PRECISION FARM TO IMPROVE CROP-LIVESTOCK SYSTEMS IN SOUTHERN BRAZIL

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ABSTRACT

The expansion of soybean crop in southern Brazil, driven by good prices in recent years, has raised concerns about decrease in cattle herd and gradual increase of monoculture economic dependency. In this work are analyzed, the productive and economic performances of three different systems: soybean crop monoculture; crop-livestock system with soybean crop in summer and ryegrass pasture in winter and crop-livestock system composed by soybean crop and Sudan grass in summer and ryegrass pasture in winter, the latter, obtained by simulation of soybean crop replacement by BRS Estribo Sudan grass in low productivity areas, obtained by productivity map evaluation in six years. The operating profit in all systems showing that crop-livestock systems can minimize the risks of soybean crop frustration due to water soil deficit. Just as crop-livestock systems can be improved using precision farming techniques. The weather forecasting as a decision-making to choose crop seeding, soybean or Sudan grass, in the different management zones is also discussed.

Key words: Precision Agriculture; Pampa Biome; Soybean

INTRODUCTION

The good prices of soybeans in recent years have led to the expansion of crops in southern Brazil and are pushing for the reduction of cattle and livestock activities, which have historically been adapted to local vegetation, soil and climate conditions. Despite the tendency to increase the cultivated area, soybean productivity has a high oscillation, mainly related to water deficiency in the soil. This factor has been identified as the most relevant for reducing the productivity of the main crops of spring and summer (MATZENAUER et al., 2002; BERGAMASCHI et al., 2004), affecting the production of nine out of twenty soybean crops (OLIVEIRA et al., 2020), facts that raise great concerns about the expansion of monoculture during the summer. This concern can be attested in the region of the Southern Campaign where, during the evaluation period of the present work, the soybean area grew by 600%, while the number of cattle was reduced by 13% (EMATER RS, 2021). The good prices of soybeans promote the expansion of crops in southern Brazil and press for the reduction of cattle and livestock activity, historically adapted to the conditions of vegetation, soil and local climate.

Currently, the use of precision technologies has allowed to detail the impact of climatic risks within the crop areas on the same farm. Harvest map helps to identify low productivity areas relating them to climatic variables and economic results (PEREZ et al., 2015). This procedure can help decision making in relation to the areas to be cultivated or not, reducing the risks of crop frustration due to the low soil humidity. Expanding this perspective, the concept of management zones was used to address the spatial variability of production within agricultural areas (LUCHIARI et al., 2011). With this information, it was simulated the partial replacement of the soybean crop with a crop more resistant to water deficiency. With that, it was possible to compare the economic results and the stability of the crop-livestock systems, considering the oscillations of the summer rains in the Southern Campaign of Rio Grande do Sul.

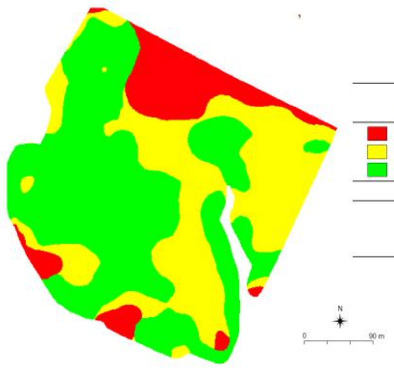
MATERIAL AND METHODS

The experiments were carried out at Embrapa Pecuária Sul, Bagé, RS, Brazil, on 13 ha, cultivated with soybean [*Glycine max* (L.) Merrill] during the summer and ryegrass (*Lolium multiflorum* L.) pasture during the winter. Grain and l beef cattle production were monitored since 2011. Soybean crop established in direct sowing after natural reseeding of ryegrass, had its productivity measured from a SLC 6300 harvester coupled to the Topper 4500 Controller from Stara Precision Agriculture, with infrared productivity sensors corrected by capacitive humidity and temperature sensors. Through interpolation, using the Krigagem method, productivity surfaces were generated for each year, which were cut out at the boundaries of the area, generating six productivity maps for the crops: 2011/12, 2012/13, 2013/14, 2015/16, 2017/18 and 2018/19. The maps were used as attributes (normalized productivity values) in a classification by Cluster Analysis, method k-averages, resulting in a map with 3 output classes, called low (red), variable (yellow) and high productivity zones (green). The interpolation was done with SURFER 9 application and the classification with QGIS 3.4.1 system.

Animal production obtained during the winter on ryegrass pasture kept under natural reseeding, between 2012 and 2019, was evaluated monthly, through the weight gain of young steers. After 12 hours fasting animals were weighed individually using an electronic scale to record weight and adjust stocking to 12% of live weight in forage dry matter. For the economic analysis, the values of a historical series of soybean production costs for Rio Grande do Sul, obtained from CONAB (2021), were used. The commercialization values of soybeans (60 kg bag) and steers (kg live weight) were provided by Emater RS (2021), internal records related to livestock (costing and weight gain) and data from the literature were used to estimate the gross margin of Capim BRS Estribo (SILVEIRA et al., 2015).Once the soybean areas and productivity zones were measured, a simulation process was carried out in order to replace the area occupied by the low-productivity soybean zone with the cultivation of BRS Estribo (*Sorgum sudanensis* L.). The results of animal productivity were converted into soybeans in the same year as the harvest, in order to mitigate the effects of price fluctuations and inflation and to allow a better comparison between the evaluated systems. Finally, a comparative analysis was made between the operating profits of soybean and fallow monocultures in winter, the real crop-livestock system and the alternative system simulating the planting of Sudan grass in the areas with the lowest productivity.

RESULTS AND DISCUSSIONS

The data set and maps of productivity of the six harvests showed the existence of variability, both spatial and temporal. The multivariate classification of soybean productivity, in 3 classes, referring to the management zones synthese and favor the understanding of the variability existing in the different zones throughout the harvests. Figure 1 shows the result of the productivity classification process in management zones: high, medium and low, with relative dimensions of 51.7%, 35.0% and 13.3%, respectively, as well as the values of productivity in bags (60 kg) in each year harvest in the different management zones and the accumulated rainfall values, in the period from November of the year of soybean planting to April of the following year.



management zones	area (%)	Soybean productivity - bags (60 kg)/ha						mean
		2011/2012	2012/2013	2013/2014	2014/2015	2017/2018	2018/2019	
low productivity	13.3	14.0	25.5	23.4	35.3	13.1	35.8	24.5
variable productivity	35.0	20.0	33.8	41.1	31.1	14.7	48.2	31.5
high productivity	51.7	23.5	37.4	39.2	45.7	20.4	50.2	36.1
total	100.0	21.0	34.5	37.8	39.2	17.5	47.6	
	accumulated rainfall (mm)	567.1	725.1	1079.6	623.4	436.1	865.3	

Figure 1. Management zones and soybean productivity data in different zones and harvests, and the accumulated rainfall in the six months of influence on cultivation (November to April).

The green zone with high productivity presented the best performances in five of six harvests. The exception occurred in the 2013/14 harvest when there was the greatest accumulated precipitation exceeding the crop requirements. The yellow zone of medium productivity presented the most unstable performance over time. In four of six harvests evaluated the yellow zone showed intermediate productivity values in relation to the other two zones. However, in the 2013/14 harvest, which excessive rainfall, it was the most productive area. Istead in 2014/15 harvest it was the least productive area. The red zone of low productivity presented the worst productivity in five of the six years of evaluation, except in 2014/15 harvest, when it overcame the yellow zone. It should be noted during the winter period that preceded the harvest the ryegrass grazing period was shortest, in order to enable the ryegrass harvest in the area, increasing the vegetable residue prior to the sowing of soybeans this year.

Table 1 presents the financial results of the different production systems. It is possible to verify in the first column that the operational profits obtained for the soybean crop were negative or very low in two of six monitored harvests. This fall in soybean productivity corresponds to periods with the lowest accumulated rainfall. Matzenauer et al. (2002) and Bergamaschi et al. (2004) point out that the main factor for decreases in productivity, both in frequency and intensity, is the water deficiency caused by the poor distribution of rainfall. In the present study drought imposed a reduction of more than 40% in the average productivity in one third of the harvests evaluated in the period. The analysis of operating profit for crop-livestock system where the results of the livestock phase are added to the soybean crop results, presented in the second column of Table 1, shows that over years the operating profit made it possible to obtain positive results in all years, even in the years of low soybean productivity.

Table 1. Operational profits of the different production systems in six monitored harvests.

	Operating profit – bags (60 kg)/ha		
systems	**soybean**	**soybean and ryegrass**	**soybean/sudan and reygrass**
2018/19	27.6	52.1	51.8
2017/18	-5.8	12.9	16.0
2014/15	22.4	46.7	46.0
2013/14	22.3	45.0	45.7
2012/13	16.8	27.5	28.2
2011/12	9.4	30.8	32.2

These results corroborate the importance of crop-livestock system to minimize the frequent crop soybean frustrations in the Campaign Region of RS in low rainfall. The simulation of operating profit obtained in crop-livestock system enhanced by harvest map information made it possible to exercise the substitution of soybean cultivation by Sudan grass cv. BRS Estribo. Considering the animal productivity in areas of low soybean productivity. To arrive at operating profit in simulated system, shown in the third column of Table 1, were used the gross margin value obtained for Sudan grass cv. BRS Estribo by Silveira et al. (2015). This value was transformed into soybeans (13.25 bags/ha) assuming the same performance for all harvests. Therefore, was considered even for driest period, there was no water deficiency for Sudan grass cv. BRS Estribo due to the lower requirement when compared to soybeans (20% moisture in the soil). Comparing the results of the two systems, real crop-livestock system (soy and ryegrass) with simulated crop-livestock system (soy / Sudan grass and ryegrass) it appears that the differences in yield are not very significant, 10% on average for the driest years, corresponding to an average increase of 2.3 bags / ha in annual operating profit in years of low productivity. This is partly explained by size of the management area used with Sudan grass cv. BRS Estribo 13.3% of the total area, which limits the effects. However, in the most favorable years for soybean production, there was no reduction in operating profit of the simulated system, when compared to the traditional crop-livestock system.Considering these results an interesting alternative would be to adopt a flexible strategy where decision to plant soybeans or Sudan grass cv. BRS Estribo in different proportions, in management areas, would be made according to the weather forecast for the coming months: i) dry periods, soybeans planted only in the high productivity zone and BRS Estribo Sudan grass in the others; ii) wet periods, soybeans in all management zones; and intermediate periods, soybeans in the high and medium productivity zones and Sudan grass cv. BRS Estribo in the low productivity zone. This flexible strategy would probably have more significant results. However, it is dependent on a good accuracy of the forecasts for the region based on the improvement of the meteorological models currently available.

CONCLUSIONS

Soybeans crops in the Southern Campaign Region of RS are often impacted by water deficiency and may have their economic risk reduced by crop-livestock sistem. The use of management zones, based on the yeld soybean maps allows the establishment of a strategic plan to minimize the impacts of dry years on soybean crops, replacing soybeans by Sudan grass cv. BRS Estribo. The strategy of using Sudan grass cv. BRS Estribo in areas of low soybean productivity, can still generate additional gains, either by calling for greater forage production during the summer period, which is fundamental for the maintenance of crop-livestock systems, or for the benefits of animals sale outside of high offer for sale just before sowing soybeans.

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