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RESEARCH ARTICLE

AGRONOMIC PERFORMANCE AND STABILITY OF SOYBEAN CULTIVARS IN NOT PREFERRED TIME

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ABSTRACT

The aim of this study was to evaluate the agronomic performance and stability of soybean (*Glycine max* L.) cultivars seeded in not preferred time carried out in northwest region the State of the Rio Grande do Sul, Brazil. Eighteen cultivars were evaluated in three experiments and seeded in January 2013. In each experiment, we used randomized block design with four replications. The traits first pod insertion height, plant height, hundred grain weight and grain yield were measured. Individual variance analysis, mean comparison and joint analysis of variance was performed. After, the stability analysis was performed by the methods of Yates & Cochran, Wricke and Lin & Binns modified by Carneiro. The soybean cultivars 'BMX Força RR' and 'BMX Potência RR' have higher agronomic performance and stability in relation first pod insertion height and plant height, and cultivar 'BMX Turbo RR' in relation to the hundred grain weight and grain yield.

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INTRODUCTION

Soybean (Glycine max L.) provides the highlight Brazilian agriculture in the international scene and its plasticity to adapt, some genotypes provides its cultivation in different edaphoclimatic regions. In Brazilian states such as Paraná, São Paulo, Goiás, Mato Grosso and Mato Grosso do Sul cultivation in two crops during the summer period is consolidated, commonly being the soybeans grown in preferred time (harvest) and corn in time not preferred (second crop) (Cruz *et al*., 2010). Studies in the states of Paraná (Braccini *et al*., 2004), Santa Catarina (Meotti *et al*., 2012) and Rio Grande do Sul (Bonato *et al*., 2001; Ludwig *et al*., 2010), with soybean cultivars seeded in October, November, December, January and February, that is, preferred times (harvest) and non-preferential (second crop), have been developed. In these studies, have been evaluated traits of the first pod insertion height, plant height, hundred grain weight and grain yield, and also adaptability and stability in study of Meotti *et al*. (2012). Overall, reductions were identified of first pod insertion height, plant height, hundred grain weight and soybean cultivars productivity when grown in non-preferences times (second crop) compared to preferences seasons (harvest) (Braccini *et al*., 2004; Ludwig *et al*., 2010; Meotti *et al*., 2012) and although the medium and early maturing cycle cultivars with high porte are more suitable for late seeding (Meotti *et al*., 2012). In Rio Grande do Sul, anticipation of seeding maize for the months of August and September, it is important in ecoclimatic regions where there is greater probability of water deficiency in the months of December and January, these coinciding with the flowering and grain filling for corn crops

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seeded in October (preferred time) (Matzenauer *et al*., 2002). In the northwest region of Rio Grande do Sul soybean cultivation in succession to corn harvested in early January, popularly known as "second crop soybean" has been highlighted as an alternative income to producers. This possibility of two crops in the summer period, requires studies on current cultivars which have good agronomic performance, as the traits as the first pod insertion height, plant height, hundred grain weight and grain yield, and high stability, since the indication is that the sowing is carried out between October 1st and December 31st (Reunião, 2012). The cultivars performance in environments (local, years and seasons) has been evaluated to check their differential behavior in the face of environmental variations. This differential behavior is attributed to genotypes × environments interaction and their existence requires study through the adaptability and stability analysis, to ensure greater security for cultivars indications (Cruz and Regazzi, 1997; Cruz and Carneiro, 2003). For the evaluation of adaptability and stability there are several methodologies that are complementary to the analysis of individual and joint variance of the experimental data obtained from tests conducted in a lot of environments. The methods proposed by Yates and Cochran (1938) (conventional method) Wricke (1965) and Lin and Binns (1988) modified by Carneiro (1998), are advantageous because they are applicable even when the number of environments is relatively low (Cross and Regazzi, 1997). Studies about traits first pod insertion height, plant height, hundred grain weight and grain yield, and stability of these traits of soybean cultivars, seeded in time of second crop, in the northwestern region of the Rio Grande do Sul, were not found in literature. Thus, this study aimed to evaluate the agronomic performance and stability of soybean (Glycine max L.) seeded in non-preferential season in the northwest region of Rio Grande do Sul State.

MATERIALS AND METHODS

Eighteen soybean cultivars ('FPS Urano RR', 'Don Mario 6200', 'BRS Tordilha RR', 'BMX Ativa RR', 'Fundacep 65 RR', 'FPS Solimões RR', 'BMX Alvo RR', 'BMX Apolo RR', 'FPS Iguaçu RR', 'BMX Força RR', 'BMX Classe RR', 'BMX Potência RR', 'FPS Paranapanema RR', 'BMX Energia RR', 'BMX Tornado RR', 'FPS Júpiter RR', 'BMX Magna RR' e 'BMX Turbo RR') were evaluated, in succession to corn, in three experiments conducted in 2013 in the northwest region of the State of Rio Grande do Sul. The experiments were conducted in Barra do Guarita (latitude 27º09'S, 53º46'W longitude and 168m altitude), in Vista Gaúcha (latitude 29º11'S, 53º47'W longitude and 338m altitude) and the other in Tenente Portela (latitude 27º23 'S, longitude 53º46' W, and 442m altitude), seeding dates were 01/09/2013, 10/01/2013 and 01/24/2013, respectivel. The experiments were conducted in a randomized block design with four replications (blocks). The experimental units (plots) were composed of four rows of 5.0m in length spaced 0.45m, and the useful area 3,6m2 obtained by eliminating both external and 0.5m rows at each end of plot. The seeding density was adjusted to 15 plants per linear meter, in no-till system on straw. The basic fertilization in the three experiments was 5 kg ha-1 N, 50 kg ha-1 of P2O5 and 50 kg ha-1 of K2O applied at seeding groove. Cultural practices, such as controlling insects and weeds, have always been made necessary, so that the culture does not suffer competition. In each experiment, we evaluated the traits first pod insertion height (FPIH), in cm, plant height (PH), in cm, hundred grain weight (HGW), in g, and grain yield (GY), t ha-1. The heights of first pod insertion and plant were obtained by measurements made at five plants randomly taken in the useful plot area. The first pod insertion height was estimated by the distance, in cm, between soil surface and the insertion point of the first pod and plant height by the distance, in cm, between soil surface and the main stem apex of the plant. The hundred grain weight and grain yield were obtained from the harvest of grains of all plants of useful plot area. Regarding to FDIH, PH, HGW and GY were performed variance analysis and the F tests for block effects and cultivar, at the 5% probability, in each of the experiments. We noted is the mean square estimates of cultivar (MSC) and the mean square error (MSE), and we calculated following the overall mean (m) and the coefficient variation by the expression:

$$CV = 100\sqrt{MS_E}/m \quad \text{.....(1)}$$

Soon after, it was estimated selective accuracy (SA) by the expression:

$$SA = (1-(MSE/MSC))^{0.5} \quad \text{.....(2)}$$

and evaluated the experimental accuracy in accordance with the limits of SA classes established in Resende and Duarte (2007). After we compared the averages of cultivars by the Scott & Knott test at 5% probability. The joint variance analysis considering the effects of cultivars as fixed and environments as random was performed. Then the stability analyses were carried out by methods based on variance analysis [Yates and Cochran (1938) or traditional Wricke (1965)] and non-parametric statistics [Lin and Binns (1988) modified by Carneiro (1998)]. These methodologies were adopted because they are suitable for reduced number of environments (Cruz and Regazzi, 1997). Thus, were obtained for each cultivar, the average and estimates of stability parameters for the indication of cultivars in general environments in relation to methods: Yates and Cochran (1938) or traditional - express stability parameter by varying environments within each genotype (MSA/Gi); Wricke (1965) - stability parameter estimated by the decomposition of squares sum of genotypes × environments in the parts due to individual genotypes (Wi, em %); and Lin and Binns (1988) modified by Carneiro (1998) - stability parameter to indicate cultivars in general environments (Pi).

In order to evaluate the agronomic performance of cultivars in relation to FDIH, PH, HGW and GY the means were ordered in decreasing order. To evaluate the cultivars stability, based on three methodologies, initially estimates of stability parameters (MSA/Gi, Wi e Pi)) were sorted in ascending order. Then, for each cultivar, the scores sum (order) of the stability parameters (MSA/Gi, Wi e Pi) was ordered increasingly. Thus, it is interpreted that the lower the average score of the cultivar, best is its agronomic performance, and the smaller the scores sum of the estimates of stability parameters (QMA/Gi, Wi e Pi), most stable is cultivar. Statistical analyses were performed using Microsoft Office Excel® application and Genes software (Cruz, 2013).

RESULTS AND DISCUSSION

Among the 12 cases analyzed (four traits × three experiments), the F test of variance analysis showed a meaning block effect (P≤0.05) in six cases (50%), showing heterogeneous blocks and the use of design blocks random was adequate. This percentage was higher than that observed by Storck *et al*. (2009), evaluating the productivity of soybeans in 216 trials in Rio Grande do Sul, and 63 trials (29.17%) blocks were heterogeneous (P≤0.05). In six cases (50%), the blocks were not heterogeneous (Table 1), and in this situation the use of completely randomized design would be appropriate.

Given this scenario, it can be inferred that the use of blocks should continue to be used in this experimental area, in order to ensure the control of this source of heterogeneity, in the case of its existence. Regarding the first pod insertion height (FPIH), plant height (PH), hundred grain weight (HGW) and grain yield (GY), there were meaningful cultivar effect (P≤0.05) in the three experiments, and the performance differences among cultivars can be identified in groups formed by Scott Knott test (Table 1). Now, in relation to grain yield (GY), there was no meaningful cultivar effect in the experiment conducted in Barra do Guarita. In this experiment, the non-discrimination of cultivars, through the F test, cannot be due to non-existence of genetic variability, but probably to moderate experimental accuracy (selective accuracy = 0.596).

Table 1. Variance analysis and meaningful of the mean square of the sources of variation in relation to the first pod insertion height, plant height, hundred grain weight and grain yield. Experimental coefficient of variation (CV), selective accuracy (SA) and means 18 soybean cultivars, evaluated in three environments of northern of State Rio Grande do Sul (E1, E2, E3)

Source of variation/cultivar	E1	E2	E3	E1	E2	E3
	First pod insertion height, in cm			Plant height, in cm		
Block (DF = 3)	5.123ns	8.609ns	5.173ns	110.536*	176.934*	321.226*
Cultivar (DF = 17)	28.567*	28.545*	8.512*	554.872*	565.847*	242.148*
Residue (DF = 51)	3.523	6.101	1.884	23.951	36.319	27.669
CV (%)	14.19	22.37	17.05	7.07	10.43	13.77
SA	0.936	0.887	0.882	0.978	0.967	0.941
'FPS Urano RR'	11.675 c	6.975 b	7.450 b	51.625 e	39.500 d	23.950 c
'Don Mario 6200'	12.925 c	9.750 b	7.600 b	59.681 d	48.575 c	31.250 c
'BRS Tordilha RR'	20.150 a	15.885 a	11.075 a	82.800 a	70.125 a	44.850 a
'BMX Ativa RR'	10.050 d	7.425 b	6.250 c	48.650 e	40.175 d	29.100 c
'Fundacep 65 RR'	15.500 b	14.700 a	9.950 a	67.175 c	45.650 d	33.000 c
'FPS Solimões RR'	11.500 c	11.050 b	6.800 c	69.375 c	60.475 b	39.150 b
'BMX Alvo RR'	12.275 c	11.175 b	8.500 b	61.100 c	62.325 b	39.250 b
'BMX Apolo RR'	9.550 d	9.050 b	5.500 c	56.625 d	52.425 c	31.800 c
'FPS Iguaçu RR'	12.438 c	8.700 b	8.050 b	83.338 a	77.975 a	48.950 a
'BMX Força RR'	15.400 b	14.700 a	10.150 a	82.300 a	72.525 a	46.750 a
'BMX Classe RR'	14.313 b	13.900 a	8.450 b	86.788 a	74.600 a	50.400 a
'BMX Potência RR'	14.713 b	10.900 b	9.250 a	83.463 a	66.400 b	49.100 a
'FPS Paranapanema RR'	11.075 c	9.450 b	7.550 b	63.650 c	50.750 c	38.350 b
'BMX Energia RR'	9.000 d	7.800 b	5.900 c	58.450 d	43.275 d	28.450 c
'BMX Tornado RR'	15.075 b	13.875 a	7.625 b	77.200 b	66.100 b	38.750 b
'FPS Júpiter RR'	13.300 c	11.150 b	8.575 b	73.175 b	55.800 c	36.515 b
'BMX Magna RR'	14.700 b	11.850 b	8.100 b	72.425 b	55.675 c	35.350 b
'BMX Turbo RR'	14.450 b	10.400 b	8.100 b	67.525 c	57.600 c	42.450 a
Average	13.227	11.041	8.049	69.186	57.775	38.190
	Hundred grain weight , in g			Grain yield, in t ha-1		
Block DF = 3)	2.188*	1.036ns	1.161*	0.071ns	0.031ns	0.447*
Cultivar (DF = 17)	7.344*	9.223*	7.740*	0.429ns	0.715*	0.277*
Residue (DF = 51)	0.348	0.473	0.328	0.277	0.185	0.078
CV (%)	4.16	5.17	5.03	20.17	21.95	26.74
SA	0.976	0.974	0.979	0.596	0.861	0.848
'FPS Urano RR'	14.623 b	15.396 b	11.265 c	2.592 ns	2.721 a	0.786 b
'Don Mario 6200'	12.798 d	12.754 c	10.493 d	2.151	1.865 b	0.646 b
'BRS Tordilha RR'	14.930 b	16.481 a	13.214 b	2.299	1.967 b	1.165 a
'BMX Ativa RR'	14.507 b	13.630 c	11.482 c	2.250	1.506 b	0.862 b
'Fundacep 65 RR'	13.179 d	12.004 d	9.428 e	2.583	1.245 b	0.679 b
'FPS Solimões RR'	12.723 d	11.724 d	10.454 d	3.000	2.383 a	1.198 a
'BMX Alvo RR'	13.915 c	13.254 c	12.087 c	2.578	2.643 a	0.965 b
'BMX Apolo RR'	14.906 b	13.586 c	12.041 c	2.145	1.704 b	1.068 a
'FPS Iguaçu RR'	17.396 a	15.064 b	14.400 a	3.306	2.507 a	1.531 a
'BMX Força RR'	13.267 d	12.590 c	10.443 d	2.385	1.939 b	0.947 b
'BMX Classe RR'	12.674 d	10.403 e	10.472 d	2.679	1.726 b	1.563 a
'BMX Potência RR'	13.940 c	12.390 c	10.255 d	2.914	1.829 b	1.285 a
'FPS Paranapanema RR'	12.919 d	12.683 c	10.780 d	2.882	2.166 a	1.190 a
'BMX Energia RR'	14.815 b	13.335 c	11.815 c	2.397	1.691 b	1.008 b
'BMX Tornado RR'	13.588 d	12.888 c	11.152 c	2.688	1.982 b	1.073 a
'FPS Júpiter RR'	13.876 c	12.686 c	10.627 d	2.887	1.502 b	0.863 b
'BMX Magna RR'	13.787 c	12.705 c	10.399 d	2.294	1.523 b	0.756 b
'BMX Turbo RR'	17.117 a	15.732 b	14.364 a	2.897	2.327 a	1.212 a
Average	14.164	13.295	11.398	2.607	1.957	1.044

Limits of experimental accuracy classes established in Resende & Duarte (2007): Very high (SA ≥ 0.90), High (0.70 ≤ SA <0.90), Moderate (0.50 ≤ SA <0.70) and Low (SA <0.50). (2) Environments: E1: Barra do Guarita; E2: Vista Gaúcha; E3: Tenente Portela. DF: Degrees of freedom. *: Meaningful effect by F test at 5% probability. ns: No meaningful. Means no followed by the same letter in the column differ at 5% probability by Scott Knott test.

As limits of experimental accuracy classes established in Resende and Duarte (2007), among the 12 cases evaluated, seven had very high experimental precision (SA≥0.90), four with high precision (0.70≤SA<0.90) and a case with moderate precision (0.50≤SA<0.70) (Table 1).

Additionally, in general, between environments the soybean cultivars showed superior agronomic performance (higher FPIH, PH, HGW and GY) in Barra do Guarita, Vista Gaúcha and Tenente Portela, in that order. In addition to the environmental differences among locals, possibly later seeding (24/01/2013) in Tenente Portela, regarding seeding performed

Table 2. Joint variance analysis and meaningfulness of the mean square of the variation sources in relation to first pod insertion height (FPIH), in cm, the plant height (PH) in cm, hundred grain weight (HGW) in g, and grain yield (GY), in t ha-1. Average, experimental variation coefficient (CV) and relationship between the largest and the smallest residual mean square of environments (MSr+/MSr-) 18 soybean cultivars evaluated in three environments in the northwest region of Rio Grande do Sul

Variation sources	Degrees of freedom	Mean Square			
		FPIH	PH	HGW	GY
Blocks/Environments	9	6.302	202.899	1.462	0.183
Cultivars (C)	17	55.399*	1,238.930*	21.456*	0.871*
Environments (E)	2	486.596*	17,694.519*	144.046*	44.373*
Interaction C×E	34	5.113ns (1)	61.968*	1.426*	0.275*
Residue	153	3.836	29.313	0.383	0.180
Average	-	10.772	55.050	12.952	1.869
CV (%)	-	18.182	9.835	4.778	22.675
MSr+/MSr-	-	3.238	1.516	1.441	3.547

Meaningful to 5% of probably by F test. ns No meaningful. (1) Value-p = 0.1236265

Table 3. Growth habit, average and estimates of the parameters of stability obtained for three methods, in relation the first pod insertion height and the plant height of 18 soybean cultivars, evaluated in three environments of region northwest of Rio Grande do Sul

Cultivar	Habit	Average (1)	MSA/Gi (2)	Wi (2)	Pi (2)	Sum (3)
		First pod insertion height, in cm				
'FPS Urano RR'	Determinate	8.700 (15)	26.777 (8)	14.765 (17)	27.392 (15)	40 (18)
'Don Mario 6200'	Determinate	10.092 (11)	28.706 (10)	1.311 (2)	16.986 (11)	23 (4)
'BRS Tordilha RR'	Determinate	15.703 (1)	82.455 (18)	17.495 (18)	0.000 (1)	37 (16)
'BMX Ativa RR'	Determinate	7.908 (17)	15.141 (4)	4.138 (12)	32.810 (17)	33 (12)
'Fundacep 65 RR'	Determinate	13.383 (3)	36.003 (13)	3.950 (10)	4.049 (2)	25 (6)
'FPS Solimões RR'	Indeterminate	9.783 (12)	26.903 (9)	3.701 (9)	19.413 (12)	30 (10)
'BMX Alvo RR'	Indeterminate	10.650 (10)	15.077 (3)	2.493 (4)	15.138 (10)	17 (2)
'BMX Apolo RR'	Indeterminate	8.033 (16)	19.503 (5)	3.397 (6)	31.693 (16)	27 (9)
'FPS Iguaçu RR'	Indeterminate	9.729 (13)	22.428 (7)	6.534 (14)	20.043 (13)	34 (14)
'BMX Força RR'	Indeterminate	13.417 (2)	32.503 (12)	3.560 (8)	4.137 (3)	23 (4)
'BMX Classe RR'	Indeterminate	12.221 (4)	42.828 (15)	7.406 (15)	7.485 (5)	35 (15)
'BMX Potência RR'	Indeterminate	11.621 (6)	31.398 (11)	3.472 (7)	9.625 (7)	25 (6)
'FPS Paranapanema RR'	Indeterminate	9.358 (14)	12.451 (2)	3.254 (5)	22.698 (14)	21 (3)
'BMX Energia RR'	Indeterminate	7.567 (18)	9.773 (1)	4.975 (13)	36.078 (18)	32 (11)
'BMX Tornado RR'	Indeterminate	12.192 (5)	64.003 (17)	12.845 (16)	6.950 (4)	37 (16)
'FPS Júpiter RR'	Indeterminate	11.008 (8)	22.386 (6)	0.292 (1)	12.599 (9)	16 (1)
'BMX Magna RR'	Indeterminate	11.550 (7)	43.830 (16)	2.329 (3)	9.139 (6)	25 (6)
'BMX Turbo RR'	Indeterminate	10.983 (9)	41.343 (14)	4.084 (11)	11.904 (8)	33 (12)
		Plant height, in cm				
'FPS Urano RR'	Determinate	38.358 (18)	769.816 (6)	1.761 (3)	569.388 (18)	27 (7)
'Don Mario 6200'	Determinate	46.502 (15)	821.227 (7)	0.745 (2)	327.639 (15)	24 (5)
'BRS Tordilha RR'	Determinate	65.925 (5)	1,493.122 (17)	5.210 (11)	18.054 (4)	32 (12)
'BMX Ativa RR'	Determinate	39.308 (17)	384.456 (1)	13.420 (17)	556.167 (17)	35 (15)
'Fundacep 65 RR'	Determinate	48.608 (13)	1,194.186 (11)	10.157 (16)	288.719 (13)	40 (18)
'FPS Solimões RR'	Indeterminate	56.333 (7)	965.011 (9)	0.628 (1)	122.668 (7)	17 (1)
'BMX Alvo RR'	Indeterminate	54.225 (11)	674.252 (4)	16.168 (18)	171.515 (11)	33 (14)
'BMX Apolo RR'	Indeterminate	46.950 (14)	706.207 (5)	5.769 (13)	318.090 (14)	32 (12)
'FPS Iguaçu RR'	Indeterminate	70.088 (2)	1,369.138 (14)	8.682 (15)	2.334 (2)	31 (10)
'BMX Força RR'	Indeterminate	67.192 (3)	1,349.136 (13)	3.906 (8)	10.527 (3)	24 (5)
'BMX Classe RR'	Indeterminate	70.596 (1)	1,372.150 (15)	3.225 (6)	1.898 (1)	22 (4)
'BMX Potência RR'	Indeterminate	66.321 (4)	1,180.800 (10)	3.069 (5)	24.454 (5)	20 (3)
'FPS Paranapanema RR'	Indeterminate	50.917 (12)	640.173 (3)	5.461 (12)	236.958 (12)	27 (7)
'BMX Energia RR'	Indeterminate	43.392 (16)	900.041 (8)	2.394 (4)	414.818 (16)	28 (9)
'BMX Tornado RR'	Indeterminate	60.683 (6)	1,566.423 (18)	7.338 (14)	61.443 (6)	38 (17)
'FPS Júpiter RR'	Indeterminate	55.163 (9)	1,345.172 (12)	4.287 (10)	144.971 (9)	31 (10)
'BMX Magna RR'	Indeterminate	54.483 (10)	1,378.816 (16)	4.177 (9)	155.012 (10)	35 (15)
'BMX Turbo RR'	Indeterminate	55.858 (8)	637.856 (2)	3.603 (7)	141.565 (8)	17 (1)

QMA/Gi: stability method Yates & Cochran (1938) (traditional); Wi: stability of the method proposed by Wricke (1965); Pi: stability environments in general, according to the method of Lin & Binns (1988) modified by Carneiro (1998). (1) Value in brackets refers to the means of classification, in descending order. (2) Value in brackets refers to estimates of stability parameters (QMA/Gi, Wi e Pi) in ascending order. (3) Value in brackets refers to the sum of the scores (order) estimates of stability parameters (QMA/Gi, Wi e Pi) in ascending order.

at 09/01/2013 and 10/01/2013, respectively, for the experiments conducted in Barra do Guarita, Vista Gaúcha, may have contributed to explain the performance variations of the cultivars in these locations. The ratio between the highest and lowest residual mean square of environments (MSr+/MSr-) fluctuated between 1.441 (PH) and 3.547 (GY) (Table 2), which enables the implementation of joint analysis because, according to Cruz and Regazzi (1997) when the MSr+/MSr- ratio is less than seven the assumption of homogeneity of residual variance is satisfied. The variance analysis in relation to FPIH, PH, HGW and GY revealed the presence of cultivar × environment (C×E) interaction (P≤0.05), with the exception of FPIH (P=0.124). But, Perecin and Cargnelutti Filho (2008) point out that the use of less stringent meaning level (P=0.25) for interpretation of the interaction "for experiment", in relation to other variation sources of variance analysis, can capturing important effects. Based on this criterion, it can be assumed that for FPIH, there is C×E interaction. The interaction characterizes the behavior of different cultivars on environments and thus cultivars indication through analysis of adaptability and stability, is a suitable procedure (Tables 3 and 4).

Considering the lower the average score of cultivating better is its agronomic performance, and the smaller the sum of the scores of estimates of stability parameters (MSA/Gi, Wi e Pi) more stable is cultivars. Cultivars with lower scores or equal to six would be ranked in the top third (best cultivars). Among the 18 cultivars did not identify cultivars with agronomic performance in the upper third, in relation to four traits (first pod insertion height, plant height, hundred grain weight and grain yield) joint, and also with stability (Tables 3 and 4), suggesting the difficulty of finding cultivars that include all the desired traits (greater FPIH, PH, HGW and GY and stability).

Regarding first pod insertion height (FPIH), the 'Fundacep 65 RR', 'BMX Força RR' and 'BMX Potência RR' cultivars presented agronomic performance and stability classified in the upper third (average scores of the cultivar and the sum scores of MSA/Gi, Wi and Pi ≤ 6). Higher FPIH are important for mechanized harvesting, and these cultivars were the average of three environments, slightly ('BMX Potência RR' = 11.621cm) or greater ('Fundacep 65 RR' = 13.383cm and 'BMX Força RR' = 13.417cm) than standard 12cm, cited by Ramteke *et al*. (2012), as minimum first pod insertion height to obtain high operating income and lower losses on harvesters.

Table 4. Growth habit, average and estimates parameters of stability, obtained for three methods, in relation the hundred grain weight, in g and the grain yield, in t ha-1, of 18 cultivars of soybean, evaluated in three environments of region northwest of Rio Grande do Sul

Cultivar	Habit	Average (1)	MSA/Gi (2)	Wi (2)	Pi (2)	Sum (3)
		Hundred grain weight, in g				
'FPS Urano RR'	Determinate	13.761 (4)	19.288 (18)	22.102 (17)	3.116 (4)	39 (15)
'Don Mario 6200'	Determinate	12.015 (15)	6.952 (6)	2.821 (11)	8.385 (15)	32 (12)
'BRS Tordilha RR'	Determinate	14.875 (3)	10.686 (13)	24.318 (18)	1.249 (3)	34 (13)
'BMX Ativa RR'	Determinate	13.206 (7)	9.686 (11)	0.358 (2)	4.165 (7)	20 (4)
'Fundacep 65 RR'	Determinate	11.537 (17)	14.728 (17)	4.198 (14)	10.427 (17)	48 (18)
'FPS Solimões RR'	Indeterminate	11.634 (16)	5.172 (2)	1.805 (9)	10.007 (16)	27 (9)
'BMX Alvo RR'	Indeterminate	13.085 (8)	3.428 (1)	3.999 (13)	4.649 (8)	22 (5)
'BMX Apolo RR'	Indeterminate	13.511 (5)	8.223 (8)	0.922 (4)	3.359 (5)	17 (3)
'FPS Iguaçu RR'	Indeterminate	15.620 (2)	9.906 (12)	10.204 (15)	0.335 (2)	29 (10)
'BMX Força RR'	Indeterminate	12.100 (14)	8.696 (9)	0.284 (1)	7.975 (14)	24 (7)
'BMX Classe RR'	Indeterminate	11.183 (18)	6.673 (5)	16.890 (16)	12.446 (18)	39 (15)
'BMX Potência RR'	Indeterminate	12.195 (12)	13.694 (16)	3.752 (12)	7.646 (12)	40 (17)
'FPS Paranapanema RR'	Indeterminate	12.127 (13)	5.499 (3)	2.188 (10)	7.930 (13)	26 (8)
'BMX Energia RR'	Indeterminate	13.322 (6)	9.004 (10)	1.569 (7)	3.875 (6)	23 (6)
'BMX Tornado RR'	Indeterminate	12.543 (9)	6.294 (4)	0.449 (3)	6.328 (9)	16 (2)
'FPS Júpiter RR'	Indeterminate	12.396 (10)	10.811 (14)	0.997 (5)	6.839 (10)	29 (10)
'BMX Magna RR'	Indeterminate	12.297 (11)	11.976 (15)	1.647 (8)	7.217 (11)	34 (13)
'BMX Turbo RR'	Indeterminate	15.737 (1)	7.577 (7)	1.497 (6)	0.107 (1)	14 (1)
		Grain Yield, in t ha-1				
'FPS Urano RR'	Determinate	2.033 (6)	4.681 (18)	24.430 (18)	0.186 (7)	43 (16)
'Don Mario 6200'	Determinate	1.554 (15)	2.554 (8)	3.278 (10)	0.485 (15)	33 (14)
'BRS Tordilha RR'	Determinate	1.810 (10)	1.361 (2)	4.226 (11)	0.290 (10)	23 (6)
'BMX Ativa RR'	Determinate	1.539 (16)	1.929 (4)	1.594 (8)	0.514 (16)	28 (10)
'Fundacep 65 RR'	Determinate	1.502 (18)	3.821 (16)	10.120 (14)	0.581 (18)	48 (18)
'FPS Solimões RR'	Indeterminate	2.193 (2)	3.356 (14)	1.895 (9)	0.057 (2)	25 (7)
'BMX Alvo RR'	Indeterminate	2.062 (5)	3.616 (15)	15.674 (17)	0.149 (5)	37 (15)
'BMX Apolo RR'	Indeterminate	1.639 (14)	1.172 (1)	5.089 (13)	0.438 (14)	28 (10)
'FPS Iguaçu RR'	Indeterminate	2.448 (1)	3.161 (13)	1.016 (6)	0.008 (1)	20 (4)
'BMX Força RR'	Indeterminate	1.757 (11)	2.168 (6)	0.910 (5)	0.307 (11)	22 (5)
'BMX Classe RR'	Indeterminate	1.989 (8)	1.454 (3)	12.172 (16)	0.231 (9)	28 (10)
'BMX Potência RR'	Indeterminate	2.009 (7)	2.750 (10)	4.697 (12)	0.171 (6)	28 (10)
'FPS Paranapanema RR'	Indeterminate	2.079 (4)	2.887 (11)	0.360 (2)	0.105 (4)	17 (1)
'BMX Energia RR'	Indeterminate	1.699 (13)	1.930 (5)	1.223 (7)	0.366 (13)	25 (7)
'BMX Tornado RR'	Indeterminate	1.914 (9)	2.619 (9)	0.083 (1)	0.195 (8)	18 (2)
'FPS Júpiter RR'	Indeterminate	1.751 (12)	4.284 (17)	11.828 (15)	0.359 (12)	44 (17)
'BMX Magna RR'	Indeterminate	1.525 (17)	2.364 (7)	0.520 (3)	0.518 (17)	27 (9)
'BMX Turbo RR'	Indeterminate	2.145 (3)	2.939 (12)	0.886 (4)	0.074 (3)	19 (3)

QMA/Gi: stability method Yates & Cochran (1938) (traditional); Wi: stability of the method proposed by Wricke (1965); Pi: stability environments in general, according to the method of Lin & Binns (1988) modified by Carneiro (1998). (1) Value in brackets refers to the means of classification, in descending order. (2) Value in brackets refers to estimates of stability parameters (QMA/Gi, Wi e Pi) in ascending order. (3) Value in brackets refers to the sum of the scores (order) estimates of stability parameters (QMA/Gi, Wi e Pi) in ascending order.

As for the plant height (PH), the 'BMX Força RR', 'BMX Classe RR' and 'BMX Potência RR' cultivars, have been identified with agronomic performance and stability located in the upper third. Then, it can be inferred that 'BMX Força RR' and 'BMX Potência RR' cultivars presented agronomic performance and higher stability compared to morphological traits, which suggests that promising as these traits, for cultivation in non-preferential season in the northwest region of Rio Grande do Sul. The identification of these cultivars is important, because studies Braccini *et al*. (2004), Ludwig *et al*. (2010) and Meotti *et al*. (2012) demonstrated reductions of first pod insertion height and soybean plant height when seeded on non-preferential time (second crop) and also, Meotti *et al*. (2012) pointed out that the cultivars with high porte are more suitable for late seeding. The cultivars 'BMX Apolo RR', 'BMX Energia RR' and 'BMX Turbo RR' showed hundred grain weight (HGW) of 13.511, 13.322 and 15.737 g, and the third, sixth and first place in stability, respectively, classifies them with agronomic performance and stability in the upper third (mean scores of the cultivar and the sum of scores of QMA/Gi, Wi e Pi ≤ 6) (Table 4). Already the grain yield (GY) of 2,448, 2,079 and 2,145 t ha-1, and the fourth, first and third in stability, to cultivars' FPS Iguaçu RR ',' FPS Paranapanema RR 'and' BMX Turbo RR ', respectively, secured to them, agronomic performance, and stability in the upper third (Table 4). Reductions in hundred grain weight and grain yield have been observed in seeded soybean cultivars in non-preferred times (second crop) (Braccini *et al*., 2004; Ludwig *et al*., 2010; Meotti *et al*., 2012), the which makes it important to identify the best cultivars for the time of seeding. Thus, we can infer that 'BMX Turbo RR' cultivar showed agronomic performance and higher stability compared to productive traits (HGW and GY) and therefore, is promising to be grown on non-preferential season in the northwest region of the Rio Grande do Sul.

Conclusion

In the northwest region of the State of Rio Grande do Sul, in times of non-preferential soybean seeding 'BMX Força RR' and 'BMX Potência RR' cultivars have agronomical performance and higher stability compared to the first pod insertion height and plant height, and 'BMX Turbo RR' cultivar in relation to hundred grain weight and grain yield.

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REFERENCES

Bonato, E.R., Lange, C.E., Bertagnolli, P.F. 2001. Desempenho de cultivares de soja de diferentes ciclos em semeaduras de dezembro, na região do planalto médio do Rio Grande do Sul. Ciência Rural. 31:935-940. doi: 10.1590/S0103-84782001000600002.

Braccini, A.L., Motta, I.S., Scapim, C.A., Braccini, M.C.L., Ávila, M.R., Meschede, D.K. 2004. Características agronômicas e rendimento de sementes de soja na semeadura realizada no período de safrinha. Bragantia 63:81-92. doi: 10.1590/S0006-87052004000100009.

Cruz, C.D. 2013. GENES - a software package for analysis in experimental statistics and quantitative genetics. *Acta Scientiarum Agronomy*. 35:271-276.

Cruz, C.D. and Carneiro, P.C.S. 2003. Modelos biométricos aplicados ao melhoramento genético. Viçosa: UFV. p480.

Cruz, C.D. and Regazzi A.J. 1997. Modelos biométricos aplicados ao melhoramento genético. Viçosa: UFV. p390.

Cruz, J.C., Silva, G.H., Pereira Filho, I.A., Gontijo Neto, M.M., Magalhães, P.C. 2010. Caracterização do cultivo de milho safrinha de alta produtividade em 2008 e 2009. Revista Brasileira de Milho e Sorgo 9:177-188.

Lin, C.S. and Binns, M.R. 1988. A superiority measure of cultivar performance for cultivar x location data. *Canadian Journal of Plant Science,* 68:193-198. doi: 10.4141/cjps88-018

Ludwigi, M.P., Dutra, L.M.C., Lucca Filho, O.A., Zabot, L., Uhry, D., Lisboa, J.I., Jauer, A. 2010. Características morfológicas de cultivares de soja convencionais e Roundup ReadyTM em função da época e densidade de semeadura. Ciência Rural 40:759-767. doi: 10.1590/S0103-84782010000400003.

Matzenauer, R, Bergamaschi, H, Berlato, M.A., Maluf, J.R.T., Barni, N.A., Bueno, A.C., Didoné, I.A., Anjos, C.S., Machado, F.A., Sampaio, M.R. 2002. Consumo de água e disponibilidade hídrica para milho e soja no Rio Grande do Sul. Porto Alegre: FEPAGRO. p105. (Boletim FEPAGRO, 10).

Meotti, GV, Benin, G, Silva, RR, Beche, E, Munaro, LB. 2012. Épocas de semeadura e desempenho agronômico de cultivares de soja. Pesquisa Agropecuária Brasileira 47:14-21. doi: 10.1590/S0100-204X2012000100003.

Perecin, D. and Cargnelutti Filho, A. 2008. Efeitos por comparações e por experimento em interações de experimentos fatoriais. Ciência e Agrotecnologia 32:68-72. doi: 10.1590/S1413-70542008000100010.

Ramteke, R., Singh, D., Murlidharan P. 2012. Selecting soybean (Glycine max) genotypes for insertion height of the lowest pod, the useful trait for combine harvester. *Indian Journal of Agricultural Sciences*, 82:511-515.

Resende, M.D.V. and Duarte, J.B. 2007. Precisão e controle de qualidade em experimentos de avaliação de cultivares. *Pesquisa Agropecuária Tropical*. 37:182-194.

Reunião de pesquisa de soja da região sul. 2012. Indicações técnicas para a cultura da soja no Rio Grande do Sul e em Santa Catarina, safras 2012/2013 e 2013/2014. Passo Fundo: Embrapa Trigo. p142.

Storck, L., Cargnelutti Filho, A., Lúcio, A.D., Lopes, S.J. 2009. Método de Papadakis e número de repetições em experimentos de soja. Ciência Rural. 39:977-982. doi: 10.1590/S0103-84782009005000027.

Wricke, G. 1965. Zur Berechning der okovalenz bei sommerweizen und hafer. Zeitschrift fur Pflanzenzuchtung. 52:127-138.

Yates, F. and Cochran, W.G. 1938. The analysis of group of experiments. *Journal Agriculture Science*, 28:556-580.

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