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A N I N T E R N A T I O N A L J O U R N A L

Selection for Grain Yield and Quality in Segregating Generations of Wheat

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ABSTRACT

The objective of the work was to combine simultaneous selection for grain yield and technological quality in elite segregating populations of wheat developed by the breeding program of IAPAR. Thirteen populations were chosen according to their potentiality of genetic variability in the F_2 generation of the 1997 crop season. One hundred heads were selected from each population and sown as F_3 head-rows in the following season. Visual selection of individual head-rows or lines was done for yield potential and maturity. Seeds of the selected lines were evaluated for Sedimentation Values as well as Protein Content. The populations were identified as C1 to C13, representing the different crosses. The number of $F_{2:3}$ lines selected within populations varied from one to 12. The populations C6, C7, C9, and C13 were classified as early maturity. Two populations (C6 and C9) presented higher potential for grain yield. The populations C12, C3, C8, and C1 were better for mean and variance of sedimentation values. The populations C2, C3 and C11 had a good performance for mean, maximum values and variance of protein content. The data indicates a good potential to obtain advanced lines with higher grain yield associated with a better technological quality.

Key words: Triticum aestivum, technological quality, grain yield, segregating generations

INTRODUCTION

The sectors involved in the production, trading and industrializaton of wheat (*Triticum aestivum* L.) are interested in several aspects of its quality. The need of quality wheat grain that fulfills the requirements of the industry, and the fact of Brazil not being self sufficient in production, increases the demands of breeding programs which can obtain improved cultivars with better grain quality associated with higher grain yield.

The purchase of wheat by the milling industry considers aspects of technological quality such as general gluten strength, which can be measured by different methodologies, allied to the fact of the grain not being affected by pre-harvest sprouting caused by excessive precipitation after grain maturation. The rain during the harvest operation stimulates the activity of the enzyme α-amilase, which initiates the starch degradation, reducing the possibility of baking bread and other products (Guarienti, 1996).

Sedimentation values correlates strongly with the general gluten strength and bread making as pointed out by Zeleny (1947). A modification of a test for rapid estimation of gluten strength in durum wheats was described by Dick & Quick (1983). A modified sedimentation test was also

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performed by Peña *et al* (1990), to find associations of quality characteristics and the presence of 1B/1R translocation wheats, indicating the exchange of chromosome segments between wheat and rye which normally reduces the overall wheat technological quality.

Many quality traits although affected by environmental factors, are under genetic control, which allows manipulation and selection by the breeders (Lukow & McVetty, 1991). The technological quality of wheat grain presents a strong relation with the total protein content, which by its turn is responsible for other physical parameters of the industrial processing of wheat (Preston *et al*, 1995). The selection for the improvement of several simultaneous traits in autogamous plants is a difficult task, considering the complexity of the genetic basis involved, the need of large size populations for selection, the need of several recombination cycles and the difficulty of environmental control that can interfere with the phenotypic expression of the traits. Considering all the above, the genetic progress obtained with the selection of a unique individual with all the desired traits becomes a very hard task for the plant breeders. It becomes important to develop systems to conduct segregating populations, which increases the efficiency of better genotypes identification (Jensen, 1988).

According to Allard (1960), the selection systems, which have shown efficiency in self-polinated crops can be grouped in pure-line and mass selection. These systems are usually used combined with different breeding methods namely: pedigree method in which individual selections are made until the fixation of characters and bulk method based on natural selection. Variations of these methods like backcrosses, single-seed descent and recurrent selection are used less extensively (Fehr, 1987; Destro & Montalván, 1999).

Considering the increasing interest of industrials, farmers and breeders in evaluating the quality of wheat for several uses, the objective of the present study was to obtain advanced lines with higher grain yield associated with a better technological quality of the grain.

MATERIALS AND METHODS

The F_3 populations were planted in the 1998 crop season at the Experimental Station of IAPAR in Londrina-PR, using seeds originated from parents with a large variability for grain yield, environmental adaptation and technological quality (Table 1). One hundred individual heads (spikes) of each of the thirteen F_2 populations were harvested in the previous year. Each harvested head in the F_2 generation gave origin to a 1 m long F_3 line. In this regard, each F_3 population consisted of a 100 head-rows. One check cultivar was placed every 20 head-rows. The checks were ´IAPAR 29-Cacatu´, ´OCEPAR 16´, ´Trigo BR 18-Terena´ and ´Trigo BR 23´.

The germplasm used in the crosses which were considered source of genetic variability for quality were: CDC TEAL, GRANDIN, ND 674, IAPAR 6, CULIACAN, AMIDON, GLUPRO, AC MINTO, and AC DOMAIN, which were introduced mainly from the United States, Canada and Mexico. The other genetic materials used in the crosses are adapted to the Brazilian environmental conditions.

The observations of agronomic and quality characteristics were done as follows: a) **Heading date**: observation in days from the seedling emergency to the plant heading at the moment in which 50% of the plants reach heading. b) **Grain Yield**: weight of grains of the total plot, done only in the selected lines. The technological quality analysis performed on the selected lines were: a) **SDS-Sedimentation**, using the Sodium Dodecyl Sulfate (MS-SDS) method (Peña *et al*, 1990). b) **Protein content**, the total protein percent was evaluated by the Kjeldahl method.

The statistical analysis of the data was done using the Minitab and Excel 7.0 programs, performing additionally the Tukey Test of the means, following the methodology of Mischan & Pinho (1996) for unbalanced data.

Table 1 - Population identification by pedigree and cross number, developed to be selected for yield and quality at IAPAR-Londrina, in 1997.

Population	Pedigree	Cross Number
C1	TRIGO BR 23 / CDC TEAL	IP 94-33
C2	GRANDIN / TRIGO BR 23	IP 93-67
C3	TRIGO BR 23 / ND 674	IP 94-35
C4	IA 8945 / E 91076	IP 94-16996
C5	IA 8945// OCEPAR 7 / PF 813	IP 94-17000
C6	IAPAR 6 / PF 88163	IP 94-17012
C7	C 86310 / IA 8719	IP 94-17447
C8	PF 87518 /6/ PAT 10 / ALONDRA // PAT 72300 /3/ PVN /4/ URES /5/ PFAU	IP 94-17457
C9	CULIACAN / PF 87107	IP 94-17606
C10	EMBRAPA 16 / AMIDON	IP 94-111
C11	EMBRAPA 16 / GLUPRO	IP 94-113
C12	OCEPAR 14 // IAPAR 29 / AC MINTO	IP 94-121
C13	OCEPAR 14 / AC DOMAIN	IP 94-122

RESULTS AND DISCUSSION

The statistical analysis performed on the C1 to C13 populations comprised by different numbers of selected F_3 lines, aimed in the identification of the higher potential ones for simultaneous selection for grain yield and technological quality. The heading date values indicated that the lines C6, C7, C9 and C13 could be classified as having early maturity cycle. The late cycle of populations C2, C3, and C11 is probably due to the fact that at least one parent of these populations is late maturity (Table 2). The grain yield analysis can be seen in Table 3. The populations C6 and C9 had a better performance for mean and maximum grain yield attained. The variance between and within populations indicates good potential for genetic variability for the trait.

Table 2 - Number of days for heading of the populations (F_3 lines) and checks selected at IAPAR-Londrina in 1998.

Population	Nº of selected lines	Mean	Amplitude of Variation		Variance
			Minimum	Maximum	
C1	6	74 b	72	79	13.06
C2	13	78 a	72	82	13.80
C3	10	78 a	72	84	17.06
C4	4	76 ab	68	74	6.00
C5	9	70 bc	64	74	10.36
C6	2	64 c	64	64	0
C7	6	69 c	64	74	20.17
C8	4	70 bc	68	71	2.25
C9	11	67 c	57	74	33.30
C10	7	72 b	68	76	7.14
C11	2	82 a	74	89	112.50
C12	8	72 b	71	74	1.92
C13	6	69 c	64	74	16.67
Trigo BR 18	2	63 c	63	63	0
OCEPAR 16	2	65 c	65	65	0
Trigo BR 23	2	72 b	72	72	0
IAPAR 29	2	63 c	63	63	0
Overall Mean		70			
St. Deviation		5.62			
Coeficient of Variation (%)		7.98			

Means followed by different letters are different between themselves at the 5% level of probability by the Tukey Test

Table 3 - Grain yield in grams per plot, of the F_3 lines visualy selected in the field compared wheat cultivars as checks at IAPAR-Londrina, in 1998.

Population	Nº of selected lines	Mean	Amplitude of Variation		Variance
			Minimum	Maximum	
C1	6	49 b	25	72	240.96
C2	13	57 ab	33	83	260.06
C3	10	67 ab	41	101	529.60
C4	4	54 b	44	67	94.91
C5	9	36 c	10	52	201.00
C6	2	82 a	80	84	8.00
C7	6	68 ab	37	102	459.50
C8	4	42 b	30	58	152.66
C9	11	71 a	50	110	433.36
C10	7	56 b	26	76	349.00
C11	2	25 c	9	41	518.42
C12	8	39 c	24	54	109.26
C13	6	30 c	22	39	30.30
Trigo BR 18	2	60 ab	56	61	12.50
OCEPAR 16	2	53 b	28	77	1200.50
Trigo BR 23	2	30 c	20	40	200.00
IAPAR 29	2	72 a	64	81	144.50
Overall Mean		55			
St. Deviation		17.43			
Coeficient of Variation (%)		32.00			

Means followed by different letters are different between themselves at the 5% level of probability by the Tukey Test.

C12, C3, C8 and C1 had better performance among the populations regarding the sedimentation values (Table 4). Good heritability values for SDS sedimentation volume in wheat crosses were found by Matuz (1988). This indicated the possibility of obtention of significant genetic gains.

The populations identified as C2, C3, and C11 showed better performance in terms of protein content (Table 5). This indicated strong relation with technological quality, according to the work done by Wall, (1979) and Preston *et al*, (1995). Although several populations had shown a good performance considering the technological quality parameters, it should be pointed out that the environmental conditions of cultivation, and grain handling could alter the values which express the quality of the lines.

CONCLUSIONS

Both agronomic characteristics of high grain yield and early heading date, along with information of technological quality performance are important in the development of advanced breeding lines which will potentially produce new cultivars. The data presented in this research work allows the visualization that certain superior populations can combine the desired characteristics of the wheat breeding priorities, helping the farmer and at the same time the miller, the baker and the final consumer to have a better product.

Table 4 - Values of sedimentation obtained by the SDS test of the populations (F_3 lines) and checks selected at IAPAR-Londrina, in 1998.

Population	Nº of selected lines	Mean	Amplitude of Variation		Variance
			Minimum	Maximum	
C1	5	12.61 abcd	10.00	14.15	2.993
C2	12	12.57 bcde	10.85	14.23	1.233
C3	10	13.98 ab	11.96	16.23	1.965
C4	4	9.61 def	8.89	10.69	0.621
C5	7	10.32 def	9.19	11.31	0.667
C6	2	9.21 ef	8.69	9.74	0.551
C7	6	9.60 ef	9.24	10.29	0.232
C8	3	13.45 abc	12.90	14.26	0.496
C9	11	9.08 f	7.46	9.86	0.502
C10	6	10.84 cdef	9.81	12.03	0.635
C11	1	10.82 cdef	10.82	10.82	0
C12	6	14.56 a	13.33	17.41	2.268
C13	1	10.45 ef	10.45	10.45	0
Trigo BR 18	2	12.96 abcd	12.22	13.70	1.095
OCEPAR 16	2	12.59 abcde	12.50	12.68	0.016
Trigo BR 23	2	12.96 abcd	12.50	13.42	0.423
IAPAR 29	2	15.24 a	15.22	15.26	0.001
Overall Mean		11.80			
St. Deviation		1.98			
Coeficient of Variation (%)		16.77			

Means followed by different letters are different between themselves at the 5% level of probability by the Tukey Test.

Table 5 - Protein percent evaluation of the populations (F_3 lines) and checks selected at IAPAR-Londrina, in 1998.

Population	Nº of selected lines	Mean	Amplitude of Variation		Variance
			Minimum	Maximum	
C1	5	14.82 ab	14.51	15.47	0.140
C2	12	15.57 a	14.46	16.58	0.575
C3	10	15.65 a	14.89	16.53	0.172
C4	4	14.09 b	13.88	14.29	0.028
C5	7	14.76 ab	12.56	16.31	1.878
C6	2	12.87 b	12.28	13.47	0.708
C7	6	14.08 b	12.79	16.21	2.175
C8	3	14.80 ab	14.31	15.34	0.266
C9	11	13.52 b	12.48	15.53	0.622
C10	6	14.78 ab	14.25	15.75	0.274
C11	1	15.05 a	15.01	15.01	0
C12	6	14.81 ab	13.84	16.17	0.671
C13	1	13.34 b	13.34	13.34	0
Trigo BR 18	1	14.69 ab	14.69	14.69	0
OCEPAR 16	1	13.84 b	13.84	13.84	0
Trigo BR 23	1	16.08 a	16.08	16.08	0
IAPAR 29	1	14.39 ab	14.39	14.39	0
Overall Mean		14.56			
St. Deviation		0.83			
Coeficient of Variation (%)		5.70			

Means followed by different letters are different between themselves at the 5% level of probability by the Tukey Test.

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RESUMO

O objetivo do trabalho foi combinar seleção simultânea para produtividade e qualidade tecnológica em populações segregantes elite de trigo, desenvolvidas pelo programa de melhoramento genético do IAPAR. Treze populações foram escolhidas, de acordo com a potencialidade de variabilidade genética na geração F_2. Procedeu-se a seleção de espigas individuais as quais foram semeadas no sistema de espigas por fileira. Na geração F_3 realizou-se a seleção individual de linhas, para potencial produtivo. Características como número de dias para o espigamento e peso de parcela foram determinadas. Sementes das linhas selecionadas, foram avaliadas para qualidade tecnológica por meio da análise de Sedimentação e teor de Proteína. As populações foram denominadas de C_1 a C_{13}, representando os diferentes cruzamentos. O número de linhagens selecionadas dentro de cada população variou de um a doze. As populações C6, C7, C9 e C13 foram classificadas como de maturação precoce. Duas populações (C6 e C9) apresentaram maior potencial de produtividade de grãos. Quatro populações C12, C3, C8 e C1 destacaram-se para a média e variância de sedimentação. As populações C2, C3 e C11 destacaram-se para teores médio, máximo e também variância de proteína. Os resultados obtidos indicam condições favoráveis de obter-se linhagens com elevado rendimento de grãos associados com melhor qualidade tecnológica.

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