L. var. *dicoccoides* in an adapted durum wheat background. Crop Sci. 41:295-301.

Gonzalez-Hernandez, J.L., E.M. Elias, S.F. Kianian, 2004. Mapping genes for grain protein concentration and grain yield on chromosome 5B of *Triticum turgidum* (L.) var. d*icoccoides*. Euphytica 139:217-225.

Graybosch, R.A., 2000. Improved quality of 1RS wheats via genetics and breeding. In: P.R. Shewry P.R., Tatham A.R. (eds), Gluten 2000. 7th Int. Workshop on Gluten Proteins, 2-6 April 2000, Inst. Arable Crops Res. Bristol, UK.

Groos, C., N. Robert, E. Bervas, G. Charmet, 2003. Genetic analysis of grain protein-content, grain yield and thousand-kernel weight in bread wheat. Theor. Appl. Genet. 106:1032-1040.

Joppa, L.R., R.G. Cantrell, 1990. Choromosomal location of genes for grain protein content in wild tetraploid wheat. Crop Sci. 30:1059-1064.

Joppa, L.R., C. Du, G.E. Hart, G.A. Hareland, 1997. Mapping QTL for grain protein in tetrploid wheat (*Triticum turgidum* L.) using a population of recombinant inbred chromosome lines. Crop Sci. 37:1586-1589.

Khan, I.A., J.D. Procunier, D.G. Humpreys, G. Tranquilli, A.R. Schlatter, S. Marcucci-Poltri, R. Frohberg, J. Dubcovsky, 2000. Development of PCR-based markers for a high grain protein content gene from *Triticum turgidum* ssp. *dicoccoides* transferred to bread wheat. Crop Sci. 40:518-524.

Kunert, A., A.A. Naz, O. Dedeck, K. Pillen, J. Leon, 2007. AB-QTL analysis in winter wheat: I. Synthetic hexaploid wheat (*T. turgidum* ssp. *dicoccoides T. tauschii*) as a source of favourable alleles for milling and baking quality traits. Theor. Appl. Genet. 115:683-695.

Kushnir, U., G.M. Halloran, 1984. Transfer of high kernel weight and high protein from wild tetraploid wheat (*T. turgidum dicoccoides*) to bread wheat (*T. aestivum*) using homologous and homoeologous recombination. Euphytica 33:249-255.

Law, C.N., C.F. Young, J.W.S. Brown, J.W. Snape, J.W. Worland, 1978. The study of grain protein control in wheat using whole chromosome substitution lines. In: Seeds Protein Improvement by Nuclear Techniques. International Atomic Energy Agency, Vienna, Austria, pp. 483-502.

Ruiz, M., J.M. Carrillo, 1995. Relationships between different prolamin proteins and some quality properties in durum wheat. Plant Breed. 114:40-44.

Pena, R.J., 2002. Wheat for bread and other foods. In: Curtis, B.C., Rajaram, S., Macpherson, H.G. (eds), Bread Wheat Improvement and Production. FAO Plant production and protection series, No:30, Roma.

Steel, R.G.D., J.H. Torrie, 1980. Principles and Procedures of Statistics: A Biometrical Approach. 2. ed. New York: Mc Graw-Hill, 631p.

Steiger, D.K., E.M. Elias, R.G. Cantrell, 1996. Evaluation of lines derived from wild emmer chromosome substitutions, I. Quality traits. Crop Sci. 36:223-227.

Zanetti, S., M. Winzeler, C. Feuillet, B. Keller, M. Messmer, 2001. Genetic analysis of bread-making quality in wheat and spelt. Plant Breed. 120:13-19.