Research Article

Combining ability and potential of wheat segregating populations for tropical environment[1]

Gabriel Wolter Lima[2], Caique Machado e Silva[2],
Victor Silva Signorini[2], Aluízio Borém[2], Maicon Nardino[2]

ABSTRACT

Estimating the combining ability in wheat (*Triticum aestivum* L.) parents is a crucial tool for selecting promising segregating populations with potential to generate genotypes adapted to the Brazilian tropical regions, supporting the wheat production expansion. This study aimed to estimate the general and specific combining abilities of wheat parents and segregating populations, in order to develop progenies with greater genetic potential for tropical environment. During the winter harvest, nine parents and 20 F_2 populations obtained through a partial diallel mating scheme (4 × 5) were evaluated using a randomized complete block design, with two replications. The evaluated traits included days to heading, plant height, tan spot, leaf rust, number of spikelets per spike, 100-grain mass and grain yield. The data were processed using diallel analysis. The general combining ability (GCA) effect was significant for days to heading, leaf rust and 100-grain mass in the group 1, and for leaf rust, number of spikelets per spike and grain yield in the group 2. The specific combining ability was significant for 100-grain mass, with the crosses TBIO Aton × ORS Madrepérola and TBIO Astro × ORS Madrepérola standing out, with at least one parent showing a high GCA for this trait. Additive genetic effects predominated in the expression of the evaluated traits. The parents TBIO Astro and ORS Destak were identified as promising for deriving tropical wheat progenies with higher genetic potential.

KEY-WORDS: *Triticum aestivum* L., promising progenies, genetic potential.

RESUMO

Capacidade combinatória e potencial de populações segregantes de trigo para ambiente tropical

A estimação da capacidade de combinação de genitores de trigo (*Triticum aestivum* L.) é uma importante ferramenta para a seleção de populações segregantes promissoras com potencial de originar genótipos adaptados às regiões tropicais do Brasil e favorecer a expansão da triticultura. Objetivou-se estimar as capacidades geral e específica de combinação de genitores e populações segregantes de trigo, visando desenvolver progênies de maior potencial genético ao ambiente tropical. Durante a safra de inverno, nove genitores e as 20 populações F_2 obtidas a partir de cruzamentos em esquema dialélico parcial (4 x 5) foram conduzidos sob delineamento de blocos casualizados, com duas repetições. Avaliaram-se o espigamento, altura de planta, mancha amarela, ferrugem da folha, número de espiguetas por espiga, massa de cem grãos e rendimento de grãos. Os dados foram submetidos à análise dialélica. O efeito da capacidade geral de combinação (CGC) foi significativo para espigamento, ferrugem e massa de cem grãos no grupo 1, e ferrugem, número de espiguetas por espiga e rendimento de grãos no grupo 2. Houve efeito significativo da capacidade específica de combinação para massa de cem grãos, com destaque para os cruzamentos TBIO Aton x ORS Madrepérola e TBIO Astro x ORS Madrepérola, em que pelo menos um dos genitores apresenta alta CGC para o referido caráter. Houve predominância do efeito aditivo na determinação dos caracteres analisados. Os genitores TBIO Astro e ORS Destak são promissores para derivação de progênies de trigo tropical com elevado potencial genético.

PALAVRAS-CHAVE: *Triticum aestivum* L., progênies promissoras, potencial genético.

INTRODUCTION

Wheat (*Triticum aestivum* L.), a globally significant species, plays a crucial role in human nutrition due to its high concentrations of carbohydrates, protein, fat, fiber and energy (Biel et al. 2020, Hazard et al. 2020). In addition to its substantial economic impact as the second most cultivated cereal, following only maize (FAO 2022), wheat also shows potential as a high-quality component of animal diets through feed or silage, with cultivars specifically bred for grazing (Quatrin et al. 2019).

Projections for the 2023/2024 harvest estimate a global wheat production of approximately 781.9 million tons, with Brazil contributing with

1.24 % (9.7 million tons) to this total (USDA 2023). However, Brazil's production falls short of domestic consumption, leading to the import of around 6.6 million tons to meet the national demand (Conab 2024). Furthermore, the global population growth, coupled with increasing food demand, climate change and shifting dietary habits, underscores the need for intensified wheat breeding efforts, leveraging genetic resources effectively (Nielsen et al. 2014).

Brazil's tropical region, especially in areas where the Cerrado (Brazilian Savanna) biome predominates, shows a strong potential for expanding wheat cultivation through the development of genotypes adapted to diverse edaphoclimatic conditions and capable of achieving sustainable production gains. In this scenario, intensifying cultivation in non-traditional wheat-growing regions presents a socioeconomic alternative, supported by the proximity to industrial consumers and off-season harvesting in the primary growing areas. This approach increases profitability for growers and contributes to national self-sufficiency (Casagrande et al. 2024, Noia Junior et al. 2024).

As the wheat production expands, it is essential to simultaneously enhance yield levels and technological quality to meet the consistent demands of processing units, thereby improving food security. Technological quality is influenced by quantitative and qualitative variations in proteins, which determine several properties and are affected by environmental (climate, soil, management, milling, etc.) and genetic factors (Pomeranz 1973, Franceschi et al. 2009).

The wheat breeding program at the Universidade Federal de Viçosa aims to develop superior genotypes for key traits suited to Central Brazil. To achieve this, the program employs methodologies that enhance the accuracy of parent selection based on their combining abilities, facilitating the development of promising segregating populations (Cruz & Vencovsky 1989, Kurek et al. 2001). In this context, the diallel analysis method proposed by Griffing (1956) estimates both the general and specific combining ability between parents, while genetic parameters guide more efficient selection methods and indicate genetic diversity (Cruz et al. 2012).

Research on recombination involving elite tropical wheat parents within a diallel scheme is scarce. From this perspective, this study aimed to assess the genetic potential of tropical wheat parents and segregating populations, concerning their general and specific combining abilities, with the goal of developing progenies adapted to tropical environments.

MATERIAL AND METHODS

The research began in 2020, with artificial crosses, followed by the advancement of the F_1 generation and the establishment of the F_2 population in the field in 2021. The experiments were conducted at the experimental field of the Universidade Federal de Viçosa, in Viçosa, Minas Gerais state, Brazil (20º45'14"S, 42º52'55"W and altitude of 648 m). According to the Köppen classification (Alvares et al. 2013), the region has a hot, temperate climate, with average temperature of 20.4 ºC and 1,200 mm of annual rainfall, being classified as Cwa.

Artificial crosses were performed among nine parents, in a greenhouse, to obtain F1 seeds. The parents were split into two complementary groups following a partial diallel scheme (Kempthorne 1957). Group 1 consisted of cultivars with superior technological traits (1 to 4), while group 2 included cultivars with better disease resistance and adaptability to the tropical environment (5 to 9). All parents also showed a high grain yield potential (Table 1). From June to October 2020, the parents were planted in two seasons to optimize pollination efficiency, using pots, with three replications per parent, totaling 27 pots per season. Pollinations were carried out between the third and fifth days after emasculations, which were performed at the growth stage 50 (Zadoks et al. 1974).

The F1 seeds were manually harvested, threshed and stored in a cold chamber. From February to May 2021, the F1 seeds were advanced in a greenhouse for subsequent sowing in the field.

During the 2021 winter season, the nine parents and 20 populations were grown in the field, using a sprinkler irrigation system. Fertilization, weed management, and pest and disease control were performed according to technical recommendations for wheat cultivation (Cunha & Caeirão 2023). The experiment followed a randomized complete block design, with two replications. Each plot consisted of three rows (each 3-m long) spaced 0.20 m apart, with seeding density of 10 seeds m^{-1}.

The evaluated traits were: days to heading - period encompassing the extrusion of at least 50 %

Table 1. Commercial and agronomic characterization of the parents used in a partial diallel mating design.

Cultivar	Pedigree	Agronomic features			Industrial features			Year of release
		Cycle	Height	Diseases	Class	W	S	
ORS Citrino	Quartzo/3/ORL 01009/Abalone//Abalone	E	Medium	MR	Enhancer	377	20.0	2018
ORS Destak	ORS 1405/3/Marfim/Quartzo//Marfim	M	Medium	R	Bread	334	12.0	2020
ORS Madrepérola	Marfim/Quartzo	M	Medium	MR	Bread	274	20.0	2017
RBO 2B5	CD 111/TA 127 J	E	Medium	R	Bread	245	16.0	2019
RBO 3B6	-	M	Low	R	Bread	255	18.0	2019
TBIO Astro	TBIO Toruk/Celebra	SE	Low	MR	Enhancer	533	16.6	2019
TBIO Aton	TBIO Mestre/Fuste//TBIO Mestre	M	Medium	R	Bread	352	15.8	2018
TBIO Duque	Toruk#3/Celebra//Noble	E	Medium	R	Bread	285	18.4	2017
TBIO Toruk	Mirante/IBIO 0901//Quartzo	M	Low	MR	Enhancer	320	29.0	2014

E: early; M: medium; SE: super early; MR: moderately resistant; R: resistant; W: gluten weight (average), expressed in 10^{-4} J; S: stability, expressed in min. Source: Cunha & Caeirão (2023).

of the spikes from the plot, considering up to the stage 55 of the Zadoks et al. (1974) scale; plant height (cm) - measured with a ruler, from the bottom to the top of the plant; tan spot (*Pyrenophora tritici-repentis*) (notes from 1 to 5) - according to the Lamari & Bernier (1989) scale; leaf rust (*Puccinia triticina*) (notes from 0 to 4) - according to the McIntosh et al. (1995) scale; number of spikelets per spike (unit); 100-grain mass (g); grain yield (kg ha^{-1}) - assessed with a precision scale, after drying to 13 % moisture. For statistical analysis purposes, the original data on disease severity were transformed by $\sqrt{x + k}$, where k is a constant.

The data were subjected to analysis of variance to verify the significance of effects. The statistic model proposed by Kempthorne (1957) was adopted for diallel analysis, thus enabling the estimation of the general and specific combining abilities: $Y_{ijk} = \mu + g_i + g_j + s_{ij} + r_k + e_{ijk}$, where: Y_{ijk} is the average value of the hybrid combination i × j or the i-th parent (i ≠ j) on the k-th block; μ the overall mean; g_i and g_j the effects of the general combining ability; s_{ij} the effects of the specific combining ability between two parents, i and j, from groups 1 and 2; r_k the average effect of the crossings on the k-th block; and e_{ijk} the experimental error.

The analyses were performed using the Genes software (Cruz 2013) and the SRplot platform for graphical visualization (Tang et al. 2023).

RESULTS AND DISCUSSION

The analysis of variance revealed significant differences among the treatments for days to heading, plant height, tan spot, leaf rust, number of spikelets per spike, 100-grain mass (p < 0.01) and grain yield (p < 0.05) (Table 2). Partitioning the variance showed significance for most traits in the populations (except for grain yield), highlighting the presence of genetic variability and the potential for selection gains. Additionally, significance was found for leaf rust (p < 0.05) and number of spikelets per spike

Table 2. Summary of the analysis of variance for seven traits in wheat evaluated in nine parents and their combinations.

Source of variation	DF	Mean square						
		DH	PH	TS	LR	NSP	M100	GY
Treatment	28	2.61**	77.37**	0.70**	1.22**	3.42**	0.08**	349,921.51*
Populations (P)	19	1.66*	51.63**	0.75**	1.18**	1.90*	0.08**	227,413.36[ns]
Parents (G)	8	5.14**	144.36**	0.68*	1.25**	6.68**	0.09**	684,608.91**
P x G	1	0.39[ns]	30.46[ns]	0.01[ns]	1.59*	6.18**	0.01[ns]	77.14[ns]
Residual	28	0.76	17.95	0.29	0.36	0.72	0.02	154,475.89
$\overline{X}_P$		67.60	88.71	3.93	2.53	19.35	3.25	1,495.15
$\overline{X}_G$		67.78	87.14	3.94	2.17	20.06	3.23	1,497.64
General mean		67.66	88.22	3.93	2.41	19.57	3.24	1,495.92
CV (%)		1.29	4.80	13.60	24.67	4.35	4.13	26.27

CV: coefficient of experimental variation; DF: degree of freedom; DH: days to heading; PH: plant height (cm); TS: tan spot; LR: leaf rust; NSP: number of spikelets per spike; M100: 100-grain mass (g); GY: grain yield (kg ha^{-1}). [ns], * and **: non-significant and significant at 5 and 1 % of probability by the F-test, respectively.

in the contrast between populations and parents, indicating differences in the sources of variation for these traits. The populations showed superiority in the desired direction for days to heading, tan spot and 100-grain mass. Although the remaining traits were not satisfactory, the values were close to those of the parents, with variations ranging from 0.01 (leaf rust) to 2.49 (grain yield). The coefficient of experimental variation was low for most traits (Nardino et al. 2023), except for leaf rust and grain yield.

The results of the diallel analysis of variance revealed significant treatment effects for all evaluated traits (Table 3). The mean square for the treatments was partitioned into mean square for parents, mean square for parents *versus* populations, and mean square for populations, allowing the estimation and partitioning of the mean square for general and specific combining abilities. This partitioning showed significant differences among the parents for all traits. However, parents in group 1 showed no differences for plant height, while those in group 2 showed no differences for tan spot, leaf rust, 100-grain mass and grain yield. In the contrast between the two groups, significance was observed only for plant height, leaf rust and grain yield ($p < 0.01$), suggesting a similarity in the number of favorable alleles controlling these traits within the groups. Significant differences were also found among populations for most traits, except for grain yield, indicating the presence of genetic variability. A highly significant difference ($p < 0.01$) for number of spikelets per spike was observed in the comparison between the means of parents and populations (G x P).

The significance of general combining ability for group 1 in days to heading, leaf rust ($p < 0.01$) and 100-grain mass ($p < 0.05$), and for group 2 in number of spikelets per spike ($p < 0.01$), leaf rust and grain yield ($p < 0.05$), suggests that at least one parent contributed with favorable alleles, highlighting the additive effects of the genes controlling these traits. These results point to the potential for developing hybrid combinations with a high frequency of favorable alleles, leading to a greater potential, as noted by Bornhofen et al. (2013) for grain yield and related components in crosses between parents with high general combining ability.

The specific combining ability source of variation showed a significant effect ($p < 0.05$) for 100-grain mass, indicating that the deviation of at least one hybrid combination differs from the others. This result suggests a limited genetic variability for the remaining traits and possibly minor contributions of dominance effects, as specific combining ability is a function of dominance deviations, which are expressed in hybrids at heterozygous *loci* (Cruz et al. 1996, Cruz et al. 2012). The performance of parents *per se* provides insight into dominance deviations and improves the accuracy of identifying superior genotypes. Positive deviations indicate negative estimates, and vice versa (Cruz et al. 1996). The presence of both positive and negative dominance deviations may affect trait expression, suggesting the existence of bidirectional dominance (Cruz & Vencovsky 1989, Cruz et al. 2012). Mezzomo et al. (2022) confirmed that certain wheat traits are determined by both recessive and dominant genes.

Table 3. Summary of the analyses of variance of a partial diallel (4 × 5) for seven wheat traits.

Source of variation	DF	Mean square						
		DH	PH	TS	LR	NSP	M100	GY
Treatments	28	2.68**	77.35**	0.35*	0.08**	3.99**	0.08**	349,922.10*
Parents	8	5.00**	144.32**	0.35*	0.09*	7.39**	0.09**	684,608.62**
G1	3	9.33**	21.85ns	0.84**	0.09*	11.17**	0.20**	1,006,935.75**
G2	4	3.00*	61.19*	0.01ns	0.02ns	6.40**	0.02ns	310,686.18ns
G1 x G2	1	0.00ns	844.26**	0.00ns	0.37**	0.01ns	0.05ns	213,316.99**
Populations	19	1.81*	51.63**	0.04*	0.08**	2.42**	0.08**	227,414.36ns
GCA 1	3	6.67**	70.87ns	0.14ns	0.35**	3.33ns	0.21*	139,350.74ns
GCA 2	4	0.85ns	83.70ns	0.01ns	0.07*	5.25**	0.06ns	490,134.01*
SCA	12	0.92ns	36.13ns	0.23ns	0.02ns	1.25ns	0.05*	161,857.04ns
G x H	1	0.50ns	30.35ns	0.00ns	0.12*	6.48**	0.00ns	77.12ns
Residual	28	0.76	17.95	0.15	0.36	0.72	0.02	154,475.89

DF: degree of freedom; DH: days to heading; PH: plant height (cm); TS: tan spot; LR: leaf rust; NSP: number of spikelets per spike; M100: 100-grain mass (g); GY: grain yield (kg ha^{-1}); G1: group 1; G2: group 2; GCA 1: general combining ability of group 1; GCA 2: general combining ability of group 2; SCA: specific combining ability; H: hybrids. ns, * and **: non-significant and significant at 5 and 1 % of probability by the F-test, respectively.

Pimentel et al. (2013) argued that wheat parent selection can rely on general combining ability, particularly in advanced generations, as dominance deviations decrease, allowing for more accurate general combining ability estimates. Similarly, Silva et al. (2023b), in a study using partial diallel analysis, found that additive effects predominate over non-additive effects, supporting the recommendation of parents for crossing blocks targeting specific traits. Since these effects persist across generations in autogamous species, additive genetic effects play a significant role in controlling key traits in breeding programs for tropical environments. Mezzomo et al. (2022) identified potential parents for generating promising populations based on this influence.

These findings enable the selection of segregating populations with strong genetic potential for further studies, with the possibility of developing progenies adapted to tropical regions, such as those with the edaphoclimatic conditions of the Brazilian Cerrado. This selection is particularly relevant for traits like grain yield, a quantitative trait determined by several associated components, including those evaluated in this study (Bornhofen et al. 2013, Gramaje et al. 2020, Mezzomo et al. 2021b).

The good performance of parents does not always translate into superior hybrid combinations. In some cases, the desired traits are linked to undesirable ones, which depend on specific recombination events to increase the likelihood of producing segregating populations with favorable parameters, such as high mean values and significant genetic variability. Thus, mean values help in understanding the additive effects or frequency of favorable alleles contributed by the parents. However, phenotypic analyses alone do not reveal genetic dissimilarity between parents and do not enable an accurate selection. Therefore,

selecting parents based on their combining ability, with the potential to produce promising segregating populations, is essential (Mezzomo et al. 2021b, Silva et al. 2023b).

Negative general combining ability estimates (Table 4) were observed for the parents ORS Citrino and ORS Destak from group 2, as well as for RBO 2B5, to a lesser extent, for the trait days to heading. TBIO Astro, with a strongly negative estimate, stood out in group 1, making it a suitable candidate for crosses with parents from other groups in studies aiming to reduce the growth cycle. Early maturation in wheat genotypes reduces exposure to biotic and abiotic stresses that can directly affect grain yield, enhancing competitiveness with regions of higher wheat production nationally and internationally (Nardino et al. 2022, Casagrande et al. 2024, Noia Junior et al. 2024, Silva et al. 2023a). It also allows for earlier subsequent harvests, especially in Brazilian regions where other cereal crops are grown (Mezzomo et al. 2021a).

For plant height, TBIO Duque and TBIO Astro from group 1 and ORS Citrino and ORS Destak from group 2 exhibited high negative values, which are desirable in crosses aimed at reducing plant height. The positive estimates observed in the other parents suggest a higher frequency of favorable alleles for increased plant height, which is undesirable in wheat cultivation. Reduced plant height is advantageous, as it enhances resistance to lodging caused by wind, rainfall and irrigation systems (Casagrande et al. 2022, Lima et al. 2022). It also positively influences dry matter allocation and grain yield by reducing plant competition (Cossani & Sadras 2021).

For disease resistance traits, TBIO Astro and TBIO Toruk showed favorable estimates for reducing tan spot, as did TBIO Astro for leaf rust. In group 2, ORS Destak showed estimates similar

Table 4. Estimates of the general combining ability effects of nine wheat parents for days to heading (DH), plant height (PH; cm), tan spot (TS), leaf rust (LR), number of spikelets per spike (NSP), 100-grain mass (M100; g) and grain yield (GY; kg ha^{-1}).

Group 1	DH	PH	TS	LR	NSP	M100	GY
TBIO Aton	0.60	1.37	-0.02	-0.08	-0.70	0.09	-14.42
TBIO Duque	0.20	-0.93	0.17	0.28	-0.10	-0.15	131.29
TBIO Astro	-1.20	-3.26	-0.05	-0.06	0.10	0.16	-152.06
TBIO Toruk	0.40	2.81	-0.10	-0.14	0.70	-0.10	35.19
Group 2							
RBO 2B5	-0.05	3.72	0.02	0.06	0.00	0.09	95.48
ORS Citrino	-0.30	-4.40	0.02	-0.08	0.25	-0.05	168.92
ORS Madre Pérola	0.20	1.82	0.02	0.12	0.00	-0.09	-137.31
ORS Destak	-0.30	-2.11	-0.04	0.00	-1.25	0.09	236.86
RBO 3B6	0.45	0.97	0.01	-0.11	1.00	-0.04	-363.95

to those of TBIO Astro and TBIO Toruk. Negative estimates for leaf rust were also observed for ORS Citrino and RBO 3B6. Using these parents in future crossing blocks could mitigate disease-related losses, which can range from 20 to 48 %, and, in extreme cases, reach up to 100 % (Duveiller et al. 2007).

The general combining ability estimates for number of spikelets per spike revealed positive values for TBIO Toruk and RBO 3B6, indicating their potential to contribute to grain yield through an increase in this trait, along with other traits (Saeed et al. 2016), as evidenced by the higher means of these parents. However, the specific combining ability estimates for grain yield (Figure 1) showed low contributions from crosses involving the parent RBO 3B6, except for the cross TBIO Duque × RBO 3B6 (281.46), which showed a superior result, indicating that the use of RBO 3B6 may not consistently improve grain yield. In contrast, TBIO Toruk resulted in notable contributions to grain yield in most crosses.

TBIO Aton and TBIO Astro stood out for 100-grain mass, along with the group 2 parents RBO 2B5 and ORS Destak, which had positive estimates for general combining ability. This supports the potential for increased grain yield.

For grain yield, ORS Destak, ORS Citrino and TBIO Duque showed the highest general combining ability estimates, indicating their superiority, when compared to the other parents. These parents can contribute to an increase in favorable alleles in their offspring, when included in crossing blocks with complementary parents. TBIO Toruk and RBO 2B5, while having positive general combining ability estimates, showed lower values, suggesting that they may not significantly differ from the mean of the diallel in the crosses in which they are involved.

The yield potential of genotypes depends on various physiological, phytopathological, phytotechnical and environmental factors, all of which can significantly affect the economic viability of wheat cultivation (Cossani & Sadras 2021, Mezzomo et al. 2021a). In this scenario, selecting potential segregating populations for the development of genotypes suited to diverse edaphoclimatic conditions is crucial for promoting wheat cultivation in both rainfed and irrigated systems. This will support national self-sufficiency, a goal that is already being pursued.

As shown by the results of the diallel analysis of variance, specific combining ability estimates indicate no significant differences between populations for most traits, except for 100-grain mass ($p < 0.05$), making it difficult to infer the diversity of the parent set. Nonetheless, these results may reflect a limited contribution of specific combining ability effects for the analyzed traits, since genetic diversity among certain parents was observed elsewhere (Lima et al. 2022). For 100-grain mass, the hybrid combinations TBIO Duque × RBO 3B6 (0.18), TBIO Astro × ORS Madrepérola (0.16), TBIO Toruk × RBO 3B6 (0.13) and TBIO Aton × ORS Madrepérola (0.10) showed the highest specific combining ability estimates (Figure 2). The combination TBIO Aton × ORS Madrepérola is
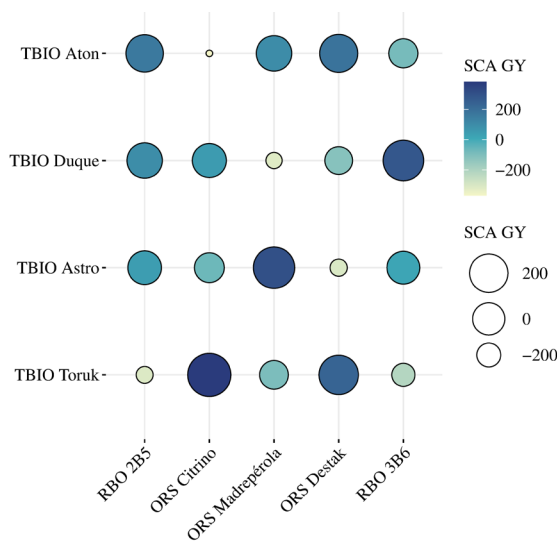

Figure 1. Estimates of specific combining ability (SCA) effect of 20 wheat hybrid combinations for grain yield (GY).
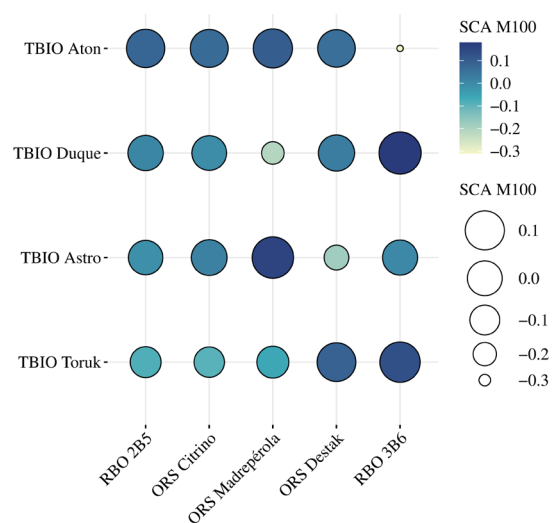

Figure 2. Estimates of specific combining ability (SCA) effect for 20 wheat hybrid combinations, for the 100-grain mass (M100) trait.

particularly noteworthy due to the favorable general combining ability of TBIO Aton for this trait.

According to the obtained estimates, a predominance of additive genetic effects was observed in the determination of traits for the set of analyzed parents. The non-significant effects on the specific performance of hybrid combinations, along with inconsistent positive and negative values and proximity to zero, suggest a nullification of values for the evaluated traits, potentially indicating a bidirectional dominance (Cruz & Vencovsky 1989). Information about the direction and magnitude of genetic complementarity between parents is a critical input for breeders to perform an accurate selection.

CONCLUSIONS

1. The parents TBIO Astro (days to heading), ORS Citrino (plant height), TBIO Astro, TBIO Toruk and ORS Destak (tan spot), TBIO Toruk (leaf rust), RBO 3B6 (number of spikelets per spike), TBIO Astro (100-grain mass) and ORS Destak (grain yield) show potential for improvement in the respective traits, based on general combining ability estimates;
2. The crosses TBIO Aton × ORS Madrepérola, TBIO Duque × RBO 3B6, TBIO Astro × ORS Madrepérola and TBIO Toruk × RBO 3B6 showed the highest specific combining ability estimates for 100-grain mass. TBIO Aton × ORS Madrepérola and TBIO Astro × ORS Madrepérola stand out due to the participation of at least one parent with high general combining ability;
3. TBIO Astro and ORS Destak are promising candidates for developing tropical wheat progenies with high genetic potential.

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