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Response of soybean cultivars according to management zones in Southern Brazil

G. M. Corassa[1], A. L. Santi[2], T. J. C. Amado[1], M. B. Bisognin[2], R. Gaviraghi[2], J. L. F. Pires[3]

[1] Department of Agricultural Engineering, Federal University of Santa Maria, Roraima Av., 1000, 97105-900, Santa Maria, Rio Grande do Sul, Brazil.

[2] Department of Agronomy and Environment Sciences, Federal University of Santa Maria, BR 386, Km 40, 98400-000, Frederico Westphalen, Rio Grande do Sul, Brazil.

[3] Brazilian Agricultural Research Corporation, BR 285, Km 294, 99050-970, Passo Fundo, Rio Grande do Sul, Brazil.

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Abstract. *The positioning of soybean cultivars on fields according your environmental response is new strategy to obtain high soybean yields. The aim of this study was to investigate the agronomic response of six soybean cultivars according management zones in Southern Brazil. The study was conducted in 2013/2014 and in two fields located in Boa Vista das Missões, Rio Grande do Sul, Brazil. The experimental design was a randomized complete block in a factorial arrangement (3x6), with three management zones (low, medium and high) and six soybean cultivars, replicated three times. The soil was classified as Typic Hapludox. The seeds density used was the recommended for each cultivar considering the germination test. The narrow row spacing used was 0.5 m. The results indicated that the soybean cultivars used in this study have different response by management zones. The correct choice by seeding soybean cultivars according management zones would increase the grain yield on 2.10% in high zone and 10.98% in low zone in relation to the traditional cultivar using in the entire field. The high cultivars should be seeding in low zones, because the height is reduced and the number of pods and grain yield are increase. The results support that the concept of soybean multi-cultivars seeding on the field can be improving the average grain yield on fields.*

Keywords. *Precision Agriculture, site-specific management, Glycine max (L.) Merrill, optimization, multi-cultivar*

Introduction

The spatial variability at field is an important factor to consider to obtain high grain yields, because the plants use the environmental resources to express its yield potential (Bunselmeyer and Lauer 2015). In this sense, to delineate management zones in a field allows farmers to apply technologies and make site-specific decisions (Bunselmeyer and Lauer 2015; Ferguson et al. 2003; Gebbers and Adamchuk 2010; Jaynes et al. 2005; Schepers et al. 2004), resulting in optimization of input resources, grain yield increase and reduction of production cost (Fridgen et al. 2000; Khosla et al. 2008; Li et al. 2008; Robertson et al. 2012; Shanahan et al. 2004; Suszek et al. 2011). The optimization of the grain yield on fields for the important crops, as is the case of soybean (*Glycine max* L.), is a new challenge to the farmers.

In Brazil, soybean represents more than 32 million ha, occupying approximately 55% of the cultivated area in the country (Conab 2015). The country average of grain yield obtained at harvest 2014/2015 it's 3.0 Mg ha^{-1}, but at Rio Grande do Sul state (RS) it obtained an average of 2.84 Mg ha^{-1}. These results are lower compared with the real soybean potential, and shown that the grain yield average in Brazil has potential to elevate in the next years. For this, it's necessary to adjust the seeding according genetic factors, environmental process or crop management (Rowntree et al. 2013; Van Roekel et al. 2015; Vanlauwe et al. 2003). Around the world, many possibilities were routinely studied (seeding date, plant population, optimum nutrition) (Conley et al. 2008; Cox and Cherney 2011; Misiko and Ramisch 2008; Pedersen and Lauer 2004; Rowntree et al. 2013; Salmeron et al. 2014; Thompson et al. 2015). However, with the technological advances new possibilities are available.

This is a case of the seeding of different cultivars in the same on-the-go operation (Jeschke and Shanahan 2015; Shanahan et al. 2004) according management zones. This possibility can be based in studies conducts by Popp et al. (2002), Norsworthy and Shipe (2005) and Thomas and Costa (2010). The authors claim that the correct choice and positioning of soybean cultivars according its environmental response, could define the most part of the grain yield potential. These studies are important for example, to identify cultivars that are productive at lower conditions, making possible to increase the average grain yield on the fields. These interactions have been described for corn (*Zea mays* L.) (Jeschke and Shanahan 2015; Sangoi et al. 2002; Signor et al. 2001) and generated the possibility of positioning hybrids with different cycles, according sub-fields on a field (Shanahan et al. 2004). However, for the adoption of this technology it is necessary to check if the soybean cultivars show different response according management zones. These studies are not available in Brazil.

The aim of this study was to evaluate the agronomic response of six soybean cultivars according to management zones in two fields in Southern Brazil.

Materials and methods

Site description

The study was conducted in two fields, one with 117.70 ha (Experiment 1) and another with 107.20 ha (Experiment 2), both are located in Boa Vista das Missões, RS. The fields are located near to each other, with 27º42'58.42"S and 53º19'59.46"W for the experiment 1 and 27º43'17.71"S and 53º20'43.80"W for the experiment 2. The soil was classified as Typic Hapludox according to U.S. Soil Taxonomy. The climate conditions during the study were satisfactory. The accumulated rainfall was 1.165 mm during the soybean cycle. The fields have been managed under continuous no-tillage system for more than 15 years. The system of crop rotations includes soybean and corn during the summer and during the winter the black oat (*Avena strigosa* L.), white oat (*Avena sativa* L.) and wheat (*Triticum aestivum* L.) are the main crops.

Delineate of management zones

For delineation of management zones yield maps were used. The maps used were white oat (harvest 2008), corn (harvest 2009) and corn (harvest 2013) for the experiment 1, and corn (harvest 2010), wheat (harvest 2012) and soybean (harvest 2013) for the experiment 2. The maps were filtered with the objective to eliminated the positioning errors and unlikely yield values (Blackmore and Moore 1999). The management zones were delimited using the overlying of harvest maps (Blackmore 2000; Molin 2002). The classes of management zones were classified according relative grain yield, as it follows: The low zone (LZ) had relative yields <95% of field average yield, the medium zone (MZ) had relative yields between 95 and 105% and the high zone (HZ) had relative yields >105% of the field average yield in the respective field (Molin 2002). The management zones were delimited using the Quantum Gis Software (QGIS Development Team 2015).

Experimental design, evaluated parameters and statistical analysis

The experimental design was a randomized complete block in a factorial arrangement (3x6), with three management zones (LZ, MZ and HZ) and six soybean cultivars (Brasmax Ativa RR®, Fundacep 65 RR®, Fundação Pró sementes Urano RR®, Fundação Pró sementes Júpiter RR®, Nidera 5909 RG® and Brasmax Força RR®), replicated three times. The soybean cultivars were selected because they are the most commonly seeding at farmers in Northwest of RS. In this study, the soybean cultivars will be called by its usual name by the farmers.

The seeding was carried in experimental units with 13.5 m², on November, 26th, 2013 for experiment 1 and November, 28th, 2013 for the experiment 2. The seeds density used was the recommended for each cultivar considering the local where the experiment was carried and the germination test. The narrow row spacing used was 0.5 m. In both experiments, all the management of soybean was conducted by the farmer, together with the management applied for fields. The harvest of soybean cultivars was carried during the first half of April. Were harvested five central rows, excluded 0.5 m at the extremity of the experimental units. The moisture was determined and adjusted to 13%. Ten plants were collected at all experimental units for the quantification of yield parameters: plant height, thousand seed weight, number of pods and number of grains per pod.

In this study the soybean cultivar 5909 was seeded in all the fields and used as a cultivar reference. The parameters were submitted to variance analysis using Assistat software 7.7 (Silva and Azevedo 2006). The means were compared by Tukey test ($p \leq 0.05$). For the evaluated the relation between grain yield and yield parameters we used Pearson correlation analysis, using the software Past 3.08 (Hammer et al. 2001).

Results and discussion

The grain yield showed significant interaction between management zones and soybean cultivars, in both experiments. For the experiment 1 and for the HZ the best grain yield was obtained for cultivar Urano, not differing from 5909, Júpiter and Ativa (Fig 1). The cultivars 5909, Ativa e Urano, also showed higher grain yield for the MZ (Fig 1). At LZ, Ativa, Júpiter and Urano remained among the most productive, however, the cultivar Força was the one that showed the best grain yield, while the cultivar 5909 showed low grain yield at LZ, along with CEP 65 (Fig 1).

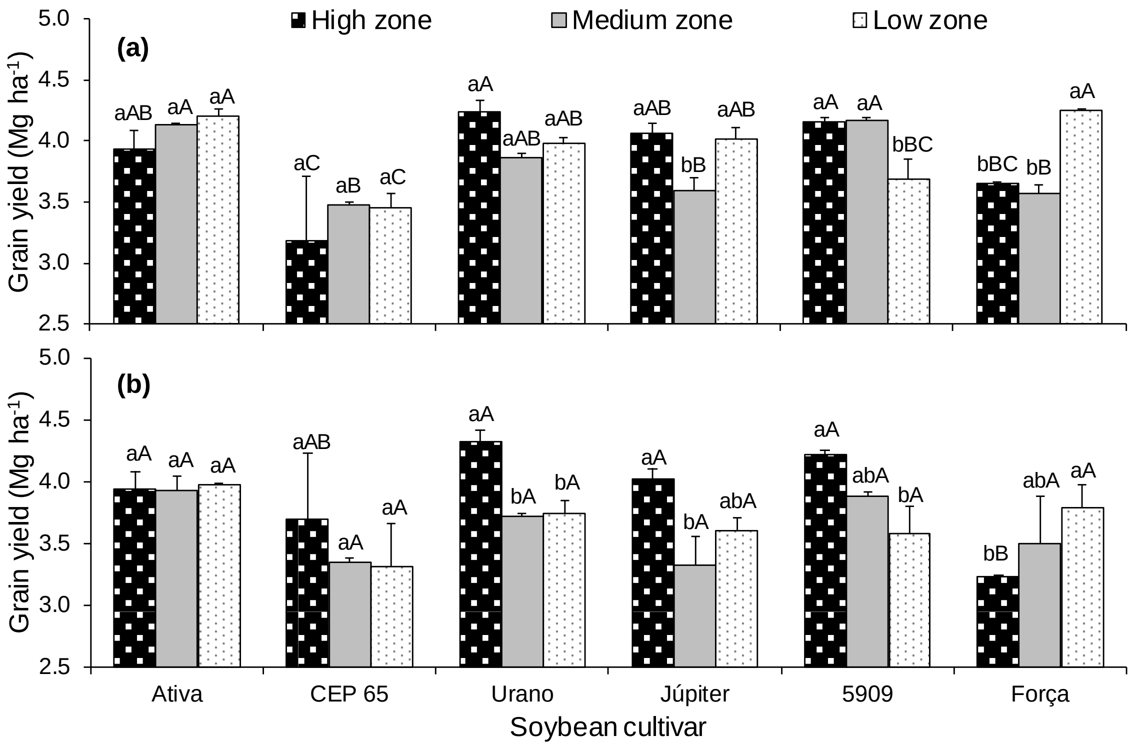


Fig 1. Grain yield of six soybean cultivars in three management zones (high, medium and low) for a) experiment 1 and b) experiment 2. * Significant by Tukey test ($p \leq 0.05$). Lowercase indicate management zones and uppercase indicate soybean cultivars at each zone.

The cultivars Ativa, CEP 65 and Urano, did not differ between HZ, MZ e LZ, however, Urano showed higher average grain yield of 6.27% for the HZ compared with MZ and LZ (Fig 1). The cultivar 5909, showed higher grain yield of 11.21% at HZ compared with LZ, however, did not differ at MZ. Higher response wasn't obtained for the cultivar Força, that showed higher grain yield of 14.06% in the LZ compared with HZ. Similar results were observed in experiment 2, where the cultivar Força also showed higher response at LZ compared with HZ (Fig 1). On experiment 2, the average of superiority was 14.83%. The cultivar Força show high height and high branching ability. It's possible that with lower production conditions, the cultivar has reduced its growing and prioritized the production of pods, as a compensatory mechanism at lower environment conditions (Board, 2000). This dynamic is confirmed at correlations analysis, where it was observed negative correlation between grain yield and plant height for the cultivar Força, while the positive correlation was obtained between grain yield and number of pods (Table 1). According to Souza et al. (2013) compact plants, can be photosynthetically more efficient, because occurs the maintenance of photosynthesis in the leaves at the bottom of the plant canopy, that results in more numbers of pods production (Liu et al. 2010).

For the experiment 2, the cultivar 5909 followed the same response tendency of experiment 1, yielding 15.01% more at HZ than LZ (Fig. 1). The cultivar Urano showed higher grain yield on 13.45% at HZ in relation by LZ (Fig. 1). This cultivar presents similar cycle of cultivar Força, however, has lower height, which can have potentiate their performance in HZ. Negative correlation between plant height and grain yield was obtained for the cultivar Urano at experiment 2 (Table 1). Souza et al. (2013), studying growth reducers for soybean, concluded that the reduction of plant height increased the lodging tolerance, the number of pods, the number of grains per pod and the grain weight. Negative relations between plant height and soybean grain yield were obtained by Liu et al.

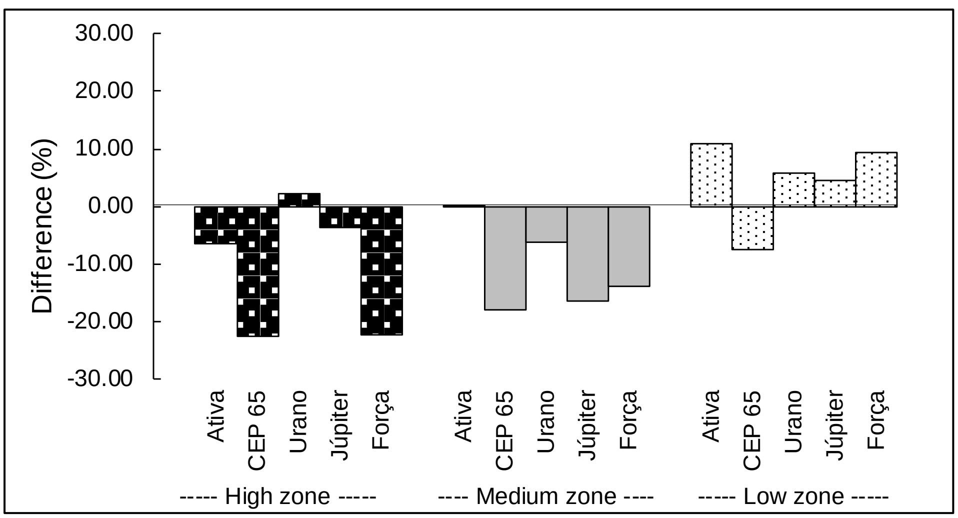
(2010).

Table 1. Pearson correlation between soybean cultivars yield parameters and grain yield.

Yield components	Júpiter	5909	CEP 65	Urano	Ativa	Força
	-- Grain Yield --					
	Experiment 1					
Plant height	ns	ns	ns	ns	ns	-0.65**
Thousand seed weight	ns	ns	ns	ns	ns	ns
Number of pods per plant	ns	ns	-0.24	ns	ns	0.67**
Number of grains per pod	-0.60*	0.77*	ns	ns	ns	ns
	Experiment 2					
Plant height	ns	ns	ns	-0.57*	ns	ns
Thousand seed weight	ns	-0.59*	ns	ns	ns	ns
Number of pods per plant	ns	ns	ns	ns	ns	0.59*
Number of grains per pod	0.55*	ns	ns	ns	0.69**	ns

** Significant p< 0.05, * significant p<0.10, ^{ns} not significant

The different performance of soybean cultivars by management zones, agree with the results obtained by Sangoi et al. (2002) in studies with corn hybrid in Brazil. They claim that the seeding of modern hybrid does not provide the best grain yield at all the fields, because the corn hybrids differ in their architecture, optimum plant population and cycle, which can conduct a different result according to the environment conditions. For the soybean, the results indicate that if the relation between cultivars and environment are identified, the positioning according management zones can increase the grain yield on fields. The results obtained showed that in average and compared with traditional cultivar, for the HZ, the cultivar Urano was 1.88% and 2.31% higher, while for the LZ Ativa was 12.14% and 9.82% higher and Força was 13.17% and 5.54 %, for the experiment 1 and 2,



respectively (Fig 1).

Fig 2. Difference at grain yield for soybean cultivars compared with traditional soybean cultivar.

Therefore, considering both experiments, the seeding of Urano in the HZ, Ativa or 5909 in the MZ and Ativa or Força in the LZ, lead to better results. In average, the optimization of soybean cultivars would be able to increase the grain yield for the HZ by 2.10 %. For the LZ the grain yield would be increased by 9.36% using the cultivar Força and 10.98% using the cultivar Ativa (Fig. 2). Hörbe et al. (2013) in experiments with corn in Southern Brazil, concluding that the optimization of plant population by management zone can increase the economic gains on 6.1% in HZ and 24.25 % in LZ. The results about the better response in the LZ agree with this study and indicated that LZ interventions are very important. The results obtained in this study also demonstrate that multi-cultivar seeding is able to increase the grain yield average on fields. Currently, the seeding of different cultivars and different population in the same on-the-go operation is a technology available at precision agriculture (Jeschke and Shanahan 2015).

Conclusions

The soybean cultivars used in this study have different response by management zones. This study demonstrates that the correct choice by seeding soybean cultivars according management zones could increase the grain yield on 2.10% in high zone and 10.98% in low zone in relation to the cultivar using in the entire field. Similarly, the results indicate that high cultivars should be seeding in low zones, because the height is reduced and the number of pods and grain yield are increase. The results support that the concept of multi-cultivars seeding on the field can be improving the average grain yield on fields. The studies must be refined and other soybean cultivars must be tested.

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