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RELATIONSHIPS AMONG ANEUPLOIDY, GERMINATION RATE AND SEED SHRIVELLING IN 6X-TRITICALES

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ABSTRACT

In this study, relationships among chromosome numbers, germination percentage and seed characters in six triticale genotypes were determined. Genotypes were selected from among 32 triticale cultivars. The genotypes were divided into two groups based on their test weight, and then each genotype was divided into two sub-group by its seed appearance (shriveling or plump). Frequency of aneuploidy in plump and shriveled seeds of the low test weight genotypes were 6.81% and 26.81%; while were 1.08% and 15.89 % in the high test weight genotypes. There was a significant relationship between shrivelling and chromosome number, while there was no or only weak relationship between test weight and aneuploidy. Among the aneuploid chromosome classes, 2n=41 was the largest and hyperplods were not found in all genotypes examined. Negative effect of seed characters was found in germination percentage and germination percentage in shriveled seeds were significantly lower than that of the plum groups. Germination percentage was higher in high test weight genotypes (87.34 %) than in low test weight genotypes (80.21 %). However, correlation between germination percentage and test weight was not significant.

Key words: Triticale; aneuploidy; shriveling; test weight

INTRODUCTION

Triticale (*X Triticosecale* Wittmack) is a man-made crop developed by crossing wheat (*Triticum turgidum or Triticum aestivum*) with rye (*Secale cereale*). While it was developed over 100 years ago, the first cultivars were only released in the 1970s. Early attempts to cross wheat and rye produced only sterile offsprings. It was not until the 1930s that techniques were available to produce fertile hybrids. Consequently, new varieties of triticale can be developed with the same methods used for breeding other cereal crops. Despite of the clear success of classical breeding, there are several traits that still need modifications. Among them are low resistance to preharvest sprouting, improvement of grain quality (for example low level of lysine content or altered gluten composition) and problem of grain shrivelling (Komen, 1992).

A major problem in the improvement of triticale is seed shrivelling at maturity. The degree of seed shrivelling is reflected in its low test-weight and thereby, total grain yield, and consequently less flour extracted during milling. Yielding ability of a crop is affected by physiological processes related to the synthesis, translocation and accumulation of the photosynthetic product during the post-anthesis phase (Guedes-Pinto et al., 1984).

Relationship between kernel size and aneuploidy frequency has been investigated previously (Hagberg and Ellerstrom, 1959; Klinga, 1986a; Klinga, 1986b; Suarez and Favret, 1986; Tosun et al., 2003). In a different approach, we classified cultivars based on low and high test weight rather than just kernel shriveling and plumpness.

The aim of this study was to determine the aneuploidy frequency in the low and high test weight hexaploid triticales, to study the correlation between kernel shriveling and aneuploidy frequency and to study germination capacity of the groups.

MATERIALS AND METHODS

Six hexaploid triticale genotypes, Tarasca 87, Cananea 79, Uron 1, Iguana-2, REH ″S″ / HARE 212-6, (obtained from CIMMYT) and Tatlıcak (obtained from Bahri Dağdaş International Agricultural Research Institute) were used in the experiments. These genotypes were selected, based on results of a previous study, in which they were the most promising lines for growing conditions in Isparta (Akgün et al., 2007). In this study, 32 Triticale cultivars were used. All genotypes were grown under the same conditions in 2002. First, the genotypes were grouped into highest and lowest test weight. Later, these genotypes were subdivided into two subclasses based on their kernel appearance (plump and shriveled) and their 1000-seed weights were determined. The reliability was checked by comparing the 1000-seed weights of groups' two parallels samples. Genotypes, kernel appearances and seed weights were given in Table 1.

Seeds (2 x 50) from each class were germinated in Petri dishes. The seedlings were planted in small pots and allowed to grow to a proper size for chromosome counting. Chromosome numbers were determined by a modification of conventional root tip squash (Tosun, 1999). Chromosome numbers were examined from least five good metaphase plates from each plant.

In order to determine germination percentage, 400 seeds from each class were sown into pots with four replications and germinated at room temperature. Emerged seedlings were counted at the end of 8 days (Anonymous, 1999). Data on aneuploidy and germination capacity were subjected to analysis of variance (ANOVA) tests.

Table 1. Test weight and 1000-seed weights of plump and shrivelled groups in 6x-triticale genotypes

Genotypes		Test Weight	1000-Grain Weight (g)	
No	**Pedigree**	**(kg/hl)**	**Plump**	**Shrivelled**
1	Tatlıcak	67.83 (low)	41,66	27,26
2	Tarasca 87	66.01 (low)	44,66	23,28
3	Cananea 79	65.71 (low)	41,73	25,47
4	Uron 1	73.90 (high)	47,66	31,12
5	REH ″S″ / HARE 212-6,	73.71 (high)	43,28	28,24
6	Iguana-2	72.37 (high)	44,25	29,17

RESULTS AND DISCUSSION

Chromosome numbers

The distribution of chromosome numbers among the seed groups is provided in Table 2. There were significant differences in aneuploidy frequencies among seed groups ($P < 0.01$). Total aneuploidy frequencies in plump and shriveled seeds in low test weight were 6.81% and 26.81%, respectively, while in high test weight genotypes were 1.08% and 15.89 %, respectively. Chromosome numbers ranged from 2n=38 to 2n=41 among shriveled seed group and only plants with 2n=41 chromosomes were found in plump seed group. In low test weight group the lowest aneuploidy frequency was observed from cultivar Tatlıcak and no aneuploidy was observed in plump seeds. For other cultivars aneuploids were observed between both seed groups; however, aneuploidy frequency was higher in shriveled seed group than plump seed group (Figure 1 and Table 2).

In seed groups, a negative correlation (-0.777) was found between test weight and aneuploid frequency but it was not significant ($P>0.05$)**.** Nevertheless, a negative and significant relationship (-0,832) was found between kernel appearance and aneuploidy percentage ($P<0.01$).

It is possible that aneuploidy could affect kernel characters in hexaploid triticale. Total of 225 plants were examined in plump seed group, belonging to 6 genotypes, among these 95.56 % were euploid, 4.44 % were aneuploid, whereas, 245 plants were examined in shriveled seed group and 77.96 % were euploid and 22.04 % were aneuploid. In addition, it was found out that aneuploidy percentage was higher in low test weight genotypes.

Aneuploids arise from chromosome pairing failures at meiosis leading to nondisjunction and the formation of aneuploid gametes. Shkutina and Khvostova (1971) noted that there was asynchronous separation of chromosomes in metaphase and anaphase of meiosis. It was suggested that incompatibility between wheat and rye genomes was the main cause of the irregularities in meiosis. The meiotic instability results in varying degrees of aneuploidy in the progeny of euploid plants. The tendency of bad seeds to give aneuploid plants may be explained by disturbed quantitative relations among the chromosome numbers of embryo, endosperm and maternal tissues.

In this study, it was found that shriveled kernels had more aberrant chromosome numbers than good kernels. The aneuploids with different chromosome numbers did not occur in equal rations. The hypoploids, 2n=41, were the most frequently observed category.

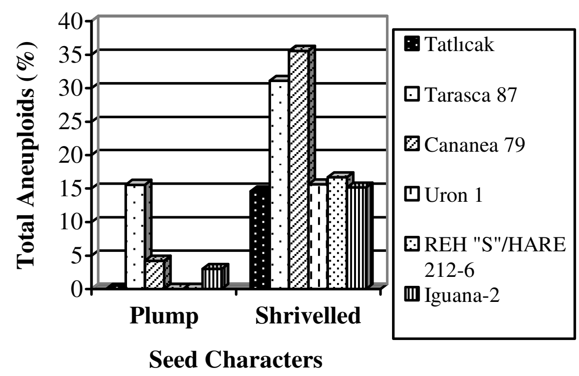

Figure 1. Distribution of aneuploids among seed groups within the hexaploid triticale genotypes

In this study, hyperploidy was not observed. The findings could be explained either by chromosome loss resulting from meiotic irregularities or hyperploid gametes being less functional than hypoploid gametes. Müntzing (1943) found that the hypotetraploid category in rye was more viable. It was determined that there was a predominance of hypoploids in the three population of tetraploid ryegrass (Ahloowalia, 1971). Similar observations have been reported in triticale (Guedes-Pinto et al., 1984; Tosun et al., 2003), rye (Hagberg and Ellerstrom, 1959), wheat (Worland and Law, 1985) and meadow fescue (Klinga, 1986a). Correlation between seed quality and percentage of aneuploids was also examined. Similar investigations in other crops displayed a close relationship between seed characters and aneuploid frequency. The frequencies of euploids in the different seed size classes (large, medium and small) and the chromosome number of bulk populations of nine hexaploid strains of triticale were studied (Tsuchiya, 1973). The euploid frequency was higher in large seed class than in medium and small seed classes with one exception. It was suggested that the screening of larger seeds could give a higher frequency of euploids. Guedes-Pinto et al. (1984) reported that aneuploidy generally increased as kernel size decreased in all hexaploid triticale. Similarly, Suarez and Favret (1986) divided a wheat

Table 2. Distribution of mitotic chromosome numbers among seed groups within the hexaploid triticale genotypes.

Genotypes	Seed Characters	Aneuploids										Euploids	
		2n=38		2n=39		2n=40		2n=41		Total		2n=42	
		N	%	N	%	N	%	N	%	N	%	N	%
Tatlıcak	Plump	-		-		-		-		-		40	100
	Shrivelled	-		-		2	4.17	5	10.41	7	14.58	41	85.42
Tarasca 87	Plump	-		-		-		7	15.56	7	15.56	38	84.84
	Shrivelled	2	4.44	-		5	11.11	7	15.56	14	31.11	31	68.89
Cananea 79	Plump	-		-		-		2	4.25	2	4.25	45	95.74
	Shrivelled	1	2.22	1	2.22	6	13.33	8	17.78	16	35.56	29	64.44
Total(LTW[1])	**Plump**							**9**	**6.81**	**9**	**6.81**	**123**	**93.18**
	Shrivelled	**3**	**2.17**	**1**	**0.72**	**13**	**9.42**	**20**	**14.49**	**37**	**26.81**	**101**	**73.19**
Uron 1	Plump	-		-		-		-		-		25	100
	Shrivelled	-		-		2	6.25	3	9.37	5	15.62	27	84.38
REH "S" / HARE 212-6,	Plump	-		-		-		-				35	100
	Shrivelled							5	16.67	5	16.67	25	83.33
Iguana-2	Plump							1	3.03	1	3.03	32	96.97
	Shrivelled			1	2.22	4	8.89	2	4.44	7	15.15	38	84.44
Total(HTW[2])	**Plump**							**1**	**1.08**	**1**	**1.08**	**92**	**98.92**
	Shrivelled			**1**	**0.93**	**6**	**5.61**	**10**	**9.35**	**17**	**15.89**	**90**	**84.11**

[1]LTW Low test weight; [2]HTW High test weight

variety into 6 sub-groups according to their seed appearance (wrinkled and plump) and seed size (small, medium and big). They found that the frequency of aneuploidy was higher in wrinkled seeds than plump seeds. In triticale, relationship between aneuploidy frequency and kernel appearance was studied and clear differences of aneuploidy frequencies between plump and shriveled kernel groups were found (Tosun et al., 2003).

In this study, a negative relationship was found between test weight and aneuploidy but it was not significant (P>0.05). Environmental factors, such as, climatic conditions, availability of minerals and genetic factors should be taken into consideration. Because all these all factors are affect seed characteristics of triticale, elimination of sub-standarted seed could be useful for maintenance of the genetic stability of cultivar.

Germination Rates

Germination percentages of genotypes having different seed characters were given in Figure 2 and Table 3. Among the examined genotypes, no significant differences were found for germination percentage (P>0.05). However, germination percentage varied with the test weight and it was found to be greater among high test weight genotypes (% 87.34) than among low test weight genotypes (80.21 %). Similarly, the germination rate in plump kernels was higher than in shriveled kernels. Effect of seed characters on germination percentage of triticale genotypes were significant (P<0.01). Emergence rates were 96.42 % for plump and 64.50 % for shriveled kernels in low test weight, and 97.33% and 77.33% in the high test weight genotypes, respectively. The correlation (-0.926) was significant between the kernel characters and germination percentage (P<0.01), while correlation (0.257) was not significant between test weight and germination percentage.

The germination capacity depends on seed characters. Germination capacity of shriveled kernels is lower than that of the plump kernels. Effects of the seed size and seed quality on the germinating capacity were investigated in different studies and similar results have been reported (Guedes-Pinto et al., 1984; Klinga, 1986a; Klinga, 1986b; Tosun et al., 2003).

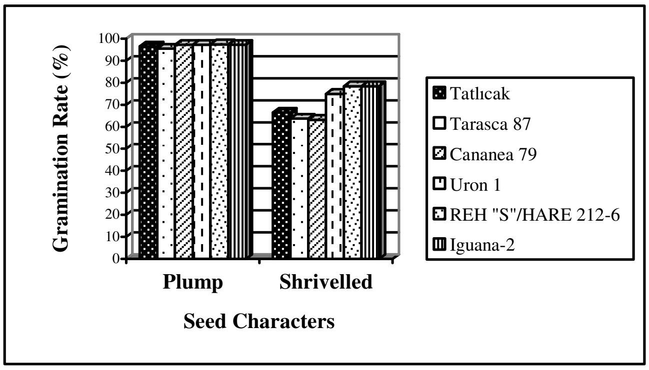

Figure 2. Germination percentages in the differnet test weight and seed characters of hexaploid triticale genotypes

As a result, emergence of plump kernels in all genotypes was the vigorous and fast. Emergence was the slowest in shrivalled kernels and growing seedlings were weak. It is possible that such seedlings could not be able to stand against environmental conditions and other factors could decrease plant numbers in unit area. For this reason, elimination of such seeds could remove off-type plants in a population and could guarantee higher yield.

Table 3. Germination percentages in the different test weight and seed characters of hexaploid triticale genotypes

Genotypes	**Seed characters**	**Germination rate (%)**	**Mean of genotypes**
Tatlıcak	Plump	96.50	
	Shrivelled	66.50	**81.50**
Tarasca 87	Plump	95.50	
	Shrivelled	63.75	**79.63**
Cananea 79	Plump	97.25	
	Shrivelled	63.25	**79.50**
Mean of seed groups (LTW[1])	**Plump**	**96.42**	
	Shrivelled	**64.50**	
Uron 1	Plump	97.25	
	Shrivelled	75.00	**86.13**
REH "S" / HARE 212-6,	Plump	97.50	
	Shrivelled	78.50	**88.00**
Iguana-2	Plump	97.25	
	Shrivelled	78.50	**87.88**
Mean of seed groups (HTW[2])	**Plump**	**97.33**	
	Shrivelled	**77.33**	

LITERATURE CITED

Ahloowalia, B.S. 1971. Frequency, origin, and survival of aneuploids in tetraploid rygrass. Genetica, 42: 129-138.

Akgun, I., Kaya, M. and D. Altindal. 2007. Determination of yield and yield components in some Triticale lines/genotypes under Isparta ecological condition. Journal of the Faculty of Agriculture**,** Akdeniz University. 20(2), 171-182.

Anonymous, 1999. International rules for seed testing rules. Seed Sci. and Technol., 27: 182 pp.

Guedes-Pinto, H., Rangel-Figueiredo, T. and O. Carnide. 1984. Aneuploidy in high yielding 6x-triticales. Cereal Research Communications, 12: 229-235.

Hagberg, A. and S. Ellerstrom. 1959. The competition between diploid, tetraploid and aneuploid rye. Hereditas, 45: 369-416.

Klinga, K. 1986a. Aneuploidy in induced Autotetraploid populations of *Festuca pratensis*, *Lolium multiflorum* and *Lolium perenne*, L. The Frequency of aneuploids and performence of spaced plants in two autotetraploid populations of *Festuca pratensis*. Hereditas, 104: 75-83.

Klinga, K. 1986b. Aneuploidy in induced Autotetraploid populations of *Festuca pratensis*, *Lolium multiflorum* and *Lolium perenne*, I. The Frequency of aneuploids and performence of spaced plants in *Lolium multiflorum and Lolium perenne*. Hereditas, 104: 121-130.

Komen, J. 1992. Grains for the tropical regions. Biotechnol. Dev. Monito, 10: 3-5.

Müntzing, A. 1943. Aneuploid and seed shriveling in tetraploid rye. Hereditas, 29: 65-75.

Shkutina, F.M. and V.V. Khvostova. 1971. Cytological investigation of Triticale. Theoretical and Applied Genetics**,** 44 (3): 109-119.

Suarez, E.Y. and E.A. Favret. 1986. Aneuploidy as an explanation of high values of phenotypicvariability in commercial wheat varieties. Cereal Research Communications**,** 14(3): 229-235.

Tosun, M. 1999. Karyotype analisis in hexaploid triticale. Turkish J.Agriculture and Forestry, 23: 943-949.

Tosun, M., Haliloğlu, K., Taşpınar, S.M. and S. Sağsöz. 2003. Test weight, kernel shrivelling, and aneuploidy frequency in triticale. New Zealand J. Agricultural Research, 46: 27-30.

Tsuchiya, T. 1973. Frequency of euploids in different seed size classes of hexaploid triticale. Euphytica**,** 22 (3): 592 – 599.

Worland, A.J. and C.N. Law. 1985. Aneuploidy in semidwarf wheat varieties. Euphytica, 34: 317-327.