Evolution of soybean cultivation in lowlands: An overview from the producers' point of view

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ABSTRACT

It is known that soybean cultivation in recent years has shown a growing behavior in its use in succession with the production of irrigated rice in lowland areas. As a result, there are gaps both in the implementation of this succession and in its duration. Soy becomes an important ally to these production systems due to nutritional factors both for the environment (soil and weed control) and for the economic side of the property. Aiming to have an overview of the real situation of the properties in the physiographic region of the western border of Rio Grande do Sul, the present work proposes a research with the survey of general characteristics of the implantation and persistence of the succession systems of soybean with rice in lowlands, a since knowing the production deficiency gaps, you can have a better problem solving focus. A tester was developed and imposed on 10 properties that already have the system implemented. The questions involve since the beginning of the implantation, as well as the current progress of the system, correlating sowing, cultural and harvest management factors. With the results obtained, it was concluded that the gaps in the soybean-rice production system are in the phase of establishing crops and maintaining them, that is, in sowing and spraying, since the soybean harvest when detected with that of rice becomes easier due to its greater fluidity and lower depreciation of the machinery.

Keywords: Agricultural research, Lowlands, Soybean farming, Rice farming.

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INTRODUCTION

Currently, CONAB (2022) estimates a production of 10.5 tons of rice (*Oriza Sativa* L.) throughout Brazil in the 2021/22 harvest, 10.5% lower than in 2020/21, with Rio Grande do Sul (RS) responsible for approximately 957.4 thousand hectares planted, with a total production of 7,360.5 tons, 11% lower when compared to the previous year. Predominantly, the rice areas are leveled to increase the efficiency of rice production (GIACOMELI et al., 2021), allying with the rammed earth system at level for water retention in the frames.

The stagnation of irrigated rice production, together with the resistance of invasive plants to herbicides used in rice cultivation (RAO et al., 2007), in addition to the instability of the price of the product, makes it necessary for the producer to pay attention to the diversification of the system so as not to take risks with monoculture. As an option for crop rotation with irrigated rice in lowlands, we have the soybean crop (*Glycine max*), which in the 2020/21 harvest was present in 370,594 hectares (39.2%) of the 945 thousand hectares of rice cultivation, according to the Riograndense Rice Institute (IRGA, 2021).

The cultivation of soybean in rotation with rice becomes an important ally for weed control, which is one of the problems present in rice growing areas in RS (MARCHEZAN, 2016; ROSSO et al., 2018), is also a good alternative due to its good economic return, in addition to the producer being able to rely on technologies already existing in the production medium, thus enabling its cultivation by them (HIRAKURI et al., 2021).

There are about so many variabilities in the production systems, also the climatic variations imposed, in addition to the fluctuations in the prices of the inputs used, make it necessary to understand the main challenges and the main advantages in the view of the rural producer of the means of production, so that the focus is on identifying and solving the possible barriers imposed. thus, making it possible to improve the systems.

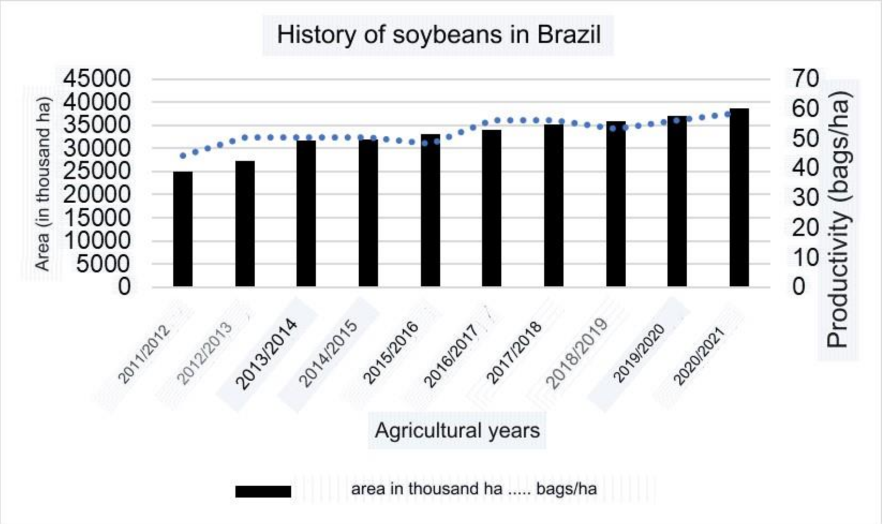
However, the present study is characterized as a tool for understanding the aforementioned issues, in order to have a perspective on the view of rice and soybean producers in fragile lowland areas, with a main focus on areas of the western border of Rio Grande do Sul (RS). In this sense, the objective of this work was to understand the situation of the production systems from a point of view directly linked to the producers of the Western Frontier of RS in the implementation and permanence of rice and soybean rotation systems in floodplains.

LITERATURE REVIEW

SOYBEAN CULTIVATION IN BRAZIL AND RIO GRANDE DO SUL

Soybeans are a widely produced legume worldwide, they are also the main source of protein meal and the second largest source of oil (UNITED STATES, 2021). Soybean cultivation in Brazil began in 1901, but showed greater expansion along with Japanese immigration in 1908 (APROSOJA, 2022). Brazil is considered the second largest producer and exporter of soybeans (CONAB, 2020). When considering the last 10 harvests in Brazil, Hirakuri et al. (2021) observed an upward trend in production areas, from 25Mha in the 2011/2012 harvest to 38.5Mha in 2020/2021. Figure 1 shows the increase in average productivity over this period.

Figure 1 - Evolution of soybean areas and productivity in the last 10 harvests in Brazil.

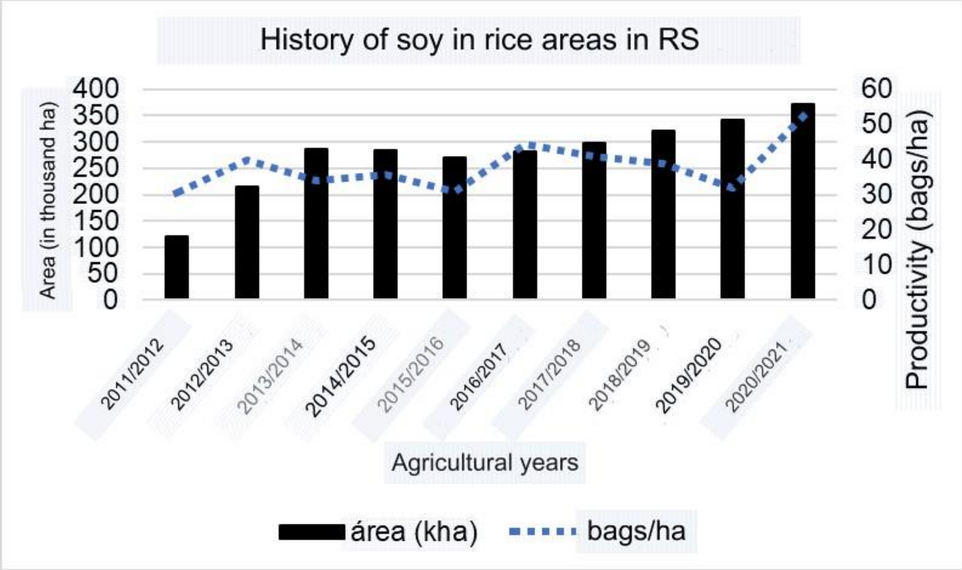


Fonte: Adapted from CONAB (2020).

Soybean cultivation in Rio Grande do Sul began in 1914, but only became economically important around 1941 in Santa Rosa (NUNES, 2022). RS presents an evolution in the area and in soybean production, according to the Riograndense Rice Institute (IRGA, 2022) we have a great advance of soybeans in rice areas, reaching a 205% increase when we compare the 2011/2012 harvest with that of 2020/2021, with the increase in the area from 121kha to 370kha, with productivity averages of 30.5 bags/ha and 52.3 bags/ha, respectively (Figure 2).

The productivity averages shown in Figure 2 are lower than the national averages (Figure 1), however the evolution towards higher productions is a trend. Present in the expansion of soybean cultivation are the areas in Figure 2, where soybean is adopted as a crop for rotation with irrigated rice, connected to this are factors of soybean remuneration capacity and the technologies present for the viability of this cultivation (HIRAKURI et al., 2021).

Figure 2 - Evolution of soybean areas and productivity in the last 10 harvests in Rio Grande do Sul.



Source: Adapted from IRGA (2022).

However, most of the production areas in Figure 2 are floodplain soils. Goulart (2016) mentions that the use of rainfed plants in lowland environments still encounters the resistance barrier of some farmers, as they are environments with low hydraulic conductivity problems. Vogel et al. (2021) state that unlike rice, soybeans need a well-drained environment. Environments with the use of ridges to elevate the root system of the soybean plant becomes a simple and effective method to avoid high levels of moisture in the soil. Takahashi et al. (2006) also point out that this soil management provides an increase in roots and nodulation, thus increasing the capacity for N absorption, provided via biological nitrogen fixation.

Rice vs. soybean succession

What is called rotation by many is actually a succession, because it involves only two cultures one after the other, what often changes is the intensity of this succession. In crop rotation, two or more plants should be grown in the same area over a period of one year (SILVA, 2017). At the beginning of soybean cultivation in succession with rice, there was the great premise of controlling the main weed of rice, red rice (*Oriza sativa* L.) which, according to Agostinetto et al. (2001), limits the yield of commercial rice, and is even capable of making its cultivation unfeasible in some areas. Currently, the use of technologies available in rice seeds alone is not effective for weed control, due to the resistance acquired to their active ingredients, thus making the monoculture of irrigated rice unfeasible (GASTAL et al., 2004; GOULART, 2016).

Several benefits are evidenced in systems that use crop variation in the same area, such as improved soil structure (SANTOS et al., 2000), greater economic stability of the system (HIRAKURI et al., 2021), nutrient cycling (DALLA NORA et al., 2013), however, there are limitations regarding the plant options that can be used in lowlands.

Soybean becomes a good ally for the floodplain production system. Goulart et al. (2020) mention that the soybean crop was genetically adapted to well-drained environments, but originated from the flooded areas of northern China (EVANS, 1996). Thomas et al. (2000) point out that there may still be genes capable of adapting their cultivation in floodplain soils. Silva et al. (2017) point out that the crop succession system should be planned, considering factors such as the requirement of the crops, edaphoclimatic characteristics of the area, and suitability for each crop. According to a report by Canal Rural (2020) using IRGA as a source, the succession of rice with soybeans increases rice productivity by 20%, when compared to systems with monoculture or integrated with beef cattle.

For greater security of the production system, the amounts of planted area of each crop must be adjusted, so that dependence on only one means of production does not occur. Hirakuri et al. (2021) simulated three systems: rainfed soybean with irrigated rice, rainfed soybean with soil chiseling and irrigated rice, and soybean in the irrigated furrow-ridge system and irrigated rice, where an area with 300 hectares in rotation was considered, all with ryegrass (*Lolium multiflorum) winter cover*. As a result, the authors found that, even with the additional costs of the construction operations of the furrow-camalhão and irrigation for soybean, there is still greater viability and better commercial return of soybean in the system.

Soybean soils and cultivars

In Rio Grande do Sul, there are five major physiographic regions, which, according to the Soil Museum of Rio Grande do Sul, of the Federal University of Santa Maria (MSRS, 2022), affect the formation and distribution of soils in the state. According to Pinto et al (2017), areas with an altitude below 200 meters cover a total of 4.4 million hectares, corresponding to 16.5% of the total area. Cunha & Costa (2013) and Goulart et al. (2020) mention that these areas were used only for raising cattle on native pastures until the arrival of irrigated rice production in these environments. Table 1 shows the main soil classes of RS, according to the Brazilian Soil Classification System (SANTOS et al., 2013), where all the soils mentioned represent 17.3% of the total area of the state, with the Haplic Planosol being the most recurrent type in floodplain environments.

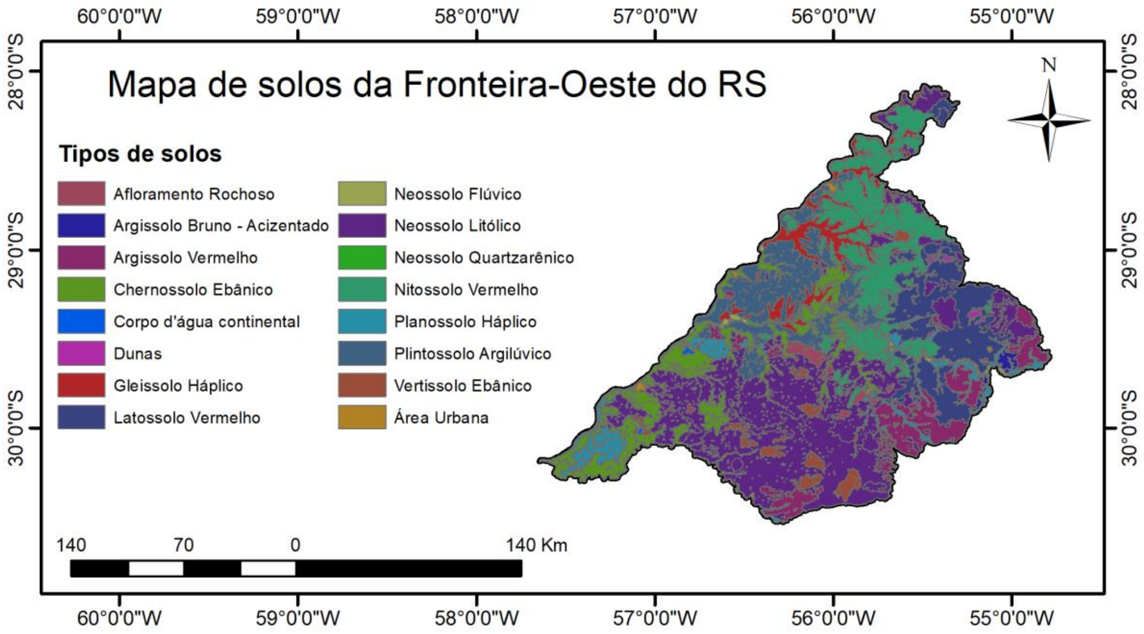
Table 1 - Main types of soils in floodplain areas of Rio Grande do Sul in their total area and relative percentage.

Class	Area (ha*)	% Status	% Floodplain
Haplic Planosol	2.520.423	9,37	54,27
Gleissolo Háplico	250.520	0,93	5,39
Melanic Gleisol	9.432	0,34	1,97
Organosol	39.572	0,15	0,85
Ebonic Chernosolus	276.199	1,03	5,95
Chernossolo Argilúvico	195.832	0,73	4,22
Chernossolo Háplico	228.540	0,85	4,92
Vertissolo Ebânico	61.110	0,23	1,32
Argissolo	181.312	0,67	3,90
Hydromorphic Quartzarenic Neosol	342.852	1,28	7,38
Ortic Quartzarenic Neosol	333.549	1,23	7,19
Neossolo Flúvico	122.372	0,45	2,64
Total	4.561.713	17,3	100

Fonte: Adaptado de Pinto et al. (2017); Santos et al. (2013); Streck et al. (2008); Lemos (1973).
*ha= hectares.

The Western Frontier region also has a high diversity in floodplain soils (Figure 3), not all of them are soils with floodplain characteristics because they are soils at higher altitudes, however, a good portion is still used for the cultivation of irrigated rice, due to the proximity or adjacent to the lowlands. According to Medeiros et al. (1995), the Western Frontier has a predominance of a friable sandstone cover, where there are sanding processes, areas presented in Figure 3 as Dunes.

Figure 3 - Soil map of the Western Border of Rio Grande do Sul.



Font: IBGE (2021).

Pinto et al. (2017) mention that soils such as those present in the western region of RS have naturally high density, high micro/macropore ratio, leading to difficulties with drainage combined with practically impermeable subsurface layers, which results in difficulty in soil management. The conditions mentioned most of the time become interesting for rice cultivation, since they help in flood irrigation, however, they make the environment restrictive for rainfed crops.

The variability in soybean production in RS over the years is worrying, the southwest region is usually one of the regions that suffers the most from the interference of summers, usually presenting yields below the state average (IBGE, 2021).

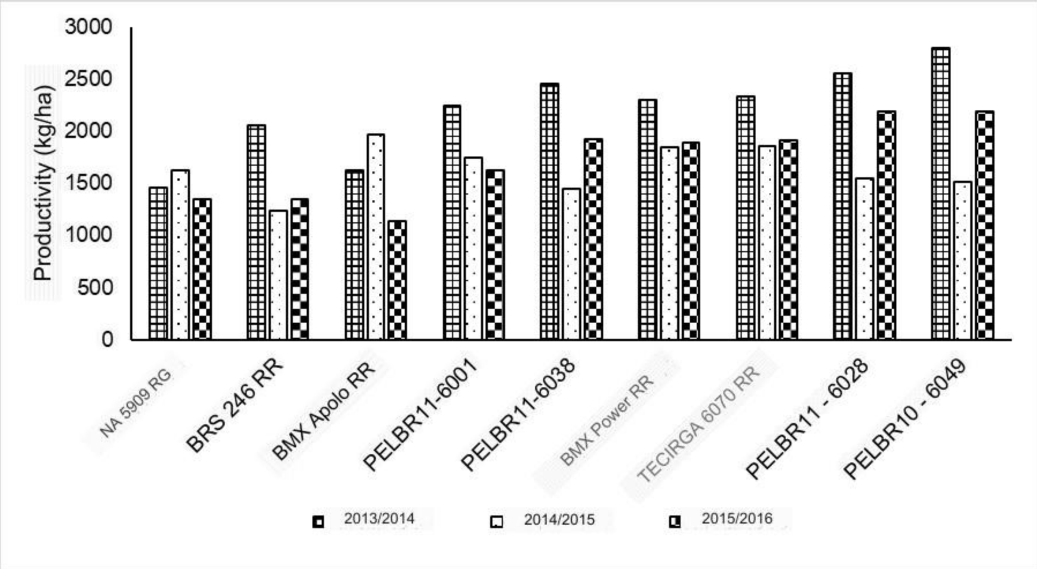
For the adaptation of soybean cultivation in poorly drained environments, in addition to having soil management that facilitates this production, it has cultivars adapted to the environment, or at least partially adapted. According to Goulart (2016), as much as there is great variability of cultivars, none is totally tolerant to water excess.

Thomas et al. (2005) mention that the use of unadapted or poorly adapted genotypes results in physiological and morphological changes, in addition to inefficiency in nodulation, which can lead to plant death when periods of hypoxia (scarcity/lack of air to the root) occur. According to Zanon et al. (2015), in the southern region of Brazil, from the 2000s onwards, the use of soybean cultivars with an indeterminate cycle and relative maturity group (GMR) between 4.5 and 6.5 began. When focusing on soybean cultivation in lowlands, Oliveira (2017) shows that certain characteristics are necessary, such as: resistance to certain diseases, plant height and first pod insertion (GMR<6.7), stable productivity and a good level of tolerance to water stress.

In RS, the group of cultivars with GMR between 4.5 and 6.5 occupied more than 90% of the area sown with soybean between 2010 and 2015, allowing planting in September and October, or even in January and February (off-season) (ZANON et al., 2016). Oliveira (2017) mentions that IRGA has already been present with programs for the improvement of soybean cultivars for lowlands, which led to the launch of a cultivar.

EMBRAPA is one of the institutions that continue with the breeding program, aiming at adaptations to lowlands in RS, having a program for the development of new cultivars, through the program an increase in productivity of some cultivars of 21% to 26% was evidenced, when compared to the control, shown in Figure 4 (FUHRMANN et al., 2014; OLIVEIRA et al., 2015).

Figure 4 - Grain yield of commercial cultivars, at 30% moisture and soybean lines of the EMBRAPA breeding program under evaluation in the 2013/14 to 2015/16 harvests, in lowlands at the EMBRAPA Experimental Station in the municipality of Capão do Leão/RS.



Fonte: adaptado de Fuhrmann et al. (2014), Oliveira et al. (2015), Oliveira (2017).

AGRICULTURAL MECHANIZATION IN LOWLANDS

The emergence of the first mechanized agricultural practices was in the eighteenth century, but the real expansion of the use of agricultural machinery arose with the rural exodus, a consequence of the great Industrial Revolution (BARICELO; BACHA, 2013). Vian & Andrade Júnior (2010) state that mechanization streamlines the processes related to agricultural production, which naturally met the demand for labor lagged by the rural exodus.

In Brazil, three phases can be identified in the evolution of the agricultural machinery sector, from 1920 to 1950 the emergence of companies in the area in the country, from 1950 to 1970 with the injection of large national and foreign capital there was a significant increase in production and from 1980 to the present day the marked presence of partnerships and innovations (CASTILHOS et al., 2008). The adoption of mechanized agricultural practices is essential to improve the productivity of rural properties, taking into account that a machine replaces a large part of the workforce, thus making the planting, cultivation and harvesting process more productive (BARICELO; BACHA, 2013).

In the rice cultivation areas of RS, the cultivation system made at a controlled level, with conventional soil preparation, ensures the requirement of many operations throughout the production cycle (DIAS et al., 2020). Scholosser et al. (2004) have already shown that rice plantations in the state have high rates of mechanization in small properties, thus having a greater work capacity. However, Dias et al. (2020) mention that larger properties with lower mechanization rates have to present greater planning of activities to the large areas that need preparation. Araldi et al. (2013) show that mechanization in rice crops is around 30% of production costs, and they also highlight that efficiency in the field is an important ally for decision-making about machine management (GRISSO et al., 2004).

Márquez (2004) calls the process of seed deposition in the soil as sowing, whether the soil is previously prepared or not, thus enabling the germination and emergence of plants. Seeders are implements intended to dose and place seeds in the soil (VALE, 2007), and there are also seeders-fertilizers, which are machines that dose seed and fertilizer in the same operation (RODRIGUES, 2012).

One of the main adaptations when adopting the rice-soybean rotation system is the sowing of the soybean crop, since in rice continuous flow seeders are used, which are implements that distribute seeds continuously, mostly small seeds that need smaller spacing between them. In soybeans, which are seeds that require a certain amount of spacing, precision seeders are used. Siqueira (2007) mentions that precision seeders contain a straw cutting unit, a mechanism for opening the fertilizer deposition furrow, a furrow for seeds, and a system for closing the rows.

GROOVE-RIDGE SYSTEM FOR IRRIGATION AND DRAINAGE

Ridge irrigation is one of the main methods used in lowland areas. Senar (2019) states that furrow irrigation has a low application efficiency, due to the inadequate convergence of the ramp length of the areas, slope, management, flow, and application time. However, according to Fiorin et al. (2009), the use of microridges proposes a surface drainage with the formation of a path trend for water runoff. Chaiben Neto (2017) mentions that the system becomes suitable for row cultivation, as long as the slope is between 0.1% and 0.4% so that there is no favoring soil erosivity in high rainfall. Parfit et al. (2017) also show that when the furrow system is used for irrigation, applications with flow rates greater than three liters/second are not recommended.

Henrique (1996), when studying the influence of field parameters on the performance of the furrow irrigation system, noticed that the characteristics of soil infiltration and the length of the furrows were the parameters that most affected the performance of the system. Folegatti et al. (1999), studying yield of irrigated common bean submitted to different water depths with furrow irrigation, noticed that the decrease of the water depth from the end to the beginning of the furrow, resulted in lower values of the yield parameters, due to the gradual stress in the treatments of 0% and 50% of the useful depth applied. Chaiben Neto (2019), analyzing furrow irrigation for corn cultivation in irrigated rice areas, noted that management with 0 to 25% of time required to replace the irrigation depth obtained the best application efficiencies.

Embrapa (DA SILVA, 2006), when analyzing two soybean crops in systematized areas with and without slope, found that the average yield of grains by the system with the adoption of ridges was higher than the conventional irrigation system, being 21% higher in areas without slope. The furrow irrigation system becomes a method that requires more manpower, in addition to requiring experience in the method (CHAIBEN NETO, 2019). Chen & Feng (2013) cite that the cost of installing the furrow irrigation system is lower than the cost of pressurized systems.

METHODOLOGY

The survey was conducted from October to December 2022. To collect the information, a questionnaire of questions was used and made available to rural producers in the Western Border of Rio Grande do Sul, who use rice and soybean rotation systems in floodplains.

SELECTION OF RESEARCH METHODS

To characterize the questions used in the questionnaire that was applied to the producers, two question methodologies were used, qualitative and quantitative (Appendices A and B, respectively). To prepare the questionnaire, the study was referenced by Aaker et al. (2001), which illustrates the main steps in Table 2.

Table 2 - Steps and steps for designing a survey questionnaire.

Stage	Steps
Plan what will be measured	Highlight the objectives of the research
	Define the subject of the survey in your questionnaire
	Obtain additional information about the subject of the research from secondary data sources and exploratory research
	Determine what will be asked about the subject of the survey
Shaping the questionnaire	For each subject, determine the content of each question
	Decide on the format of each question
Text of the questions	Determine how questions will be worded
	Evaluate each of the questions in terms of their ease of understanding, knowledge and skills required, and willingness of respondents
Decisions about sequencing and appearance	Arrange the questions in an appropriate order
	Group all questions in each subtopic to get a single quiz
Pre-testing and fixing issues	Read the entire questionnaire to see if it makes sense, and if it can measure, what is expected to be measured
	Check for possible errors in the questionnaire
	Pre-test the quiz
	Fix the problem

Cast iron: Aaker et al. (2001).

The questions that were incremented in the questionnaire, which was applied, took into account questions so that there was no misunderstanding or to avoid any offense to the target audience, these questions being:

I. In opinion questions, is it interesting to know the degrees of favorability/unfavorability, or is it enough to know if you are for or against?
II. Will respondents be willing to give the information?
III. What objections might someone have to answering this question?

IV. Is the topic addressed too intimate, disturbing, or does it expose people socially in a way that causes resistance and false answers?

V. Is the topic embarrassing for the respondent because it endangers his or her prestige if it is contrary to socially accepted ideas?

VI. Is the question properly neutral, so as not to influence the answers?

VII. Does the question contain opinions or judgments related to the subject?

To meet the questions of interest of the research, quantitative questions and multiple-choice questions were used, thus facilitating the analyses. The quantitative questions were obtained from relative data, so that comparisons could be made between the properties. While the multiple-choice questions were classified into five categories: very poor, poor, average, good, and very good.

DATA CAPTURE AND ANALYSIS

The questionnaire was applied to 10 farms that have the soybean-rice rotation system implemented for at least one (1) agricultural year. The material was made available only online and the time for the application of the questionnaire was free, since some information on the questions may not have been available at the time of completion. Thus, the questionnaire was available for a period of 3 months to correspondents. The application of the questionnaire was done remotely because it contained succinct and easy-to-understand questions, thus making this type of application viable.

For quantitative purposes, the values of soybean area that replaced the irrigated rice over the years that the property uses this system were obtained, thus obtaining the growth rate of the areas over the years. Data were also obtained on how many producers started the system with their own investment and how many had to obtain financing of any kind, in addition to obtaining the quantification of producers who use rented machinery. The equipment available for the study areas was also quantified, as well as the number of sowing rows, spray tips, harvesting platform feet and total tractor power available.

In the case of qualitative data, although they were obtained in multiple-choice parameters, for a better understanding of the results, the questions sought to know the levels of adaptation of rural producers in the cultivation of soybean in lowlands in relation to the environments of sowing systems, cultural treatments and harvesting.

RESULTS AND DISCUSSIONS

The results obtained were analyzed and arranged in relative numbers, so that there was no exposure of any type of result. The relationships were all established in percentages, both qualitative and quantitative. The essay questions helped in the discussion and justification of the results, since their presentation would be difficult due to the variety of forms that each producer expressed when answering the questionnaire.

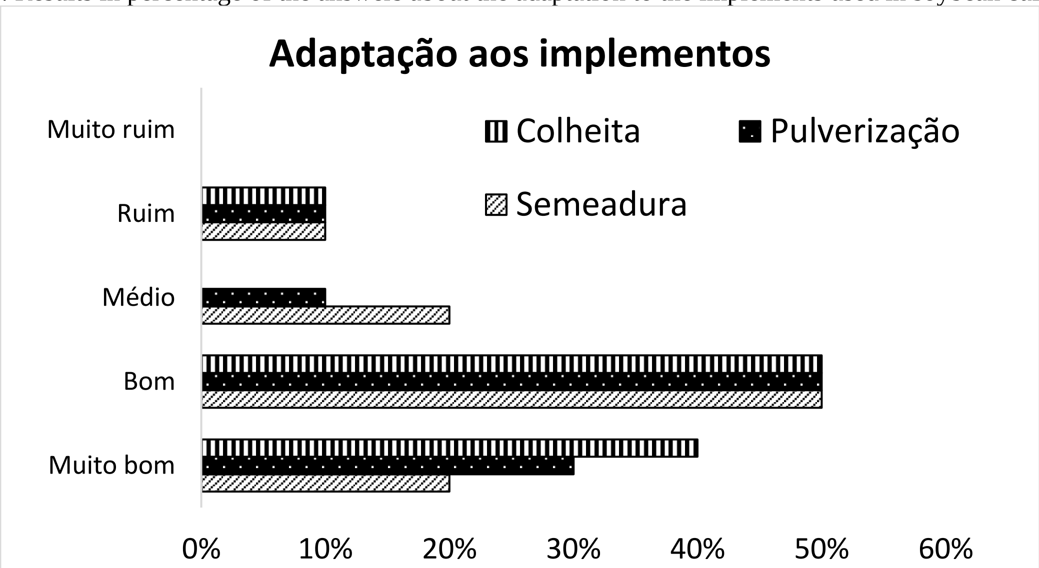
QUALITATIVE PARAMETERS

For the qualitative parameters, the analysis was performed in percentages, relating the suggested conditions, namely: Very good, good, medium, poor and very poor. In the question of adaptation to the implements used in soybean cultivation, varied answers were obtained, as shown in figure 5. All categories, sowing, spraying and harvesting had 50% of responses listing them as good, however, 10% listed them as bad. Only the harvest showed a level of 40% as very good the adaptation to the implements.

When it comes to the adaptation of the equipment, the respondents report the greatest demand for techniques for calibration and adjustment of all the points present in the precision seeders. Silveira (2001) shows that precision seeders actually contain several mechanisms, such as individual lines for seed and fertilizer, where each one has its respective reservoir, seed coating device, conductors, compactor wheels, depth controllers, etc. (MELO, 2013).

When it comes to adaptation to spraying in soybean cultivation, the most frequent reports are the number of applications, which is higher than the reference crop, rice. As recommended by Zanon et al. (2015), the cultivars used in the western border region of Rio Grande do Sul have longer cycles, thus requiring a greater number of applications for protection (mainly fungicides) and ensuring higher grain yield (ALESSIO, 2008).

Figure 5. Results in percentage of the answers about the adaptation to the implements used in soybean cultivation.



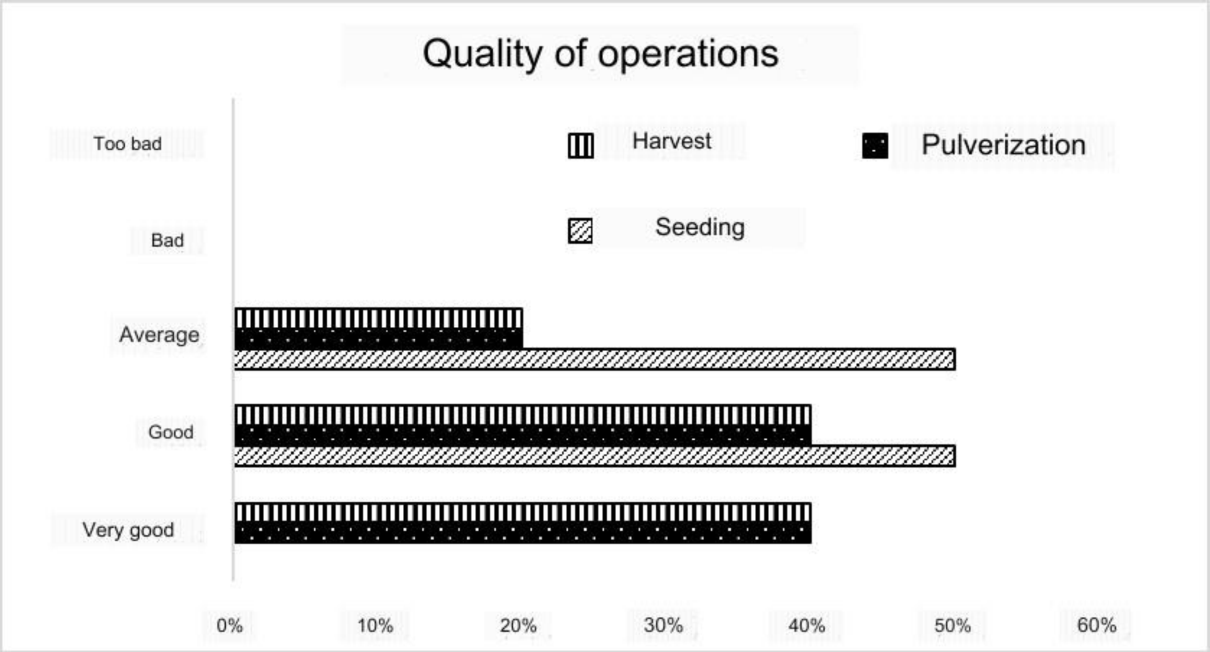
Source: Authors.

In the adaptation to the harvesting implements, the main point highlighted, different from sowing and spraying, was positively addressed a greater fluidity of harvesting, thus having a higher operational yield, in addition to lower depreciation of the harvester. Velasquez et al. (2010), when analyzing the costs in small rice farms, ended up reaching the result that the cost of harvesting rice is around 10.28% of the net production. While for the soybean crop, it is estimated that the total depreciation cost of the machines involved is around 6.76% of the total cost of production (CHBAGRO, 2021).

The qualities of these operations were also questioned, and the results are presented in Figure 6. It is noted that sowing is an operation that still presents 50% of the results as average, since soybean sowing is more difficult when compared to rice sowing. Harvesting and spraying have the same behavior, with 40% being very good and good, but also 20% of respondents rated it as medium.

The main limiting factor in the sowing item mentioned in the discursive questions was speed, which is directly linked to the other limitations, namely: initial plant stand and plant population. Dias et al. (2009), when analyzing different densities submitted to different speeds, came to the conclusion that the greater the number of seeds per meter, the lower the number of acceptable spacing.

Figure 6. Results in percentage of responses on the quality of operations in soybean cultivation

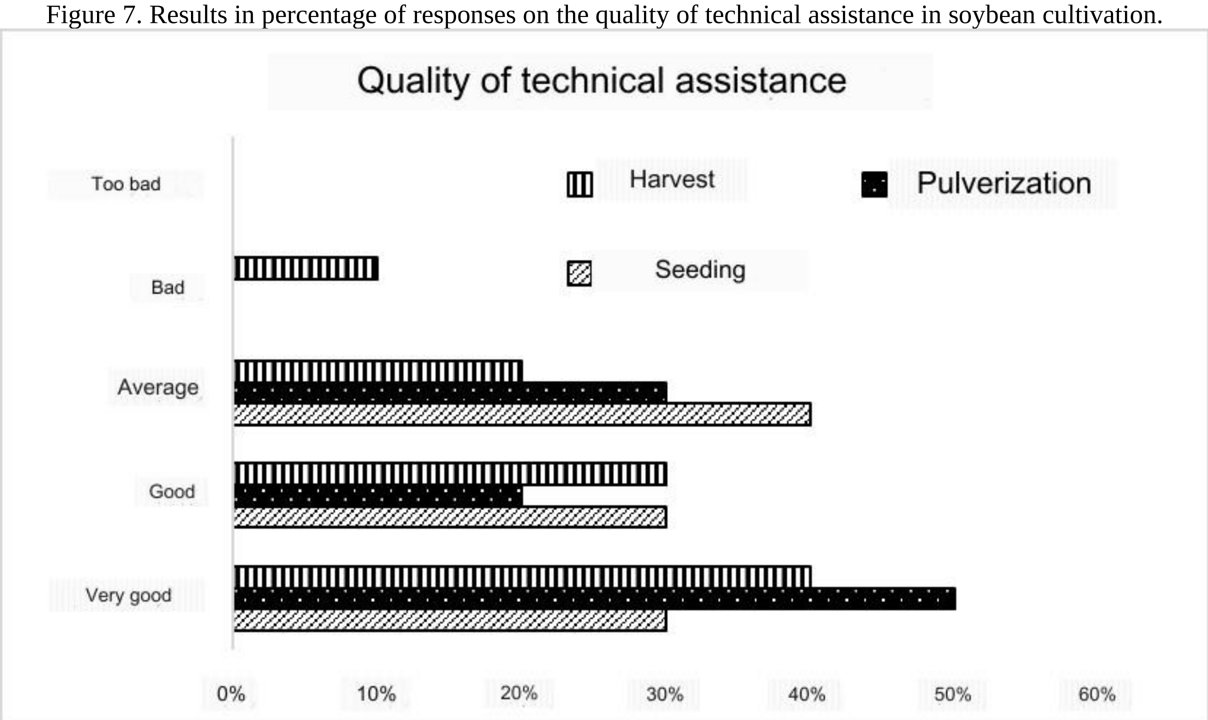


Source: Authors.

In terms of the quality of the operations, when it comes to spraying, there was only the indisposition regarding the kneading of the crop, since the terrestrial applications, in environments without controlled traffic of machines, end up causing a significant kneading in the areas. Mitigating measures can be adopted in relation to this, such as larger spray bars or even differentiated row spacing, allowing the implementation to move without the occurrence of denting (OLIVEIRA et al., 2014).

When asked about the quality of technical assistance, the answers varied according to the operations under study. When it came to sowing, 40% of the answers were classified as medium, dividing the remaining 60% into good and very good (Figure 7). When it comes to spraying, 50% of the producers rated it as very good, however 30% still rated it as medium and the rest (20%) marked the option good. The harvesting operation turns out to be the most varied in the category, with 40% being very good, 30% good, 20% average and 10% poor.

Figure 7. Results in percentage of responses on the quality of technical assistance in soybean cultivation.



Source: Authors.

The technical assistance presented a lot of divergences between the answers, since it depends a lot on which company it is evidenced or what is the real knowledge of the producer. It was noted that the worst opinions of producers in relation to technical assistance came from producers who are, in some way, also professionals in the area, such as agronomists or agricultural technicians.

EQUIPMENT STATUS

When the questions were on the side of the situation of acquisition of seeding and spraying equipment (Figure 8), only 10% of the interviewees stated that they use the system in which they have both options, i.e., rented and acquired (purchased) equipment. Among the justifications, the most present was to have partnerships with places that rent this equipment used in soybean sowing and spraying operations.

It was noted that the majority (90%) of the producers still acquire such equipment, since the soybean seeders are precision seeders or seeders with a vacuum distribution system, different from the ones most used in rice sowing, which are continuous flow.

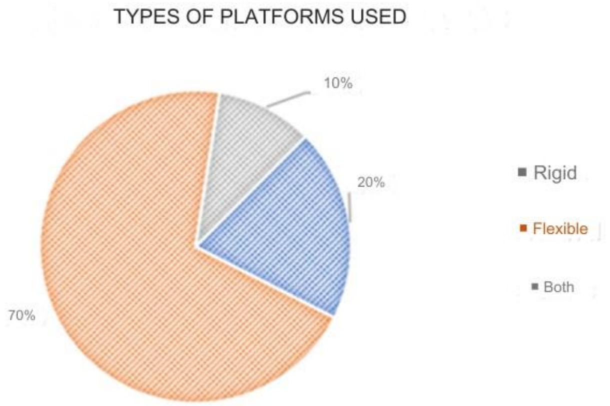
Figure 8. Situation of soybean sowing (A) and soybean spraying (B) equipment present in the respondent properties.

Source: Authors.

Terrestrial spraying equipment in rice cultivation is only used before full crop establishment, then complementation fertilization and agrochemical applications are carried out via aerial spraying (by airplanes). The various inputs for application in soybeans, at different stages of development, end up becoming a new challenge for producers when it comes to application efficiency.

Information was also collected on the type of cutting platform used in the soybean harvest (Figure 9), since in the rice crop rigid platforms are used that work in high cuts, unlike the soybean crop that emits pods on low branches, making it necessary to use flexible platforms so that it is possible to copy the soil as close as possible to the ground to avoid losses of the grains present in the soil. lower docile. One of the main losses in the harvesting process is directly linked to the cutting platform, which can be caused by its unevenness, high reel speeds, too low helical feeder, advanced reel, among other reasons (APROSOJA, 2019).

Figure 9. Types of cutting decks used in the soybean harvesting operation.



Source: Authors.

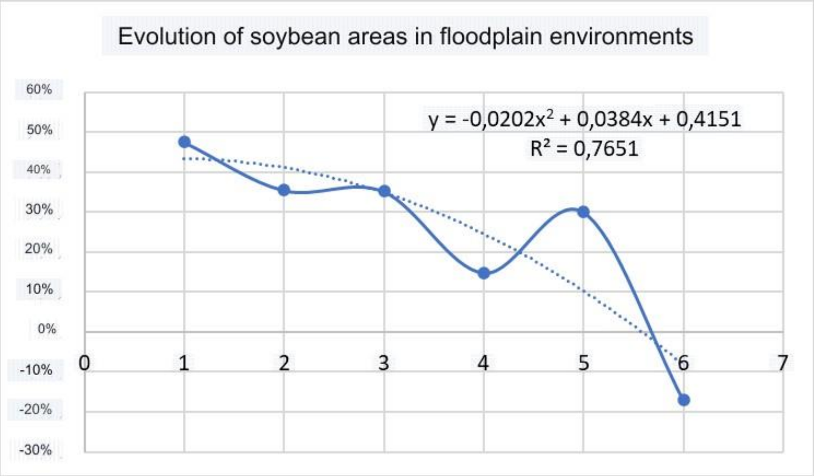
It was noticed that 20% of the producers still use rigid platforms, 70% use only flexible platforms for soybean harvesting and 10% use both. When questioned about the reason for the use of rigid platforms, part of the producers were not aware of the differences that both presented at the time of harvest, and those who did, justified that the prices of flexible platforms are high, even more so the Draper type, when compared to the snail system. Draper platforms contain rubber conveyor belts, which promote better feeding and greater stability, as well as greater adaptation of cutting height and terrain undulations (SAMOGIM, 2020).

EVOLUTION OF SOYBEAN CULTIVATION IN RICE LANDS

The relative evolution of the areas had decreasing peaks in the first years, tending to increase when the agricultural years present greater stability in rainfall, as in the year 2020/21. The areas for the subsequent year had an increase, however, the 2021/2022 agricultural year did not show good stability. As shown in figure 10, in relative numbers of the properties analyzed, year 5 coincided with the year 2021/22, showing a significant increase in percentage compared to the previous year.

The downward trend in the first years of cultivation is due to the increase in the complexity of the system when the soybean crop is introduced, since it is a crop, considered among the respondents, that requires greater precision and accuracy when compared to rice cultivation, from sowing to harvesting, as presented in item 4.1.

Figure 10. Relative evolution of the areas of the producers responding to the questionnaire.



Source: Authors.

According to IRGA (2021), the Western Border of Rio Grande do Sul has a growing demand for areas for soybean cultivation, resulting in contrasts with the results presented here. The recurrence of these areas that have already been implemented the soybean-rice succession system, in years of water scarcity, require further studies to have a real behavior.

AVERAGE MECHANIZATION RATIOS

The mechanization indices with the average of the soybean areas, in general, all respondents are within the average, since their operational capacities were simulated (Table 3).

Table 3. Indexes with the averages and simulation with the same operational capacity and days of service execution.

Indexes	values	Cop (ha/hours)	JD (Hors/Diya)	Stamp (ha/he)	Medium area (ha)	Days to Execution
Mechanization (KW/ha)	0,86					
Seeding (ha/row)	21,15	5,09	11,00	56,02	678,40	12,11
Spraying (ha/nozzle)	13,93	15,86	11,00	174,41	678,40	3,89
Harvest (ha/ft)	12,74	4,54	11,00	49,99	678,40	13,57

Cop= Operational capacity; Jd= Daily working hours; Cap= Ability to execute on the day; ha = hectares.
Source: Authors.

The simulation with a working day of 11 hours/day, taking into account an average area of approximately 678 hectares, with 70% efficiency. Acceptable values were obtained, for sowing it takes an average of 12 days, considering the number of rows available and an average spacing of 50 centimeters for soybean.

For spraying, using the same simulation, with the same working day, it would take approximately 4 days to realize the total area, which means optimal operational capacity. For the harvest of the soybean crop, when the same conditions are used, there are approximately 14 days to carry out the agricultural operation.

CONCLUSIONS

I. For sowing and spraying operations, there is still a need for improvement in the regulation parts and adjustments for the sample of producers that the research covered.

II. The operation of soybean harvesting, when compared to rice harvesting, in the view of producers, is an easier practice and with greater agility and fluidity, even though 20% of the interviewees use inappropriate cutting equipment.

III. The technical assistance in the view of most producers is efficient, with most of them in the categories being very good and good, although in the harvest operation they have results that present the parameter bad.

IV. The evolution of soybean areas in terms relative to the previous year showed a decreasing trend, except when analyzed after the year with regular rainfall.

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