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EFFECT OF THE 1BL.1RS WHEAT-RYE CHROMOSOMAL TRANSLOCATION ON YIELD POTENTIAL IN BREAD WHEAT

SUMMARY

To investigate the effect of 1BL.1RS wheat-rye chromosomal translocation on bread wheat yield, four and six commercial cultivars with and without translocation, respectively, were evaluated in the field. In addition to yield, three agronomic traits were measured: days to heading, plant height and 1000 kernel weight. Experiments were performed in two different locations (one cold and one dry) for three years at each location, and four replications were conducted. Despite observed differences between the genotypes, translocation was not found to produce an advantage. Even though the two cultivars did not differ, the one without translocation was ranked first and the one with translocation was ranked second. The cultivar Kavkaz/Cgn, one of the donors for translocation, was ranked eighth, and the fourth cultivar with translocation was ranked last. Based on these results, we studied the genotypes in each location to determine whether translocation produced any adaptation effect. The results revealed that three of the four cultivars with translocation performed well in the cold environment, and only one performed well in the dry area. One of the cultivars without translocation exceeded the yield of the cultivars with translocation. In the dry area, five of the non-translocated cultivars performed as well as the translocated ones. Thus, it could be concluded that translocation had no obvious positive effect on yield. Similar results were recorded for the other three traits. Further research with more environments and more sophisticated analysis is needed to achieve more accurate conclusions.

Keywords: fixed model, analysis of variance, adaptation, yield, days to heading, plant height, 1000 grains weight.

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INTRODUCTION

The continuous deterioration of the environment, the increasingly declining agricultural area and the simultaneous increase in human food needs have created a stifling environment in agricultural research. For these reasons, the plant breeders have turned to the search for new germplasm to overcome the problem (Fehr, 1987). An interesting case is the use and integration of new genes in high yielding varieties. The 1BL.1RS wheat-rye chromosomal translocation carrying valuable genes appears as an interesting alternative (Tang et al., 2009). According to literature the presence of the translocation offers to the host cultivar high yield potential (Kim et al., 2004; Xynias et al., 2007), mainly due to increased seed weight and production under drought conditions (Ehdaie et al., 2003). Furthermore wide adaption (Rajaram et al., 1983; Schlegel and Meinel, 1994), the resistance to stress conditions (Bartos and Bares, 1971; Zeller, 1973; Moreno-Sevilla et al. 1995; Karelov et al. 2018) and the increased plant regeneration rate (Rabinovich, 1998) are three more valuable traits which can be transferred to new cultivars via the translocation.

The translocation was transferred to modern wheat cultivars though the Russian cultivar Kavkaz (Weng et al., 2007). The 1BL. 1RS translocation, despite the positive genes it also carries some other genes, reducing the bread making quality of the host cultivar (Graybosch et al., 1993; Fenn et al., 1994). However, their expression is influenced by the genetic background of the host cultivar (Rabinovich, 1998; Dimitrijevic et al., 2008) rendering the production of new germplasm with good end product quality, despite the presence of the translocation feasible.

The aim of the present study was to investigate the effect of the 1BL.1RS wheat-rye chromosomal translocation on yield performance and three other traits in bread wheat cultivars carrying the translocation compared to cultivars without the translocation under low input. conditions.

MATERIAL AND METHODS

a. Plant material

For the purpose of the study nine hellenic bread wheat cultivars (Acheron, Elissavet, Orfeas, Apolonia, Acheloos, Vergina, Doerani, Nestos and Strymonas) that were developed at the Cereal Institute of Thessaloniki (Anonymous, 2016) and the Russian cultivar Kavkaz/Cgn, one of the donors of the 1BL.1RS wheat-rye chromosome translocation (Xynias et al., 2006; Weng, 2007) were used. Three of the hellenic cultivars were found to carry the 1BL.1RS wheat-rye chromosome translocation (cvs. Acheron, Elissavet and Orfeas) whereas the other six cultivars, were lacking the specific translocation (Xynias et al., 2006; Peros et al., 2015).

b. Method

The experiments were established for three successive years 2015-16 to 2017-18 in the main Farm of the School of Agricultural Sciences, in Florina (40°46΄ N, 21°22΄E, 707 m asl), representing a cold and wet environment and in the main farm of Plant Breeding and Genetic Resources Institute, Hellenic Agricultural Organization-“Demeter” in Thermi (40°32′ N, 23°00′E, 15 m asl), representing a marginal dry environment Table 1). Seedbed preparation included mouldboard plough, disc harrow and cultivator. Nitrogen and P205 at 80 and 40 kg ha-1, respectively, were incorporated into the soil as diammonium phosphate (20-10-0) before sowing. The crop was kept free of weeds by hand hoeing when necessary.

Table 1. Rainfall and temperature regimes in the environments of Florina and Thermi (Thessaloniki).

Crop.	Florina				Thermi			
Season*	Rainfall (mm)		Temperature (^{0}C)		Rainfall (mm)		Temperature (^{0}C)	
	Total	Critical**	Min	Max	Total	Critical**	Min	Max
2015-16	526.8	292.4	-14.6	35	294.9	188.4	-8	38
2016-17	423	193.2	-21.8	37.6	385	98***	-10	40
2017-18	921	232.4	-9	34.2	482.3	153.6	-4	36

*From November till July, **In March, April, May, ***only 15.8 mm rainfall from the second half of March till the end of the first half in May

Randomised complete blocks field design statistical analysis for each location and combined over cropping seasons was made (Steel and Torrie, 1960). The fixed model was used, in which the years were the random and the evaluated genotypes the fixed variable (McIntosh, 1983). The plots were consisted of five rows (plot area 3m^2) of which the three inner were threshed (harvest area 1.8m^2). Except yield, three more traits influencing yield potential were studied: i. e. days to heading, maturity height and 1000 kernel weight were studied. Comparisons were performed between the aforementioned traits to reveal how they affect each other (Steel and Torrie, 1960).The means were compared according to the L.S.D. method. The data obtained were analyzed statistically with Mstat-C (Freed and Eisensmith, 1986).

RESULTS AND DISCUSSION

The across testing environments combined analysis of variance produced significant genotypic effects for all traits studied (Table 2). The expected significant environment effect was observed for all traits. Except in the effect of the environment which accounted 11.6% of the yield total sum of squares - TSS (as compared to 6.9% and 58% for genotypes and genotype x environment interaction - GEI effects respectively), the values on the other traits were the ones expected. Thus, the environment accounted for 93.6% of the earliness to heading TSS (as compared to 1.2 and 4.4% for genotypes and GEI effects respectively), 84.4% of the plant height at maturity TSS (as compared to 7.0% and 3.5% for genotypes and GEI effects respectively) and 73.3% of the 1000 kernel weight TSS (as compared to 4.7 and 11.6% for genotypes and GEI effects respectively).

Similar results were reported in bread wheat (Yan et al., 2000) and in durum wheat (Agorastos and Goulas, 2005). A highly significant GEI effect was observed for grain yield and for all other correlated traits.

Table 2. Over environments analysis of variance for yield, days to heading, maturity height and 1000 kernel weight in 10 bread wheat varieties.

Source	Degrees of freedom	Mean squares			
		Yield	Heading	Maturity height	1000 kernel weight
Environments (E)	5	**	**	**	**
Cultivars (G)	9	**	**	**	**
GE interaction	45	**	**	**	**
CV		17.01	1.68	5.61	6.72
TSS environments		11.6	93.6	84.4	73.3
TSS cultivars		6.9	1.2	7.0	4.7
TSS GE interaction		58.0	4.4	3.5	11.6

Table 3. Ranking for yield (g/plot), days to heading, maturity height (in cm) and 1000 kernel weight (g) of the evaluated bread wheat varieties.

a/a	Cultivar	Yield	Heading	Maturity height	1000 kernel weight
1	Acheron*	CD	DE	CD	A
2	Elissavet*	A	C	CD	E
3	Kavkaz/Cgn*	D	C	B	D
4	Orfeas*	D	BC	B	E
5	Apollonia	A	D	C	D
6	Acheloos	AB	BC	A	BC
7	Yecora E	CD	E	E	CD
8	Doerani	BC	B	B	AB
9	Nestos	BC	A	D	BCD
10	Strymonas	D	C	B	CD
	LSD	54.95	1.508	2.641	1.373

(*) Cultivars carrying the 1BL.1RS wheat-rye chromosomal translocation
Cultivars followed by different letters are significantly different at p=0.05 level

The ranking of the examined bread wheat cultivars for each individual trait is presented in Table 3. It becomes evident from this table that there is no general effect of the presence of the translocation in all traits. Only cultivar Elissavet performed well in yield but with no differences from cultivars Appolonia and Acheloos, which did equally well. The other three cultivars carrying the translocation were ranked last. In days to heading only Aheron was equally early with cultivar Yecora E, which is one of the earliest cultivars under the hellenic climatic conditions.

No differentiation was noticed between the rest of the cultivars, carrying the translocation or not. Cultivar Acheloos was the most vigorous one, whereas cvs Kavkaz/Cgn and Orfeas were equally vigorous with cultivars Doerani and Strymonas. In 1000 kernel weight, cv. Acheron performed equally well with cv. Doerani, whereas cvs Elissavet and Orfeas were ranked last.

Table 4. Over years analysis of variance for yield, at each location, of the bread wheat cultivars studied.

Source	Degrees of freedom	Mean squares	
		Florina	Thermi
Years (y)	2	ns	**
Varieties (V)	9	**	**
Y x V	18	**	**
CV		17.35	16.66
TSS	Years	1.2	22.3
	Cultivars	19.9	19.3
	Interaction	54.1	37.9

Table 5. Ranking for yield (g/plot) at each location, of the bread wheat cultivars studied.

a/a	Cultivar	Florina	Thermi
1	Acheron*	A	CD
2	Elissavet*	A	AB
3	Kavkaz/Cgn*	A	E
4	Orfeas*	E	BCD
5	Apollonia	AB	A
6	Acheloos	A	ABC
7	Yecora E	DE	AB
8	Doerani	BC	AB
9	Nestos	CD	A
10	Strymonas	BC	D
	LSD	79.56	77.02

(*) Cultivars carrying the 1bl.1rs wheat-rye chromosomal translocation
Cultivars followed by different letters are significantly different at p=0.05 level

A second issue that was attempted was to study the genotypes in each location separately in order to find out whether there was any adaptation effect of the translocation. In this analysis, the differences in yield between the genotypes tested were significant in both locations (Table 4). The expected significant year effect was observed only in Thermi. This could be interpreted by the similarity in weather conditions in the location of Florina during all testing years. The ranking of the cultivars studied revealed that three of four of them carrying the translocation performed well in the cold environment (Table 5). Only one cultivar without the translocation exceeded in yield the aforementioned cultivars carrying the translocation. These results support the view that there must be some advantage of the translocation in cold environments, but this cannot be generalized since one cultivar carrying the translocation was ranked last. In the dry area, five of the non-translocated cultivars were ranked in higher places. Only one of the cultivars carrying the translocation performed equally well with the translocated one.

The above results suggest that there is not any positive effect of the presence of the translocation on yielding potential of the host cultivar. Only in the cold area of Florina there was some advantage of the translocation. In the dry area only one cultivar with the translocation performed well. This does not agree with the results of Hoffmann (2008), who stated that the translocation offers resistance to drought to the host cultivar. One could presume from the performance of the evaluated germplasm that the presence of the translocation is not enough to ensure any yielding advantage. Probably, the genetic background of the host cultivar is essential for the translocation to express its valuable properties. The same was concluded by Lisova *et al*., (2005) who studied the biotic resistance of cultivars carrying the translocation, by Lazaridou *et al*., (2014) who studied the of the effect of the translocation on the androgenic response and Xynias *et al*. (2018) who studied the effect of the translocation on bread making quality.

CONCLUSIONS

Summarizing the data discussed applicable to the particular set of bread wheat genotypes evaluated under the range of environments, no effect of the presence of the translocation was observed. However, since the fixed model was used these conclusions apply only to the varieties and environments studied. Further research, applying the random model, is needed to draw general conclusions.

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