INSTITUTO RIO GRANDENSE DO ARROZ

PROJETO 10

MANAGEMENT STRATEGIES TO INCREASE PRODUCTIVITY AND SUSTAINABILITY OF IRRIGATED RICE GROWTH IN THE STATE OF RIO GRANDE DO SUL, BRAZIL: *DEVELOPMENTS AND NEW CHALLENGES*

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PREFACE

Projeto 10 emerged from the evidence that was a considerable difference between the potential of productivity and what used to be produced in rice crops in the State of Rio Grande do Sul – Brazil, in the beginning of the first decade of this century. The following step was to set the most important agronomical practices in the production process. The implementation of the Project together with the producers has become in an action of technology diffusion, taken as priority by the Rice Institute of Rio Grande do Sul (IRGA).

The viability of this project has resulted from a joint work between a team of professionals that work in the technical assistance, rural extension and research at IRGA and the rice farmers in Dom Pedrito in 2001/2002 growing season. Due to the success of this experience, a great expansion in the harvest occurred in the following year in the six rice producing areas of Rio Grande do Sul. In that occasion, the first edition of the **Projeto 10: Management strategies to increase productivity and sustainability of irrigated rice in Rio Grande do Sul**, containing technical recommendations a systemized way for the organization of the rice process was designed. That publication represented the accumulated research knowledge and the experience in the technology diffusion process, becoming the main focus of the Programa Arroz (Rice Program) – RS, to increase productivity and decrease production costs and environmental impact, as well increase of rice grain quality of the product obtained.

As the challenges in the adoption of the recommended agronomic practices were being overcome, the goals for increase rice grain yield and competitiveness were being reached. Along with this process, IRGA started to develop actions towards the **Cleaner Technologies Program** (*Tecnologias Mais Limpas*) program, suitable for the production process with improvement in efficiency of the use of natural resources, to the legislation and environmental preservation. By taking this conduction, IRGA consolidates its position in irrigated rice production and sustainability of the production system.

Now, it is necessary to critically analyze the results obtained and to establish new challenges to be overcome in Projeto 10 in relation to agronomic practices, supported by the **Technical Recommendations of Research**. In this sense, it is important to insert such recommendations in the sustainability of rice production context, as part of the environmental management, and also be part of what is called **Good Agricultural Practices**. This is the main goal of this publication.

Figure: Robispierre Giuliani

SUMMARY


Imagem: Robispierre Giuliani

1. PROJETO 10 AND ITS INSERTION IN RICE CROPS IN THE STATE OF RIO GRANDE DO SUL

Rice is one of the most important staple food in the world because it serves as a basic food for more than 3 billion people, which has a tremendous impact on social, economic and environmental aspects. These aspects are of particular importance, since the production of rice in the State of Rio Grande do Sul involves 18,500 farmers, generates more than 230,000 jobs and the gross value of the activities is estimated to be at around BRL 5 billion. Besides, the annual collection of ICMS (State Value Added Tax) reaches BRL 500 million (> 3% of the GDP of the State of Rio Grande do Sul) (IRGA, 2010). In the 2010/11 growing season, Rio Grande do Sul produced around 9 million tons of grains of irrigated rice (Figure 1). This production, which accounted for more than 60% of the Brazilian production and more than 50% of the production in the Mercosul countries, has been increasing over the recent years, to the point of the state of Rio Grande do Sul, is becoming an important exporter of this "commodity". The increase in production is due to gains in the cultivated area and yield grain, notably from the 2003/04 growing season onwards, in that the cultivated area exceeded 1 million hectares and the yield grain exceeded 6.0 t/hectare for the first time.

Rice cultivated area in the State of Rio Grande do Sul has increased significantly over the last years. Up until 2004, the rice area in the State was around 900,000 hectares. From that year onwards, it exceeded 1 million hectares

Figure 1. Historical evolution of irrigated rice production in Rio Grande do Sul from 1991 to 2011.

Source: DATER/IRGA (2012)

and reached its highest in the 2010/11 growing season, with more than 1,170.000 hectares. The increase in the area is higher than the rice area in the State of Santa Catarina, Brazil, or Uruguay (Figure 2).

Analysing the history of irrigated rice grain yield in Rio Grande do Sul it can be noticed that from 1922 to 1969, the average productivity was around 2.0 t/ha (Figure 3). Only in the late 60s the productivity exceeded 3.0 t/ha. The gains can be attributed to the improvements in the process of mechanization in the crop, to the use of new cultivars released by the EEA (Rice Experimental Station) at IRGA, to the introduction of US cultivars and the adoption of new agronomic practices, such as land ground leveling and the introduction of chemical control of weeds, since 1966.

In the 70s, the productivity kept on increasing from 3.0 to 4.0 t/ha mainly because the planting system adoption of technologies introduced in the previous decade and to the use of Bluebelle cultivar in large scale. Early in the 80s, the productivity exceeded 4.0 t/ha and, in 1988 it reached 5.0 t/ha. Basically, this development was due to the introduction of modern cultivars, such as BR-IRGA 409 and BR-IRGA 410, both released in 1981. The expansion of the rice area to the Fronteira Oeste and Campanha regions, whose soils were more fertile and less infested with red rice, and had for longer periods of fallow ground between two harvests, also contributed to reduce the pressure of weed occurrence and recovery of soil fertility.

Since the late 1980s, up until the earliest years of the XXI century, including the 1990s, the average productivity of rice Rio Grande do Sul remained around 5.0 t/ha. Only in 2004 the grain yield exceeded 6.0 t/ha. Between 2004 and 2011, the productivity of rice had the largest gains in its history in Rio Grande do Sul. During this period, it increased in more than 2.0 t/ha when compared to the average of the three harvests prior to the period looked at. Within this period, the annual average growth of grain yields in Rio Grande do Sul reached 246 kg/ha per year, whereas the gains in the world productivity was around 52 kg/ha per year.

Another important factor to be taken into consideration is that during the years of "El Nino" occurrence, the grain yield had a decrease because of the less incidence of light and the excess of rain, which make it difficult to manage soil and crop at the proper moments. This can be noticed in the agricultural years of 1994, 1998, 2003 and 2010 (Figure 4). However, due to the improvements introduced in the crop management, the reduction in grain yield was lower because of this phenomenon. In the 2009/10 growing season, the average rice grain yield in Rio Grande do Sul was of around 6.5 t/ha, higher than the grain yield of other years with the phenomenon "El Nino" occurrence, which ranged from 4.0 to 5.0 t/ha. In a way this behavior tells us that the impact caused by environmental stresses is minimized by the adoption of more suitable manage-

Figure 2. Historical evolution of irrigated rice area in Rio Grande do Sul, from 1991 to 2011.

Source: DATER/IRGA (2011)

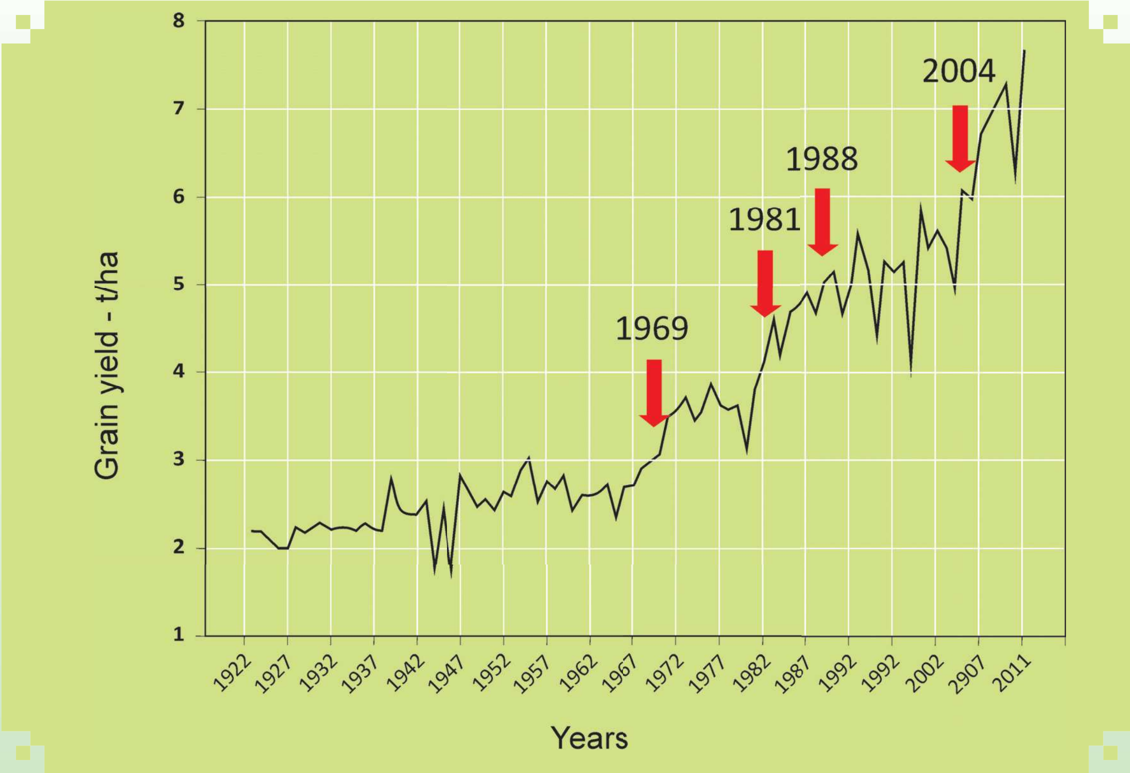

Figure 3. Historical evolution of irrigated rice area in Rio Grande do Sul, from 1922 to 2011.

Source: IRGA (2011)

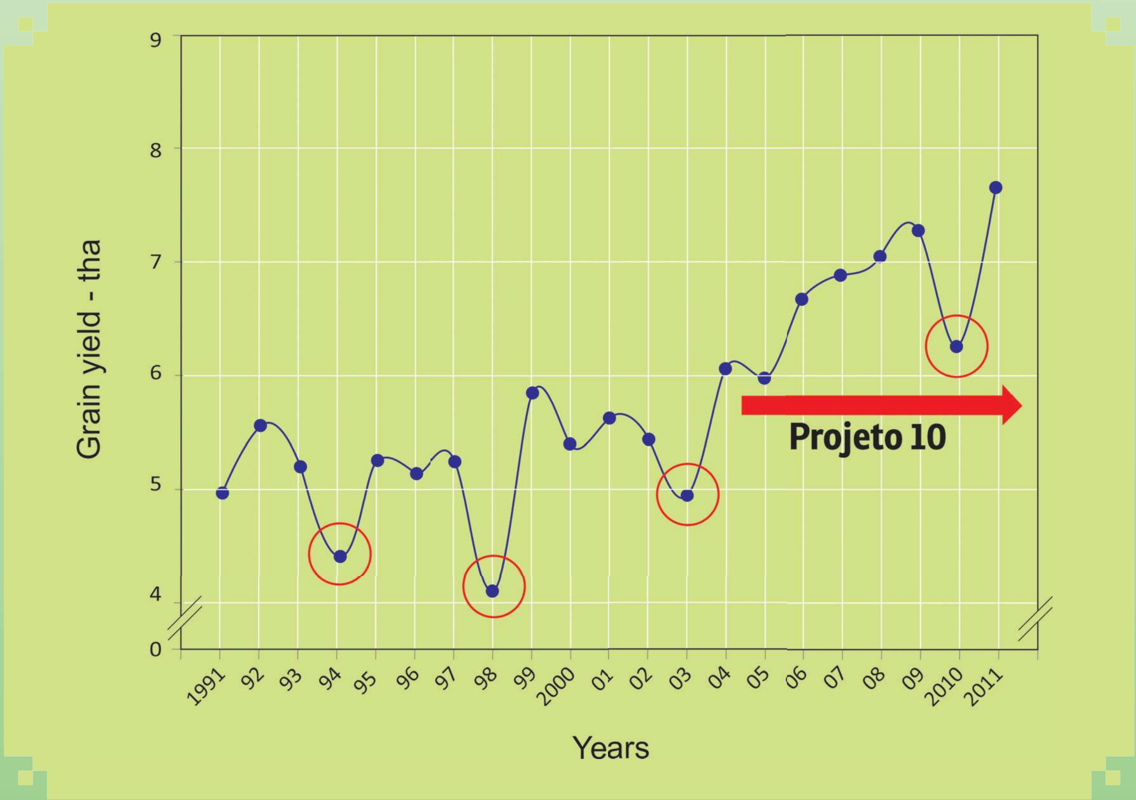

Figure 4. Grain yield evolution of irrigated rice in Rio Grande do Sul, from 1991 to 2011, before and after Projeto 10 implementation. Red circle indicates the occurrence of "El Niño".

Source: DATER/IRGA (2012)

ment practices. Regardless of the rice production area, we can notice higher productivity of irrigated rice by virtue of the use of more suitable management practices, even in an unfavorable year due to the occurrence of the "El Nino" phenomenon.

Despite the historical increase in rice grain yield in Rio Grande do Sul (Figure 3), especially due to the use of cultivars with high yield potential, the average yield in the first three harvests of the current decade (2000/01 to 2002/03) was of 5.3 t/ha, when was noticed that the main problem with rice production of the State was the technology diffusion. This was mostly due to the rice grain yields were much lower than the yield potential (higher than 8.0 t/ha). Besides, the Census of the Irrigated Rice Crops conducted by IRGA during the 1999/00 harvest (IRGA, 2002) showed that in 20% of the cultivated area, the average yield was higher than 7.0 t/ha; that means that in almost 190,000 hectares of cultivated area, the productivity was 31% higher than the State average (5.5 t/ha). Data from the IRGA Census have also shown that higher productivities were being reached in all rice production areas of Rio Grande do Sul, regardless of the size of the farm. It was common to find crops whose productivity exceeds 9.0 t/ha. Even so, the farmers of crops whose average yield ranged from 5.0 to 6.0 t/ha, produced in part of their crops, what was being produced in the best crops was very close to the yields reached in the experimental fields. Another important fact was that the cultivars used by farmers whose productivity was higher than 9.0 t/ha were the same used by those who would produce less than 5.0 t/ha.

Based on diagnoses carried out by Menezes (2001) and Pulver (2001), two important aspects were pinpointed to explain the disparity observed in the grain yield obtained in different farms of irrigated rice in Rio Grande do Sul. First, the yield potential of the available cultivars was not the limiting factor to reach higher levels of rice productivity, regardless of the rice producing area and the size of the farm; second, the agronomic practices used to increase productivity levels were already available but were not being properly transferred to rice farmers. What was actually missing was an initiative to organize them within a productive process so that they could be then transferred to farmers. Once this step was over, the main problem remained in deficiency in the technology diffusion process.

Because of the existing gap between the productive potential of cultivars being used and the average State productivity, the "Projeto 10" emerged with the intent of offering rice farmers the agronomic principles and practices advocated in the Integrated Management. Before the technology diffusion process started, it was necessary to go through a very important but unnoticed phase, which was the definition of the most important (key) to the agronomic practices for the organization of the productive process. The implementation of the Project turned into an action of technology transfer for the increase of competition and sustainability of rice production in Rio Grande do Sul. Then, a joint action of extension and research at IRGA and farmers began, in Dom Pedrito area of Campanha region, during the 2001/02 harvest. As a result of the successful experience, a work strategy was defined for its implementation in the six rice producing regions of Rio Grande do Sul in the 2002/03, with a great expansion in the following growing season.

From the success of the results achieved, Projeto 10 became the main focus of the Programa Arroz RS (Rice RS Program), with goals of increasing the average yield in the State (1.0 t/ha in four years, from 2004 to 2007), reduction in the cost of production and environmental impact with quality of the final product. Projeto 10 was so successful that in the 2007/08 harvest, in 63% of the cultivated area, the average productivity was higher than 7.0 t/ha, in that, 29.5% of the area, the yield was higher than 8.0 t/ha and, in 7.2%, was higher than 9.0 t/ha. The average increase in productivity in this period was of 1.5 t/ha, even higher than the initial goal. In the following harvest (2008/09), the yield average reached 7.3 t/ha and in 2010/11, 7.7 t/ha. Despite the magnitude of the improvements, there is still a lot more to be done, since the average productivities obtained in the farms in Rio Grande do Sul are still far from the productivities reached in farms where the Projeto 10 was adopted and much lower than the higher productivities obtained in these areas in all rice producing regions (Table 1).

Table 1. Results obtained in the 2010/11 growing season with Projeto 10 implementation in the six rice producing regions of Rio Grande do Sul State

Rice producing regions [1]	FO	CA	ZS	DC	PCI	PCE	RS
PROJETOS 10 NUMBERS	102	137	55	78	46	29	447
AREA OF PROJETO 10 (ha)	24,634	7,028	15,661	13,370	2,730	1,689	65,111
PROJETO 10 YIELD (t/ha)	9,62	9,06	9,74	9,29	8,40	8,88	9,45
CROP AREA PROJETO (ha)	73,975	11,577	44,416	20,717	15,980	8,736	175,400
CROPS P10 YIELD (t/ha)	8,61	8,18	8,65	8,78	7,55	7,52	8,46
NUMBER OF INDIRECT FARMERS	1,110	1,345	385	1,000	642	665	5,147
AREA OF INDIRECT FARMERS (ha)	240,000	68,575	139,427	100,000	64,200	41,320	653,522
RS YIELD (t/ha)	8,34	7,34	8,02	7,95	6,88	6,51	7,68

[1] FO = Fronteira Oeste; CA= Campanha; ZS= Zona Sul; DC= Depressão Central; PCE= Planície Costeira Externa; PCI = Planície Costeira Interna and in Rio Grande do Sul State.

Source: DATER/IRGA (2012)

2. CONCEPTUAL MODEL, EXPERIENCE AND RESULTS OBTAINED WITH THE IMPLEMENTATION OF PROJETO 10

2.1. Conceptual Model

Similarly to what had been found in rice production in Rio Grande do Sul in 2001 (MENEZES, 2001; PULVER, 2001), FAO studies (2001), through a joint action with FLAR, conducted in 2000, the low efficiency in the technology diffusion process had been regarded as one of the main reasons behind the gap in productivity noticed in the irrigated rice production in Latin American countries. The basic reason for the disparity between the technology available and the one that had been adopted by rice farmers lied mostly on how the technology was generated and transferred. Overall, it was generated apart from the reality of rice farmers, who did not play any roles in identifying the demands of the most important problems in their communities. Besides, many of the findings of studies carried out in the experimental stations were hard to be adopted by them due to adaptation of problems concerning the different local realities. At that time, IRGA had improved its technology diffusion program, but not enough, since in the 1990s the research work used to be carried out almost exclusively at the Experimental Rice Station (EEA), located in Cachoerinha – RS.

The complexity of agriculture in a globalized world requires a different research approach. Rice farmers have a lot to offer researchers and their practical expertise is extremely relevant in indentifying the research demands on rice. The more active participation of rice farmers in the problems identification and in the search for solutions increases the probability that researchers and extensionists actually meet the answers and so, it makes easier the adoption of new technologies and recommendations generated by research.

In the traditional models of technology generation and diffusion (Figure 5), the decision on what to research falls to the researcher (1), after a field visit to see if the results obtained are useful to rice farmers (2); then they will return to the experimental station to make adjustments (3) and only then, they will pass on the information to the extension service (4). Once they have new information and technology, extensionists initiate the knowledge dissemination to rice farmers (5) and finally, the technology will be available to them (6).

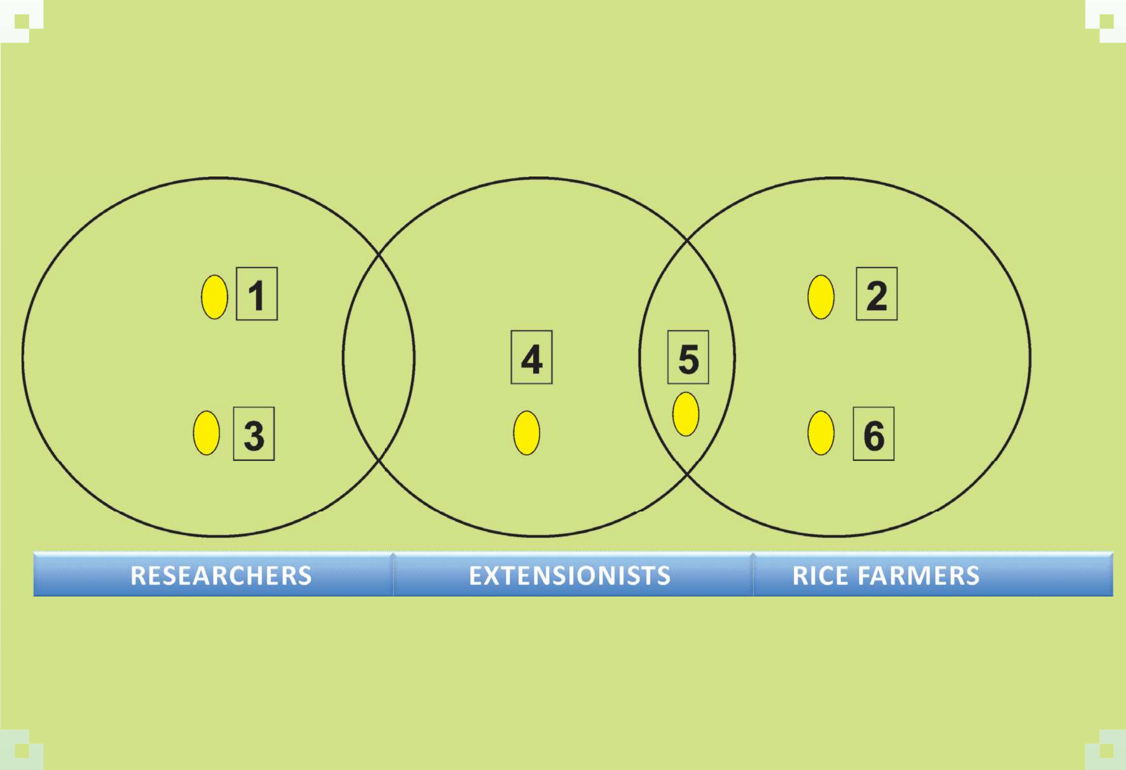

Figure 5. Traditional flow of information used by IRGA before Projeto 10 implementation in Rio Grande do Sul: generation and diffusion among researchers, extensionists and farmers.

In the model for technology generation and diffusion adopted by IRGA for the Projeto 10 implementation (Figure 6), the decision on what needs to be researched starts from a diagnostic action which involves extensionists (1), rice farmers (2) and researchers (B) and many of the problems identified may already have a solution to be adopted by rice farmers (2A). In that scenario, it will fall to the researcher to notify rice farmers and organize workshops on the new technology jointly with the extensionists and rice farmers. If the problem needs to be investigated, researchers will return to the experimental stations for a solution (2B). With the problem being solved, researchers, extensionists and rice farmers will get together again to validate the new technology in experimental areas. After that, it falls to the extensionists to disseminate the advocated technologies in large scale (4). At the end of the process, rice farmers may be able to adopt the proposed suggestions (5).

In this model (Figure 6), both the extensionists and rice farmers take part in the technology generation and dissemination processes as they take an active role in these processes. Therefore, it is very likely that what has been generated may meet the users' actual demand and the probability that new technologies will be adopted will be higher. Researchers also take part in the transfer process and by doing so, they have the opportunity to get to know the object to be investigated better and interact with rice farmers. On top of that, the extensionists will be more confident in disseminating new technologies since they will no longer take a passive role but an active one, from the beginning of the process. This transfer model requires the implementation of demonstration areas in properties level as the main mean of technology diffusion. Lectures, seminars and technical meetings are important too, but they serve as complementary tools.

In the technology diffusion process, it is essential to decide on what do to, that is, which techniques will be made available. No transfer model will be successful if the technologies to be transferred to farmers are not suitable to meet their demands. Thinking that any transfer model is the key to the process of technology dissemination is to increase the gap between farmers and technicians even more. The importance of the model is the participation of the different agents in identifying the limiting factors to be worked on properly both by research and extension along with farmers. In view of the conceptual research and technology transfer models used in Brazil, the actions of IRGA are unique and distinct, since they bring together research and extension in one single institution, with necessary funds to accomplish its mission arising from the Contribution for the Development of Rice Farming (CDO), which is paid by rice farmers by bag of commercialized rice. This has consequences both on the crops and on research and extension. The business view of rice farmers has been influencing the technology generation and diffusion

Figure 6. Flow of information used by IRGA for generation and diffusion among researchers, extensionists and farmers in Projeto 10 implementation in Rio Grande do Sul.

actions of IRGA. For instance, in the 1930s, by decision of rice farmers, the Agronomist Bonifácio Carvalho Bernardes was sent to the United States of America to work on his Master's at the University of Texas. All the activities carried out by him were developed at the Beaumont Experimental Station, and it was mostly intended to develop rice farming in that country. Whether this was a conscious or unconscious action, the attitude of the rice farmers has contributed significantly for the construction of the IRGA institutional profile (Figure 7). Since the 1960s, IRGA started to encourage exchange programs to foreign countries, by sending many of its staff to pursue specialization degrees in US universities and/or at the International Center for Tropical Agriculture (CIAT), in Colombia. In the 1960s and 1970s, most researches and extensionists from IRGA received instruction on rice production technologies at CIAT. On the other hand IRGA had also established connections with Brazilian universities and research institutions, as per the model shown in Figure 7. Along with these exchange programs, a higher flow of germoplasm and the introduction of agricultural machinery, such as planes and levee plow, has started to occur, which has modified the technological profile of rice crops in Rio Grande do Sul. Another important factor in the construction of the rice crops profile was the entrepreneurial view of farmers, who have always required a reciprocal attitude from their institution somehow. The breakthrough attitude, the ambition and expertise of rice farmers in working with machines and implements in the water collection and distribution were fundamental in the conformation of rice crops in Rio Grande do Sul. **IRGA Research exchange program between other local and foreign institutions as well as with farmers, was essential for the success of Projeto 10, since they have enabled them to reach higher technology standards currently en vogue in the rice crops in the State.**

Additionally, in the years that preceded the implementation of Projeto 10, IRGA researchers were granted investments for their educational development. There were many meetings with these researchers and extensionists and rice farmers to set the crop demands in all rice producing regions and exchanges with technicians from all over the world in order to search for information and curb the limiting factors. The II Congresso Brasileiro do Arroz Irrigado (II Brazilian Congress of Irrigated Rice), conducted by IRGA in 2001, in Porto Alegre, focused on the management of the crop and its transfer. The model of technology diffusion used in Australia, called "Rice-check", was addressed by the researcher Warvick Klampet and served as a basis for the transfer system adopted by Projeto 10. From that congress, the extension service of IRGA changed its focus; after almost a decade without making concrete decisions, leaving behind so many years' work, focused on the storage and distribution of water in the crops, then the agronomic management of rice started to receive some more attention.

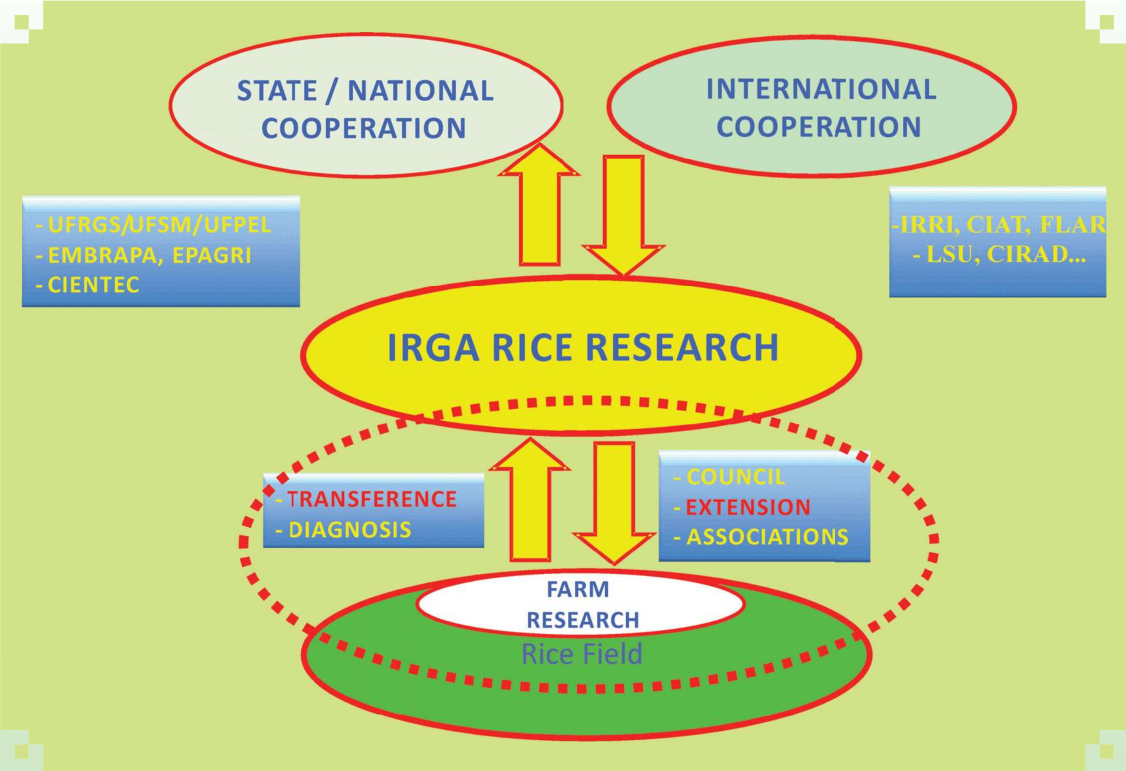

Figure 7. Conceptual model adopted by IRGA for technology generation and diffusion to rice growers of Rio Grande do Sul in Projeto 10 implementation.

2.2. Experience and results obtained with Projeto 10

Throughout the years, the experience has shown that rice farmers could easily adopt new rice cultivars made available by research. However, such reality cannot be observed in the adoption of agronomic practices, in which both research and extension services were responsible for identifying the limiting practices and changing the way they should be transferred to users. In this sense, the diffusion of regional information through research has become a necessity for the process of adoption of the available technology, in order to shorten the gap between the productive potential of cultivars and the average productivity in irrigated rice in Rio Grande do Sul. That was when "Projeto 10" came up with the intent of providing rice farmers the Integrated Management principles and practices advocated for this crop.

"**Projeto 10**" then started in the 2001/02 growing season, based on a joint action of extension and research from IRGA and rice farmers, in a pilot area located in the Campanha region of Rio Grande do Sul. As a result of the success of this experience (MENEZES et al., 2004), a plan of action for the expansion of Projeto 10 for the six rice producing regions of Rio Grande do Sul was defined. In the 2003/04 growing season, 294 projects were developed in an area of 9,248 hectares, which was expanded to 447 projects distributed in 37 farmer groups in an area of 65,111 hectares, in the 2010/11 growing season (Figure 2). In this harvest, the eleven highest productivities were higher than 11.0 t/ha (Figure 3).

The Project begins with the development of a group of rice farmers for the implementation of crops with the use of technology in order to increase productivity, assisted by a duly trained technician. Each group is, then, comprised of rice farmers disposed to increase productivity in their crops. The actions start with the conduction of a crop where the recommended technology is used, either in part or throughout the entire cultivated area. Then, farmers will visit the crops implemented and exchange experiences, following the technical guidelines provided (Figures 8 and 9). These visits are open to the community. In this state, another group of rice farmers joined the process of technology transfer in meetings and discussions (Figure 10). That is, those who still had not implemented a high technology crop, take part in meetings, observe, listen and discuss what has been done in the already implemented crops. In these occasions, both the rights and wrongs are pointed out, means of correction of problems that can still be solved are proposed and the next harvest starts to get planned. Through involvement in the process of technology transfer and analysis of results, farmers feel more confident to adopt the new recommended techniques.

The number of groups and farmers per group in each community depends on the decision made by the participants. In this process, the distances to be traveled between the cultivated areas and the number of farmers

Table 2. Indicators evolution of Projeto 10 in the State of Rio Grande do Sul, from 2004 to 2011

Indicators	2004	2005	2006	2007	2008	2009	2010	2011
Projeto 10 fields	492	333	241	698	540	610	477	447
Area of Projeto 10 (ha)	9,248	22,804	32,992	65,040	58,950	60,501	63,128	65,111
Grain yield of Projeto 10 (t/ha)	7,7	7,7	7,9	8,0	8,2	8,4	8,1	9,5
Rice fields area with Projeto 10 (ha)	78,408	145,345	141,517	137,689	181,320	205,920	148,291	175,400
Grain yield of farm with Projeto 10 (t/ha)	6,6	6,7	7,2	7,7	7,4	7,7	7,2	8,5
Rice field area in RS (1000ha)	1032	1018	1028	941	1067	1105	1053	1170
Grain yield of RS (t/ha)	6,1	6,1	6,7	6,9	7,1	7,3	6,4	7,7

Source: DATER/IRGA (2012)

Figure 8. Farmers groups discussing at the fields results obtained with the Projeto 10 recommended management practices, carried out in different rice producing counties of Rio Grande do Sul.

involved must be taken into consideration in order to facilitate visits and exchange of experiences.

The main moments for exchange of experiences and visits to crops are decided by the groups' participants themselves. Such moments, which will be mentioned below, have proven to be important in this process. The first moment suitable to visit to the rice production areas is before the sowing season. At this moment, the agronomic practices to be adopted are discussed. The second moment to visit the crops is after the emergence of seedlings, before weed control, the application of the first top-dressing nitrogen fertilization and the use of water in the crop. In this

Table 3. Top rice grain yield productivity in the 2010/11 growing season in Projeto 10 areas, in different producing areas and county of the State of Rio Grande do Sul

Farmer	Rice region	County	Area (ha)	Grain productivity (t/ha)
Carlos Schenini	Fronteira Oeste	Itaqui	80	12,30
Pedro Schmidt	Fronteira Oeste	Maçambará	87	12,05
Pedro Degrandi	Campanha	Sta. Margarida do Sul	20	12,00
Mario Cadore	Depressão Central	São João do Polesine	3	12,00
Clecio Karsburg e Renato Zimmer	Depressão Central	Agudo	16	11,85
Olavo Predebon	Campanha	São Gabriel	50	11,50
Luís Prochnow	Depressão Central	Agudo	6	11,50
Parceria Raguzzoni/Teixeira	Campanha	Dom Pedrito	96	11,50
Suc. Eurico Pegas Dias	Campanha	Bagé	390	11,44
Magno Bastiani	Fronteira Oeste	São Borja	348	11,35
João S. de Moraes	Zona Sul	Jaguarão	50	11,35

Fonte: DATER/ IRGA (2012)

occasion, the stand, emergence uniformity, initial plant development, weed control strategies, and timing for application of urea and use of water are observed. Two other suitable moments for visiting the farms are at the end of the flowering process and during the harvest. During the entire growing season, technical discussions on the important stages of development of the crop, field days and implementation of technological showcases are carried out at the Rice Experimental Station in Cachoeirinha (Figure 11) and in the experimental substations of IRGA and in farms (Figure 12). At the same time, technical development and human resources management programs are available for technicians (Figure 13), farmers (Figure 14), rural foremen and other field workers (Figure 15).

Table 4 shows the number of technicians, farmers and field workers trained during the first eight years of execution of Projeto 10. Whenever possible, Regional Committees headed towards the development of rice production activities are formed (Figure 15). That is an innovative model of institutional organization (Figure 7), which enables the shift from a traditional technology transfer flow (Figure 5), where there is little interaction among researchers, extensionists and farmers, to another in which this interaction is more intense (Figure 6).

Since the early time, IRGA team has noticed that the task to increase the rice grain yield in Rio Grande do Sul was not exclusive to the institution. Quite the contrary, it was important to work with the largest number of institutions and technicians involved in the production of irrigated rice. The contribution made by farmer associations and trade unions, cooperation companies, private technical assistance companies and commercial establishments were essential for the whole process of technology diffusion. Besides the contribution of these segments for the productive process, the participation of the farmers was very important to foster the necessary changes. In this sense, it fell to IRGA to take a leading role in the process and share the knowledge acquired with technicians from other partner institutions (cooperation companies, trade unions, commercial establishments, planning offices, etc.). Hence, IRGA has trained more than 17,000 people, among which 815 agronomists from both public and pri-

Figure 9. In technical discussions, growers talks to the other ones, telling what is being done in their farmers and the results that are being achieved with the use of the Projeto 10 recommended technology.

Figure 10. Meetings to discuss the recommended technology diffusion by Projeto 10 to rice growers, at different rice producing regions of Rio Grande do Sul.

Figura 11. On field days at EEA/IRGA and Regional Rice Stations, researchers inform the new management technologies recommended by Projeto 10.

Figure 12. On field days at the farms, IRGA researchers, extensionists and farmers discuss the new management technologies recomended by Projeto 10.

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Figure 13. Technical capacitation, for public and private institutions, about Projeto 10 recommended technology, at EEA/IRGA.

Figure 14. Training sessions offered to rice field workers on the technology recommended by Projeto 10, given lectured by IRGA extensionists and researchers.

Figure 15. Training programs for rice field workers and small farmers given lectured by IRGA extensionists and researchers.

vate schools, 507 agricultural technicians and more than 15,000 farmers and field workers since the full dissemination of Projeto 10, in 2004 up to the 2010/11 harvest (Table 4).

The training offered to rural employees was essential so that the planned changes were successful, once the majority of them have shared the profits of the harvest. In the beginning, many of them were against the management proposals since fearing that these changes would not bring any results and would bring losses in the profit sharing. On the other hand, they were important partners when they learned the intent of the ongoing changes in programs and courses and started to take part in field days, technical discussion and lectures, and will continue to be in the implementation of recommended management practices. Technicians, farmers and farm workers were trained through many courses on Integrated Management of Rice Cultivation (MICA) (Figure 13), since there was, and there still is, the need to increase the knowledge on the technology of irrigated rice production so that the changes can be accomplished.

However, the large number of field days and technical discussions in experimental areas carried out in the farms owned by the farmers themselves on the new technological proposals were the main strategies used to transfer technology and to share knowledge in all rice production areas of the State of Rio Grande do Sul (Table 5). The adoption of a new technology is easier when farmers and technicians can notice what is being proposed in the field, in larger areas, especially when farmers share the results obtained from the use of such technology with their peers (Figure 16). So, around 30,000 technicians and farmers have taken part in field days and technical guidelines organized by IRGA and/or its partners, throughout the duration of Projeto 10 (Table 5). Lectures and seminars were important complementary actions, but the core of the transfer process was the field days.

The results obtained (Tables 1 to 3) based on the model used by IRGA in technology diffusion (Figures 6 and 7) have clearly noticed some important points which will be discussed as follows.

First of all, we could see that there is technology available, including cultivars, to reach productivities much higher than those that had been presented, through the examples of farmers themselves. The good results obtained with Projeto 10 were achieved even with the use of cultivars that have been on the market for almost 30 years. Therefore, in order to get a leap in productivity, there are no limiting factors in terms of the yield potential of available cultivars in the market. It is important to highlight that the release of new cultivars with higher productive potential, grain quality, more resistant stems and stability in productivity is always welcome. Cultivars that have higher tolerance to stress caused by the environment, mainly in mid cycle and cold-tolerant in the vegetative phase will contribute largely to expand the recommended sowing

Table 4. Technical training for all the staff level was of fundamental importance to the success of Projeto 10

Growing seasons	Agronomists	High School Level Technicians	Farmers and Workers	Total
	---------------------------------Number of participants-------------------------------			
2003/04	115	67	464	**606**
2004/05	145	75	2.370	**2.590**
2005/06	150	80	1.313	**1.542**
2006/07	155	80	1.850	**2.085**
2007/08	50	63	2.720	**2.883**
2008/09	62	46	3.796	**3.904**
2009/10	67	47	1.357	**1.471**
2010/11	71	49	1.798	**1.918**
TOTAL	**815**	**507**	**15.627**	**16.949**

Source: DARTE/IRGA (2012)

Figure 16. When workers are involved in the change process, they are important allies in transformations and in the new technologies adoption.

Table 5. The massive participation of farmers and technicians in field days, technical workshops and lectures were very important for the process of technology transfer proposed by Projeto 10

Growing seasons	EEA/IRGA field days	Regional field days	Farm technical discussions	Lectures
	---------------Number of participants-------------		------------------Number of events--------------	
2003/04	1,598	486	112	**86**
2004/05	1,476	1,438	216	**107**
2005/06	1,500	1,600	250	**170**
2006/07	1,350	2,185	191	**150**
2007/08	4,000	1,902	183	**185**
2008/09	3,500	2,340	179	**237**
2009/10	-	2,928	150	**214**
2010/11	800	2,835	72	**174**
TOTAL	**14,224**	**15,714**	**1,363**	**1,323**

Source: DATER/IRGA (2012)

period and turn the rice production in the State less vulnerable to environmental adversities.

Secondly, as higher productivities are achieved (11, 12 and even 13 t/ha), it is clear that there is technology to produce more than what has been produced now, in average, in the fields of irrigated rice in Rio Grande do Sul. However, it is still unclear whether extraordinary management practices in these fields have been adopted in order to achieve such productivities. Not really. Farmers have done simple things, in the right way and at the right moment, that is: they have followed the recommendations of Projeto 10.

Nevertheless, it is important to stress that not all farmers that took part in Projeto 10 have obtained high productivities. The differences between the results achieved are due to the fact that farmers adopt the practices recommended at different levels. The partial adoption of the technology makes farmers obtain lower results than expected. In agriculture, it is not enough to do some things the right way in order to get better results, it is necessary to adopt the whole set of recommended agronomic practices of integrated management. The undone practices or those that have been implemented partially will act as limiting factors in the success. **Third factor** that may explain the difference between the results obtained by farmers is how long the project has been adopted by farmers. The best results are usually obtained after two or three harvests (Table 2). The factors that have a negative effect on the establishment and development of the staple need to be corrected in the growing season. F**ourth important factor** to be considered is the execution of **team work**. If there is no team work, the expected results will not be achieved or will take longer than expected. The degree of technology adoption in the farms is related to the management level of the human resources and the productive, administrative and financial process.

The results obtained with Projeto 10 in Rio Grande do Sul are, so far, very encouraging in their several aspects: productivity, cost effectiveness and profitability of crops and environmental adequacy. In order to evaluate the importance and magnitude of the results of the project, we used "Caracterização da Lavoura de Arroz Irrigado (Characterization of Irrigated Rice Crops) – Safra (Harvest) 1999/00" (IRGA – Censo 2000) as a reference, which portrays the situation prior to its implementation.

The average productivity of rice crops in Rio Grande do Sul in the 2010/11 harvest was of 7.7 t/ha (Figure 4 and Table 1), with gains of 2.2 t/ha (40%) compared to the reference harvest (1999/00). It was a tremendous result, since in 62% of the cultivated area, the productivity ranged between 7.0 and 9.0 t/ha and only within 7.4% of the area, productivity was below 6.0 t/ha (Figure 17). It is also important to highlight that in around 11% of the area, productivity was higher than 9.0 t/ha, reaching 10 t/ha or more. These data show a great evolution in relation to the 1999/00 harvest, as in 63% of the area in which rice was cultivated in Rio Grande do Sul, productivity was below 6.0 t/ha and, among these, in 28% of the area, it was lower than 5.0 t/ha.

However, the gains in productivity obtained in the 2010/11 harvest in relation to 1999/00 was unique among the rice producing regions, ranging from 1.8 t/ha, in the Depressão Central Region to 2.7 t/ha in the Sul Region (Figure 18). The Fronteira Oeste Region showed higher average productivity (8.3 t/ha) in the last harvest, with gains of 2.5 t/ha in relation to the 1999/00 harvest, within an area of around 330,000 hectares. Prior to Projeto 10 (Figure 19a), in 83% of this area, grain yield was below 7.0 t/ha. Currently, only 5% of the area presents productivity below these figures, that is, 95% of the area is producing above 7.0 t/ha, with 52% of the area showing productivity from 8.0 to 9.0 t/ha and, in over 15% of the area, productivity was higher than 9.0 t/ha. Rice production data from two important cities in this region, Uruguaiana and Alegrete, reflect to a greater of lesser extent, the same thing (Figure 20a), especially Uruguaiana, within 81% of the area productivity above 8.0 t/ha.

The results of rice productivity in the Fronteira Oeste Region may be attributed to soils with higher fertility (Chernozen and Litholic Neosol), to the areas which have been least affected by red rice, to the use of mid cycle cultivars and the less intense use of soil in relation to other regions of the State. However, these conditions were already a reality before Projeto 10 and the average productivity of this region was usually below 6.0 t/ha (Figure 18). Other factors help explain the evolution of productivity in the region: rice farmers are those who have the higher percentage of area in which the soil has been tilled beforehand; they also sow a greater part of this area within the recommended period for rice and are among those who fertilize their crops more efficiently.

Among the six rice producing regions of the State, the Sul Region was the one that has grown the most in ter-

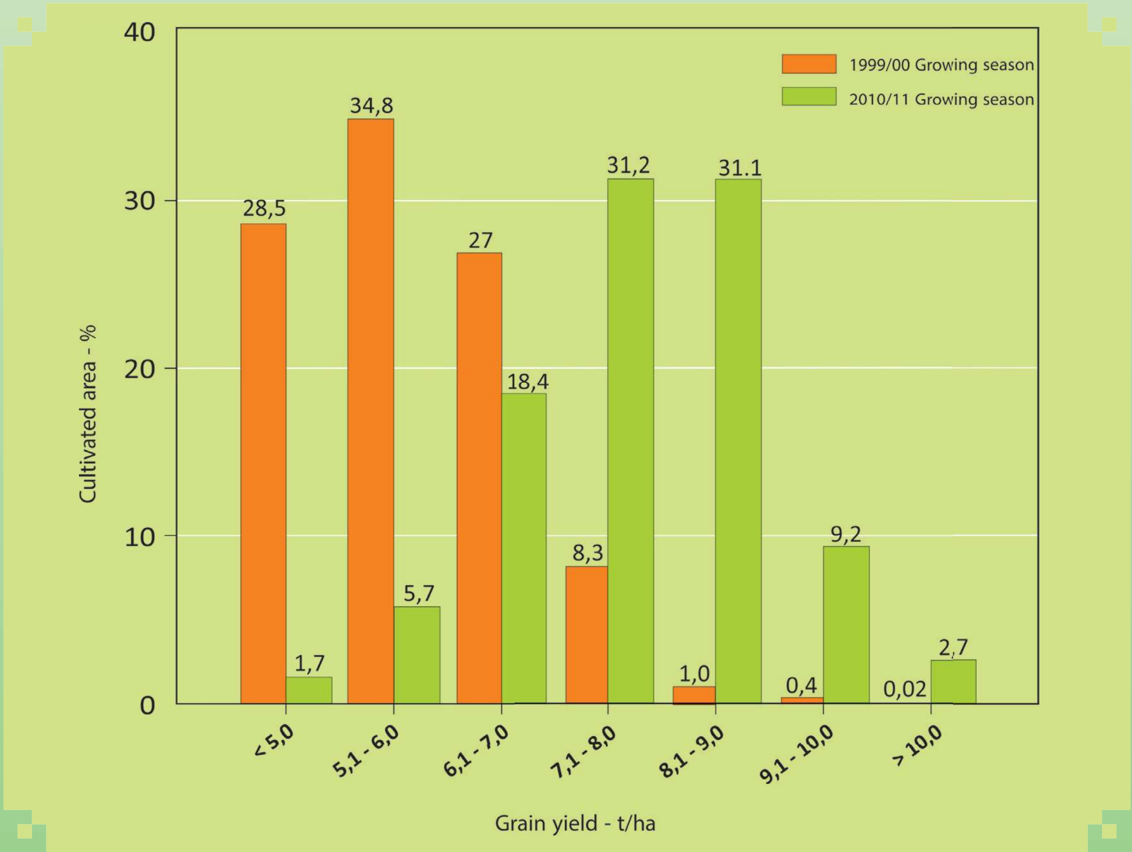

Figure 17. The percentage of the area in which rice is cultivated that shows higher productivities has been increasing significantly in Rio Grande do Sul after the implementation of Projeto 10. Note: the 1999/00 harvest, from the IRGA Census, has been taken as a reference.

Source: IRGA (2012)

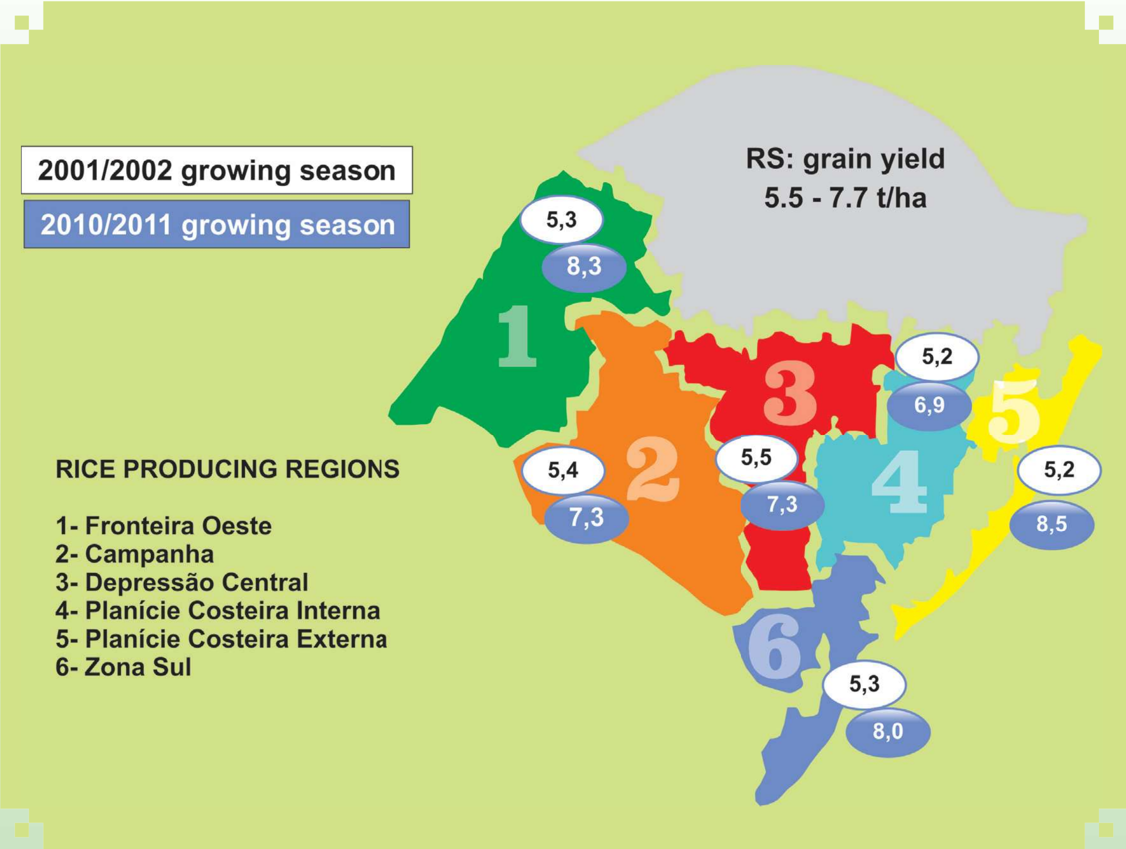

Figure 18. In the six rice producing regions, grain yield has increased significantly after 8 years of the Projeto 10 implementation.

Source: DATER/IRGA (2012)

ms of productivity: 2.7 t/ha within the period (315 kg/ha per year) and, in the last harvest, the productivity reached 8.0 t/ha (Figure 18) within an area of 185,000 hectares. In the 1999/00 harvest (Figure 19c), in 96% of the area, the productivity was lower than 7.0 t/ha; in that in more than 25% of the area, the productivity was lower than 5.0 t/ha. In the 2010/11 harvest, however, in 84% of the area the productivity was higher than 7.0 t/ha: in 6% of the area, the productivity ranged between 9.0 and 10.0 t/ha and, in 6% was higher than 10.0 t/ha. Another relevant fact was that in the last harvest, the productivity was lower than 6.0 t/ha in 3% of the area, whereas in the 1999/00 harvest, it occurred in 63% of the area (Figure 19c). Even the southernmost cities in this region, such as Santa Vitória do Palmar and Jaguarão, which have a cultivation area of about 95,000 hectares (Figure 20c), regarded as lower productive potential, due to lower air temperature during the cycle, had considerable improvements in the rice grain yield. Santa Vitória do Palmar stands out in the region with 50.4% of the area with productivity above 8.0 t/ha.

The reason behind this evolution in productivity in the Sul Region is due to sowing in the right time due to the adoption of the minimum tillage system and to a larger area in which the soil was tilled beforehand. This area is the one that has the lowest "sowing gap" by virtue of colder temperatures in the spring and the lower incidence of sun light, mostly observed from mid-February and, also by virtue of higher probabilities of lower temperatures in the reproductive stage of rice. That is, in this region, sowing has a higher negative impact whenever when it occurs after November 05. Good results in the region can be also attributed to the control on red rice by the adoption of the **Clearfield**® system, the use of the IRGA 424 cultivar with higher productive potential and more intense use of fertilizers and certified seeds. This is the rice producing region which has the highest percentage of certified seeds in the State.

In the Campanha Region, the productivity reached 7.9 t/ha in the 2010/11 harvest (Figure 18), within 196,000 hectares of irrigated rice crops. The improvements are very clear (Figure 19b), since in the 1999/00 harvest, within 89% of the area, the grain yield was lower than 7.0 t/ha. On the other hand, in the 2010/11 harvest, within 82% of the area, the productivity was higher than that, since in 16.6% of the area, the productivity ranged between 8.0 and 9.0 t/ha and in 6.7% of the area, the productivity exceeded the average of 9.0 t/ha. It is important to highlight that only in less than 1% of the area; the productivity was lower than 5.0 t/ ha in the 2010/11, whereas previously in 30% of the area, it was lower than that. Dom Pedrito and Rosário do Sul (Figure

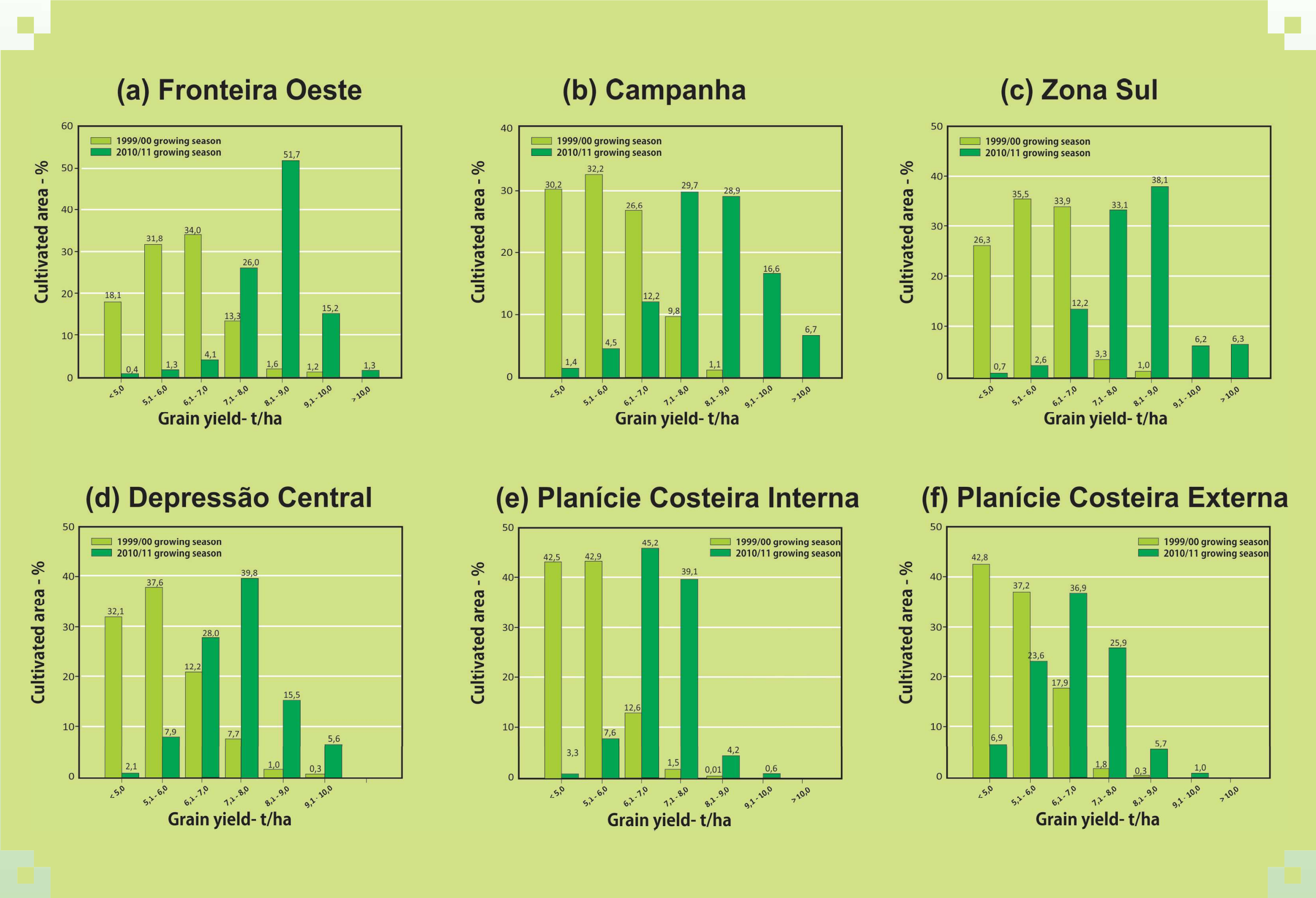

Figure 19. The significant increase in the percentage of cultivated area with high grain yield, after Projeto 10 implementation, has been noticed in all RS six rice production regions.

Source: IRGA (2012)

20b), counties in which almost 76,000 hectares are cultivated, represent the attitude of the region very clearly (Figure 19b). Dom Pedrito, where Projeto 10 began (Figure 20b), saw one of the greatest productivity gains, since 82% of the area had productivity lower than 7.0 t/ha and now 95.5% of the area is above this figure. Currently, productivity between 8.0 and 9.0 t/ha occurs in 43% of the area, and in 24% of it, the productivity ranges between 9.0 and 10.0 t/ha and in 12% it is higher than 10.0 t/ha.

The analysis of the evolution of productivity in the Campanha Region is complex due to the differences in soil fertility. The fact that the area has been adopting Projeto 10 (two years) the longest compared to other area can be an important reason for this gain, since this factor is considered fundamental for the success of the technology diffusion process (Table 2). Just like in the other regions, the evolution can also be attributed to the adoption of agronomic practices recommended by Projeto 10 and by the control of red rice with the **Clearfield® system**. Gains could be higher if it were not for the sowing being conducted outside of the recommended period, low fertility of a significant area taken over by Planosol soils, the confluence of Santa Maria and Ibicuí rivers, and also, by the high infestation of red rice and the insufficient use of certified seeds. Contrary to that, in counties where the soils are more fertile, such as Bagé and Dom Pedrito, and the areas south of the cities of São Gabriel and Rosário do Sul, where there is a predominance of Chernozen, the productivity evolved positively with few fields showing productivities lower than 8.0 t/ha.

The Depressão Central cultivation numbers are around 171,000 hectares, with productivity of 7.3 t/ha in the 2010/11 harvest (Figure 18). The gain in productivity in this region, though it was the lowest (193 kg/ha per year), was also significant. This is probably due to its productivity standards in the 1990/00 harvest, which were lower than the Fronteira Oeste only. Despite the evolution was positive, since back then, grain yield was lower than 7.0 t/ha in 89% of its area and had productivity gains above this figure in 82% of the cultivated area (Figure 19d).

Currently, most areas reach productivity levels ranging between 7.0 and 9.0 t/ha, and in 16.6%, the produc-

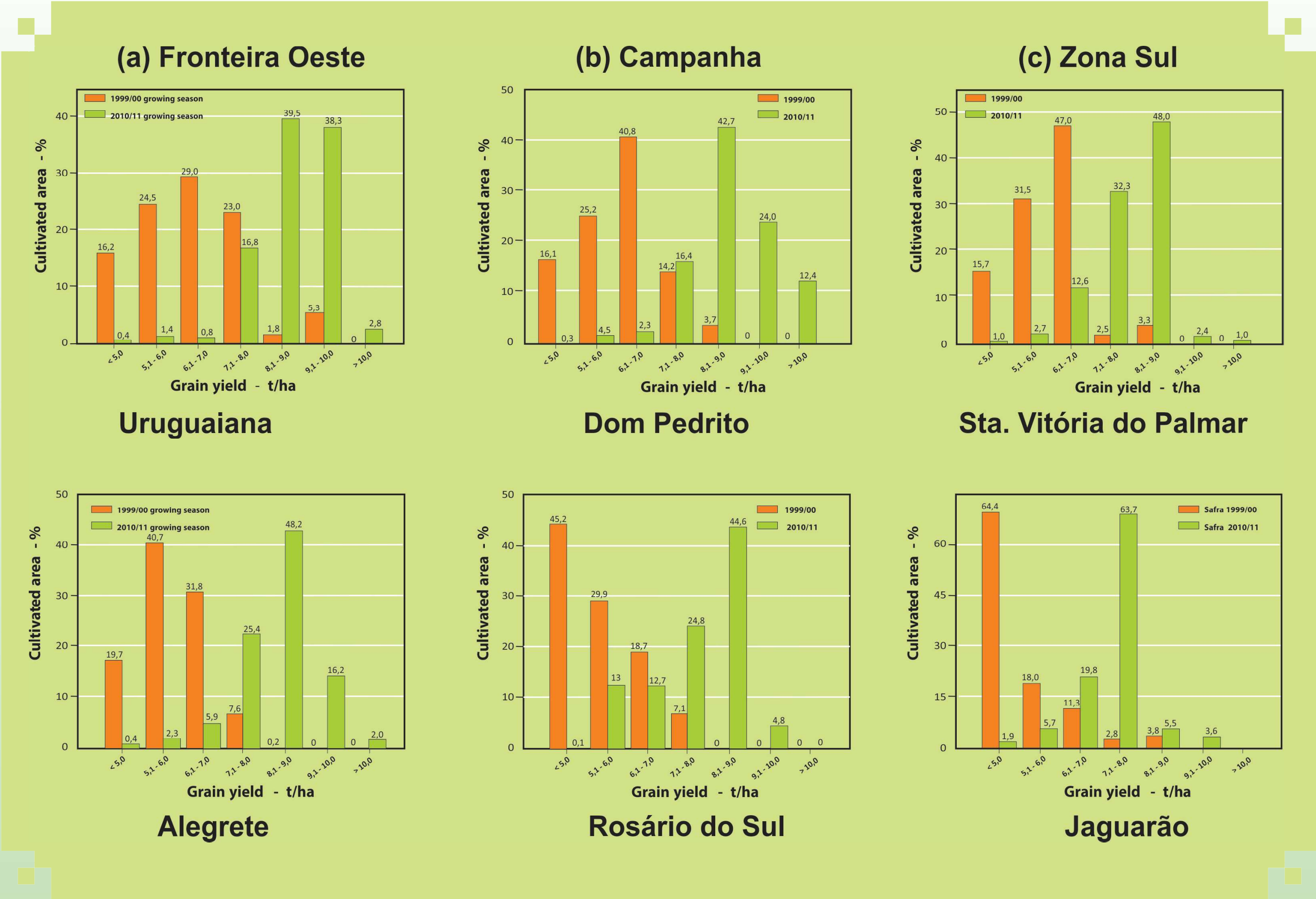

Figure 20. Most areas where irrigated rice was cultivated in some counties of the Fronteira Oeste, Campanha and the Zona Sul have grain yield higher than 8.0 t/ha.

Source: IRGA (2012)

tivity ranged between 9.0 and 10.0 t/ ha, and 6.7% of this area was above 10 t/ha. Today, however, the production is lower than 6.0 t/ha in only 6% of the area. In the 1999/00 growing season, in 62% of the area, the grain yield was lower than that (Figure 19d). The greatest productivity gains occurred in the Fronteira Oeste region. Those are cultivated areas in cities colonized by both Italian and German immigrants, being the ones which have been producing rice in the State for the longest period of time. These are small farmers who have high levels of efficiency in the use of technology and property management. The soil is used intensively and the rice has been sown every year in the same area, for around 100 years. Paraíso do Sul, Agudo (Figure 21a) and Dona Francisca, in which around 16,000 hectares are cultivated, saw greater productivity gains compared to other cities, such as Candelária (Figure 21a). Dona Francisca hit a record of productivity in the region in the 2010/11 harvest, with 9.2 t/ha. The use of the technology recommended by Projeto 10 by small farmers shows us that it can be adopted successfully regardless of how big the property is; however, it requires management abilities to to the "things" at the right time.

The most constraining factor to the evolution of productivity in the Depressão Central Region is the conduction of sowing outside of the recommended period, due to the use of a conventional tillage system and also because only a small area has been tilled beforehand. The cities that have had higher productivity gains were those that used systems in which sowing could be done with minimal interference from weather conditions. The pre-germinated system is widely used in some cities in this region, such as Agudo, Dona Francisca, Candelária, Paraíso do Sul, Faxinal do Soturno, São João do Polesene and Restinga Seca. On the other hand, the minimum tillage system with previously tilled soil system is widely used in Caçapava do Sul. Not until the Central Depression region starts to conduct soil tillage beforehand and/or use systems less dependent on weather conditions, will their productivity grow. Other practices that contribute to small growth in productivity are the intense use of cultivars of early cycle, insufficient use of certified seeds and insufficient use of fertilizers in some counties.

Around 148,000 hectares are used for cultivation in the Planície Costeira Interna Region and the average

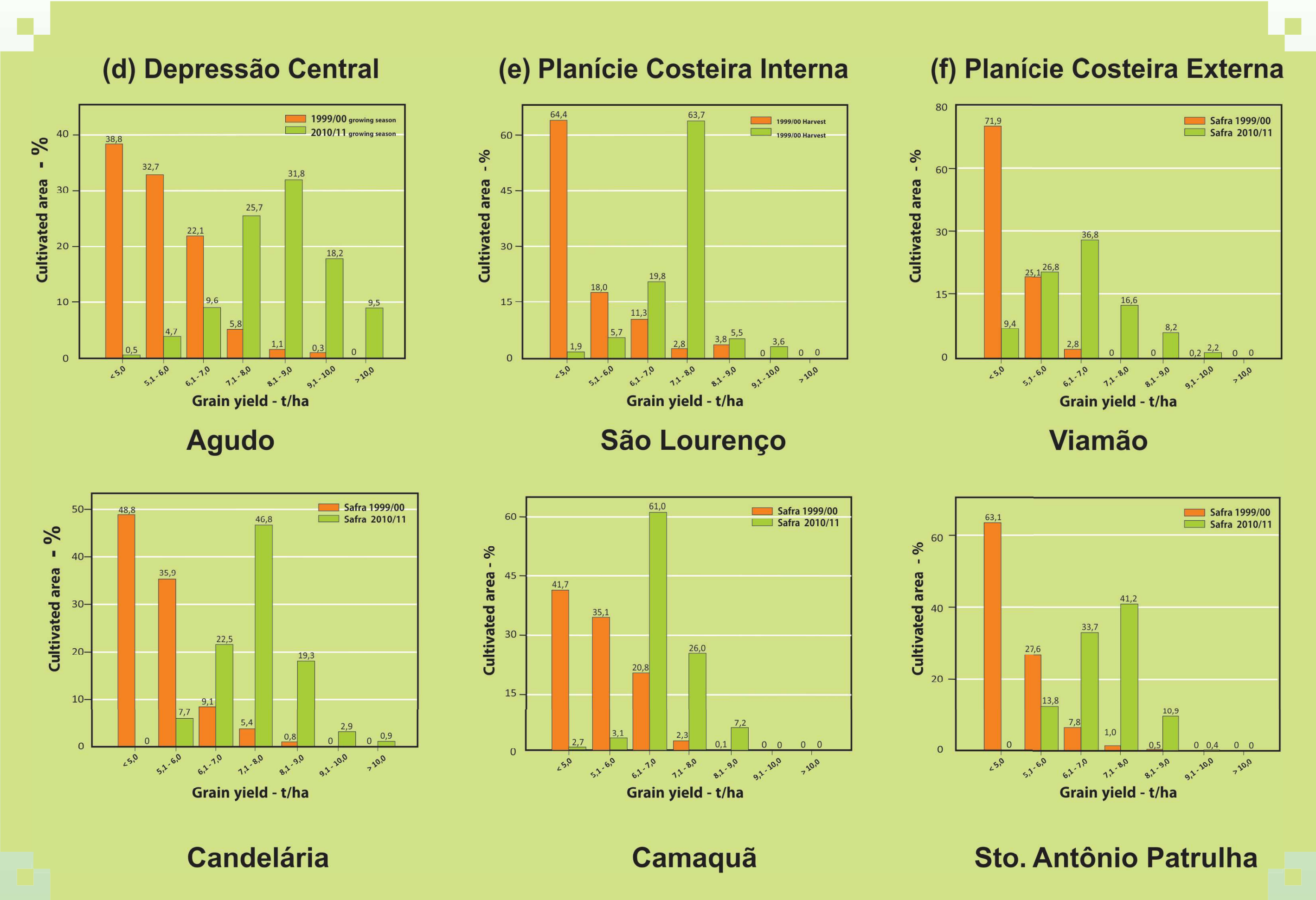

Figure 21. In some counties of the Depressão Central, Planície Costeira Interna and Planície Costeira Externa regions, only a cultivated areas produce less than 6.0 t/ha and they have been improved, since after the Projeto 10 implementation, the productivity ranges from 7.0 to 8.0 t/ha.

Source: IRGA (2012)

productivity in the 2010/11 growing season was of 6.9 t/ha (Figure 19). The productivity growth compared to the 1999/00 harvest (1.7 t/ha) can be considered good, when compared to its own previous records. However, it could have been larger, if we consider the productivity gains obtained in the areas covered by Projeto 10 (Table 2). A factor that makes the region's potential evident is that in 43% of the area, the productivity is now higher than 7.0 t/ ha, whereas previously (1999/00 harvest) in 85% of the area, the productivity was lower than 6.0 t/ha and, among these, in 42.5% of the area, the productivity was lower than 5.0 t/ha (Figure 19e). In the 2010/11 harvest, in 11% of the area, the grain yield was lower than 6.0 t/ha. A good example of productivity growth in this region was in São Lourenço do Sul (Figure 21b), with 13,000 hectares used in rice cultivation, whereas previously, in 65% of the area, productivity was lower 5.0 t/ha. Currently, this productivity is a reality in less than 2% of the area. Another city that has shown improvements, though smaller ones, was Camaquã (Figure 21b), with 54,000 hectares used in rice cultivation, where productivities smaller than 6.0 t/ha rose to 47% in only 5.8% of the area.

The conduction of sowing outside of the recommended period has been the most constraining factor to productivity growth in the Planície Costeira Interna Region mostly due to the fact that the soil has not been tilled beforehand. While the farmers that presented gains sow their seeds in the few days available for work, in September and October, majority of them are only beginning to prepare soil tillage. This region has the largest area used in rice cultivation in the pre-germinated system in the State. This is partly because farmers from Santa Catarina, where this system is prevailing. The frequent use of this system has contributed to increases the productivity in the region. However, it could have been better if the varieties of long cycle, such as EPAGRIs, were not sown late and, still, with little use of fertilizers. Other factors, such as the use of early cultivars in most areas, the insufficient use of certified seeds and late irrigation also constrain productivity.

In the Planície Costeira Externa Region, 138,000 hectares of rice were cultivated and the average productivity reached 6.5 t/ha in the 2010/11 harvest (Figure 18); this is the region which has presented the lowest productivity gains (only 1.3 t/ha). Though it has grown when compared to its own previous records, there is evidence that it could have grown more. In the 1999/00 harvest, in 80% of the area, the productivity was lower than 6.0 t/ha, in that in 43% of this area, the productivity was lower than 5.0 t/ha (Figure 19f). In the 2010/11 harvest, in only 7% of the area, the productivity was lower than that and, in 35% of the area, the productivity was higher than 7.0 t/ha, in which the productivity was higher than 9.0 t/ha in 6.7% of the area (Figure 19f). Whereas in Viamão (Figure 21c), only 27% of the 25,000 hectares cultivated produced more than 8.0 t/ha, in Santo Antônio da Patrulha, 52.1% of the area of 22,000 hectares produced higher figures than that.

Results from the 2010/11 harvest in the Planície Costeira Externa Region could have been better. However, because the sowing occurred mostly from November on, the reproductive phase of plants in most crops coincided with the period of rainfall above the average and high temperatures. This enabled a severe epidemic of leaf blast, causing by significant productivity losses, since many farmers were not able to harvest anything in part of the crops. This evidences the biggest problem of this region, which is the conduction of sowing outside the recommended period. Out of all rice producing regions of RS, this is the one in which the sowing occurs later and as a consequence, is the one that shows lower productivity gains. The insufficient use of certified seeds and fertilizers, and the use of early cultivars in most crops have also had an influence on that. The predominance of sandy soils and low fertility has also contributed to low productivity obtained. But despite this natural constraining factor, the productivity could have been higher, since in many crops in the region (Table 1), the productivity has been higher.

Looking at the average rice productivity (Figures 4 and 18) and productivity data issued for the State (Figure 17), in the different regions (Figure 19) and in cities in each region (Figure 20 and 21), we can see significant increases over the latest years. However, if we consider the productive potential based on the best results obtained in areas where Projeto 10 was adopted (Tables 2 and 3), we can notice that there is still is a productivity gap of 3.0 t/ha. The yield potential of the areas of Projeto 10 remained high over the last two harvests in question (Figure 22) though weather conditions have been very different. In the 2009/10 growing season, the average productivity in the State was lower (6.5 t/ha), due to the phenomenon **"El Nino"**, but yet the grain yield was high (8.1 t/ha) in areas where Projeto 10 was implemented (Table 2). On the other hand, in the 2010/11 growing season, weather conditions were very favorable to rice cultivation, due to the phenomenon "**La Nina**", with intense solar radiation and low intensity and frequency of rainfall in the spring, thus allowing farmers to conduct sowing at the right time even without a good management of the productive process. In the 2010/11 growing season, 447 Projeto 10 fields were implemented in different rice producing regions, covering an area of 65,000 hectares, with an average grain yield of 9.5 t/ha; the eleven best grain yields were higher than 11.0 t/ha, up to 12.3 t/ha (Table 3). In the properties where Projeto 10 was implemented, the cultivated area reached 175,000 hectares, with grain yield of 8.5 t/ha (Table 2). As these results are based on crop records, we can conclude that there are enough technology and cultivars to produce more than what has been currently produced in the State of Rio Grande do Sul.

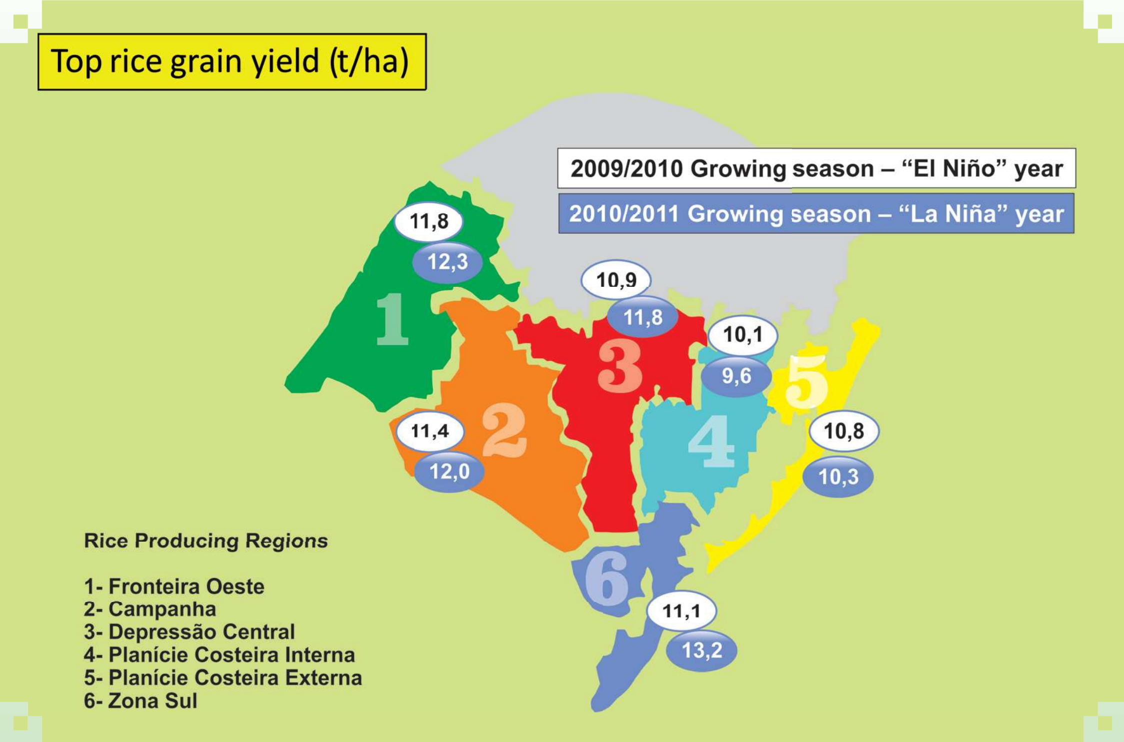

Figure 22. The use of technology reduces the impact of stresses caused by negative weather conditions such "El Niño", once, due to the excess of rainfall, the sowing is done after the recommended period reduces solar radiation at flowering time.

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Source: IRGA/DATER (2011)

2.3. Testimonyals of farmers who adopted Projeto 10

The success of Projeto 10 can be evidenced by the testimonials of farmers from different rice producing regions in RS who adopted it. These are testimonials that were published in several issues of the magazine Lavoura Arrozeira (Rice Field), as follows.

In the **Campanha Region**, farmer **Valter José Potter**, one of the pioneers in the adoption of Projeto 10 in the city of Dom Pedrito, stresses that the project fostered alterations in all processes involving rice crops, seen that the soil used not be tilled beforehand. According to him, in the past average profits in harvests ranged 6.0 and 6.5 t/ha and, after taking part in Projeto 10, the grain yield arose to 9 and 10 t/ha. Changes adopted were very significant, especially after an anticipated technical analysis of the soil, prior soil tillage (from the previous summer up to sowing), use of wide and reduced levees system, anticipation and concentration of the sowing period (Sep 20 to Oct 20), fertilization compatible with productivity expectations, dry nitrogen fertilization (before irrigation), choice for high productivity cultivars with industrial quality with certified and treated seeds, early weed control and reduced use of herbicides and irrigation up to three of four leaves. As a consequence of the actions conducted by farmers, the production of rice has seen a significant increase in Dom Pedrito, with a major leap of productivity compared to the past. Hence there has been a higher demand for technical assistance, input, services, qualified workforce, silos and dryers. That has been a real silent, consistent and irreversible revolution. Farmers who used Projeto 10 were convinced of the results obtained and adopted this technology massively. Another farmer from Dom Pedrito, **Alamir Viero**, has also presented a testimonial: "Since the 2001/02 growing season, the project's practices have been changing the ways rice is produced in the property, starting from the sowing season. In the past, I used to start conducting soil tillage in the spring and sowing rice in October and November; now I conduct soil tillage in the summer in rotative areas where I may alternate with the cultivation of soybeans, and sow rice in September and October". So, in addition to sowing the entire crop in the recommended period, he highlights other techniques of the project, such as the early weed control and crop irrigation, as essential for productions higher than 10.0 t/ha. Farmer **Gilberto Raguzzoni**, who has been monitoring Projeto 10 since the very beginning, has weighted in the differences noticed by rice farmers in the Campanha Region. Raguzzoni recalls that Projeto 10 was started by a joint decision made from both Associação dos Arrozeiros de Dom Pedrito (Rice Farmers Association of Dom Pedrito) and IRGA offices, both regional ones and from Porto Alegre. The process evolved quickly and efficiently because it was based in some strategies different from the ones previously used, as he mentions the technology diffusion from experimental fields in research stations. Now, the diffusion takes place from experimental crops in areas in which farmers produced 10.0 t/ha or more. In these crops, production would rarely reach 6.0 t/ha; the fundamental difference was that some farmers "created" areas of approximately 10 ha and the recommendations of Projeto 10 were followed carefully, such as the sowing season, fertilization, dry urea, irrigation period, weed control, etc. These areas used to receive frequent visits by IRGA extensionists to monitor the staples and recommend new management stages for the following period. The farmer stresses that another relevant factor in the process of diffusion was the conduction of field days, with visits to all areas where Projeto 10 was implemented, with the presence of technicians and a large number of farmers from Dom Pedrito. "Then he mentioned how he had done it those who listened and went to see the crop by themselves would believe it more then only relying on the words of the extensionists". After the experimental fields were harvested, there used to be an important meeting where grain yield figures would be published and, again, there used to be an exchange of information between extensionists and farmers, highlighting the high productivities obtained. "This mode of operation would make the entire rice production community even more aware". To conclude, Raguzzoni stresses that the incentive given by the leaders of the project was very important so that the farmer's teams could participate and get convinced. Without that, the Project would not have been successful.

In the city of São Borja, in the **Fronteira Oeste** Region, the implementation of Projeto 10 relied on the community's mass participation. Farmer **Aldo Marino Heck,** from São Borja, stresses that the access of farmers to technology is a great merit of Projeto 10, since the Project brings together the smartest practices for rice crops. According to him, these are simple techniques, without costs that have been transferred to the group of farmers who did not have access to that information before. For the farmer **Gilberto Alvarez da Costa**, the innovations focused on larger productivity with lower cost. According to him, in an area of 9,104 hectares that belonged to farmers from Cooperativa Imembuy (Imembuy Cooperation Company), the average grain yield gains were of 2.5 t/ha. He highlights that it is expected that all farmers from the cooperation company become aware in order to obtain at least the current average productivity of 8.2 t/ha and, so, keep consistent results and enjoy the potential of cultivars. For **Celso Rigo**, president for Pirahy Alimentos (Pirahy Foods), a company that benefits from the rice of São Borja, Projeto 10 has enabled a significant reduction of costs in the crop, in addition to improving the quality of the product. The rational use of natural resources, the quality of seeds, the sowing period, irrigation management and weed control were the main factors that helped increase grain yield. **Jonas Dalla Porta** reckoned that the main change was the integration between researchers and farmers through lectures, field days, technical workshops, training for farmers and employees and the exchanges from the visits in properties. **Edgar Posebom**, from Uruguaiana, has adopted all recommendations of Projeto 10 in his entire crop (1,100 ha) and the grain yield reached 9.6 t/ha, a gain of 2 t/ha compared to the previous productivity. He basically dealt with the conduction of soil tillage beforehand and sowing during the recommended period, reduction of sowing density and irrigation with rice plants of 3-4 leaves. He also stressed that harvesting during the ideal period is very important for the quality of grains.

For the farmer **Luis Carlos Ceretta**, from the city of Piratini in the **Depressão Central** Region, Projeto 10 has come to raise awareness of farmers of the importance of the sowing period. In the 2007/08 harvest, the sowing began on October 20 and ended on November 08. In this harvest (2011/2012), the farmer obtained an average of 7.8 t/ha in a crop whose area was of 230 ha in his property, whereas in the area of 110 hectares with the Projeto 10 technology, the productivity was of 9.0 t/ha. For the farmers **Gilberto Milanesi** and **Saul Cervi**, some of the first to adopt this technology in this city, Projeto 10 brought researchers closer to the crops, cleared some doubts and brought the best technologies for rice farmers in the region. **Aldo Hay**, who has been a farmer in Agudo for 29 years, states that Projeto 10 was the best technology to gain high productivities. In the past he used to produce 6.0 t/ha and in the earliest years of the project, this number rose to 8.0 t/ha. He states that Projeto 10 is a successful experience and is essential that all farmers take part.

Agronomist **Sérgio Borba**, from the company Agropaty, based in Eldorado do Sul, in the **Planície Costeira Interna** Region, has noticed that in each harvest, farmers are more professional and are more committed to developing their crops. He acknowledges that farmers are more technical and are seeking professional development and IRGA has made it available over the recent years, either through early irrigation or by improving the level of fertilization among other important practices. According to him, farmers used not to care about these practices, but as their mentality has changed, he has noticed an increase of up to 2.0 t/ha in productivity results. "Before Projeto 10 the average productivity of rice of many farmers was of 4.0 t/ha. Currently the average productivity has reached around 7.0 t/ha". **Rafael Albuquerque** through a partnership with

Jorge Brauveres, from the city of Barra do Ribeiro, are in compliance with the recommendations of Projeto 10 and have already obtained around 8.0 t/ha in rice grain yield in a crop of 103 ha. Albuquerque claims that they try to sow at the recommended period and give special attention to both basis and top dressing fertilization. He states that both field days and technical workshops made him raise awareness of the possibility to reduce the number of seeds from 170 kg to 100 kg/ha or less and of the importance of the use of certified seeds.

Farmers from the **Planície Costeira Externa** Region also believe that Projeto 10 has brought significant changes in the process of rice production. According to **Walter Dutra**, from the city of Santo Antônio da Patrulha, the project has aggregated income to the business due to productivity gains. In the past he used to harvest only 5.0 t/ha and, currently he harvests more than 8.0 t/ha within an area higher than 1,100 hectares. According to him, sowing in the recommended period along with the systematization of the areas has enabled him to expand the cultivated area with the same quantity of water. **José Mathias**, from the city of Mostardas, highlights that besides the importance of the productivity gains with the use of new technological recommendations on the reduction of the density of the seeds, of weed control and earlier sowing, there has also been a significant gain with the stabilization of productivity in higher standards, which has risen from 6.0 to 8.0 t/ha. He states that the diffusion model enables farmers to see what others do and this increases their self-confidence. "Many times farmers do not believe in research, but in view of the results obtained by their neighbors they feel they can improve their results even more". For **Geraldo Azevedo**, from Mostardas, Projeto 10 has brought a new vision to rice crops, which has led to higher productivity and improved business profits. This has encouraged the work team to seek innovations to produce 10.0 t/ha throughout all crop, as the ultimate goal. According to him, "with the project we had access to new technologies, productivity gains, income gains in the property and we were able to rely on employees who have an entrepreneurial view of the business, which has enabled us to plan and carry out the crop activities properly". With these changes, he increased productivity in more than 2.5 t/ha and, in part of his farm, he has produced 12.1 t/ha, with the cultivar IRGA 424 in the 2008/09 harvest. The farmer **Maria Isabel Cardoso Terra**, also from Mostardas, highlights that Projeto 10 has contributed to significant changes on rice production in the State. Soil tillage is done much earlier and sowing is conducted at the recommended time; there is an increase in fertilization, with the largest part of urea being applied to dry soil, lower water layer and more efficient use, as well. The professional development of owners and employees has also improved greatly with the courses sponsored by IRGA and SENAR at the properties. She acknowledges that constant visits of IRGA extensionists to implement project's crops and meetings with local farmers for the exchange of information and experiences keep farmers up-to-date on new technologies.

Renato Amaral, a rice farmer in Santa Vitória do Palmar, **South Zone** of the State, has achieved average productivities above 9.0 t/ha with the adoption of the technologies recommended by Projeto 10. For him, the most important part of the project is that IRGA extensionists are there in the crop to clear the farmer's doubts. He highlights that there needs to be integration between research and farmers for the exchange of experiences. Among the recommended technologies, he highlights prior soil tillage as a factor to enable rice sowing at the recommended time. For **Marcio Silveira**, from Sta. Vitória do Palmar, a production manager at Granja do Salso with around 5000 ha of rice sown, has obtained a grain yield gain of around 3.5 t/ha by adopting the agronomic practices recommended by Projeto 10. The average rice grain yield of the last two harvests was of 9.0 t/ha. He highlights that with the increase in productivity, there has been reduction in the production costs, since more than 70% of the costs of his crop will not change if the rice productivity reaches 5.0 or 10.0 t/ha. For him, the foundations of Projeto 10 is the conduction of sowing at the recommended period based on prior soil tillage, following the early weed control and irrigation of areas when they have 3-4 leaves and fertilization in accordance with the production expectations.

3. AGRONOMIC PRACTICES RECOMMENDED BY PROJETO 10

Reaching high productivities of irrigated rice depends on several factors, in which some factors can be controlled others cannot. The interaction between these several factors that influence in the productive system as a whole is what determines grain productivity and quality and the desired economic return. Therefore, it will not be the adoption of one or another isolated agronomic practice that will change the current productivity standards.

The agronomic practices adopted in Projeto 10 are based on **Technical Recommendations Research for Rice** (SOSBAI, 2010) and are related to the sustainability of rice production activities. They are part of the environmental management of crops and are part of what is known as Good Agricultural Practices, as defined in a proper guide (MUNDSTOCK et al., 2011).

Even by taking in consideration the importance of all different agronomic practices, Projeto 10 has prioritized the **sowing date, plant nutritional status, soil fertilization, management of irrigation water and weed control as the most restrained ones for rice productivity in RS. However, soil adequacy practices, choice of cultivars, use of good quality seeds and insect and disease management has been given attention in order to reach high rice grain yield of rice grains**. In order to monitor the rice production process more effectively, firstly are presented the practices that are related to the definition of productivity, so called "construction" practices, and then, those that deal with its protection, so called "maintenance" practices.

3.1. Practices related to the "construction" of productivity

3.1.1. Sowing period

Sowing period is one of the most important practices that define irrigated rice productivity (Figures 23 to 25). It is important to decide on its implementation once it depends on several factors such as: weather conditions, soil type, level of weed incidence, cultivars and cultivation system used. It affects several agronomic characteristics relevant of the crop, without significant interference in its production cost. Regardless what had been the norm previously, the sowing period must be planned not only by virtue of the occurrence of low temperatures during the reproductive phase of the crop, but mainly as a goal to achieve higher grain productivity, thus the plant's reproductive phase coincides with the days with higher solar radiation (Figures 26 and 27).

In the State of Rio Grande do Sul, the recommended period for sowing is from September 01 to November 05, regardless of the rice producing region (Table 6). Sowing must start as soon as the soil has friability conditions that enable this operation, even if the soil temperature is no longer suitable for seed germination and seedlings emergence. When sowing occurs in the beginning of the recommended period, the duration of the sowing-emergence subperiod is higher and seeds are exposed to possible pathogenic attacks for a longer period of time (item 3.2.2), as the seeds can be treated with fungicides. In these cases, it is recommended to conduct sowing at a shorter

Figure 23. . The right sowing time is one of the factors that determines high rice grain in crops Projeto 10 fields. Grain yields presented here refers to the BR-IRGA 410 cultivar.

depth (2.0 cm), since the occurrence of low temperatures during September and October lowers the growth rates of mesocotyl, which makes the emergence of coleoptiles more difficult when seeds are placed at a higher depth, as they may result in a lower number of plants.

Use of cultivars with higher capacity to tolerate low temperatures during the phase of seedling establishment allows for the conduction of sowing in the beginning of the recommended period. This allows for the enjoyment of benefits of more favorable weather conditions for so-

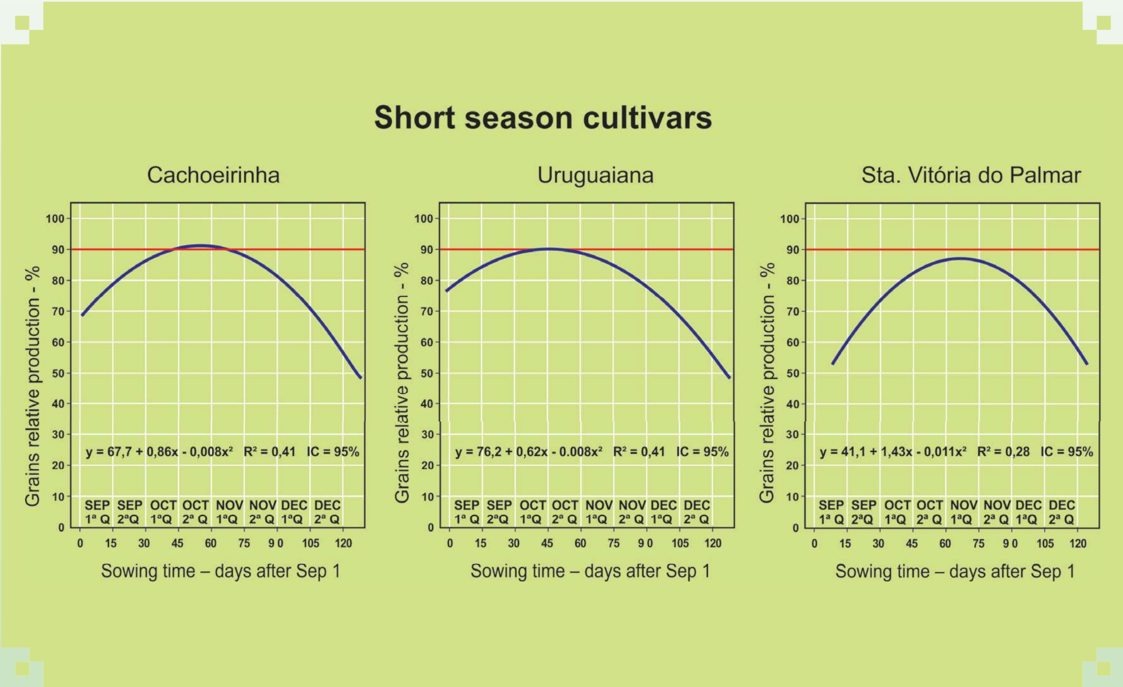


Figure 24. The recommended sowing time for the short season cultivars is from Oct 01 to Nov 10 according to experiments conducted by IRGA for eight years (from 2002 to 2009), in three counties located in three rice producing regions of Rio Grande do Sul.

Source: Agronomy Team EEA/IRGA (2012)

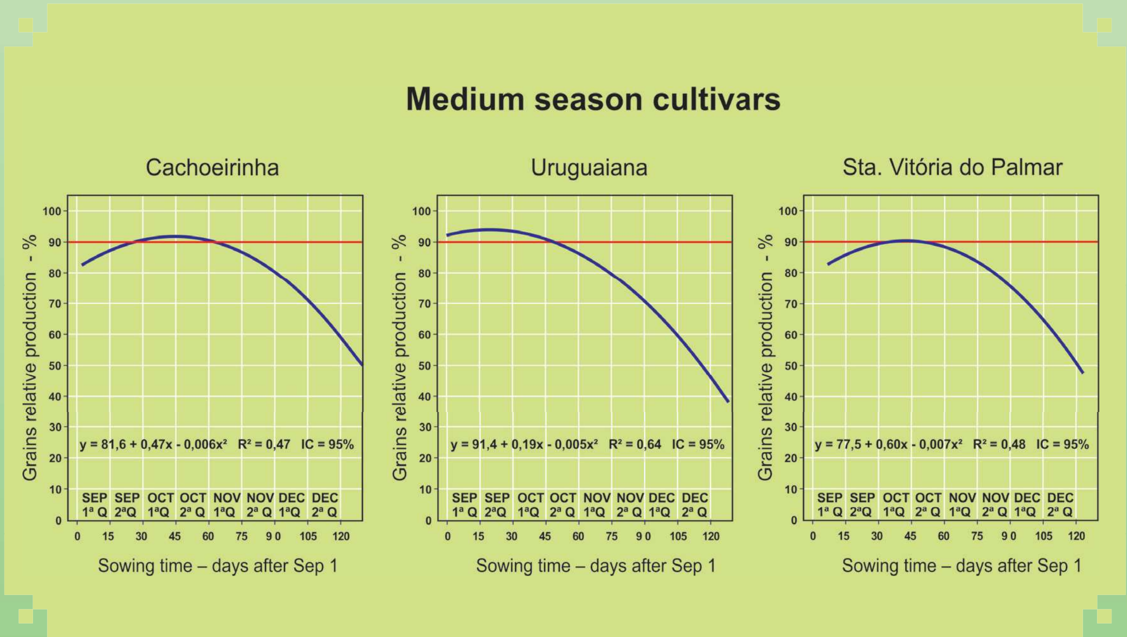


Figure 25. The recommended sowing time for Mid season irrigated rice cultivars is from Sep 01 to Oct 30, according to experiments conducted by IRGA for eight years (from 2002 to 2009), in three counties located in three rice producing regions of Rio Grande do Sul.

Source: Agronomy Team EEA/IRGA (2012)

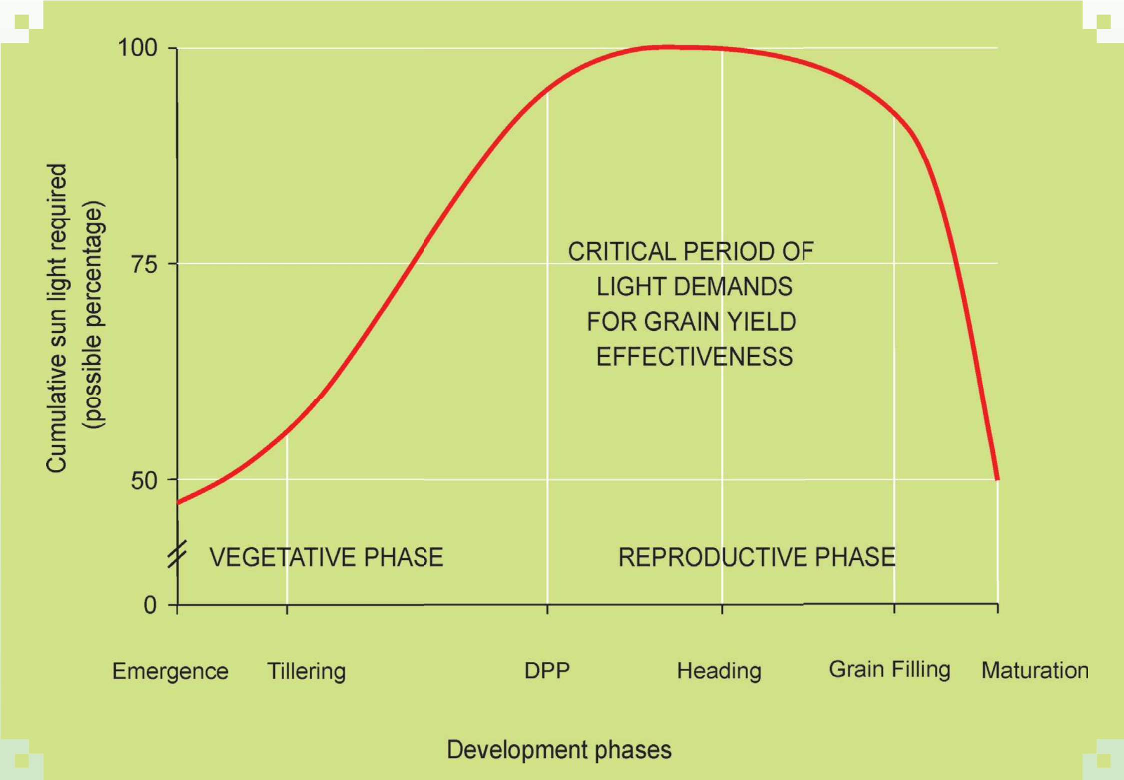


Figure 26. Recommended sowing time for irrigated rice is the one that coincides with the plant's reproductive period with the one of higher solar radiation.

Source: Adapted from Stansel (1975)

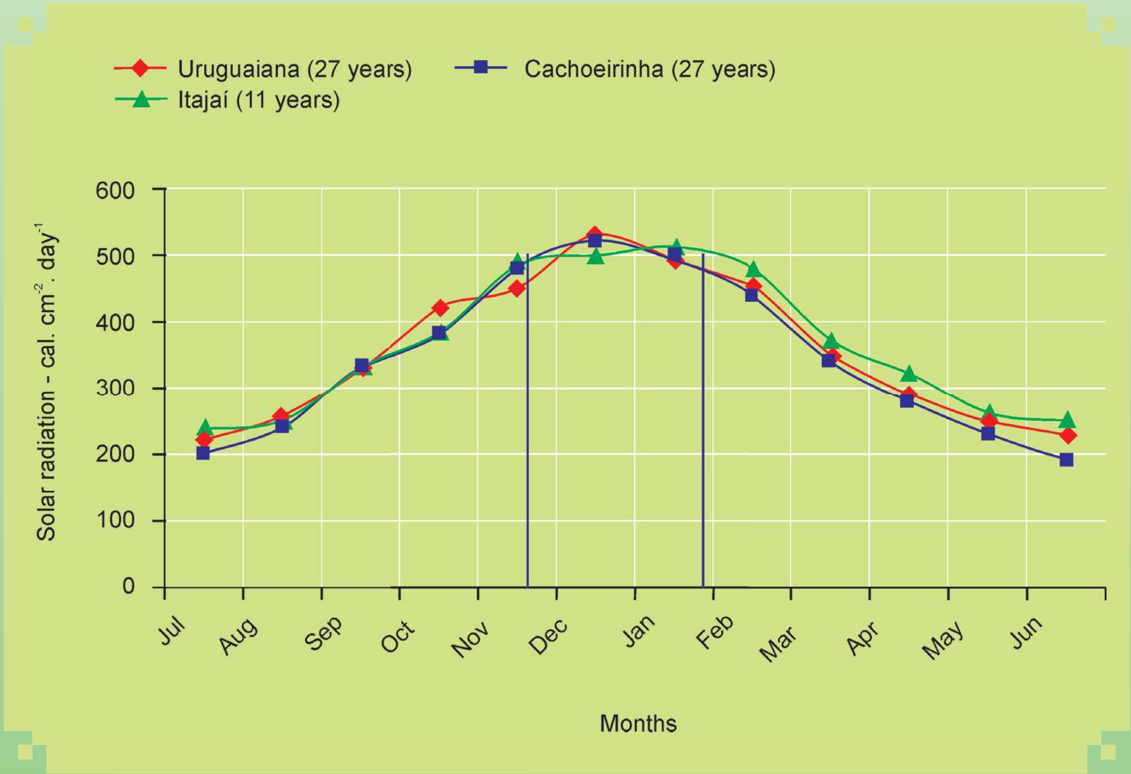


Figure 27. Higher solar radiation occurs between mid-November and mid-February, independently of which part of Southern Brazil.

Source: Eberhardt (1998)

Table 6. Recommended period for sowing irrigated rice cultivars for higher grain yield according to the development cycle, in Rio Grande do Sul State

Cycle of cultivars	Sowing period
Very short season	15 Oct - 10 Nov
Short season	1º Oct - 10 Nov
Mid season	1º Sep - 30 Oct
Late season	1º Sep - 15 Oct

Source: Agronomy team, EEA/IRGA (2012)

lar radiation in November, December and January (Figure 27), especially in rice producing regions with higher probability of lowest temperatures lower or equal to 15 ºC within this period. Besides that, the use of such cultivars broadens the sowing period, thus minimizing high investments necessary to seed a great part of land within the recommended period. The availability of cultivars with these characteristics is a challenge to research for the next years.

Unfortunately, as there are no cold-tolerant cultivars for the weather conditions of Rio Grande do Sul, it has been suggested to start sowing the medium or long cycle cultivars at the beginning of the recommended period. This is mostly due to its best performance in bioclimatic tests, since they show higher recovery capacity of the stress caused by the cold, even though some present slower initial growth (as IRGA 424).

The principal point is that as we desire to increase grain yield potential and stability of the crop, we must choose the sowing date with the maximum solar radiation at the plant's reproductive phase. Temperature is considered essential during the reproductive phase since data show that when sowing starts after November 05, the chances of cold weather in the reproductive phase are higher. Cold temperature that occasionally occur during this phase are unpredictable and the most suitable solution is the use of cold-tolerant cultivars in this phase too, though they are still not available.

There has been a great improvement in bumping up the sowing season in the State of Rio Grande do Sul by virtue of the implementation of Projeto 10 (Figure 28a). In the 2008/09 growing season, 55% of the area had been sown until late October, not shown result. The challenge to sow 90% or more of the area of the State until the first two weeks of November was reached in the 2010/11 growing season, with 92.5 % of the sown area until this date. This goal had already been reached in the city of Jaguarão, in the 2009/10 growing season (Figure 28b). Another positive factor in this growing season was that the end of the sowing season occurred until the first two weeks in December. Previously, it was common to end sowing at the end of December, though in some cases there used to be an extension until the earliest days in January, thus contributing for low average productivity in the crop.

For the sowing season occur during the recommended period, the soil needs to be tilled beforehand. Farmers who initiated sowing in mid-October will only complete it within the most suitable period if there are good weather conditions, since spring rainfall in the state of Rio Grande do Sul is frequent and there are few days for sowing.

Sowing in the recommended period, in addition to providing higher productivities, is essential for the good management of the crop as a whole, since it makes easier its technical and operational management, thus allowing for the conduction of subsequent activities in a timely fashion.

For the sowing of rice be able to occur within the recommended period (Table 6), the area needs to be tilled beforehand, paying special attention to aspects related to draining, prior soil tillage, choice for cultivation system and systematization, as shown as follows.

a) Draining

Deficient draining (Figure 29), which still occurs in most of the rice fields in the State, is due to the flat topography of lowlands along with the frequent rainfall that usually occur during the winter and in the beginning of the spring. Efficient crop draining (Figure 30) is important for soil tillage, in order to enable sowing at the right pe-

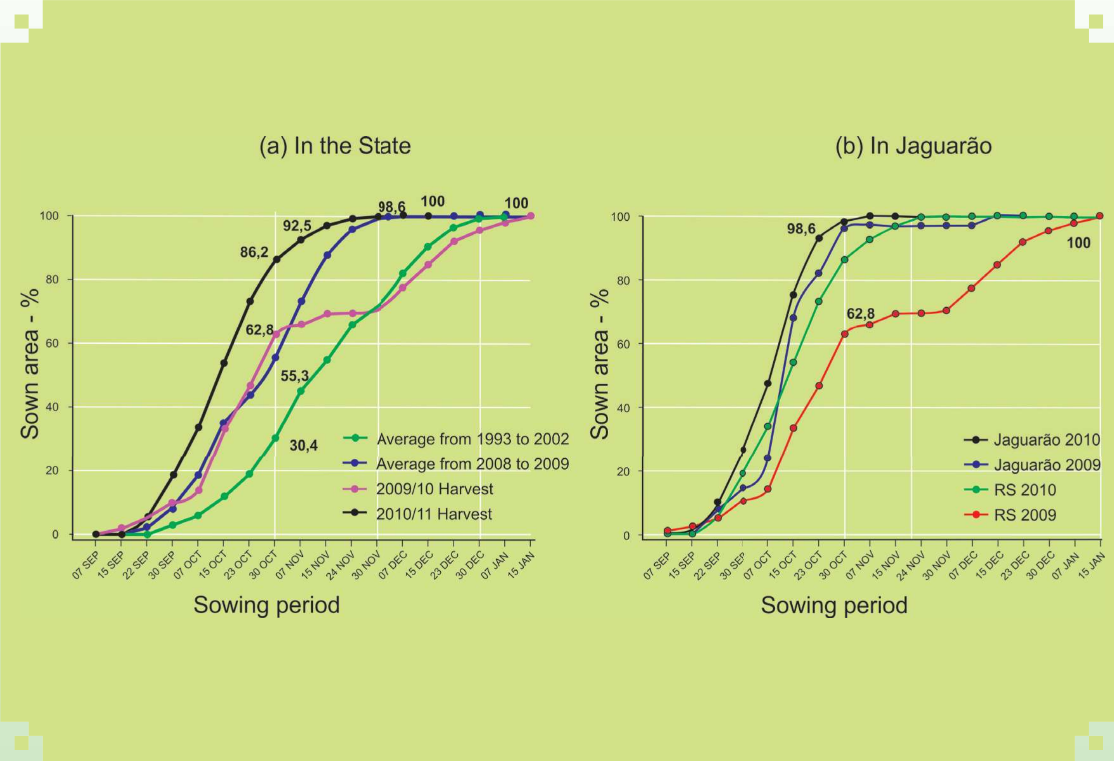


Figure 28. Evolution of rice irrigated area sown in the recommended period in Rio Grande do Sul (a), in Jaguarão county (b) and in the Zona Sul. It has significantly increased with the Projeto 10 implementation.

Source: IRGA (2012)

riod, to establish the staple properly and to enable harvesting at the right time. Poorly drained areas during off--season can also be a source of problems arising from iron toxicity and from the occurrence of weeds such as stoloniferous grass, pest insects and snails (pre-germinated system). The optimization of the crop's useful area, that is, the reduction of areas without plants (Figure 31) is one of the pre-requisites for obtaining high productivities of irrigated rice.

b) Anticipated soil tillage and cultivation system

Prior soil tillage (Figure 32 and 33), with the previous construction of levees is fundamental to enable sowing at the recommended time. Farmers who conduct soil tillage close to the sowing season may not reach this goal by virtue of the usual occurrence of adverse weather conditions in the end of the winter and in the beginning of the spring. It is important to have enough time for the development of a crop cover, which must be controlled beforehand, with the use of broad spectrum herbicide. This system is characterized as minimum tillage in the rice production industry of South of Brazil. The adoption of this system has become widely popular, as it is prevailing in the rice crops of Rio Grande do Sul because in the 2010/11 growing season, it was used in 67.5% of the area (Figure 34). The relationship between the anticipated soil tillage and the probability of high productivities can be seen in Figure 35. The larger the area in which the soil has been tilled beforehand, the higher the probability for higher productivities of rice.

Among the cultivation systems used in the State, the conventional one, which still occupies an area of 20.7 % (Figure 34), is the biggest limiting factor for sowing during the recommended period, since soil preparation is done right before sowing. The occurrence of rainfall in the spring is frequent and sometimes it is not possible to prepare to soil and sowing in the recommended period. On the other hand, the pre-germinated and the minimum tillage systems are less dependent on weather conditions and must be preferably used for the viability of sowing at the recommended period.

Figure 29. Deficient drainage is harmful for the establishment of irrigated rice fields.

c) Area adequacy

For the area to be cultivated and used efficiently and rationally, it is necessary to previously subject it to a process of adequacy or systematization in a broad sense (Figure 36). This process consists in the creation of a functional management system, which includes the opening of irrigation and draining channels, the construction of internal roads, ground leveling at either the ground level or under or above, the construction of levees and complementary structures, such as bridges and manholes, as needed. Therefore, the systematization of the area consists of a set of practices and not only ground leveling.

The systematization of lowland soils, for leveling the soil, is an important factor in the shift of technological standards of rice crops. Whether it is done in the water or dry soil, with animal force or mechanical machines, or with laser, it is important that it is done correctly (Figure 36). Ground leveling and the planning of irrigation systems, draining and roads enable the expansion of the useful area of the crop. This operation also improves the soil's superficial draining, enables the use of lower water layer and maintenance of a more uniform layer. With this, the execution of other management practices is facilitated, making sowing and the harvesting of rice on levees easier. They must have a wide and low base and come without ditches.

The large availability of land has made farmers of Rio Grande do Sul negligent when it comes to the use of the area where rice is effectively cultivated, with many lost areas (Figures 29 and 31). More commonly, these places are the "holes" that are seen in the crops close to levees, roads and poorly drained areas. In these areas, herbicides and fertilizers are used, fuel is used for tillage and land and/or water rental should be paid. This kind of waste must not be present in a crop, which is intended to increase productivity.

3.1.2. Choosing cultivars

The adoption of agronomic management practices recommended by Projeto 10, as previously seen, has enabled improvements in the rice productivity in Rio Grande Sul, once many of the cultivars used were released almost 30 years ago. By virtue of the genetic variability of culti-

Figure 30. Areas that have efficient drainage enable the crop sowing in the recommended period, which results in suitable plant density and establishment.

Figure 31. The optimization of the useful land reduces areas without plants, is one of the requirements for obtaining high rice grain yield.

Figure 32. Early soil tillage is one of the essential requirements that enable crop sowing in the recommended period.

Figure 33. Early soil tillage is fundamental for the irrigated rice to be sown in the recommended period, regardless the method used.

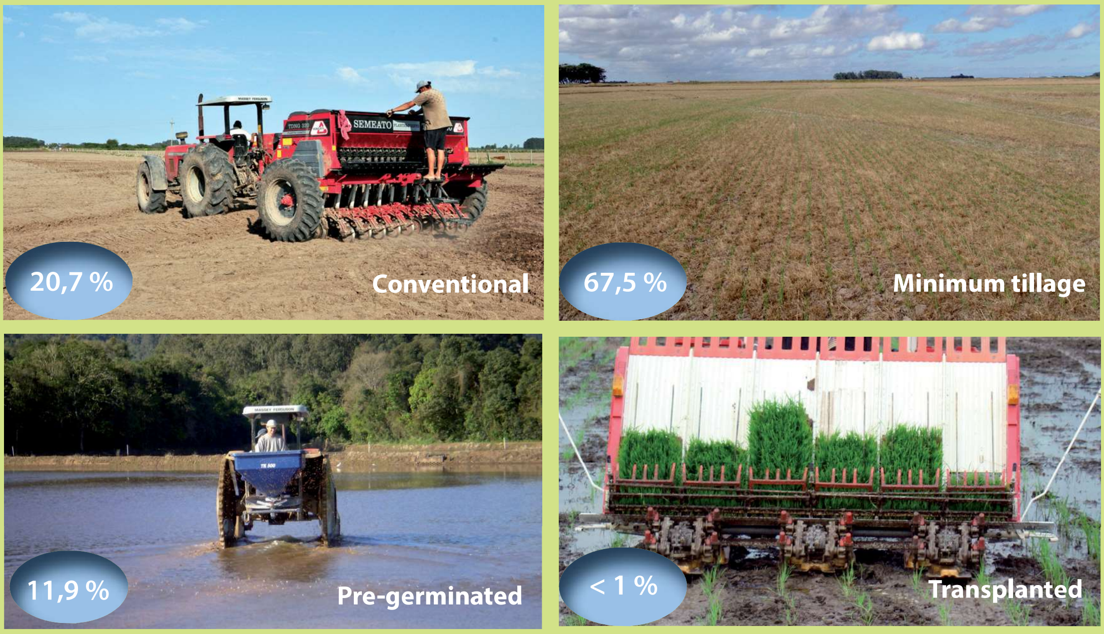


Figure 34. The use of the minimum tillage system, with early soil tillage, was the most used in the irrigated rice fields in Rio Grande do Sul, in the 2010/11 growing season.

Source: DATER/IRGA (2012)

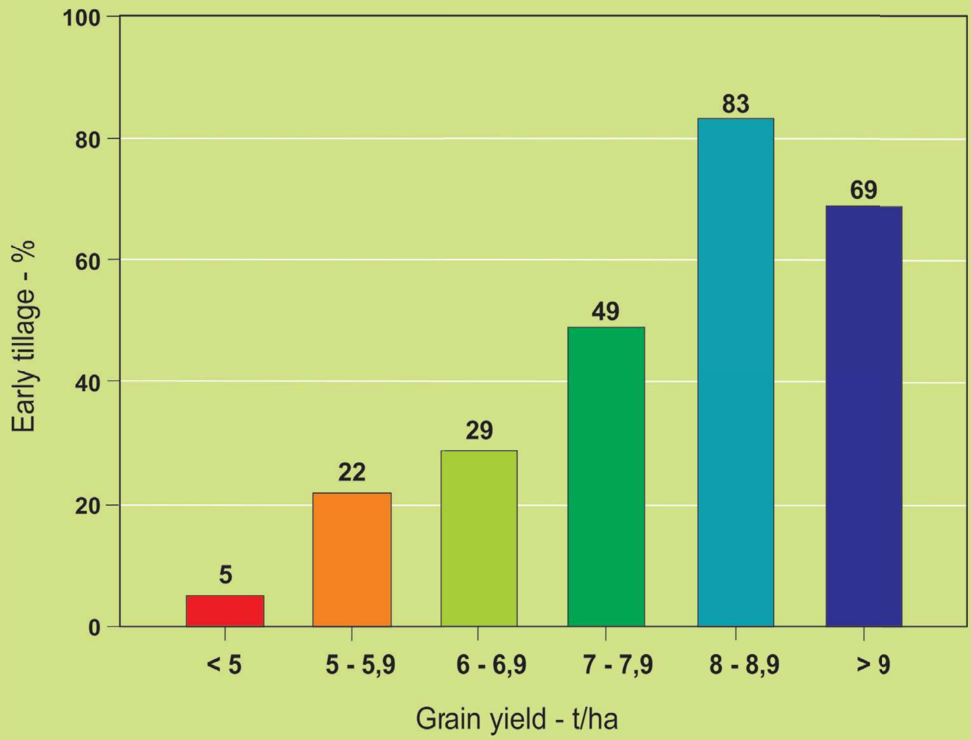


Figure 35. Higher grain yield in rice crops were obtained as the percentage of areas in which early tillage increased (Zona Sul, 2010/11 harvest).

Source: DATER/IRGA (2012)

Figure 36. Early soil tillage, that includes systematization, is one of the requirements to sow at the recommended time.

vars, represented by differences in the productive potential in reactions to environmental diseases and stresses, in response to fertilization and cycle duration, it is recommended that cultivars with unique characteristics be used in order to ensure greater stability in productivity and facilitate the harvest's staging. Another measure to enable the harvest's staging is sowing the same cultivar in different sowing dates within the recommended sowing period (Table 6).

It is important to stress that the release of new cultivars, be them either conventional ones (such as IRGA 424) or hybrid ones, with higher productive potential, quality of grains and profitability (Figure 37), is always welcome. The greatest challenges faced are to obtain genotypes that could be resistant to environmental stresses, especially those that have an median cycle, and are tolerant to cold in the beginning of the vegetative phase. Such cultivars will contribute greatly for the sowing during the entire recommended sowing period and for making the production of rice in the State less vulnerable to environmental variables. It is also necessary to continue with the improvement program for obtaining **Clearfield**® cultivars, even if they have lower productive potential (Figure 38), for use in areas infested with red rice, with higher resistance to fitoxicity by the imidazolinone type of herbicide or to other chemical groups and which have higher yield potential in relation to the ones that are currently cultivated.

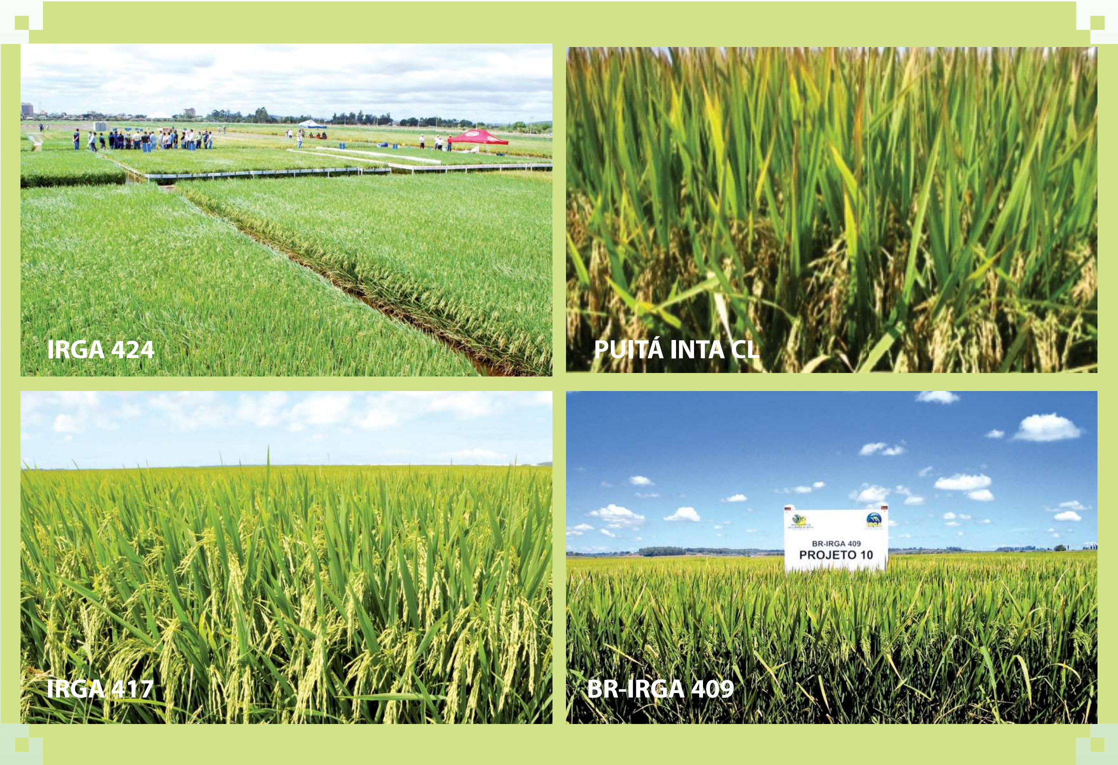


Figure 37. Cultivars availability with high yield potential is one of the most important factors of Projeto 10.

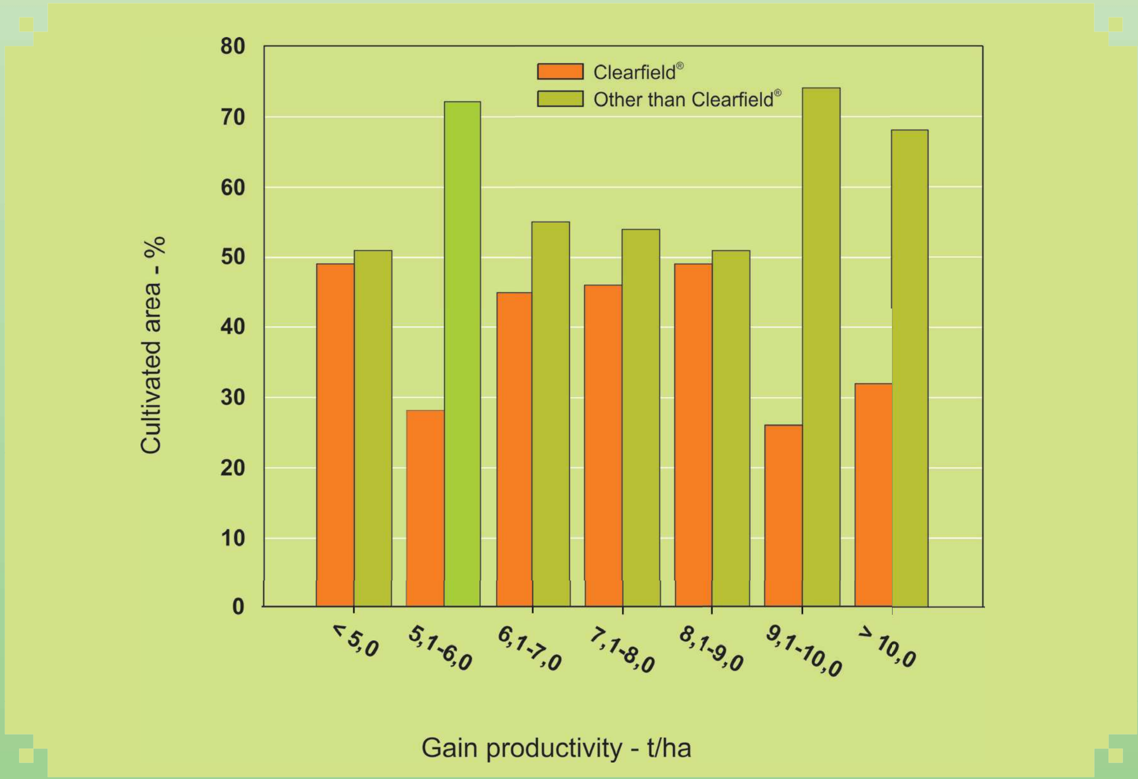


Figure 38. Higher grain yield of irrigated rice are obtained with the use of conventional cultivars in relation to Clearfield® ones (Zona Sul, 2010/11 harvest).

Source: DATER/IRGA (2012)

3.1.3. Crop setting

The appropriate number of plants (Figure 39) is one of the main factors behind the construction of productivity, due to its importance in the efficiency in intercepting solar radiation. In the main cultivation systems used in Rio Grande do Sul, around 600 panicles are used per square meter to express the highest productive potential of the cultivars. In order to achieve this number of panicles, the initial number of plants for the conventional cultivars of irrigated rice ranges from 150 to 200 per square meter, and should be uniformly distributed, whereas for hybrid cultivars, the number ranges from 100 to 150 plants per square meter.

Achieving this number is also dependent upon the adoption of other agronomic practices recommended, such as sowing period, fertilization, irrigation and weed control management, pests and diseases. Besides, it is important to use high-quality seeds, since not only do they provide quicker and more uniform settlement of the crop, but also it guarantees the desired number of plants, increases efficiency in the use of fertilizers and reduces the damages caused by weeds. Very effectively, we have noticed higher availability of high-quality seeds for rice crops, because there was an expansion in the area available for the production of certified seeds, from 3,165 hectares, in the 2005/06 growing season, to 14,591 hectares, in the 2010/11 growing season (Figure 40a), whereas the total production of seeds increased from 917,170 bags (20 kg each) in the 2008/09 growing season to 1,402.160 bags in the 2010/11 growing season (Figure 40b).

However, the red rice and black rice contamination in rice crops still persists, and the seed is the main means of dissemination and propagation of weeds. When it comes to actions for monitoring the quality of the seeds used in the cultivation of rice developed by IRGA (Figure 41), we could notice that in the 2009/2010 growing season (215 samples), 52% of the samples were official and the rest comprised of seeds of random origin, which is still a high number. However, it is interesting that whereas in official seeds, 89% of the samples were free of red and black rice, in common seeds, only 44% of the samples were free from these contaminating agents. The distribution of seeds whose origin is known and the proportion of contaminated seeds vary in the rice production areas of the State (Figure 42). The Região Sul Region is the one that most uses official seeds (75%), whereas the Depressão Central Region is the one that uses this type of seeds the least (25%). Among official seeds, contamination is a reality, which varies from 12% in the Região Sul Region to 25% in the Planície Costeira Interna Region. As for the seeds of random origin, the lowest contamination rates occur in Campanha

Figure 39. Setting a suitable plant density is one main factor for high rice grain yield.

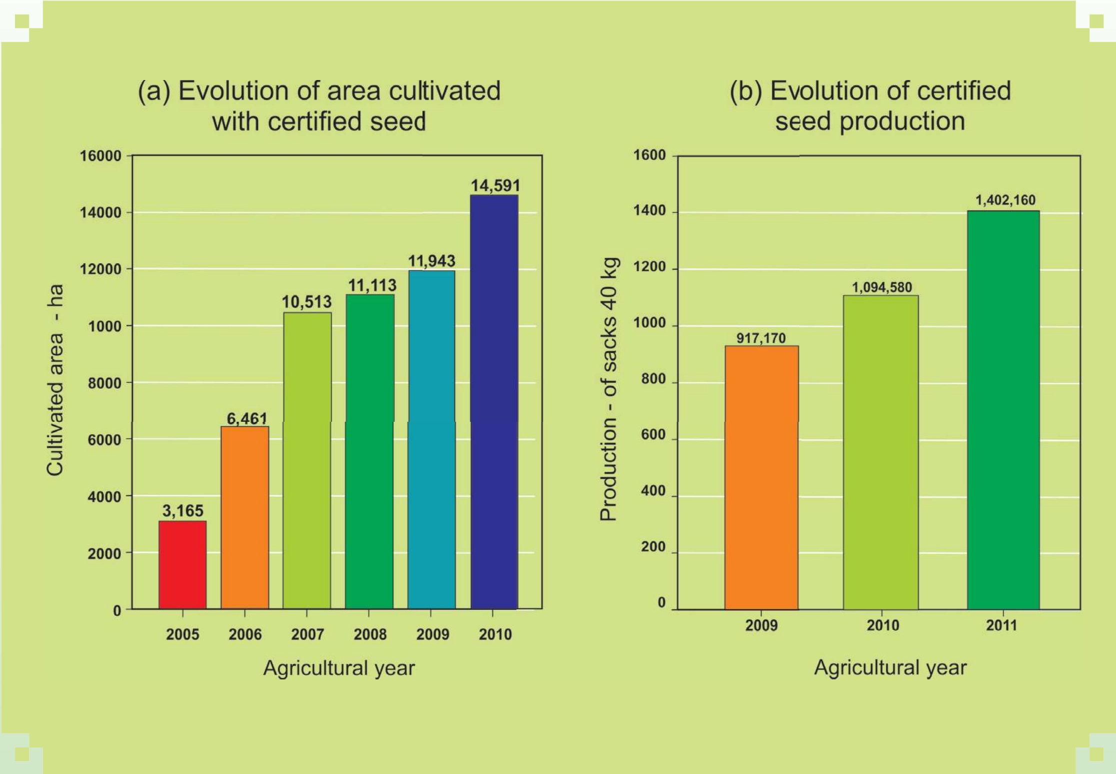


Figure 40. Certified seed is essential for setting an appropriated plants stand. In this sense, seed quality of irrigated rice has significantly improved in Rio Grande do Sul, but it is still necessary to keep on improving.

Source: DATER/IRGA (2012)

52 52% of the area in Rio Grande do Sul uses official seed and 16% of the samples are contaminated with Red rice.

48 48% of the area in Rio Grande do Sul uses seed of random origin and 61% of them are contaminated with Red rice.

Seeds quality in RS		
	Origen	With red rice
Official seed	52%	16%
Seed without origin	48%	61%

RICE PRODUCTION REGIONS
1- Fronteira Oeste
2- Campanha
3- Depressão Central
4- Planície Costeira Interna
5- Planície Costeira Externa
6- Zona Sul

Figure 41. Official seed use in irrigated rice has increased whereas the use of seeds without origin, contaminated with Red rice grains, has decreased with the Projeto 10 implementation in all rice producing regions in the State of RS.

Source: Seeds team EEA/IRGA (2012)

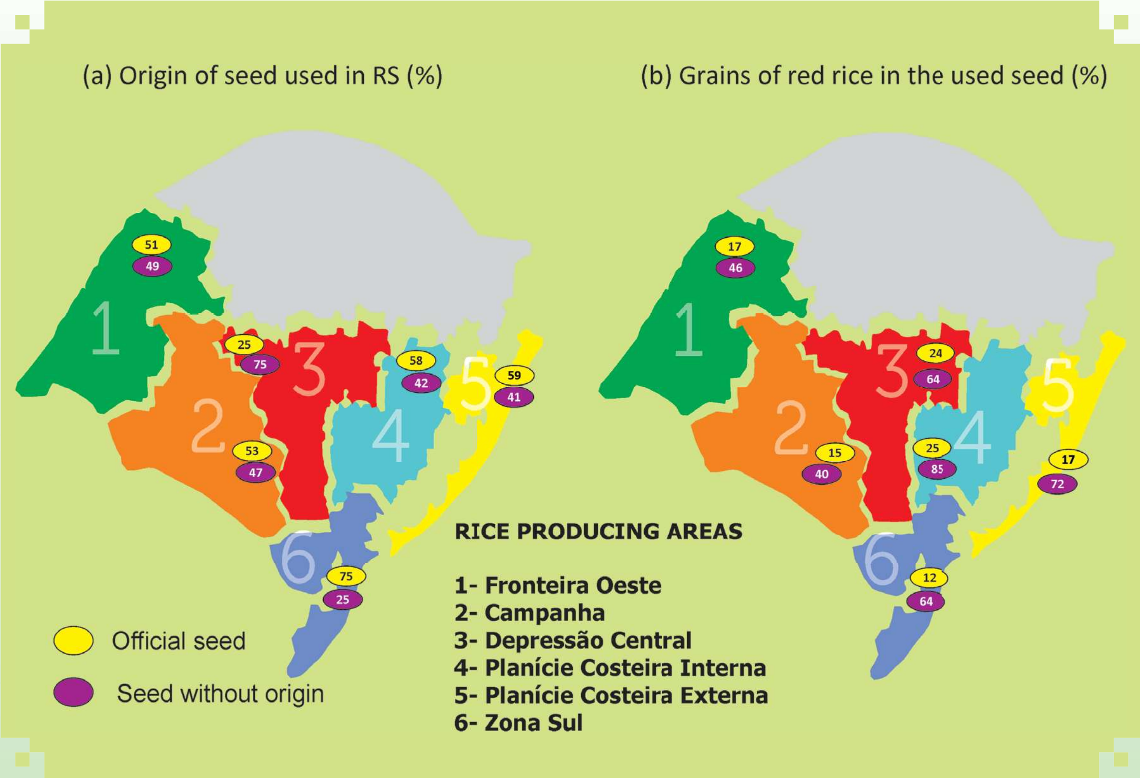


Figure 42. Use of official seed and seeds without origin in rice fields varies according to the rice producing region.

Source: Seeds team EEA/IRGA (2012)

Region, 40%, and the highest ones in the Planícies Costeiras, 72% in the Planície Costeira Externa Region, and 85% in the Planície Costeira Internal Region (Figure 42).

To reach the number of plants desired, it is recommended to sow from 60 to 100 kg/ha of seeds, for conventional cultivars, and from 40 to 50 kg/ha, for hybrid cultivars, regardless of the tillage system and the sowing season used (Figure 43). This number of seeds is a lot higher than necessary in order to reach the number of plants desired from 150 to 200 plants/m^2 and from 100 to 150 plants/m^2, for conventional cultivars and the hybrids, respectively. This means that if soil tillage and sowing depth are adequate, it is possible to sow smaller number of seeds (80 kg/ha). The proper operation of sowing machines, sowing speed and the operator's training are also important for an adequate sowing. Special care, such as adequate depth of sowing (Figure 44) and the treatment of seeds with fungicides, must be taken in order to reach the desired density of plants in the beginning of the recommended period (up to Oct 10). After this date, data show that there are no advantages in the treatment of seeds with fungicides (Figure 45).

With high sowing density, the plants compete for light and nutrients, due to the larger number of plants per square meter, as there can be higher incidence of diseases and lodging of plants, especially when doses of fertilizers for high productivity are used. Farmers who use low density of seeds end up saving up when buying them; hence they can buy higher-quality seeds and/or use more fertilizers and, as a consequence, increase crop productivity and profitability. The higher or lower number of seeds used within certain limits will not interfere in the productivity, but it is necessary to use more intense fertilization in order to reach higher productivities.

Among the management alterations proposed by Projeto 10, the use of a lower number of seeds has become more popular, but farmers still encounter a huge resistance concerning the adoption of this practice. Despite all advantages resulting from the use of lower density in sowing, the last Census of Rice Crops of the State of Rio Grande do Sul designed by IRGA in the 2004/05 growing season (IRGA, 2007), evidences that the average density of seeds used is still very high, around 200 kg/ha, and many farmers use 240 kg/ha or more. However, during the latest growing season (2011/2012), most farmers started to use among 100 and 120 kg/ha of seeds. Anyway, it is still possible to reduce the sowing density to even lower figures (80 to 100 kg/ha), as long as other management practices recommended for the staple are used. In order for that to happen, it is necessary to note that a sowing machine with a line spacing of 17 cm, regulated for a density of 60 kg/ha distributes 38 seeds per meter and around 240 seeds per square meter (Figure 43). In the occurrence of only 150 seedlings per square meter one of each with three ti-

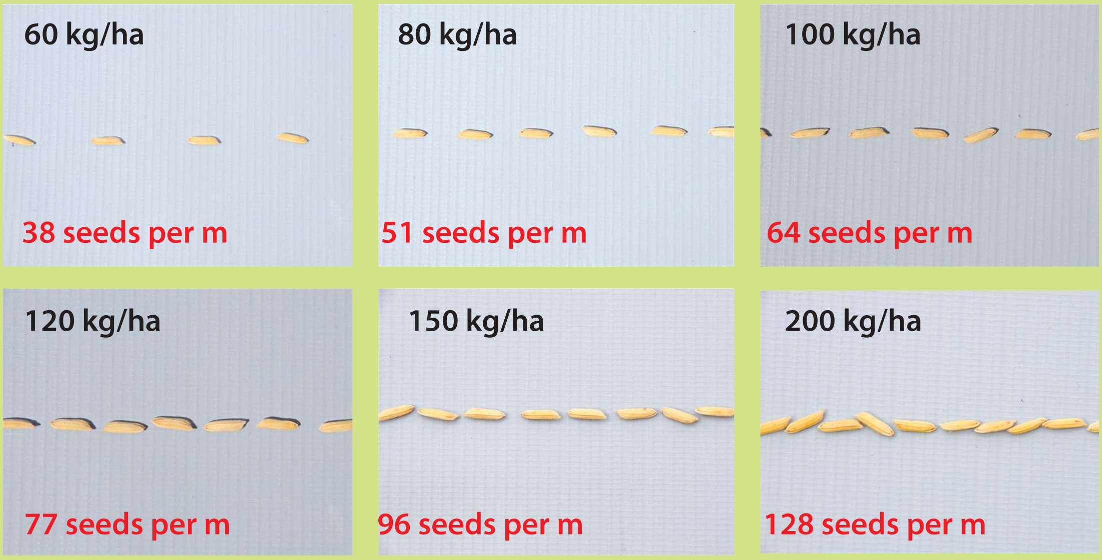


Figure 43. An adequated plant stand is obtained with the use of 60 to 100 kg per hectare of good quality seed.
Note: a line spacing of 17cm was used for obtaining these figures.

Source: Agronomy team, EEA/IRGA (2012)

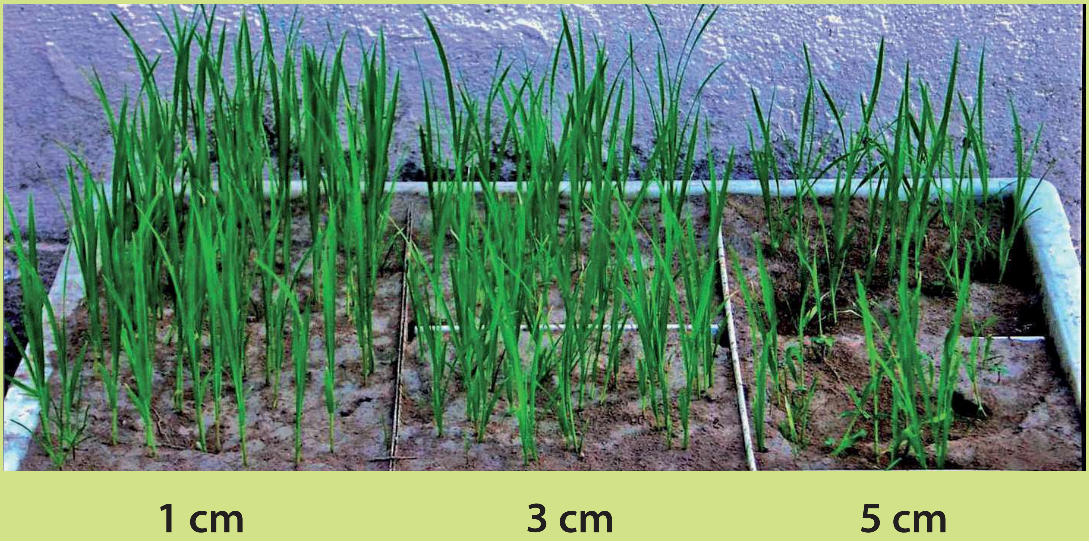


Figure 44. With lower sowing depth, higher the number of rice seedlings emerged and the better is their development.

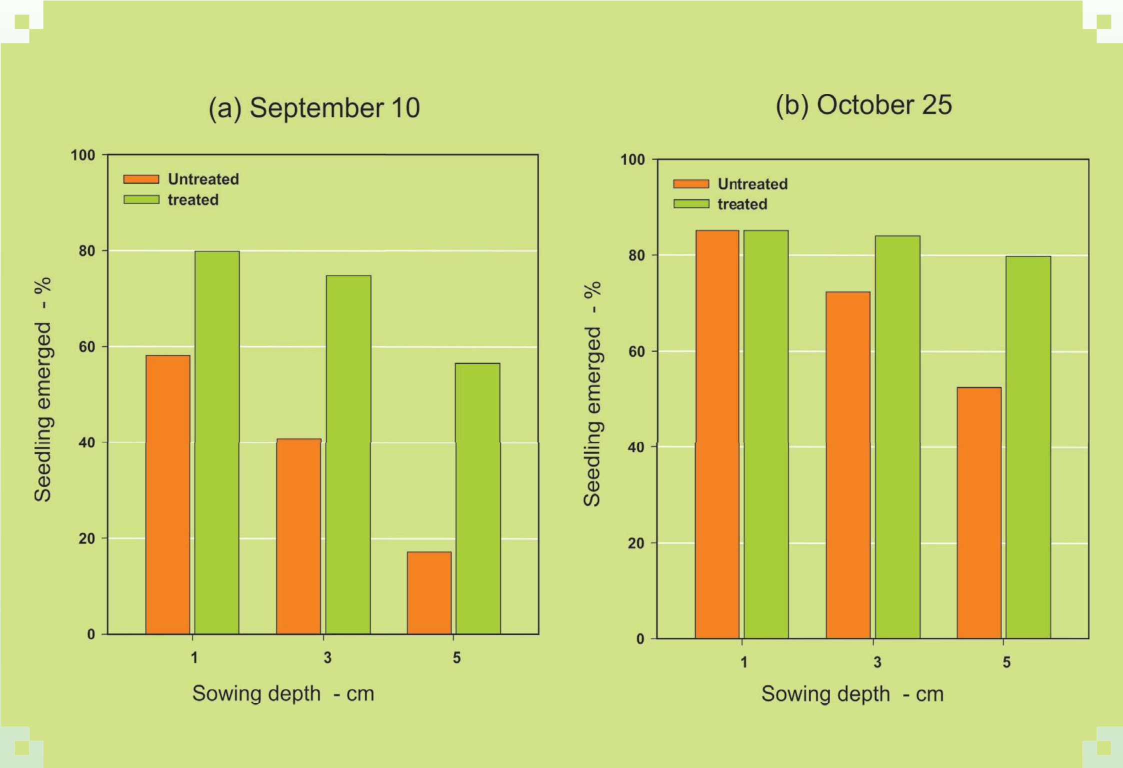


Figure 45. Sowing depth lower than 3 cm and seed treatment with fungicides are important practices for the establishment of an adequate plant stand in areas sowed in the beginning of the recommended period.

Source: Agronomy team, EEA/IRGA (2012)

llers, we can have 600 panicles per square meter, which is enough to harvest 10 t/ha of grains.

The reduction of the depth of sowing was a decisive factor to reduce the number of seeds used in rice crops in State of Rio Grande do Sul. Sowing machines used to be equipped with depth constrainers in the 5.0 cm cutting discs. This made sense, when sowing was conducted at a later period, in mid November and December, or even in January, when the soil was moist dry. Farmers used to place seeds in areas where the soil was still moisty so that germination and emergence could occur. However, when sowing occurs during the recommended period, in September, October and early November, soil moisture is usually not a limiting factor. Sometimes it is quite the opposite; there is too much moisture and consequently, lack of oxygen for germination of seeds. Another important factor in seed germination is the temperature of the soil, which is lower when compared to later periods of time. In order to combine these three factors, soil moisture temperature and oxygen availability, it is recommended that during sowing be conducted in the right period and at a maximum depth of 2.0 cm (Figure 44). Actually, with the use of the depth constrainer in the 3.0 cm cutting disk, seeds stay at a distance of 1.5 cm from the soil surface.

Seed treatment with fungicides for protection from soil fungi is recommended for sowing conducted until mid-October, once the sowing period and emergence might last for more than 20 days. However, it is important to stress that the depth of sowing is more important than the seed treatment for the suitable establishment of seedlings when sowing occurs until mid-October (Figure 45). When sowing occurs in lower depths at the beginning of the recommended period, there is more oxygen in the surface and the temperature is higher. Soil moisture is usually not a problem at this time.

3.1.4. Fertilization and liming management

Among all of the agronomic recommended practices by Projeto 10, correct fertilization is undoubtedly the factor that most farmers show resistance to adopt. This is because it is the only recommended practice by Projeto 10 in which the farmers needs to invest and, as an individual practice, it is the most costly one, as the cost is proportionate to the fertilizer applied rate.

Fertilization of irrigated rice crops in the South of Brazil has been somehow neglected. This, besides under conditions of low productivity, the response to fertilization was low and uncertain (Figure 46a) and determined by the lacking management used. As a result, fertilization was basically intended to replace the exported nutrients by grain. However, because of recent changes, mainly in the management practices, the responses of irrigated rice to fertilization have been significant, consistent and economically valuable, being one of the most important factors for the "construction" of productivity (Figure 46b). Such results are against the prevailing sense, which is still found among part of farmers, extensionists and researchers. Among them, there is a mistaken "consensus" that irrigated rice would not respond to fertilization. This "belief" was determined by deficiencies in its management. This occurred in both production and experimental areas, having low productivities, even with the use of cultivars with high productive potential (Figure 46a).

Recent results from research conducted by IRGA (Figure 46b) show that within Integrated Management, the rice response to fertilization increases with the fertilizer applied rates, until a certain limit. It is possible to obtain average gains of 4.3 t/ha and up to 6.0 t/ha by fertilization in different genotypes (cultivars, hybrids and bloodlines), in relation to treatment without fertilization, in several types of soils, locations and growing seasons. This could also be noticed in field crop areas, with a positive relationship between productivity and rate of base (Figure 47a) and top-dressing fertilization (Figure 47b). Figure 48 shows the current rice response to fertilization levels in the State of Rio Grande do Sul, under integrated soil and crop management.

Another improvement in this area was the different response of cultivars of irrigated rice to fertilization, as shown by results from 23 experiments conducted by IRGA leading to form two genotype groups (Figure 49). In Group 1, comprised by BR-IRGA 409, IRGA 424 and IRGA 428 (Bloodline 2913) and Arize QM 1010 cultivars, the gain obtained with fertilization was of 4.7 t/ha, with an average productivity of 10.7 t/ha. In Group 2, by IRGA 422 CL, IRGA 417, IRGA 423 and BR-IRGA 410 cultivars, the gain was smaller, of 3.1 t/ha, with an average productivity of 8.2 t/ha. Based on these data and fertilization costs, even being high, and considering two prices of rice, an unfavorable one (BRL19.00/bag) and a favorable one (BRL26.00/bag) (Table 7), the response to fertilization was always positive, ranging from 52 to 71 bags/ha in Group 1 cultivars and, from 32 to 41 bags/ha in Group 2. As shown, the produc-

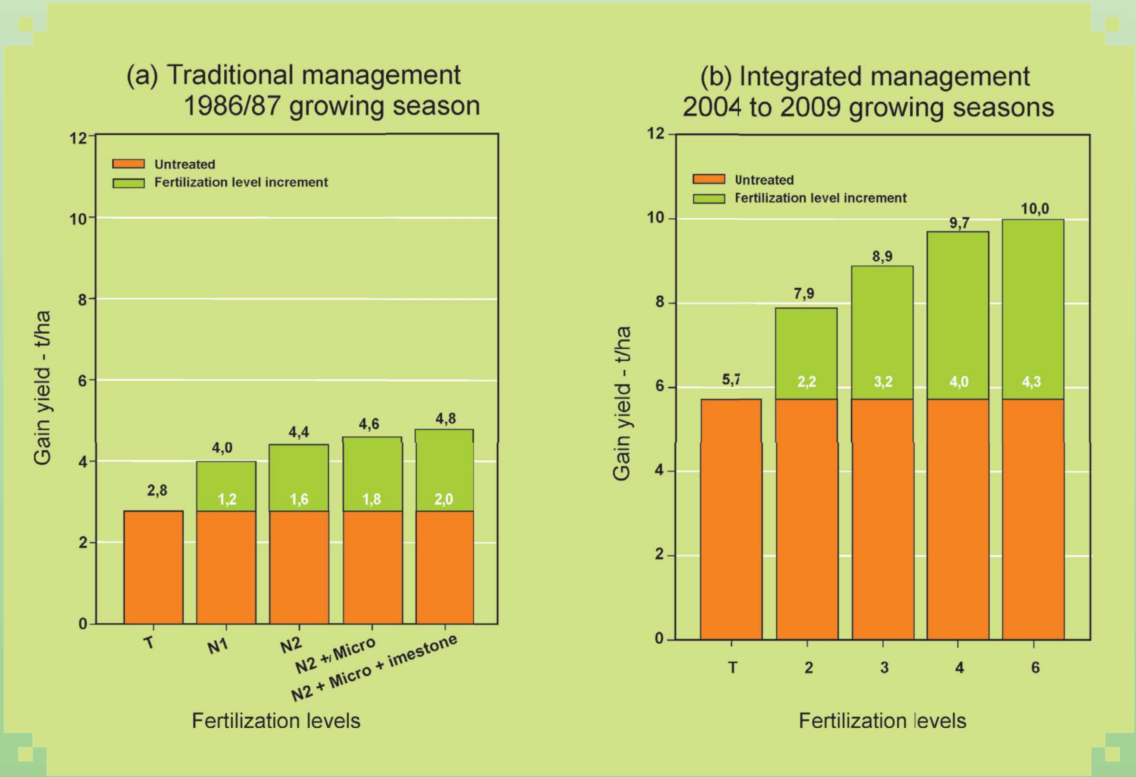


Figure 46. Grain yield and response to fertilization are higher with the integrated management of cultural practices, in an average of 23 field experiments, compared to those obtained in fields where traditional management was conducted.

Source: Anghinoni (2009)

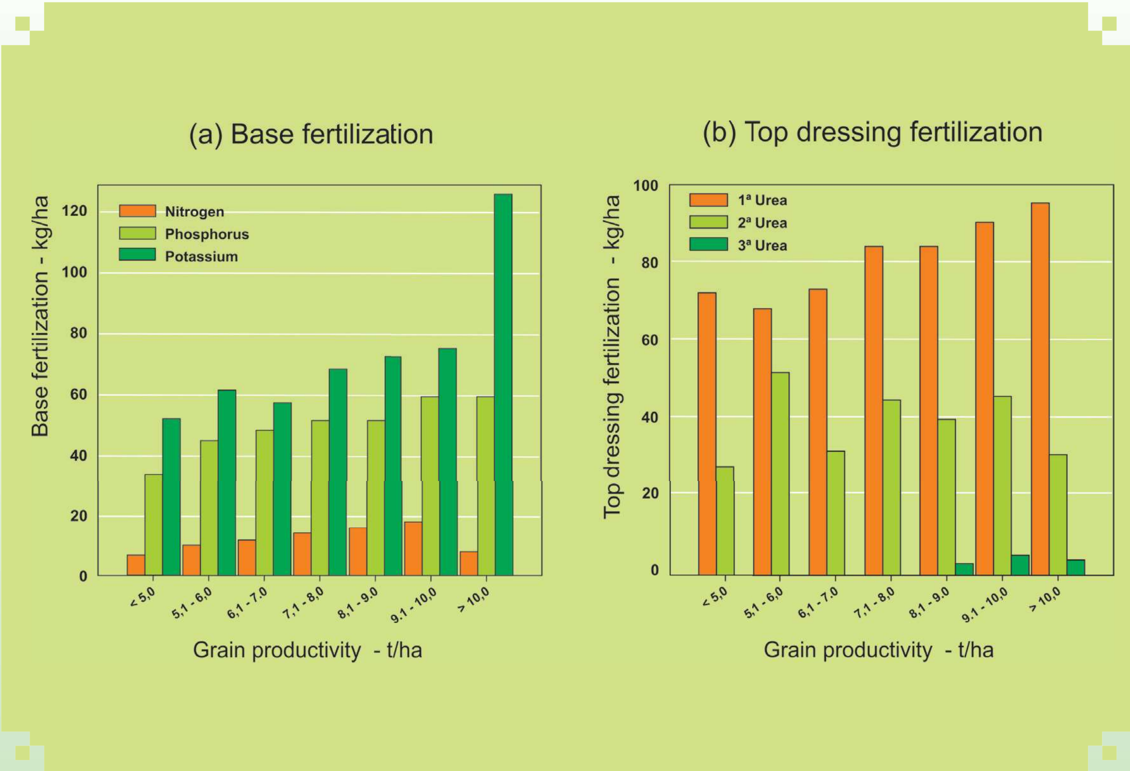


Figure 47. Higher rice grain yield are obtained by farmers that use higher rates of fertilizers in sowing and in top dressing (Zona Sul, 2010/11 growing season).

Source: DATER/IRGA (2012)

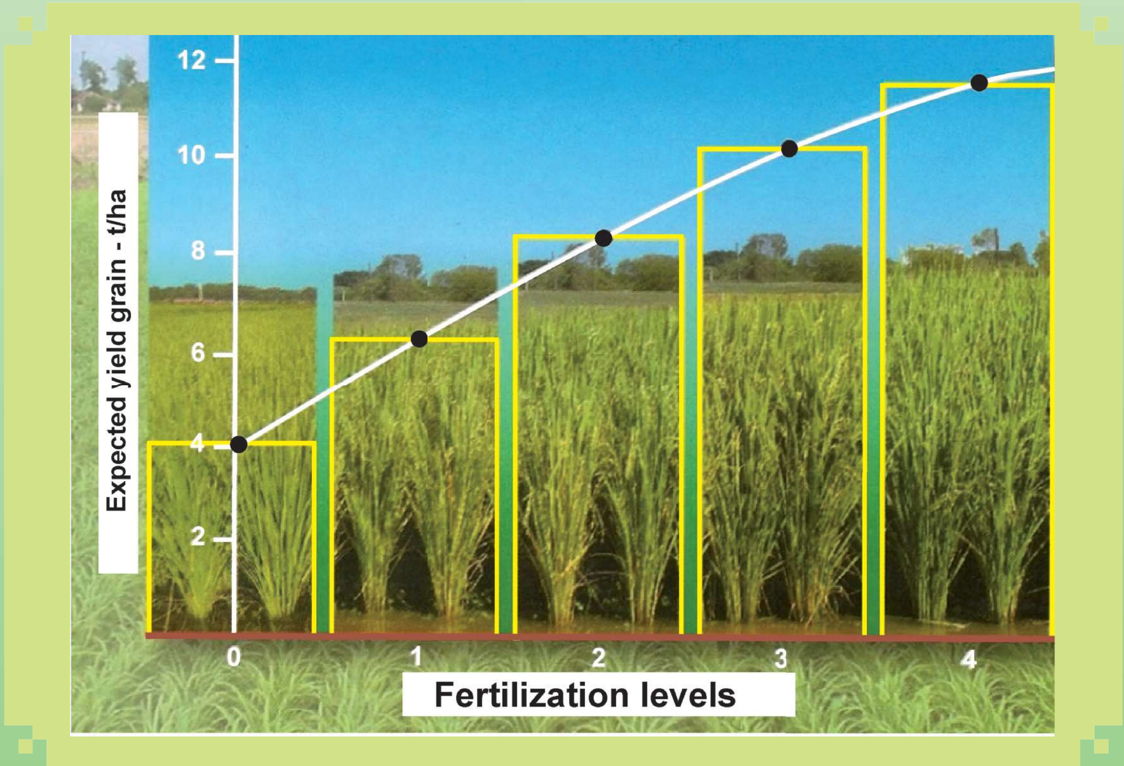


Figure 48. The response of irrigated rice to fertilization is significantly higher with the adoption of integrated management and other cultivation practices.

Source: Agronomy team, EEA/IRGA (2012)

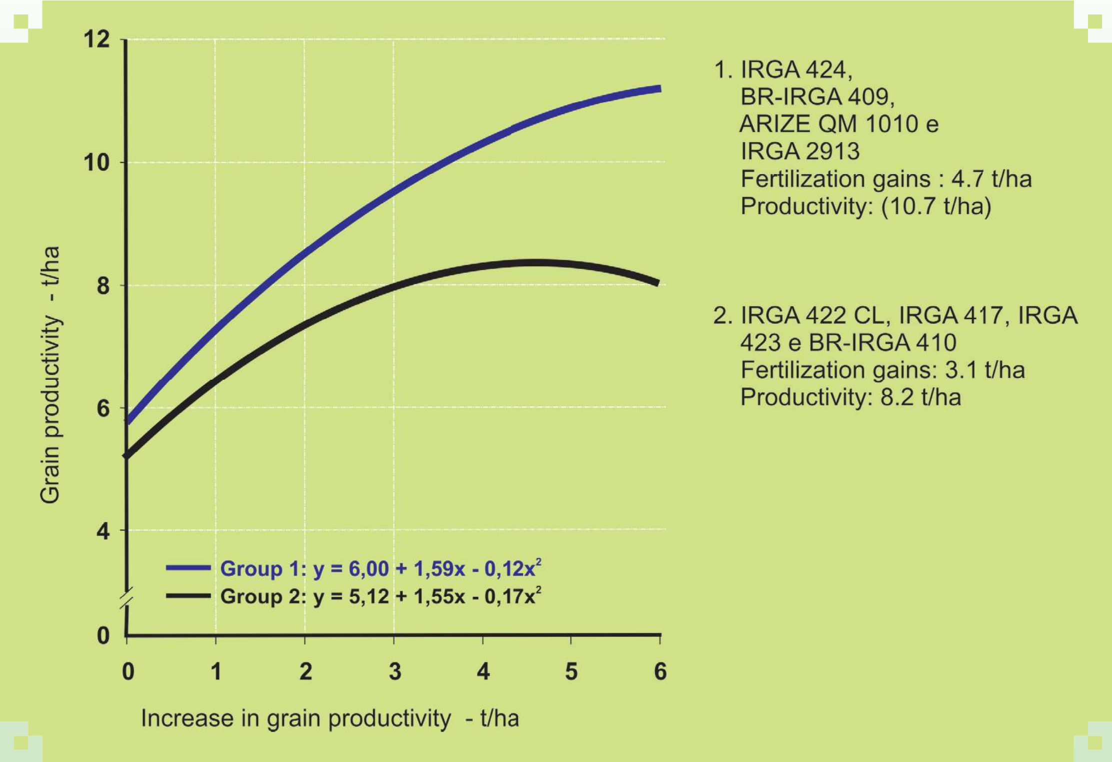


Figure 49. The irrigated rice response to fertilization in Rio Grande do Sul varies according to the cultivars used.

Source: Agronomy team, EEA/IRGA (2009)

tive potential of conventional and hybrid cultivars, soil management and climate and climate conditions determine distinct productivity potentials and response to fertilization.

The fertilization recommendations for irrigated rice were altered in 2010 for **different response expectations to fertilization** (SOSBAI, 2010). The level of response to fertilization must, then, be based on the level of adequacy of all factors that determine rice productivity.

The new SOSBAI (2010) recommendations are presented in next tables according to the expectations of **Medium** and **High** response to fertilization, complemented with footnotes for **Low** and **Very High** expectations**.** In order to be used in Projeto 10, the nitrogen, phosphorus and potassium recommendations are presented in next Tables. Recommendations for **Very high** expectations

Table 7. The use of fertilization brings good results, especially for Group 1 cultivars

Cultivar	Productivity increase		Cost of fertilizer[3]	Selling price of the bag of rice	
				BRL 26.00	BRL 19.00
	t/ha	bag/ha	BRL/ha	Net gain - bag/ha	
GROUP 1[1]	4.7	94	583.00	72	58
GROUP 2[2]	3.1	62	424.60	60	32

[1]Fertilization using 350kg/ha of the formula NPK 5-20-30 + 255kg/ha of urea;
[2]Fertilization using 260kg/ha of the formula NPK 5-20-30 + 180kg/ha of urea;
[3]Cost of BRL1,010.00/t of the formula NPK 5-20-30 and BRL900.00/t of urea.

Source: Agronomy team, EEA/IRGA (2009)

only should be done for exceptional cropping conditions. More detailed indications on the management of fertilization and liming application are presented in the Research Technical Recommendations for Rice (SOSBAI, 2010).

a) Nitrogen fertilization

Nitrogen recommendations (Table 8) are carried out according to the level of organic matter in the soil and for **High and Very High** expectations. Nitrogen supply must satisfy rice demands, especially at the growth stages of the plant in which the yield components are defined (number of panicles per square meter, number of grains per panicle and weight of grains). Hence, in dry soil sowing systems, it is recommended to use between 10 and 20 kg/ha of nitrogen in the sowing and the rest in top dressing. In the pre-germinated system, all nitrogen must be applied in top dressing. This application should usually be applied twice (Figure 50a). The first (soil dried application) with 2/3 of the recommended rate, when the main culm presents three to four extended leaves, and the second one, with 1/3 of the rate must be applied on the water layer at the beginning of the expansion of the first nod of the main stem (Figure 50b). Attention should be given for the cycle of the cultivars and environmental conditions. After setting the number of panicles per area and spikelets per panicle, nitrogen application has low efficiency. The first top dressing fertilization in the dry sowing system must be broadcast applied (Figure 51), preferably in one day, up to no more than three days prior to irrigation (first application) or on water layer (second one). In this application, water inlet and outlet must be interrupted for a period of three to five days; the most recommended nitrogen sources for top dressing fertilization are urea and ammonium sulphate.

The response of irrigated rice to top dressing nitrogen fertilization and the efficiency in the use of the applied nitrogen depends on the sowing period and the response is lower when sowing is done after November 10, compared to when sowing is conducted in the recommended period (Figures 52 and 53).

b) Phosphate fertilization

Phosphate fertilization (Table 9) is established according to the interpretation range for available phosphorus in the soil for **High** and **Very High** responses to fertilization expectations.

In dry soil sowing, phosphate fertilizers must be pre-

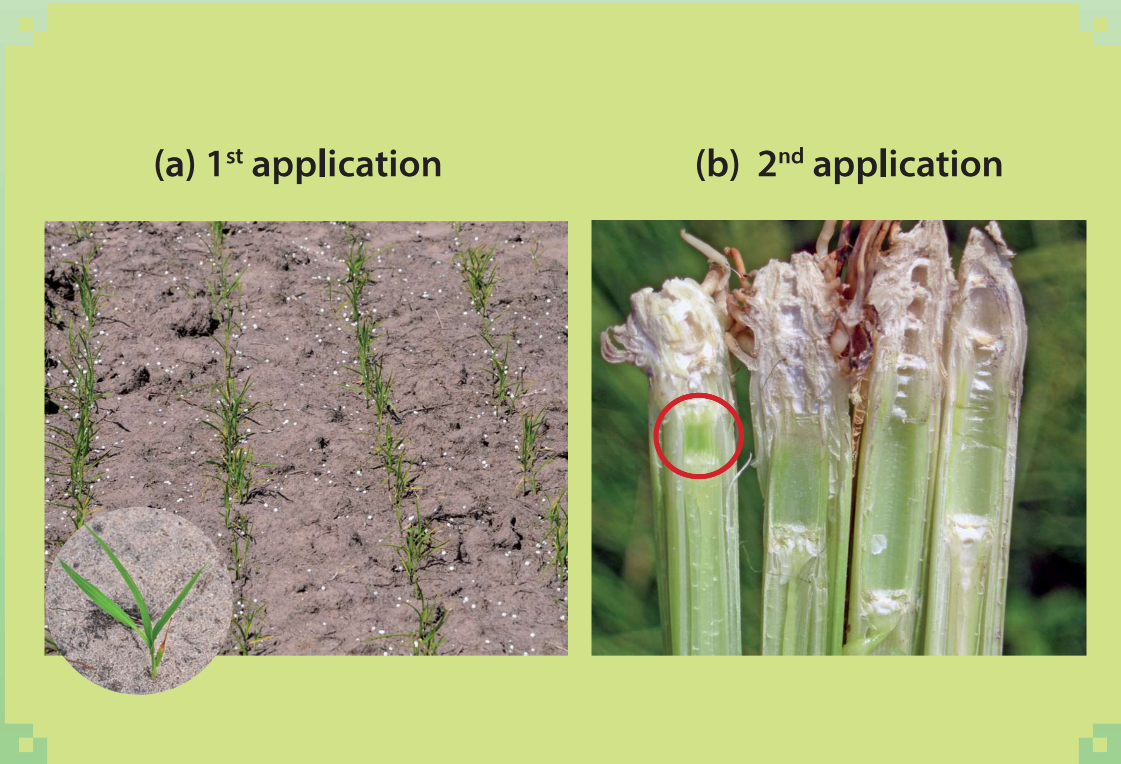


Figure 50. Most top dressing nitrogen fertilizers (2/3) in irrigated rice must be applied in dry soil, when the main stem has three to four leaves. The rest must be applied in a water layer at the beginning of the expansion of the first nod of the main culm.

Figure 51. The efficiency of top dressing nitrogen fertilizer in irrigated rice is higher with the application of the first rate in dry soil, immediately before the beginning of irrigation.

Table 8. Nitrogen fertilization[1] recommendations for irrigated rice, considering the content of organic matter in the soil and the expectations of response to fertilization

Content of organic matter in the soil	Expectation of response to fertilization	
	High	Very high
%	------------------------ kg/ha of N -----------------------	
≤ 2.5	120	150
2.6 - 5.0	110	140
> 5.0	100	130

[1] The rates indicated in the table may be reduced in up to 30 kg/ha of nitrogen, for medium response to fertilization, taking in consideration the use of cultivars of lower response and the history of the crop, with previous cultivation of legumes, high plant development and unfavorable expectations of weather conditions and soil and crop of management level.

Fonte: Adapted from SOSBAI (2010)

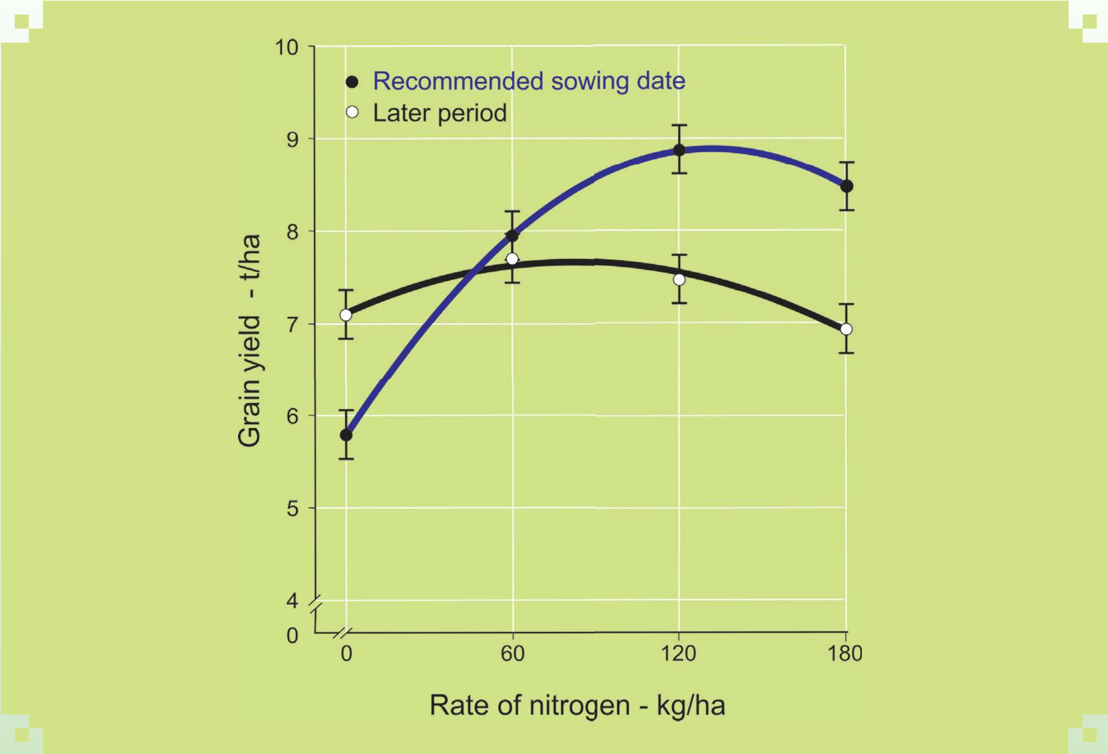


Figure 52. Higher responses of irrigated rice to nitrogen fertilization occur in the areas sown at the recommended time.

Source: Freitas et al. (2008)

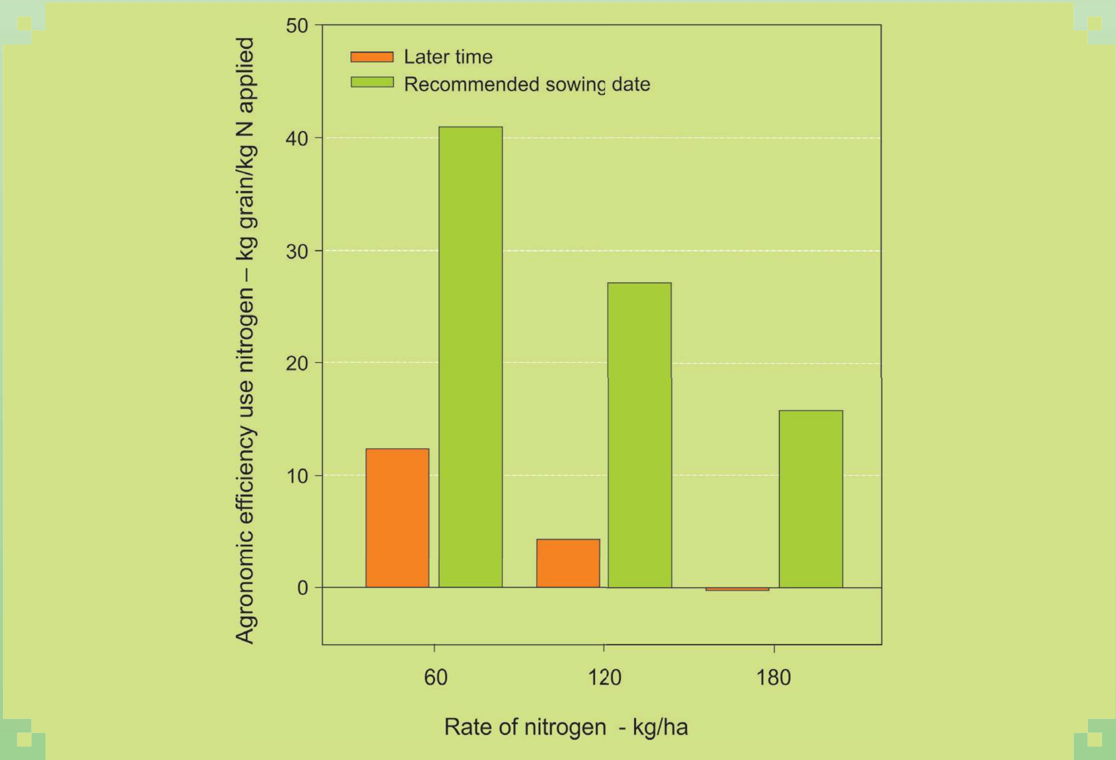


Figure 53. The efficiency of nitrogen is higher when rice is sowed at the recommended time.

Source: Freitas et al. (2008)

ferably band applied at sowing. In the pre-germinated system, fertilizers must be applied and incorporated in the soil at the mud formation or after the leveling of the area, before sowing. In this cultivation system, the area should not be drained after sowing in order to avoid water, soil and nutrient losses, which generate a negative environmental impact and economic loss to farmers. Application of phosphate fertilizers prior to soil tillage in the pre-germinated system may stimulate the development of weeds, which may damage the initial development of rice plants.

c) Potassium fertilization

Potassium recommendations take into consideration the soil cation exchange capacity ($CEC_{pH\ 70}$) classes: < 5.0 (Low); 5.0 – 15.0 (Medium); and > 15.0 (High) $cmol_c/dm^3$, for the different potassium interpretation classes, as indicated in the Research Technical Recommendations for Rice (SOSBAI, 2010) bulletin.

Table 9. Phosphate[(1)] fertilization recommendations for irrigated rice, considering the level of phosphorus (P) in the soil and the expectation of response to fertilization

Interpretation of phosphorus content in the soil	Expectation of response to fertilization	
	High	Very high
	----------------------- kg/ha of P_2O_5 -----------------------	
Low	60	70
Medium	50	60
High	40	0
Very High	≤ 40	≤ 50

[(1)]The rates indicated in the table may be reduced up to 10 kg/ha of P_2O_5 considering the medium response to fertilization expectative.

Source: Adapted from SOSBAI (2010)

The recommended rates of potassium (Table 10) are higher than those previously recommended (SOSBAI, 2007). This happens because not only they depend on available potassium levels in the soil, but also on cation exchange capacity, which determined the use of distinct critical levels. The recommendations increase with the cation exchange capacity for the same interpretation class of this nutrient in the soil (Table 10).

Potassium fertilization may be partially applied in order to avoid potassium losses, especially when rates above 60 kg/ha of K_2O are recommended for Low CEC soils. In this case, half the rate is applied during soil tillage (pre-germinated) or sowing (dry soil) and the other half in top dressing, in the water layer at the beginning of the expansion of the first nod of the main culm (Figure 50b), along with the second nitrogen application. Potassium application before sowing can be an alternative in large scale crop area and/or when there are not enough sowing machines or workforce to enable the sowing to be made at the right time. However, this practice presents risks of losses of this nutrient in low CEC soils (sandy ones and those with low levels of organic matter), especially when spring rainfall occurs after fertilizers are applied in high slope areas, such as those in the Fronteira Oeste and Campanha Regions.

For the fertilization management, it is necessary to consider the interaction between plant nutrition with the productive potential of cultivars and with other agronomic practices, such as the sowing period, weed and pest control and irrigation water management (Item 3.1.5). Making nutrients available in a balanced way at the right moments for the establishment and development of plants is as important as fertilization.

Base fertilization, with formulas containing phosphorus and potassium, must be done during the sowing period whenever possible. In dry soil sowing, fertilizers can be applied at once, but preferably band applied, because it is more efficient (Figures 54 and 55). Root growth is favored by the localized application of nitrogen (NH_4) and soluble phosphorus (superphosphate) that stimulate growth of rice seedlings, giving them higher chances to compete with weed plants. When high rates are necessary, fertilizers containing N and P (MAP and DAP) are good choices to save time during sowing. This can be done as long as the potassium fertilizer has been previously applied or the available potassium level in the soil is Medium or High. In this case, the fertilizer (chloride and urea) can be applied as top dressing.

In the pre-germinated system, fertilizers must be applied at once and incorporated into the soil at formation of mud or after the area is leveled. In most rice production areas of the State, rice is cultivated in highly acidic soils, with low exchangeable calcium and magnesium levels. When dry soil sowing system is used, lime is required at rates indicated by the SMP method in order to increase the soil pH to 5.5 (SOSBAI, 2010). This is very important when the beginging of irrigation exceeds four weeks because of low temperatures that limit the plant growth. In the pre-germinated and seedling transplantation systems, liming is mostly recommended to supply Ca and Mg, when the exchangeable levels are lower than 2.0 and/or 0.5 $cmol_c/dm^3$, respectively. The challenge now is to determine the response given by liming as a method for correcting soil acidity in dry soil sowing system with early irrigation when the main stem has three to four expanded leaves. When rice is cultivated in succession to pasture or plant cover or in rotation (soybeans, corn, etc.), it is recommended to apply lime to increase the soil pH to 6.0, as required by the

Table 10. Potassium fertilization[1] recommendation for irrigated rice, considering the level of potassium (K) of the soil and the expectation of response to fertilization

Interpretation of the level of K in the soil	Expectation of response to fertilization	
	High	Very High
	----------------------- kg/ha of K_2O ----------------------	
Low	90	105
Medium	70	85
High	50	65
Very High	#50	#65

[1] For soils that have high CTC $_{pH70}$ (above 15.0 $cmol_c/dm^3$) 20 kg/ha of K_2O should be added to values indicated in the table; [2] The rates indicated in the table can be reduced in up to 15 kg/ha of K_2O, taking into consideration the expectation of medium response to fertilization.

Source: Adapted from SOSBAI (2010)

most acidity affected crop of the system, as indicated by SOSBAI (2010).

The investments made in fertilization and liming are worthless if sowing is not done at the right time, if weed control is not efficient, if irrigation starts late or if the top dressing nitrogen is not applied at the recommended stages. Fertilization will only have positive results if these and other factors do not present constraints, for instance, late sowing (Figure 56).

The most recent fertilization recommendations (SOSBAI, 2010) show significant progress in relation to previous recommendations, since now they are the same for the distinct sowing systems (dry soil and pre-germinated) and enable adjustments for different climate and soil conditions, productive potential of cultivars, level of management and availability of farmer's financial resources. This represents a great improvement in the fertilization recommendations as compared to all other crops cultivated in the State.

Even if the consumption of fertilizers has increased in the latest years, as seen in the Census of the Rice Crops (IRGA, 2000; 2007), and if we could notice the high economic potential of irrigated rice with fertilization (Table 7), it is necessary to improve the nutritional status of rice plants cultivated in the State. Attention may be necessary for more balanced rates of fertilizers, especially in locations whose productivity is below the regional average. To determine the nutritional balance and status of deficiency or toxicity, especially for micronutrients through foliar diagnosis becomes a challenge especially in farms with a high technological level.

Another challenge is related to the application of higher rates of fertilizers at rice sowing, especially in cultivars that have high response to fertilization. This practice may be harmful to seeds because of salinity effects, especially in dry sandy soils, during the sowing-emergence sub period. One of the alternatives to avoid this potential harm is to apply part of potassium fertilizers as top-dressing, along with nitrogen, as previously shown.

3.1.5. Water management

The correct management of irrigation water (Figures 57 and 58) is one of the most important factors for the success of Projeto 10. The magnitude of this importance lies on the fact that it is a process of rice production within a conflictive use of water due to other demands from the urban society and interference in ecosystems around the cropping areas. This turns the optimization of the use of water by the rice a priority issue in the rice production process, which is seeking for technical and economic alterna-

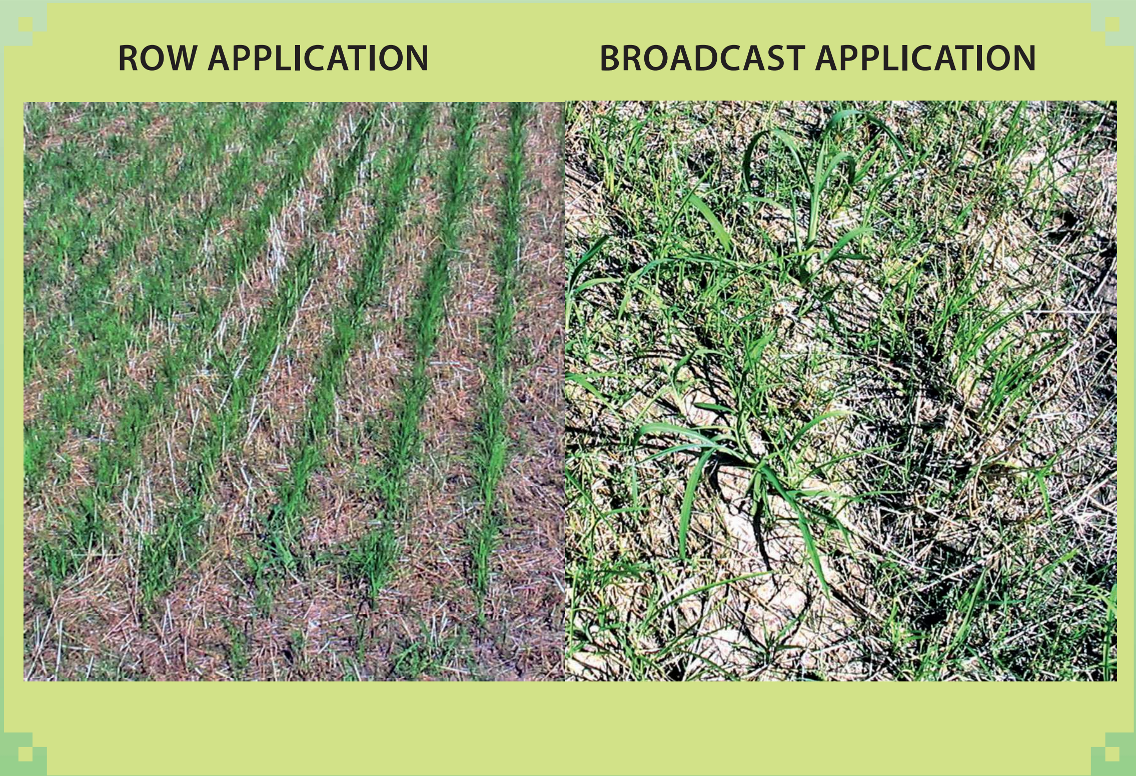


Figure 54. Irrigated rice plants grow with the fertilizer application in the sowing line, whereas weeds are favored with broadcast fertilization.

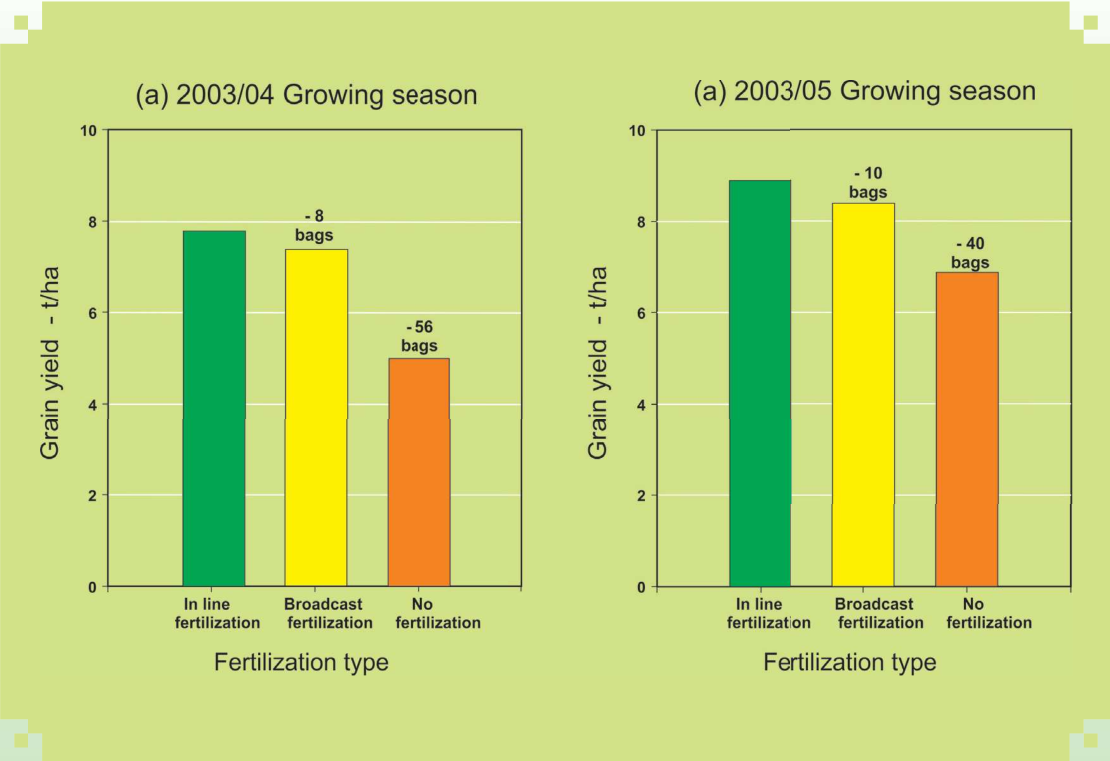


Figure 55. The rice grain yield is higher with the fertilizer application in the sowing row.

Source: Agronomy team, DATER/IRGA (2012).

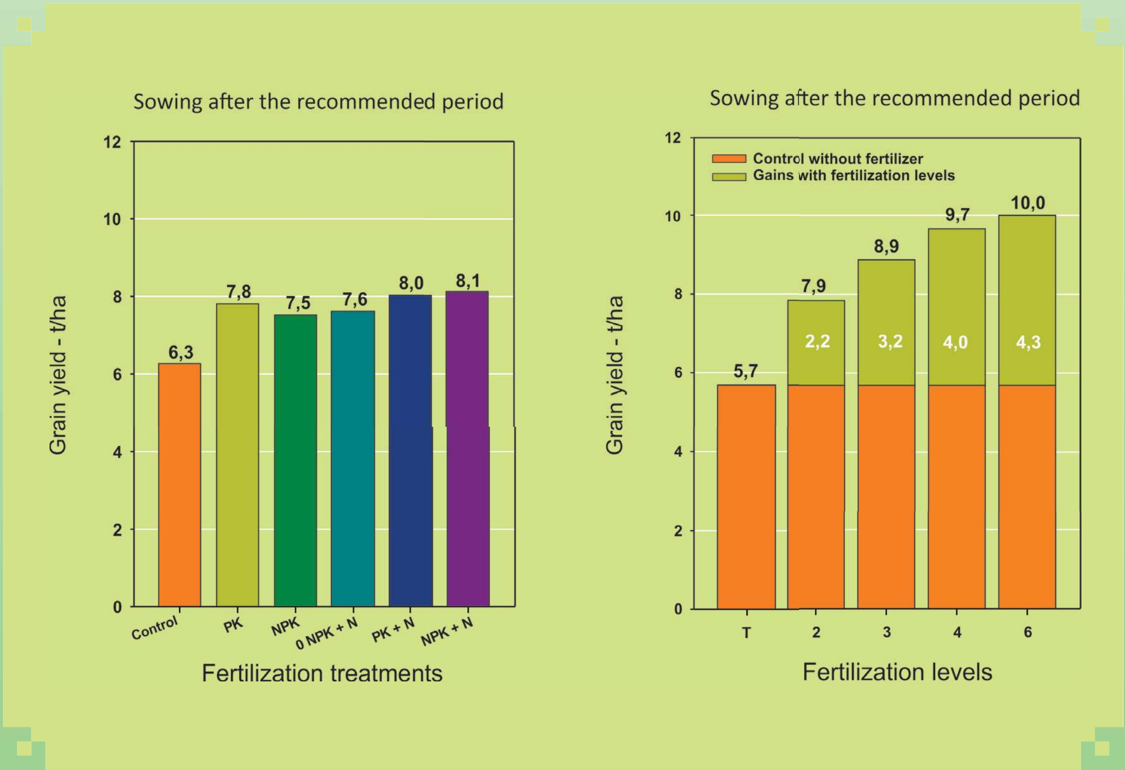


Figure 56. The response to fertilization is higher when rice is sowed at the recommended period.

Source: Agronomy team, EEA/IRGA (2012)

tives for its environmentally sustainable management.

In order to obtain higher efficiency in the use of water, that is, higher quantity of grains per cubic meter of used water, it is recommended to start using it as early as possible, at the stage in which the plant's main stem has from three to four expanded leaves. In this stage, rice plants are high enough to stand a water layer from 5.0 to 10.0 cm. The irrigation must occur right after the application of

Figure 57. In order to ensure high rice grain yield, it is necessary to adopt a dimensioned irrigation system to rapidly irrigate the crop.

Figure 58. The ideal rice development stage to start flooding is when the main stem has three to four expanded leaves.

herbicides and the first application of top-dressing nitrogen fertilizers. The early use of irrigation water enables a more efficient weed control, since herbicides are applied when the weeds are not fully developed. In this condition, there is an interaction between irrigation and herbicides, thus avoiding regrowth and emergence of new weeds and lower rates of defensives may be used. Other benefits resulting from the early use of water are: the prompt nutrient availability for rice plants, more efficient control on insects and pests and diseases and the regulating effect on soil temperature. Hence, the earlier the irrigation, the earlier rice plants will be able to use its benefits. Research results has shown that for every 10 days of irrigation delay, the plant's development gets reduced (Figures 59 and 60) and there is a loss of about 1.0 t/ha in grain productivity (Figure 61).

One of the essential requirements to enable the early use of water by crop is the area's adequacy. In this operation, the soil is subject to a systematization process, as previously shown (item 3.1.1). In order for the water come as promptly as possible to the entire crop area, it is also necessary for the irrigation system to be in full operation conditions to adequately distribute water and avoid block by block irrigation. After the introduction of water, it is ideal that this water layer be uninterruptedly maintained at the same level. The decision to stop irrigation is hard to be made, due to factors such as area's steepness, type of soil and weather conditions. The duration of the sub period for grain formation and filling is of about 30 days when grains reach the highest accumulation of dry mass and start to lose water more rapidly. Until this moment, plants are absorbing water, but there is no need to use a water layer in the soil.

Another improvement in irrigation management, especially in the pre-germinated system is related to the permanent maintenance of water in the crop, which avoids loss of water and becomes an efficient strategy for the control of red rice, once soil oxygenation due to draining stimulates weed plants emergence. In addition, this practice reduces water losses and avoids the transportation of soil particles and nutrients that impoverish the soil and cause silting in draining channels and wellhouses hydric sources.

Because of that, it is not very plausible to set a date or moment to stop irrigation without reducing grain yield and quality. In this scenario, the experience of farmers and technical assistants should be decisive to define the best moment to stop irrigation, considering that plants continue to absorb water up to around 25 days after flowers development. The ceasing of the process must be done in a way that crops do not need to be drained in order to be harvested. Draining should be avoided in order to avoid high irrigation costs, water, soil and nutrient waste, especially potassium. The harvest must be preferably con-

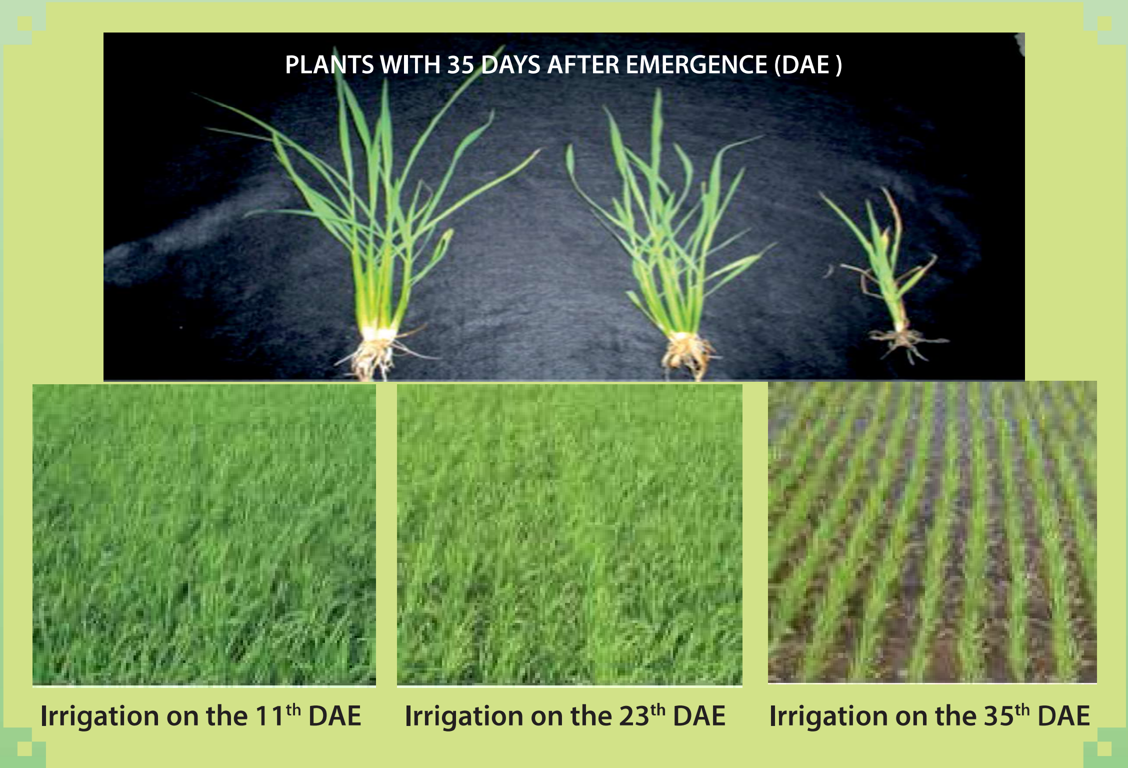


Figure 59. The early crop flooding is one of the main factors to reach higher grain yield of irrigated rice.

Figure 60. Delayed crop flooding reduces plant's development and grain yield of irrigated rice.

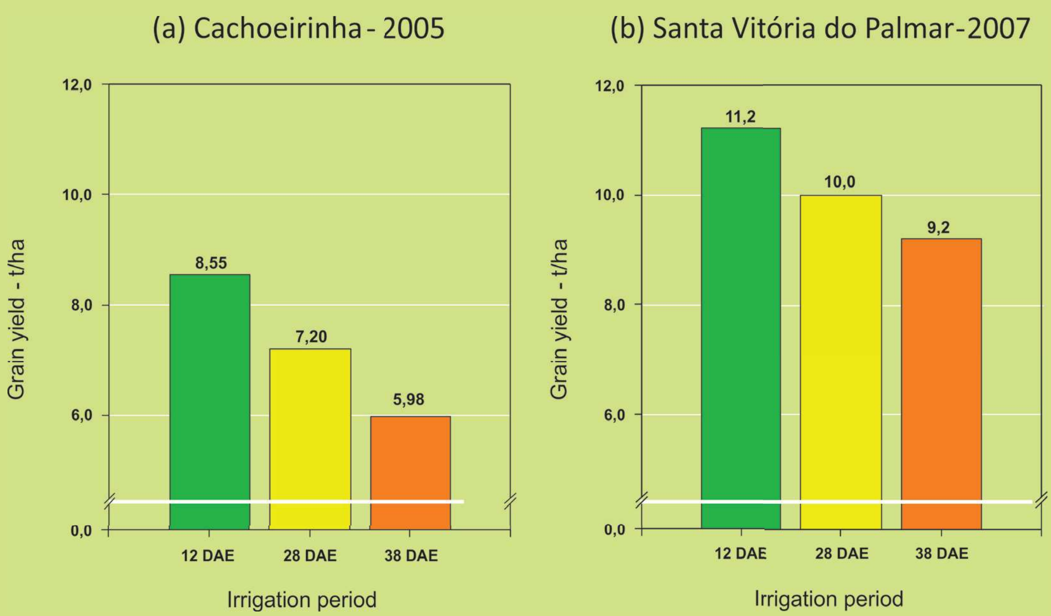


Figure 61. For every 10 days of irrigation delay, one t of rice grain per hectare is lost.

Source: Agronomy team, EEA/IRGA (2012)

ducted in a dry soil, as a way to reduce the consumption of fuel and avoid damages on the soil surface caused by machines and other equipment.

The effect of irrigation is also associated with how top dressing nitrogen is applied. The efficiency of use of nitrogen is higher when irrigation occurs earlier and when the fertilizer is applied in dry soil, prior to irrigation (Figure 62). The efficiency is decreased with late irrigation to a point in which there is no difference between nitrogen-free control, when the irrigation cycle starts 30 days after emergence. The positive effects of the quality of irrigation in the productivity of crops of the Zona Sul Region can be noticed in Figure 63.

The greatest improvements resulting from the correct management of irrigation are related to how dependant it is on alternative sources of water to rainfall and the increase in efficiency of these wellheads (weirs, dams, lakes, rivers, etc.) by rice crops. Until not long ago, in the 1970s and 1980s, 14 to 16 mil m^3/ha of water to average productivities of 4.0 t/ha were necessary in state of Rio Grande do Sul. Currently, with the recommended technology by Projeto 10, productivities from 8.0 to 10.0 t/ha (Item 2) can be reached with the use of 8,000 to 10,000 m^3/ha of water, what makes possible to use less than one cubic meter of water to produce one kg of grains. The viability in increasing the efficiency in the use of water has been shown through IRGA research (Table 11).

It seems obvious to discuss the importance of water for irrigated rice. However, most of rice fields in state of Rio Grande do Su do not have proper irrigation management, and the main reason lies in starting properly to irrigate. Many crops are still irrigated when rice plants have more than three to four leaves expanded (recommended period). This factor alone reduces the development of rice plants and the productivity of grains (Figures 60 to 62). Late irrigation has a negative impact on the management of weed species (Item 3.2.1), on the availability of nutrients, on the efficiency of nitrogen applied, on the self-liming process besides enabling the attack of soil pests to rice plants. Besides, late irrigation increases the plant cycle (Figures 59 and 60) and may increase the use of water, as irrigation occurs in mid-November and December, periods in which the soil is drier. This actually has a higher impact on the production costs. On the other hand, farmers who start irrigation earlier find more moist soils, and thus, use less water and have higher speed of irrigation. Farmers' awareness of water management and earlier irrigation may help explain the increase of around 200,000

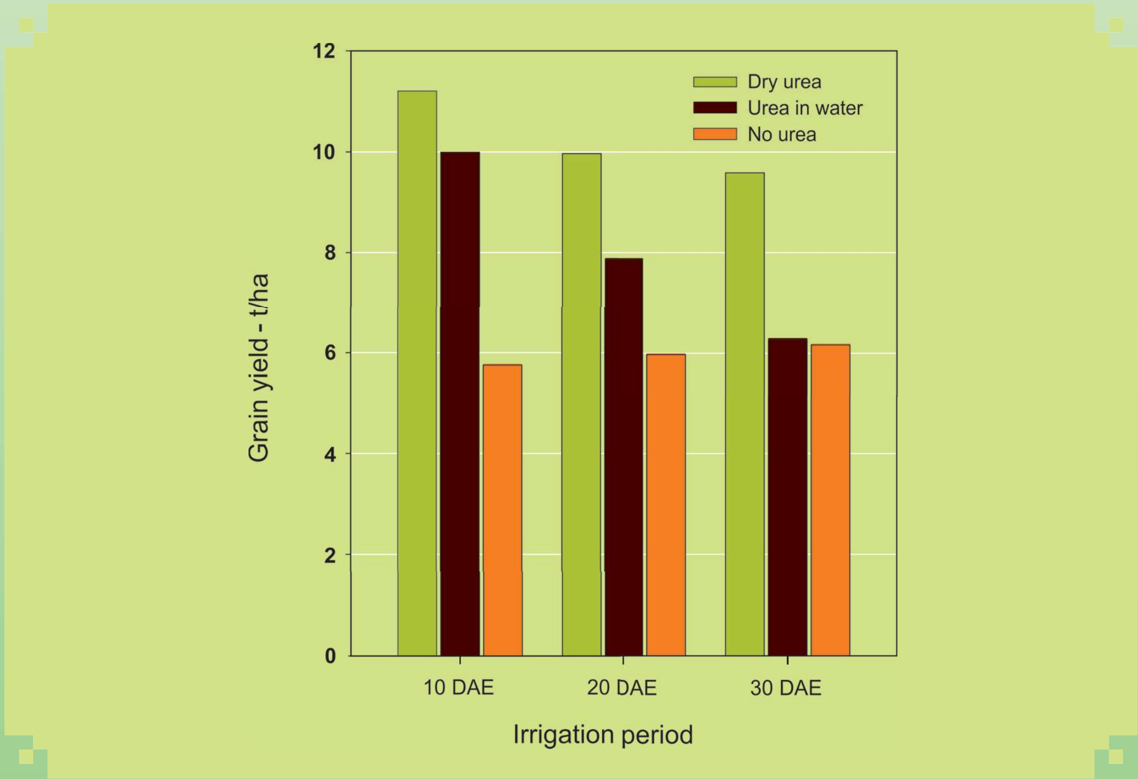


Figure 62. Higher grain yield can be reached with early flooding and with the application of the first nitrogen rate, immediately before starting irrigation.

Source: Agronomy team, EEA/IRGA (2012)

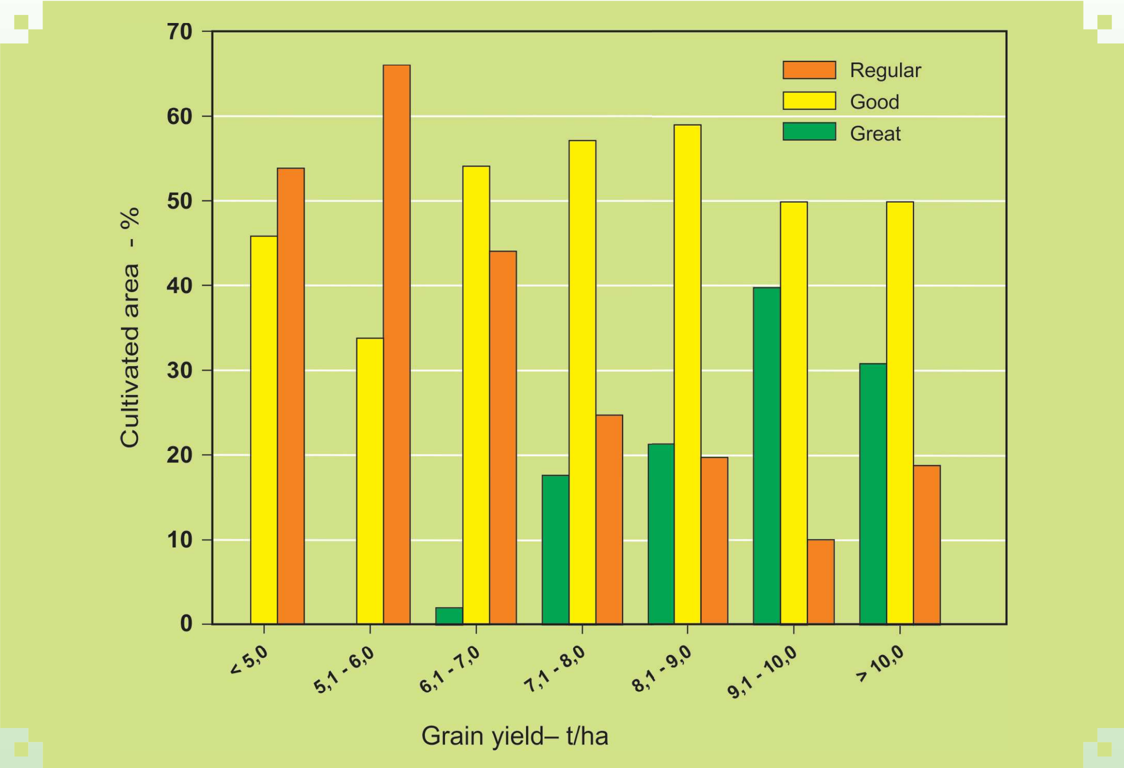


Figure 63. Higher rice grain yield is obtained by farmers that can best manage irrigation water in their crops (Zona Sul, 2010/2011 growing season).

Source: DATER/IRGA (2012)

Table 11. Water use efficiency is higher with higher rice productivity

Parameters	Arroio Grande
Water volume - m^3/ha	11,808.0
Irrigation period - days	110.0
Average flowing - L/s/ha	1.2
Grain yield - t/ha	9.1
Water use efficiency - kg de arroz/m^3	0.8

Source: Marcolin et al. (2009)

hectares over the last eight years (Figure 2), roughly with the same amount of water available. Even though, it is important to consider that within this period there was no investments in either public or private institutions to increase the amount of stored water for irrigation in RS. Another important factor to point out is that the crops that are poorly irrigated are more likely to have diseases (Item 3.2.2.b). It is because, by all these reasons, rice productivity of the Sul Region has been increasing as water management has improved (Figure 63).

3.2. Practices related to the "maintenance" of productivity

3.2.1. Weed management

In order to reach the highest rice grain productivities, crops must be free from weeds (Figure 64) since the very beginning. Most fields of irrigated rice in state of Rio Grande do Sul are highly infested with weeds. High levels of infestation are one of the main factors that limit their productivity, grain quality and profitability. This becomes clear in the survey conducted in rice fields in the Sul Region, in an area of 185,000 hectares, where the highest productivities were achieved in areas in which the quality of infesting species control ranged from good to great. As the efficiency in weed control decreases, the productivity of crops decreases (Figure 65).

Irrigated rice fields in state of Rio Grande do Sul are a favorable environment for the development of many species of weeds, both during the period of rice cultivation and off-season. The most frequent and important ones concerning aggressiveness and/or competitiveness, the damages they cause to crops as a whole and the difficulties to control are the Red rice (*Oryza sativa*) and Cockspur grass (*Echinochloa colona* and E. *crusgalli*) (Figure 66). Recently, other weeds have become more important due to the intense use of soil and/or to changes in the systems of rice tillage. Among them, we can mention some annual true grasses (Figure 67), such as Wiregrass (*Eleusine indica*) and Brachiaria (*Urochloa plantaginea*), due to the low efficiency in the ALS enzyme inhibitor herbicides and to the management of irrigation water, and legumes, such as Jointvetch (Figure 68) (*Aeschynomene denticulata, A. indica and A. sensitiva*). The increase in the infestation of Sedges (Figure 69) (*Cyperus esculentus, C. ferax, C. difformis and C. iria*) is due to the deficient control of some herbicides and/or to the decision made by farmers in not control them, since infestations usually occur in small areas within the crop. Perennial grasses, so-called stolononiferious plants (Figure 70) (*Luziola peruviana, Leersia hexandra, Paspalum modestum, Panicum dichotomiflorum*), have become very important in the crops due to the adoption of the minimum tillage system in large scale, in which soil tillage is reduced and/or done with more moisture and with the use of fences or fenced ploughs.

In poorly drained areas, in crops under the pre-germinated system, and in channels and drains, the so-called acquatic species (Figure 71) (*Sagittaria montevidensis, Heteranthera reniformis, Eichornia azurea and E. crassipes*) are predominant and quite relevant. In some regions, there are other species that have become quite relevant; for instance, in the Fronteira Oeste Region, Hairy Crabgrass (*Digitaria ciliaris*) (Figure 70) and the Signalgrass (*Urochloa platyphylla*) are important.

For the management of the main species of weeds, within most part of the area, rice farmers in the state of Rio Grande do Sul use chemical control, with efficient herbicide alternatives available in the market. The chemical control is the most efficient way, less costly and most practical in the weed management of irrigated rice. In view of the fact that most herbicides available in the market are efficient for the control of most species of weeds, one question still needs to be answered: Why are there so many crops that do not have an efficient control of invasive plants? Apart from operational flaws in the application of products, the main reasons behind the lack of efficiency of herbicides are: application at a later period, dry soil aspersion and late irrigation. Besides of these three reasons, the lack of vision on integrated management from most technical assistants and rice farmers of weed control strategy makes this task more successful. Chemical control is part of the integrated management of weeds in the irrigated rice cultivation. Just like other methods, which do not provide a satisfactory control of weeds, the efficiency of herbicides is related to good management practices. The use of this management strategy as the only alternative rarely provides good control and, usually leads to the selection of species that are hard to control and/or are herbicide-resistant. In order to reach a higher biological and economic efficiency and cause lower environmental impact, it is necessary to bring together basic knowledge on the action of herbicides and the crop management. The efficiency of herbicides is related, in addition to environmental conditions and the application of products, to the stages of development of weeds, to the conditions of implementation and establishment of the staples and to the application of proper cultivation practices, especially the management of irrigation water.

It is ideal that the chemical control be conducted as early as possible. The most suitable period for weed control is when the plants have from three to four leaves (Figure 72), before rice tillage and the irrigation of the crop. However, as in many areas farmers start weed control la-

Figure 64. In order to reach high grain productivities, irrigated rice must not suffer weeds interference, since the very beginning.

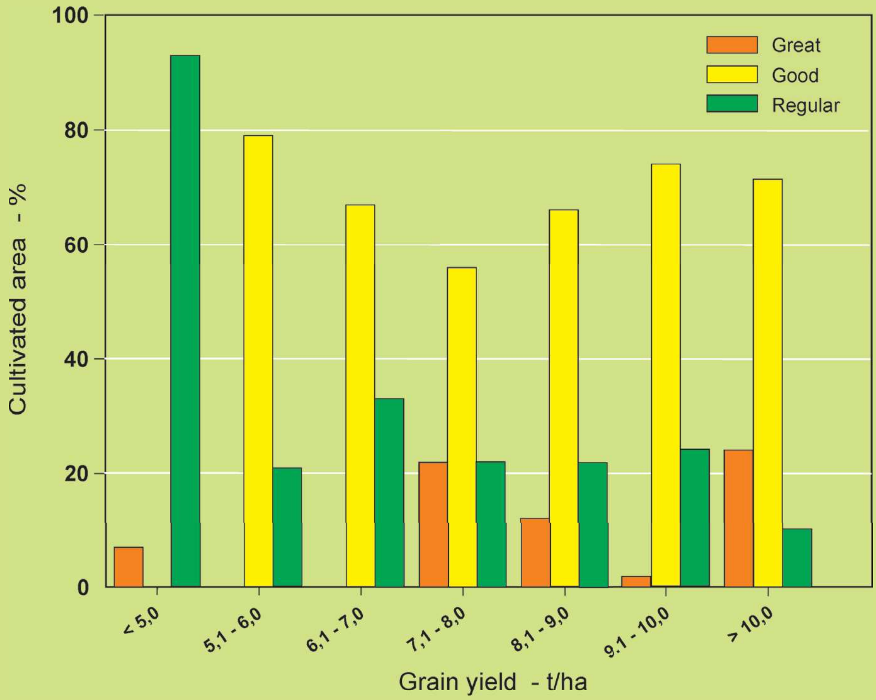


Figure 65. Rice yield increases along with the weed control efficiency (Zona Sul, 2010/11 growing season).

Source: DATER/IRGA (2012)

Figure 66. Red rice and *Echinochloa* species are the main weeds that infest fields of irrigated rice in Rio Grande do Sul.

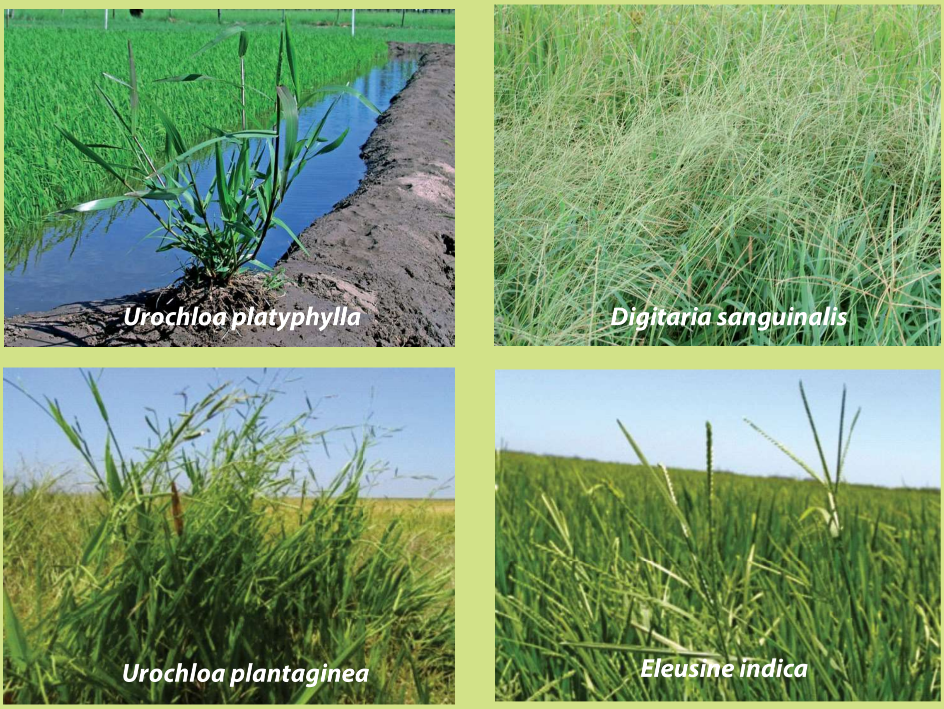


Figure 67. Annual grasses have become very important in the fields of irrigated rice in Rio Grande do Sul.

ter, it results in higher costs with the use of higher doses of herbicides, lower efficiency of weed control and reduction of the grain yield (Figure 73).

The interaction between herbicides and water management is very important in weed control, in all tillage systems. When herbicides are applied at an early state, when weeds have up to three leaves, the rate of herbicide can be reduced and so increase its effectiveness, thus providing

Figure 68. The infestation of irrigated rice fields with the *Aeschynomene* species reduces the grain yield and quality.

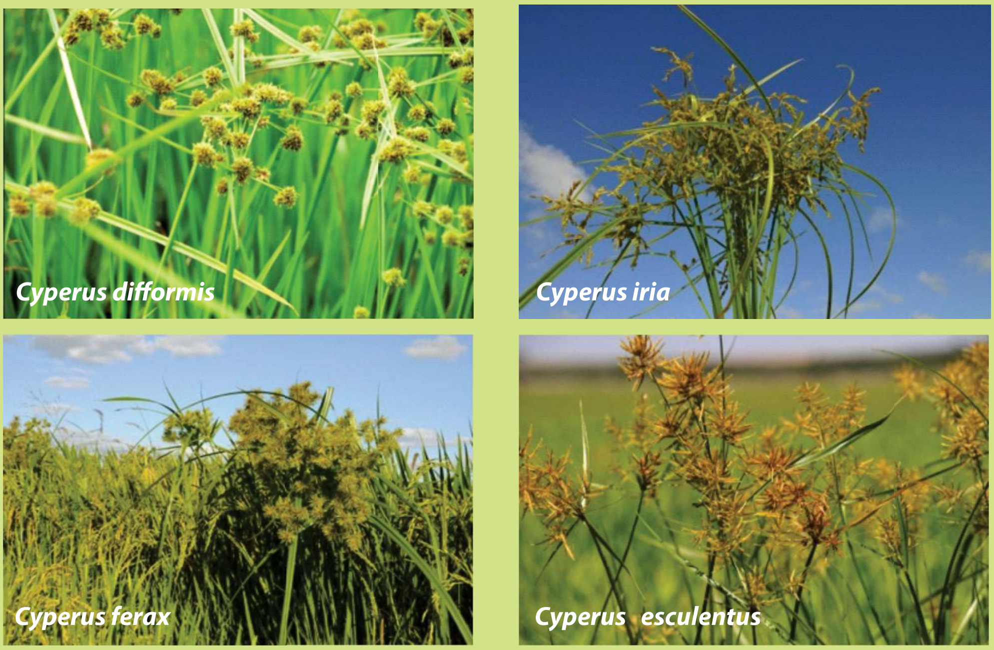


Figure 69. Species of Sedges have grown in importance over the last decade as irrigated rice weeds.

a satisfactory control. Right after the weeds starts the absorption of herbicides, it is recommended to start irrigation. The longest you delay the irrigation of the crop, less efficient will be the herbicides (Figure 74). The irrigation must be kept with a low and permanent water layer. Intermittent irrigation enables the emergence of new weeds.

Figure 70. Perennial grasses have become more important as weeds in fields of irrigated rice.

Figure 71. *Sagittaria montevidensis* and *Heteranthera reniformis* species are among the ones that produce the highest infestation levels in pre-germinated rice fields of Rio Grande do Sul.

Herbicides can be sprayed either before or after emergence. Pre-emergence applications require that the soil is moist in order to be efficient. In Rio Grande do Sul, it is mostly applied after emergence. This form of spraying is better because of the inconstant soil moisture due to the period of weed control. Hence, the best chemical control

Figure 72. The control is most effective when weeds have from three to four expanded leaves, regardless of the species.

strategy for weeds is the spraying of herbicides with post-emergence action, though pre-emergence is required, too. This can be achieved with the application of a single product or with the use of two herbicides. This strategy is preferred because in most crops, irrigation is done with the use of contour-line levees. In these conditions, the speed of irrigation is low, the water layer's height is uneven and the levees get infested again without the residual action of herbicides. These difficulties are more pronounced in medium-sized and large fields. In systematized

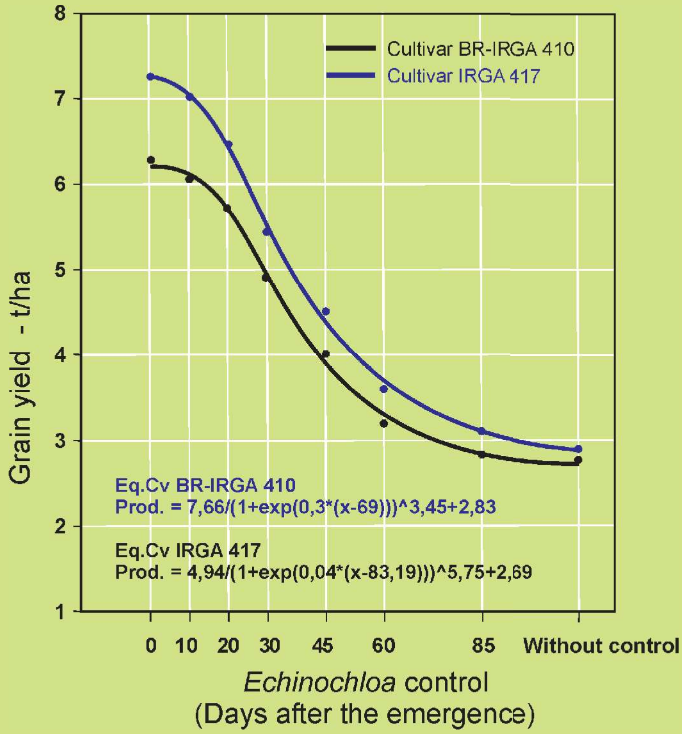


Figure 73. In order to reach higher rice grain yield, it is necessary to start weed control as early as possible.

Source: Agronomy team, EEA/IRGA (1999)

areas, in which the fields can be rapidly flooded, the use of herbicides after emergence, without residual action, is effective in weed control.

However, for crops sown at the beginning of the recommended period (September), in which the sowing--emergence period is expanded, it is recommended to use two applications of herbicides, in which: the first one, after sowing but before the emergence of rice seedlings, with a pre-emergence action herbicides, and the second, when the weeds have from three to four leaves, and the crop must be irrigated as quickly as possible.

In the direct sowing system with early tillage crops, two relevant aspects must be noted: the right moment to dry out the plant cover and the amount of dry mass produced. Rice plants grow more when the cover is dried at least 30 days in before, in a way that, at the moment of sowing, the plant cover is fully dead (Figure 75). The amount of dry mass must not be higher than 2.0 t/ha.

Infestation with perennial stoloniferous grass (Figure 70) requires special management during the off-season. The problem with stoloniferous grass came with the superficial soil tillage with fences or fenced ploughs, with the incorporation of areas that are hard to drain, with the increase of the direct sowing system and with the lack of effective and selective herbicides for its control after the staple grows.

The morphological characteristics of the perennial weeds species make them hard to control, since they multiply both through seeds and plant parts (stolons and rhizomes). Besides, their leaf area index is small when compared to fully developed root systems, which makes herbicide absorption and translocation hard to conduct. As the action of post-emergence herbicides is not efficient, the effectiveness of the management of these species depends mostly on what was done during off-season or in the period preceding sowing. The first steps start with improvements in the draining system and dry soil tillage. Field observations show that tillage in very moist and poorly drained areas enables the development of perennial grasses.

The best results in the management of these species are obtained by the combination of chemical and mechanical control methods. The use of one isolated method enables less control than the combination of methods, and it is still many times insufficient. Chemical control, with glyphosate herbicides in a single or sequential application, even in rates higher than 10 L/ha is not efficient. However, one single application of up to 5 L/ha can be enough, if combined with adequate tillage. The effective action of glyphosate during off-season can be damaged if applications occur on low temperatures, once stoloniferous grasses have reduced metabolism and make them

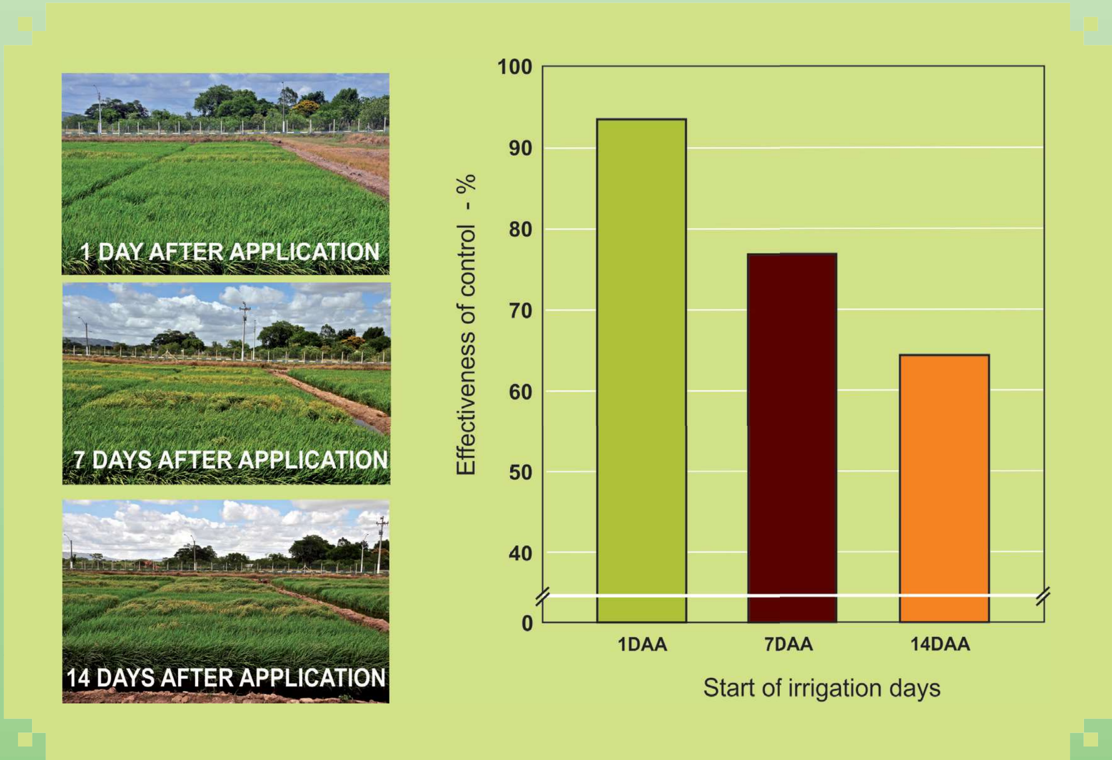


Figure 74. Weed control efficiency is higher when the flooding starts shortly after herbicide spraying.

Source: Agronomy team, EEA/IRGA (2012)

Right died cover crops	Wrong cover crops with green parts

Figure 75. Irrigated rice plants grow better in the minimum tillage system when sowing occurs on died cover crops.

hard to translocate. Mechanical tillage, though, when used alone, will only be effective if the soil is dry so that the root system of these species is exposed to solar radiation. On the other hand, soil tillage with too much moisture can pave the way for these species to multiply, due to the segmentation of vegetative parts.

Another improvement observed in weed control is related to the growing use of high quality, physiological and sanitary rice seeds, which are free of red rice seeds. We could very effectively notice an increase in the use of good quality seeds over the latest years (item 3.1.3). The challenge is to use high-quality seeds in all crops all over the State. Overall, most farmers are concerned with weed control only during the cultivation period. The strategy of only dealing with the problem when it appears makes the farmers forget a set of preventive measures that would contribute to the right management of weeds, making it easier and less costly.

The use of practices that inhibit the introduction, growth and dissemination of weeds should be part of the control strategy by farmers. Overall, preventive actions have low-cost and can be easily done at the properties. The main preventive measures in the crops of irrigated rice are: use of weed-free rice seeds, cleaning of irrigation and draining channels, of fence lines and roadsides, cleaning of agricultural machines and equipment, and caution in the handling and management of animals in the pasture area. Besides these actions, water management in rice crops is very important since weed seeds are easily transported by the irrigation water and, in areas difficult to be drained; they grow and are hard to control. All these actions can be done by farmers before sowing.

Weed control during the off-season is essential for those species that cannot be controlled or are hard to control during the cycle of the staple, due to effectiveness problems and/or selection of herbicides or by high costs. Infesting species that are extremely hard to control in the irrigated rice cultivation of Rio Grande do Sul are red rice and stoloniferous grasses. The intense use of areas in which rice is cultivated, along with the use of seeds contaminated with red rice seeds by farmers, has made this infestation one of the biggest problems of rice production in the state of Rio Grande do Sul, due to the reduction of the rice productivity and the difficulties in controlling since they are the same species.

Red rice management requires a combination of different actions, such as the use of high-quality rice seeds, proper soil tillage, the right choice for cultivation systems and staple rotation and succession, correct irrigation management, correct use of herbicides and proper management of the soil's seed bank. Out of all items mentioned, the management of the seed bank in the soil can be done during the off-season. Researches conducted by IRGA have shown that in some crops in Rio Grande do Sul, an equivalent of 20 bags per hectare of viable red rice seeds in the soil are reported. The reduction in the seed bank is essential for successful management. Red rice seeds can be used in the soil for long periods, and in certain conditions, their longevity lasts for many years. The viability in the use of seeds is related to the depth in the soil, that is, the deeper they are, the longer they will be used.

During the fall and the winter, the red rice seeds are largely dormant. They must be on the soil surface so that they lose their viability by virtue of adverse environmental factors and/or pathogens and predators. Bury the red rice seeds right after harvest increases their viability for a longer period of time. Soil tillage, as an alternative to encourage the emergence of red rice seeds, must be done in the summer only in those areas that enable a fallow period between one or another period of rice cultivation. Even in these situations, soil tillage must be superficial. Small rice fields in Santa Catarina and in the Depressão Central region of Rio Grande do Sul, cultivated in the pre-germinated system, use ducks to reduce the bank of red rice seeds in the soil.

Among the species of weeds, red rice deserves special attention since it is widely spread. The alternatives for control are only partial and it is estimated a reduction of 1.2 millions of tons on rice grains per harvest in Rio Grande do Sul because of it. In addition to the damages caused by red rice, once it is disseminated, it will not enable the adoption of certain agronomic practices, which are essential for obtaining high productivities, such as the use of higher rates of nitrogen fertilizers or sowing during the recommended period.

So that the productivity ceiling can be increased in Rio Grande do Sul, it is necessary to reduce the red rice infestation in the crops. In this sense, the use of the system **Clearfield**® has brought a huge contribution for the rice crops (Figure 76). Most improvements observed in the productivity can be attributed to this technology. With the use of **Clearfield**® cultivars, it was possible to control red rice selectively with imidalizone herbicides. Once this weed is under control, the use of essential management practices for the increase in grain yield is made available, which is not possible in infested areas.

However, there are some limitations in the indiscriminate use of the **Clearfield**® system. Red rice biotypes resistant to inhibitor herbicide acetolactate synthase (ALS) (Figure 77) have been reported in all rice producing regions of Rio Grande do Sul (Figure 78), thus lowering the efficiency of this technology in some crops. The basic reason behind it was the adoption of the system that does not follow the research recommendations and, mainly the use of seeds contaminated with grains of red rice (Figure 78).

In addition to red rice, other biotypes of Cockspur grass resistant not only to imidazolinones, but to all herbicides that are inhibiting to the ALS enzyme (Figure 79) have been reported. Biotypes *Sagitaria montevidensis, Cyperus difformis, Cyperus iria* and *Fimbristyllis miliaceae* that are resistant to this group of herbicides have also been reported (Figure 80). In this scenario, new challenges come up: the correct management of resistant weeds and the preservation of the **Clearfield**® technology. Without being preserved, the productivity in Rio Grande do Sul can be reduced in the next years. For the correct management of resistant weeds, the main action to be taken is the use of herbicides with different chemicals. If a weed is not controlled with the recommended dose, it will not be controlled with a higher rate either. Alternating between tillage systems is also a tool to be used. An example of that are the species such as *Sagitaria montevidensis* and *Cyperus difformis* prevailing in the pre-germinated system, which does not grow in tillage systems where sowing is done in dry soil.

For the success of weed management in the irrigated rice crops, it is necessary to combine different control methods with good management practices for the staple and control actions during off-season.

3.2.2. Pests and diseases control

The pressure inflicted by insects and other pests and diseases in rice crops can be noticed in some areas of the State or occurs due to the incorrect management of the crop. So, the set of several agronomic practices recommended by Projeto 10, whenever they are carried out in an integrated way, reduces the incidence of pests and diseases in the crop and serve as preventive action, decreasing its occurrence and the level of damage in the crop. The knowledge of the damage history along the years, of crop management and of the characteristics of the cultivar are important for decision-making when it comes to the need to apply insecticides and fungicides.

a) Insects and other pests

Rice crop is a favorable environment for the development of a broad diversity of insects. In addition to the terrestrial species, we can find large amounts of arthropods, which develop either partially or in full in an aquatic environment. In this environment, few of them feed on rice and may cause economic losses. Pest insects are those species that occur constantly and in high numbers, which may reduce the rice grain yield.

Figure 76. The use of the CLEARFIELD® technology was essential for the Projeto 10 success in irrigated rice crops infested with red rice.

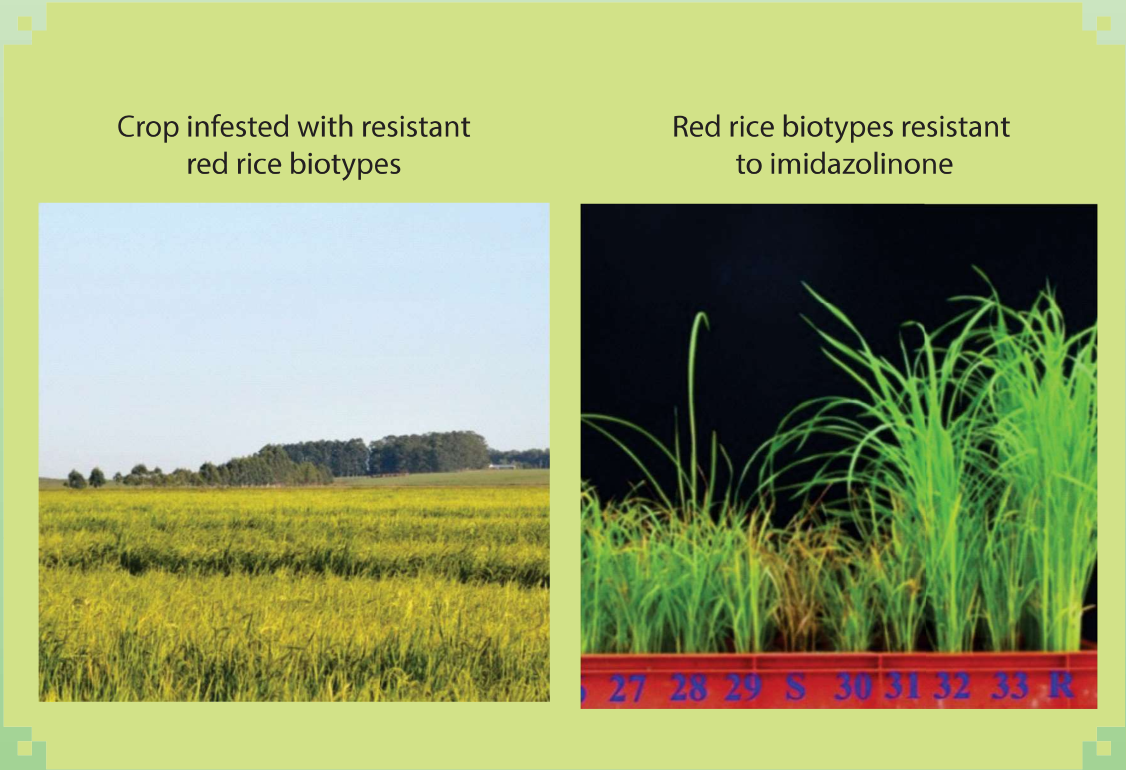
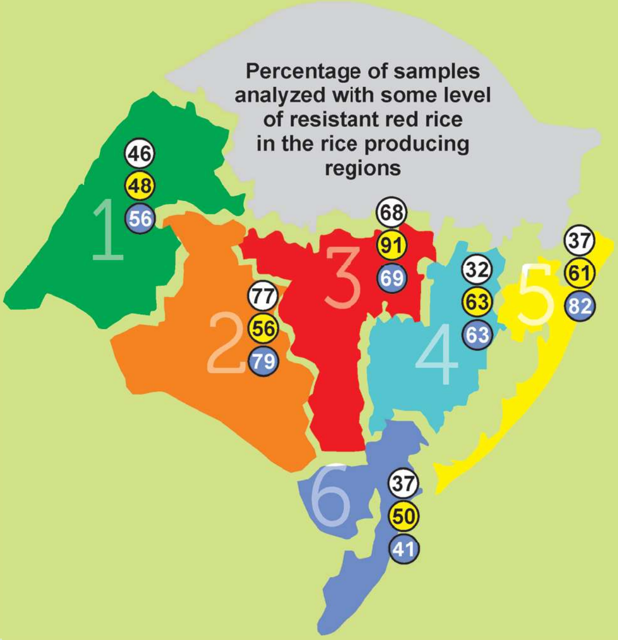


Figure 77. The misuse of the **Clearfield®** technology by rice farmers has made irrigated rice cultivation unfeasible in many fields of Rio Grande do Sul.

Just like the diseases, the pressure of pest insects in irrigated rice fields in temperate climates in much smaller than in tropical areas. Overall, their occurrence in rice fields in Rio Grande do Sul is not systematic. The only exception is the Rice water weevil (*Oryzophagus oryzae*) (Figure 81). This is a pest insect, which has been reported



RICE PRODUCING REGIONS

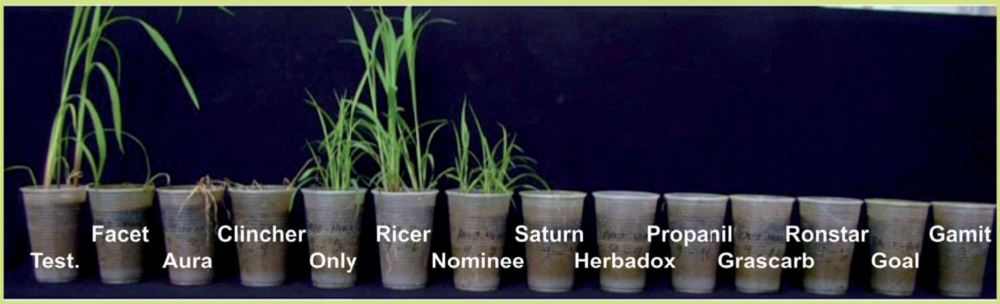
1- Fronteira Oeste
2- Campanha
3- Depressão Central
4- Planície Costeira Interna
5- Planície Costeira Externa
6- Zona Sul

Percentage of Clearfield-resistant red rice samples in Rio Grande do Sul

Growing seasons	%
2006/07	56
2007/08	71
2008/09	68

Figure 78. The occurrence of imidazolinone-resistant red rice plants has been increasing in all rice producing regions of Rio Grande do Sul.

Source: Agronomy team, EEA/IRGA (2009)



1 2 2 3 3 3 4 5 6 7 8 8 9

1 - Auxina synthetic
2 - ACCase inhibitor
3 - ALS inhibitor
4 - Inhibitor growing in the upper part
5 - Div cellular inhibitor
6 - FSII inhibitor
7 - FSII inhibitor + those growing in the upper part
8 - PROTOX inhibitor
9 - Syntehtic Carotenoid inhibitor

Figure 79. The occurrence of imidazolinone-resistant red rice plants has been increasing in all rice producing regions of Rio Grande do Sul.
Note: Facet (quinclorac); Aura (profoxidhim); Clincher (Cyhalofop butyl); Only (imazethapyr + imazapic); Ricer (Penoxulan); Nominee (bispyriba-sodium): Saturn (thiobemcarb);Herbadox (pendimenthalin); Propanil (propanil); Grascab (propanil + thiobencarb); Ronstar (oxadiazon); Goal (oxyfluorfen); Gamit (clomazone).

Source: Agronomy team, EEA/IRGA (2009)

in all regions every year, which explains us why the seed treatment with insecticides is being used as the main form of control in most fields of the state of Rio Grande do Sul. Concerning the pest-control mentioned above, in the 1980s and 1990s, when granulated or pulverized insecticides were used, the treatment of seeds had environmental advantages. Despite being a preventive action, the impact on the natural enemies is weaker, since these are much

Figure 80. Weeds species that are proven to be resistant to herbicides in irrigated rice fields in Brazil.

less affected by the seed treatment than pulverization. A factor that has contributed to the adoption of this practice in large-scale was the reduction of the density of sowing, making it less costly. Practices that received priority in Projeto 10, as the use of low levees and without the less productive part of the soil, with the consequent reduction of the water layer's height, contribute for the management of this insect. On the other hand, areas sown within the recommended period may be subject to attacks of Rice water weevil, since the adult insect wakes from hibernation around August/September and looks for the first crops to develop. According to the cycle of the cultivar, there may be more than one generation of insects in a same crop cycle, unlike when most fields used to be irrigated in late November and December.

Other pest insects such as Rice stem bug (*Tibraca limbativentris*) (Figure 82a), Rice stink bug (*Oebalus spp.*) (Figure 82b), Wheat armyworm (*Pseudaletia spp.)* (Figure 83a), Fall armyworm (*Spodoptera spp.*) (Figure 83b) and Rice root aphid (*Rhopalosiphum rufiabdominale*) (Figure 83) occur sporadically in certain regions or years. When they come in large numbers, they may cause damages so, preventive actions should be taken and/or interventions should be carried out in order to control them.

Rice root aphids (Figure 84), which used to be associated with fields in the Fronteira Oeste Region, due to the large number of levees and the difficulties in the irrigation and maintenance of water layer by virtue of rice cultivation in areas with steep slopes, now occurs in almost all rice production areas of the state of Ro Grande do Sul. Building low levees and early crop irrigation when the plants have from three to four expanded leaves are efficient management practices for controlling this insect. Using chemical control to fight them is more effective with the seeds treatment, once pulverizations cannot reach them since they are underneath.

Rice stem bugs (Figure 82a) have become an important pest insect over the last years. It occurs mostly in the State's warmer areas, such as the Fronteira Oeste Region and Depressão Central Region. It has occurred in crops over the last years due to the lack of adoption of specific management practices. Perhaps the more intense use of areas where rice is cultivated has created more favorable conditions for their growth, like what happened with some weeds and diseases. This insect may reduce productivity significantly, since it reduces the number of panicles affecting the base of the main stem and tillers, both during the vegetative and reproductive phase (Figure 82a). Each adult insect per square meter may reduce the productivity of grains in up to 1.2% (SOSBAI, 2010). Chemical control with pulverizations have left a lot to be desired, since it is difficult for the product to reach its target, once the insects prefer to stay at the base of the plant's stem, next to the water layer surface. Chemical control is more effective when applied in the morning, since the insects travel to the canopy's surface until noon.

Rice stink bugs (Figure 82b) become an important pest insect after the flowering of plants, though it may be

Figure 81. Rice water weevil is the most harmful insect to rice, especially when its larvae damages the root system of the rice plants to feed on.

found in the crops since the beginning of the vegetative phase. Weeds, specially Red rice and Cockspur grass, attract these bugs to the crops before the cultivated rice is in a susceptible development stage, since it has a shorter cycle and make milky grain available earlier in the crop. So, the infestation tends to start in the parts where more weeds are found in the crop, such as in the edges and roadsides, channels and drains. Weed control is extremely important for the management of these species. They bring significant damages, since they affect both productivity

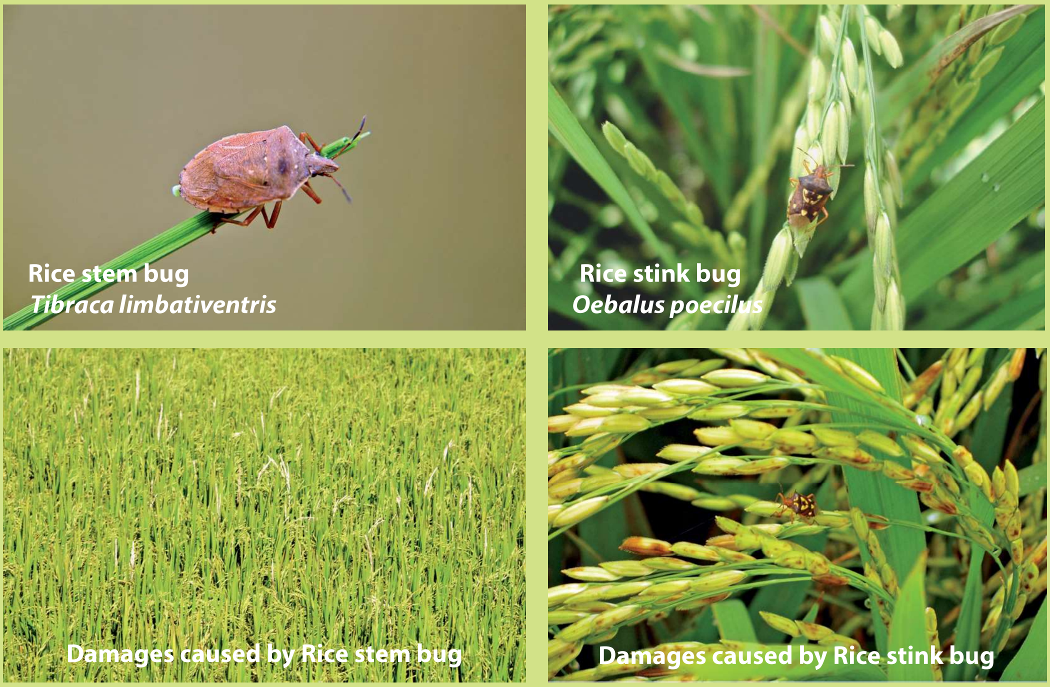


Figure 82. Both the rice stem bugs and rice stink bugs reduce the productivity and quality of grains.

Figure 83. Both the wheat and the fall armyworms may bring severe damages to rice plants when in large numbers.

and grain quality. Controlling these species is easier than controlling Rice stem bug since they prefer to be in the plant's surfaces and is easily affected by insecticides.

Wheat armyworm (Figure 83a) is relatively a recent pest insect in irrigated rice fields. It is prevailing in dry years when crop irrigation tends to be deficient and there is little food. Sometimes the only green areas in rice producing regions are rice crops. Large rye grass areas in rice production areas may have contributed to the large numbers of these pests in rice crops, since they occur largely in

Figure 84. Rice root aphids affect the plant's root system during crop growth and may cause their death, especially in the levees, thus affecting the initial stand and the grain yield.

winter cereals. The less moist areas of the crop, such as edges, levees and higher parts, are usually where the infestation begins and then it extends to other areas as irrigation ceases. The recommendations to conduct harvesting in dry soil for higher effectiveness of machines and equipment, reduction of fuel consumption, thus avoiding soil degradation by virtue of harvesting machines, tractors and bulk carriers, may have contributed to the high levels of occurrence of this armyworm. 3% of the production is damaged per each insect per square meter.

Fall armyworms (*Spodopera frugiperda*) (Figure 83b) occur sporadically in rice crops. It occurs more frequently in crops that are sowed later, in November and December. It attacks rice plants in the vegetative phase, usually before irrigation and, when in large numbers, it causes severe economic damages and needs to be controlled. Sowing in the recommended period (before November 05) is a preventive strategy against the attack because the insects may be in pastures or other crops, and early crop irrigation when plants have from 3 to 4 leaves reduces the number of armyworms in the rice. Previously, most fields used to be sown when the armyworms were already settled in the areas and irrigated 30 days after the emergence of seedlings, which contributed to more serious attacks.

Sugarcane beetle (*Euetheola humilis*) (Figure 85) is an insect that affects crops without water layer, since it does not survive flooding. When the crop is growing, the damage usually starts from the larvae, which attacks the seedlings' roots, affecting the initial population of plants. So, the early irrigation is a practice that minimizes the feeding period and the damage caused by it. Early sowing contributes to the management of this insect too, since it usually appears in the initial stage of the crop, in November and December. This insect may also affect the rice plants' root system at the final phase of the cycle when crops no longer use water layer, causing lodging and impeding the harvest. In this sense, ceasing irrigation so that the harvest can occur in dry soil may enable attacks from this insect.

Practices adopted by farmers and the interaction with the environment (climate, type of soil, etc.) determine the development of prevailing species and, along the years, this combination results in crops with higher or lower economic and environmental sustainability. The use of Integrated Pest Management (MIP) calls for a set of measures that impede the development of these species. In this sense, weed control is important since it reduces alternative sources of food for pests. Low levees and water layer control are essential to avoid dry parts, where many pests can develop easily.

The management of pest insects needs a long-term view that covers not only the target insect but also the presence of their natural enemies. Because of that, the most suitable action to be taken is to monitor the number of insects in the crop and only conduct preventive control with the seed treatment with insecticides in areas where it has occurred before. Chemical control should only be employed when the number of insects reaches economic levels, always avoiding indiscriminate control or sequential applications. It is important to bear in mind that this is only one of the tools and should not be used apart from the other practices that mitigate the damages caused by insects, as sowing and irrigation in the recommended period.

So, it is recommended that farmers and field technicians incorporate the monitoring of the pest and natural enemies population as a strategy for the correct management of pest insects in irrigated rice fields in Rio Grande do Sul. Periodical visits to observe all parts of the plant, since the roots to the panicles avoid the unnecessary application of insecticides. Large scale fields must be monitored frequently and carefully too. In those crops, the easiest way is by training people who frequently work at the crops, such as water carriers and machine operators, to get to know the pests and their natural enemies.

The occurrence of pest insects and the degree of the damages caused are directly related to the agronomic practices adopted and to the environmental conditions, as well as the population of natural enemies of these insects. Hence, it is necessary to monitor pest insects constantly and the population of natural enemies as well, and consider using insecticides only as a strategic tool for the management of insects inside the rice field. A positive example is the increase in the average rice grain yield in the crops of the Sul Region of the State with improvements in the quality of management of pest insects (Figure 86).

b) Diseases

The pressure from diseases in the irrigated rice cultivation in temperate zones, such as the State of Rio Grande do Sul, is also much lower when compared to the irrigated rice crops in tropical regions. Maybe this will explain why cultivars that have been around for longer than 30 years in the State, such as BR-IRGA 409 and El Paso 144, still continue to be sown in significant areas of the state of Rio Grande do Sul and Uruguay. Overall, the higher occurrence of diseases, such as Rice blast, is less frequent in Uruguay and rice crops in Rio Grande do Sul at the border with that country. However, the further away the cultivated areas are from the border, the pressure of diseases in the crops increases, because the air temperature and relative humidity are higher in the warmer months of the year (January and February). Still, the conditions are more

Figure 85. Sugarcane beetles can cause damages to the plants during their growth in the larvae phase or as an adult, cutting the plants' root system and causing lodging in the crop before harvesting.

favorable in the Northern located in the Northern Coast of Rio Grande do Sul and in the State of Santa Catarina, where the combination of more sandy soils and fog and more humid days, during the summer, determine the higher risk of epidemics.

Additionally, it should be noted that climate and soil conditions in Rio Grande do Sul are heterogeneous and vary from a cultivation station to another and there are management issues that interfere in the occurrence of diseases, as well as the tolerance of cultivars to them. For instance, in the 2010/11 growing season, the conditions for rice cultivation of were highly favorable in Rio Grande do Sul, so much so that a record in average productivity was reached. However, that was not an absolute truth, since in the Northern Coast of the Planície Costeira Externa in Rio Grande do Sul there was an epidemic of Rice blast in levels that have not been observed recently, mainly in areas sown from November onwards. Therefore, general recommendations of strategies for disease management, especially when it comes to the use of fungicides must be avoided.

The interaction of the genotype and the environment and the agronomic management is essential to keep the occurrence of diseases from reaching economic levels. In warm and humid years with lower lighting, the probability of incidence of some diseases such as Rice blast (*Pyricularia grisea*) (Figure 87) and the set of foliar diseases, of which we can mention the Brown spot (*Bipolares oryzae*) (Figure 88) is higher. On the other hand, the incidence of Kernel smut (*Tilletia barclayana*) (Figure 89) increases under weather conditions different from the previous one. Usually, it is mostly associated with moderate relative humidity and high lighting levels.

The use of disease-tolerant cultivars is the main alternative for its integrated management. For instance, in the experiment named Bioclimático conducted at the Experimental Rice Station in Cachoeirinha, the spots of cultivars IRGA 417, IRGA 418 and IRGA 420 were not attacked by Rice blast (Figure 90) from September to October. However, the spots sown with the cultivar BR-IRGA 410 in December 15th suffered severe attacks during the vegetative phase.

The most serious damages caused by diseases in the rice cultivation in Rio Grande do Sul occur in the periods of flowering and grain filling. Then, two productivity components are defined: the number of spikelets per panicle and the weight of the grains. Likewise, the components that define the grain quality, such as the percentage of whole grains, are defined in these periods. The technology brought by Projeto 10 is based on the sowing period in which the staple can use the highest level of solar radiation available in the reproductive period. So, the importance of keeping the staple healthy during this period becomes clearer. Research findings from disease management have reinforced the advantages of the implementation of rice crops in Rio Grande do Sul until no later than October. Overall, during this period, the damages caused by most diseases are smaller (Figure 91). Likewise, the probability of diseases in this period is low. That is, the risk for reduction of productivity and quality in the recommended sowing period is very low and when losses occur, they are usually less impacting (Table 12), which enables the application of fungicides in smaller rates and /or higher efficiency.

Fungicide use effects on irrigated rice in Rio Grande do Sul have been hotly debated, possibly due to the erratic results obtained with their use. Unlike the conditions for irrigated rice cultivation in tropical areas, where the use of fungicides is almost mandatory, what has been under discussion there is whether two, three or more applications will be needed. In this discussion, the changes that occur in the agronomic management of crops and the expectations for productivity of grains must be taken in consideration, too. Early in the last decade, the average productivity of rice crops reached around 5.0 t/ha, whereas in the 2010/11 harvest, the average productivity of grains in RS reached 7.7 t/ha; it is quite common to have areas with productivities higher than 10.0 t/ha. It is sensible to protect a highly productive crop and maybe this helps explain why the use of fungicides has shot up in the State over the latest years. Today the use of fungicides in irrigated rice in RS is estimated to be higher than 80%, unlike in the beginning of the previous decade, in which their use in rice crops was lower than 5%.

Some mistakes made in past which still continue to be made now, is the use of fungicides in fields with low productive potential, mostly due to the poor management of the staple, especially when the sowing takes place after the beginning of November. Research findings have shown that the grain yield is higher in areas in which sowing occurred in the recommended period without the application of fungicides than those in which sowing occurred later with the use of fungicides (Figure 92). Many farmers conduct sowing at a later time and use fungicides in crops hoping to increase the grain yield. They forget that the application of fungicides, though it is done accordingly, only protects the productivity potential. We suggest that these farmers give priority to improving the agronomic management of their fields. In this sense, the first step is to conduct sowing in the recommended period, with the use of sowing density recommended by Projeto 10, with balanced fertilization and adequate weed and water management (Figure 93). Additionally, we recommend that preventive actions be taken before looking at fungicides as the “salvation of the crop”. On the contrary, the

Figure 86. Higher rice yield grain is obtained by farmers that can more efficiently manage pest insects in their crops (Zona Sul, 2010/11 growing season).

Source: DATER/IRGA (2012)

Figure 87. Rice field severely infected with Rice blast fungus Palmares do Sul county, 2010/11 growing season).

Figure 88. Rice severely affected with the Brown spot may have decrease in the grain yield and quality affected.

Figure 89. Rice area severely infected with Kernel smut (*Tilletia barclayana*).

effectiveness of the use of fungicides in crops with poor agronomic management is low. Even when fungicides are applied twice, disease control may not be efficient.

Fungicide can be recommended in areas sown from September 01 to November 05, due to unpredictable weather conditions in Rio Grande do Sul and to the diversity of conditions between the rice producing regions and within each region. Such unpredictable character may indicate that weather conditions that had been not very favorable to the occurrence of diseases that could bring economic losses change constantly and be favorable to their occurrence. The hardest thing in this decision-making process is that weather forecasts are not able to certainly define when and where this will occur. Along with that, the fact that more than 80% of the area sown with irrigated rice in the Rio Grande do Sul in the 2010/11 growing season was sown with cultivars susceptible to Rice blast and/or other diseases, such as Kernel smut (*Tilletia barclayana*). As grain productivity in these areas is expected to be high, it is recommended to use fungicides to protect the productive potential. In these cases, the effectiveness with the use of fungicides is high, since one single application can result in a good control and anticipated protection to a highly productive crop.

Of all management factors, the one that is more closely related to the level of incidence of diseases is the sowing period (Table 12). Research works conducted by IRGA have shown that as sowing is conducted at a later period there is a higher occurrence of diseases. Overall, the chances of occurrence of such diseases in the areas sown by the late October is low, increases in areas sown in November and is very high in December. Not only the likelihood of diseases occurrence increases with late sowing, but its severity will get even higher in areas which were sown outside the period recommended by Projeto 10 (Table 12). So, sowing during the recommended period enables farmers to reach higher productivities in their crops with healthier plants, as occurred in the Zona Sul Region (Figure 94).

To sum up, as a technology recommendation of Projeto 10, chemical control of diseases will focus on the prevention for those farmers who use cultivars susceptible to diseases, which have historically affected their regions. Then, fungicides are used only to keep the crop productive potential, which was previously defined. By virtue of the lower pressure of diseases, which is expected in fields following the technology recommended by Projeto 10, a single application of fungicides is enough to control the diseases most times. Sequential applications can only be used in regions which have a historic high frequency of diseases and/or which use susceptible cultivars.

3.3. Integrated agronomic practices

Several important interactions (relations) among agronomic practices and productivity were reported

Figure 90. The use of disease tolerant cultivars is the main alternative for rice integrated management. Severe *Pyricularia* attack on plots with cultivar BR-IRGA 410 sown on Dec 15. The IRGA 417, IRGA 418 and IRGA 420 cultivars were not affected by the disease. In this same experiment, in the October sowing, the BR-IRGA 410 grains yield reached 8.7 t/ha.

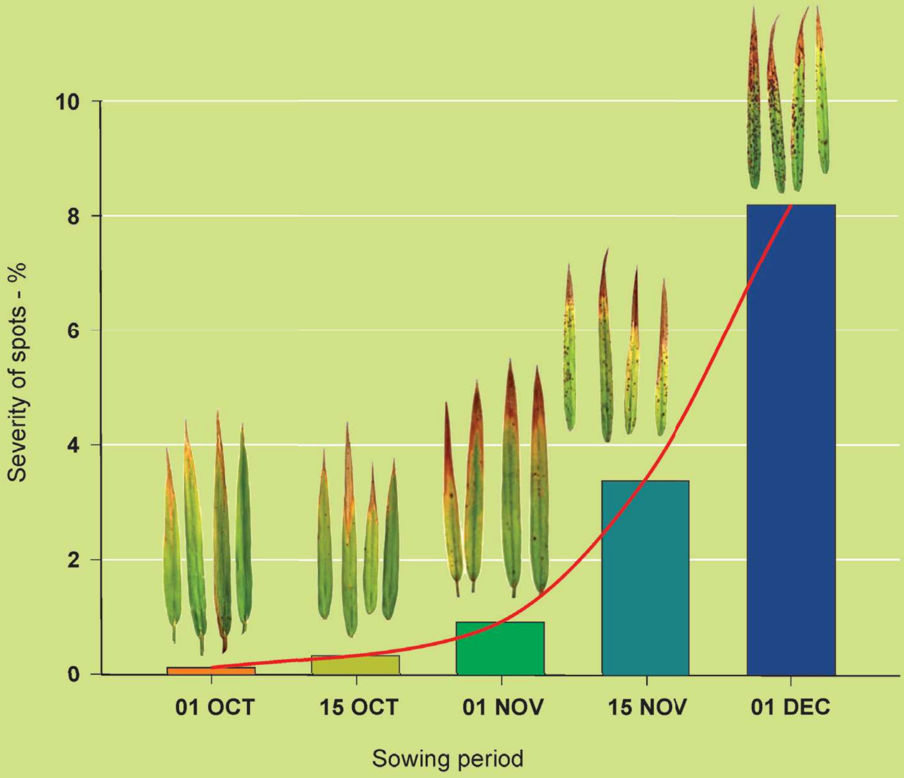


Figure 91. The severity of occurrence of Brown spot increases when sowing is conducted at a later period.

Source: Adapted from Grohs et al. (2010)

Table 12. The severity of occurrence of most diseases is lower and the rice yield grain and quality are higher when sowing is conducted at the recommended period (Biodiseases Test) – 2003/09 growing seasons – EEA/ IRGA)

Sowing time	Probability of occurrence [1]	Severity of incidence [1]	Grain yield	Whole grains
	%		t/ha	%
Oct 01 to Oct 10	35	Very low to low	8,30	64
Oct 15 to Oct 30	45	Low	8,15	63
Nov 01 to Nov 11	65	Low to mid	8,00	62
Nov 15 to Nov 30	65	Mid to high	7,45	59
Dec 01 to Dec 12	75	High to very high	6,65	56

[1] Joint analysis of the effects of Brown spot diseases, Grain spots, Rhizoctonia solani and Rice blast fungus on cultivars BR-IRGA 410, IRGA 417, IRGA 420, IRGA 423 and IRGA 424.

Source: Adapted from Grohs et al. (2010)

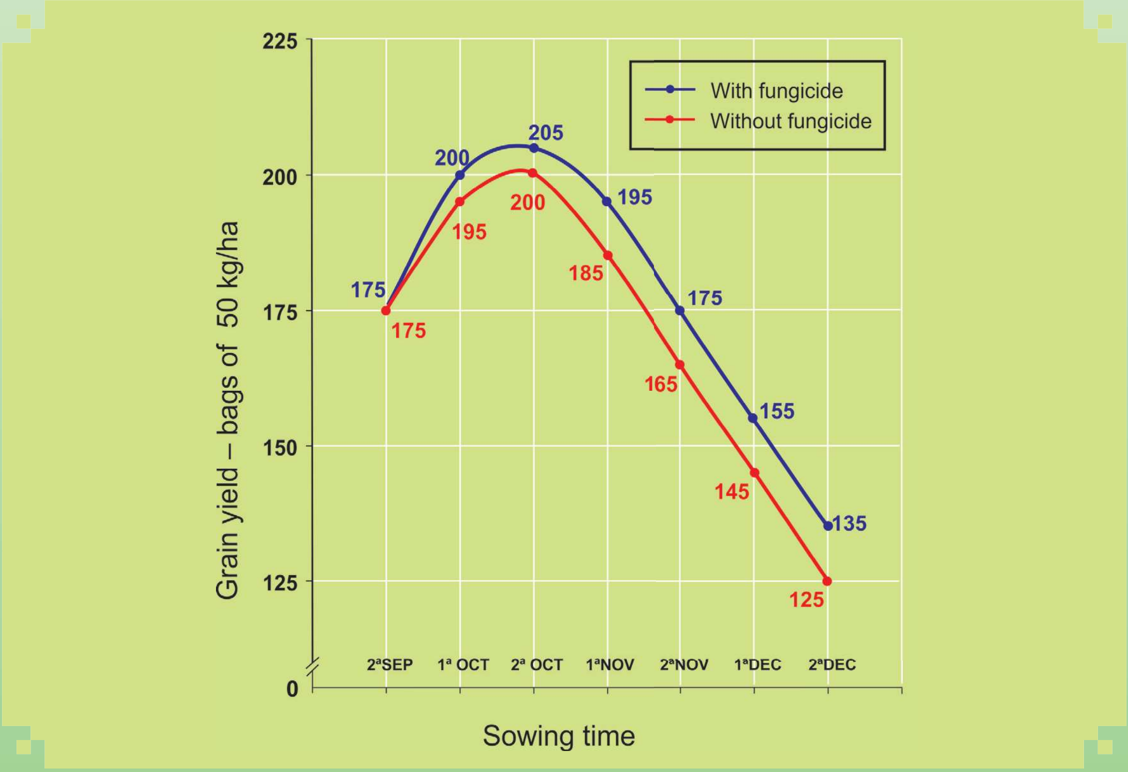


Figure 92. Rice grain yield is higher in areas sowed at the recommended period without fungicides spraying, than in those sowed in late period, with the use of fungicides.

Source: Adapted from Grohs *et al.* (2010)

along this publication: the sowing period, soil tillage, early weed control, top-dressing nitrogen fertilization and the starting of irrigation. Occurrence of weeds and diseases is lower when sowing is conducted within the ten first days in November, and the use of low sowing density, of healthy seeds, cultivars more tolerant to diseases and proper fertilization management. Even when we consider some agronomic practices, such as the sowing period and the plant emergency and establishment and choice of cultivars, fertilization and irrigation management and weed control, as the most important (key) points, the success of Projeto 10 is attributed to the joint and integrated use of all practices, both those related to the "construction" and those related to the "maintenance" of productivity (Integrated Rice Management – MICA), as shown in Figure 95. Thus, the adverse factors that cause stresses to plants are fully reduced, enabling to use more efficiently natural resources, such as soil, water, and the resources added as input and work. Extensive adherence to MICA is still a major challenge to be dealt for reaching high productivities of irrigated rice with the improvement of the productive process by the use of Good Agricultural Practices (MUNDSTOCK et al., 2011).

3.4. Technical and operational management in rice production system

Management of rice production systems consists basically on planning, organization and direction and control of crop operation to enable integrated crop management entirety. This type of management goes beyond the economic planning, that only requires knowledge of the production cost and an approximate estimation of the price to be received.

Actually, it is necessary to manage things in a way that agronomic practices can be carried out accurately, at the right moment as recommended. Hence, it is essential to use management tools correctly; such tools include the annual planning for the definition of actions (along with employees and partners), with the monitoring and critical evaluation of results and personnel's performance, keeping track of failures and awards. It is essential to set common goals, generate motivation, organization and unity, in which everyone plays a role and contributes collectively. In addition to motivation, it is necessary to set roles for each employee, who should seek or be offered training for the execution of the respective task. In this process, we are looking at the development of values for growth, personal accomplishments, organization and commitment to work, to society and environment by the group aiming sustainable rice production.

Figure 93. Deficient irrigation and the presence of host weeds close to the crop enable the development of Rice blast fungus, which may spread throughout the entire field.

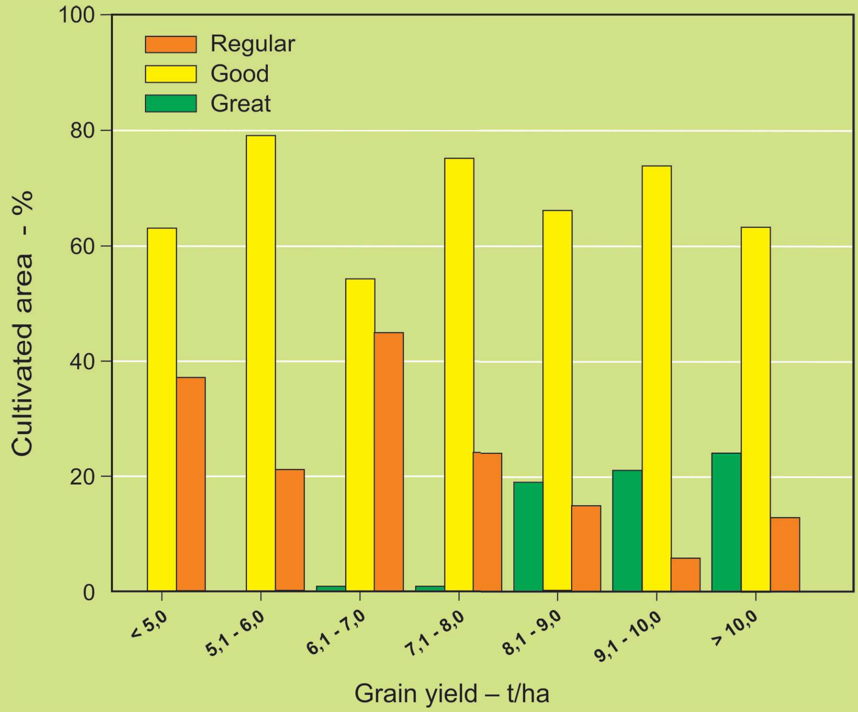


Figure 94. Higher rice grain yield is obtained by farmers that can more efficiently manage diseases in their crops (Zona Sul, 2010/11 growing season).

Source: DATER/IRGA (2012)

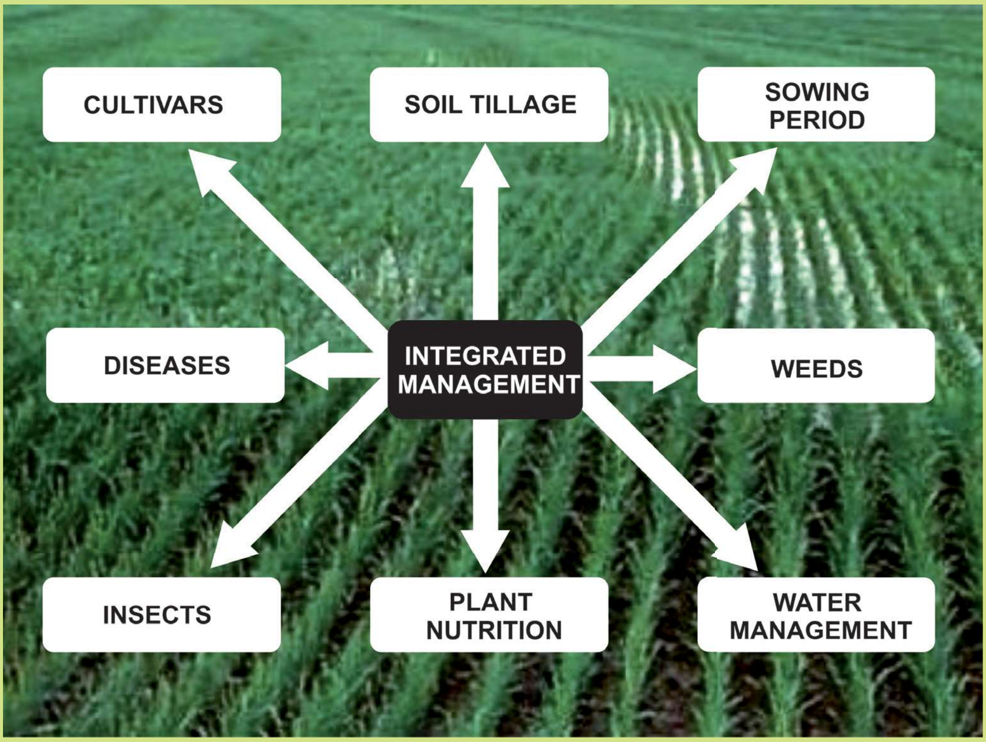


Figure 95. Only with the adoption of integrated cultural practices high rice grain yield can be achieved.

4. PROJETO 10 AND RICE PRODUCTION SUSTAINABILITY

By adopting the Good Agricultural Practices, (MUNDSTOCK et al., 2011), the technologies recommended by Projeto 10 promote sustainability of rice production since they ensure the rational and efficient use of natural resources, thus avoiding their degradation, increasing efficiency in the use of input as well as contributing to the efficient use of energy sources. It must be done without losing the focus on crop competitiveness in the market, its adherence to environmental legislation, looking for food safety and quality of life of the people who produce and consume rice, as follow.

4.1. Competitiveness and profitability

In a globalized world, even those sectors of the agricultural economy that are geared towards the internal market, as most part of the rice production process, suffer from the interferences of policies adopted by other countries, both when it comes to purchase of input and competitiveness from the introduction of products whose prices are mostly subsidized. Hence, if rice farmers want to continue working on this activity, they need to seek the same degree of competitiveness as those reached by farmers from countries that operate in this market. Besides that, rice production industry has to be able to compete with other agriculture sectors. **Because of that, in an increasingly globalized world, those who are not aware for productivity on their business will have problems in the future due to the lack of competitiveness. In Projeto 10, productivity should be understood as the capacity to produce more food, with better quality and less input.**

With the constant crises experienced by rice production industry of Rio Grande do Sul, notably over the last two decades, farmers have sought to reduce costs as a means to increase competitiveness. This strategy was somewhat successful for those whose costs were low. However, once production costs are increased, what should be done to increase crop competitiveness? Surely the best thing to be done is not to reduce the use of input since it causes lower productivity and difficulty in handling the crop's fixed costs. Likewise, the expansion of the cultivated area with low productivities will not be of any help. **Farmers who have higher economic return, regardless of the size of their cropped area, are those who are able to keep their costs under control and reach high productivity (Figure 96). Over the last years in Rio Grande**

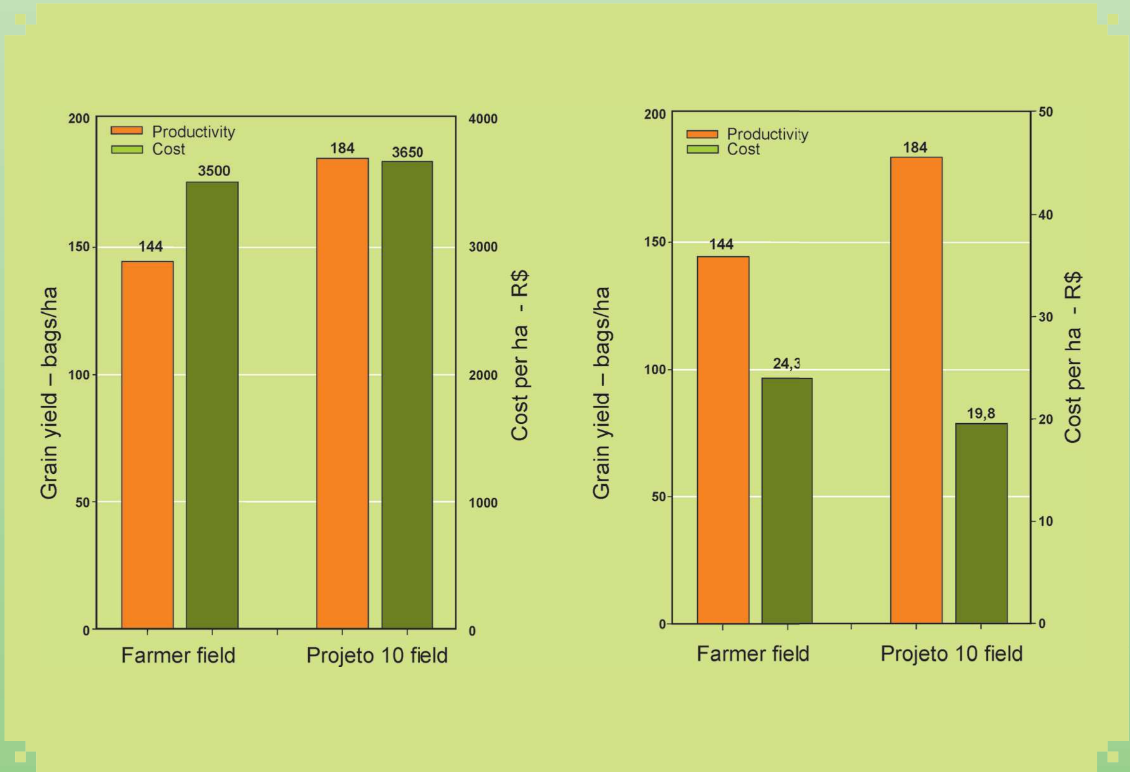


Figure 96. The average production cost per bag of irrigated rice has been decreasing with the increase of grain yield.

Source: DATER/IRGA (2012)

Figure 97. The rice production cost per hectare has remained stable whereas the cost of bag has decreased due to increase in grain yield.

Source: IRGA (2012)

do Sul, the average production cost per rice bag has been decreasing with the increase in productivity (Figure 97). The analysis of production cost of IRGA in the 2010/11 growing season shows that a great part of this cost (>70%) has not changed because of productivity (IRGA, 2011). Indeed, irrigation, herbicides, seeds and fuel costs remain the same whether the productivity reaches 5.0 or 10.0 t/ha. On the contrary, if research recommendations are used, it is possible to reduce the costs of these items. So, in order to increase productivity, the most costly item is fertilization. Harvesting, transportation, drying, fees and taxes are the costs that get higher with the increase in productivity, but they are called "good costs" by farmers.

Rice profitability increases significantly with improvements in technology (Figure 98) since all agronomic practices recommended are fully and permanently used (Figure 99). However, productivity is simply an item in the rice business. Buying inputs and selling the product requires both abilities to manage and to produce well. Overall, farmers do not buy input at the best moments and sell their rice when the price curve descends. They expect obtaining higher profits, they speculate on their business with the intent of always selling rice at higher prices. There were cases in which the rice bag cost BRL 35.00 and farmers waited it would go at BRL 40.00 to sell their product and, consequently, many farmers ended up selling their product below BRL 25.00 per bag in the same growing season.

When it comes to making investments choices, it is very common for farmers to make emotional rather than reasonable decisions. For instance, it is common for farmers to buy a tractor because there is credit available at an affordable interest rate, even if they do not need it. In this scenario, the new investment will not aggregate any benefit to the business but a debt that will have to be paid sometime in the future. With the increase in productivity and production, it is necessary to have more investments in grain storage capacity in the property even to be able to have a better profit. However, few rice farmers invested in grain storage structure. Most investments were made in machines and implements. Industry was the sectors that most invested in storage.

Staff management in rice business needs to evolve. Today the investments in personnel training and labor conditions in rice farms in Rio Grande do Sul continue to be not sufficient. Rice farmers still have not understood that the most important capital to their business are their employees. There are farmers who own land and big machinery park and

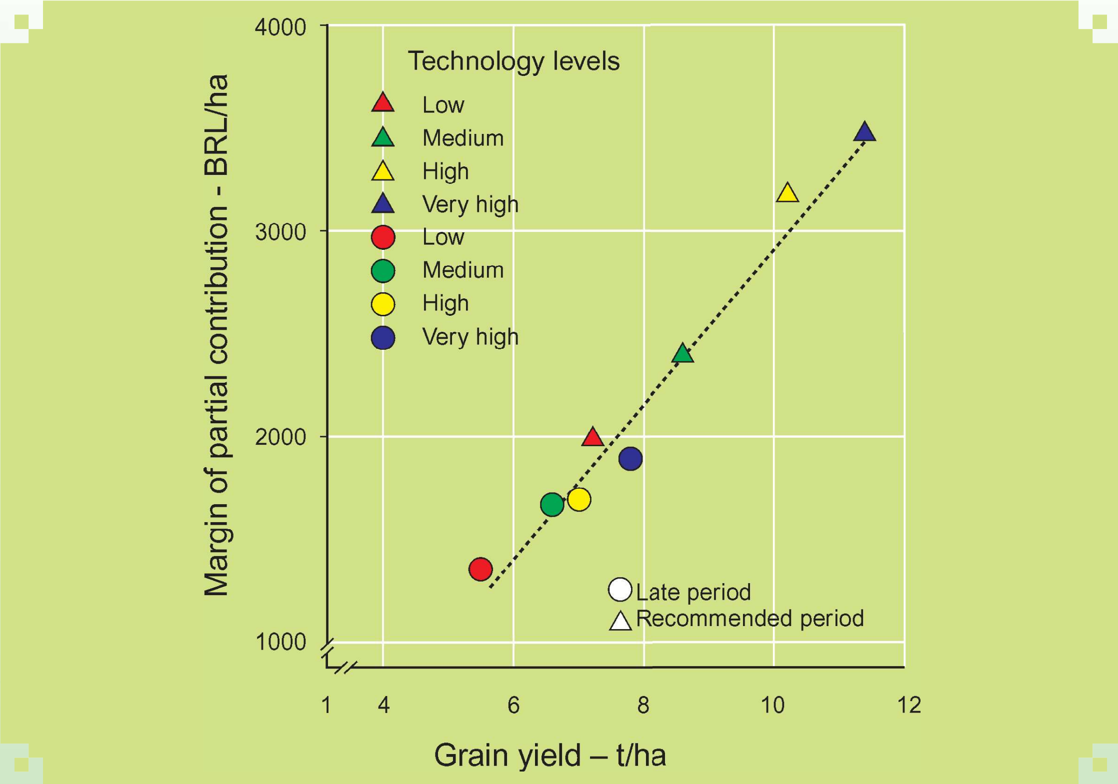


Figure 98. The grain yield and the economic return increase with the higher technology level used, especially when sowing is conducted at recommended period.

Source: Mariot et al. (2009)

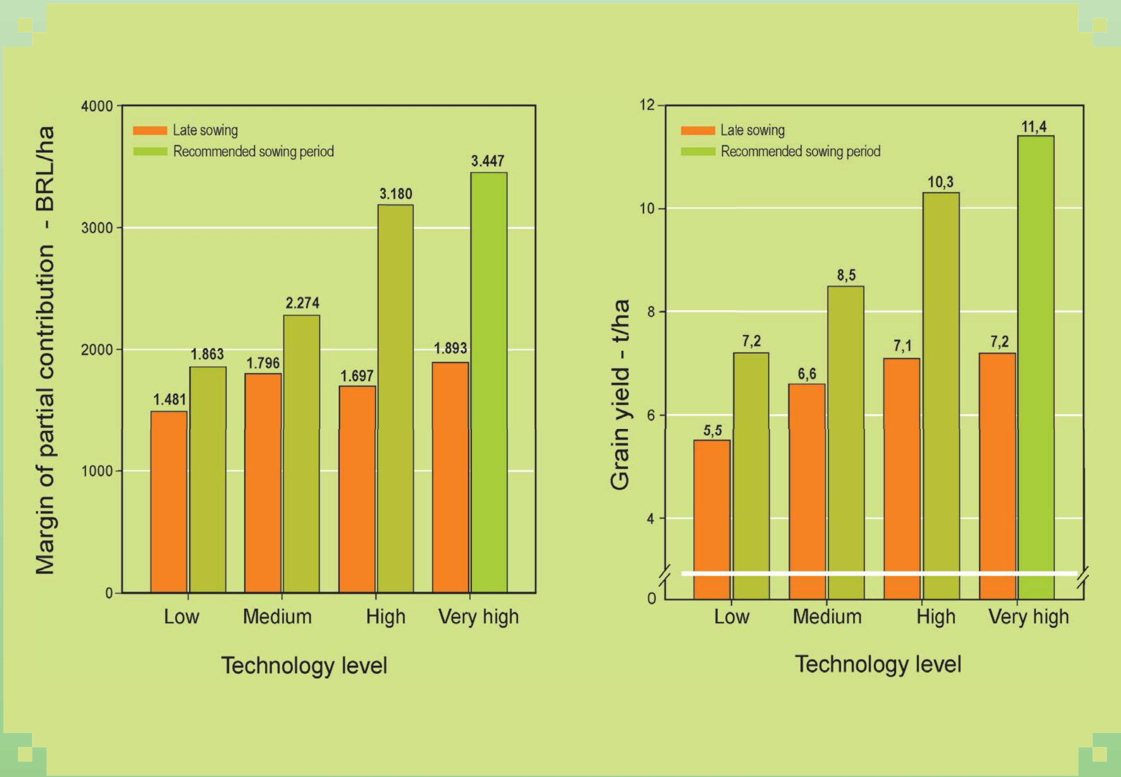


Figure 99. The use of high technology in irrigated rice should only be done when sowing is conducted at the recommended period.

Source: Agronomy team , EEA/IRGA (2009)

have problems due to the deficiencies in human resources management. These are the keys for the success of rice business since one only single group of trained employees working as a team is able to evolve as the rice economy has evolved. Producing 4.0 to 5.0 t/ha does not require major abilities. However, producing 8.0 or more t/ha requires planning and organization in all corporate levels.

Higher production, with lower costs and higher quality, is an aspect which is within the farmer's governability. However, there are factors that have a negative impact on the success of the business and are outside of its management's territory. For instance, the agreement with Mercosul that enables the importation of rice from Uruguay, Argentina and Paraguay, whose prices can be lowered in the country. Fiscal asymmetries inside and outside of the country make it difficult for the competitive capacity of rice farmers in Rio Grande do Sul. **Inside the productive chain, farmers are the less organized connection and, hence, an important part of the gains arising from the evolution in technology in irrigated rice did not end up with them. The greatest beneficiaries of this technical progress were Brazilian consumers, who are able to buy high-quality rice at a low cost, since whereas the price of rice has gone down, the minimum wage has increased above inflation** (Figure 100). These results confirm studies conducted by the International Center for Tropical Agriculture – CIAT, which show how the first greatest beneficiaries of the investments in research on irrigated rice in Latin America are the consumers. This is most relevant in Brazil, where 19% of the calories and 11% of proteins in the population's basic diet comes from the consumption of rice, thus benefitting people with lower purchasing power. **To sum up, we can state that the efficient management of the productive process of rice is essential for rice development in the State of Rio Grande do Sul, but it is not enough when farmers continue to be the weaker connection of the productive chain.**

Besides the profit increase brought by Projeto 10, the resources used in the productive system are used more efficiently. Prior to the implementation of agronomic practices recommended by Projeto 10, more than 2m^3 of water were necessary to produce 1kg of rice. Current data evidence that we can have the same production with less than half this volume of water, that is, use even less than 1m^3 of water per every kilogram produced (Figure 101), which is the goal to be reached in all rice fields in Rio Grande do Sul. This logic can be used in other resources such as, oil, electricity, machines and implements, human resources, etc. **Only in these conditions will farms fulfi-**

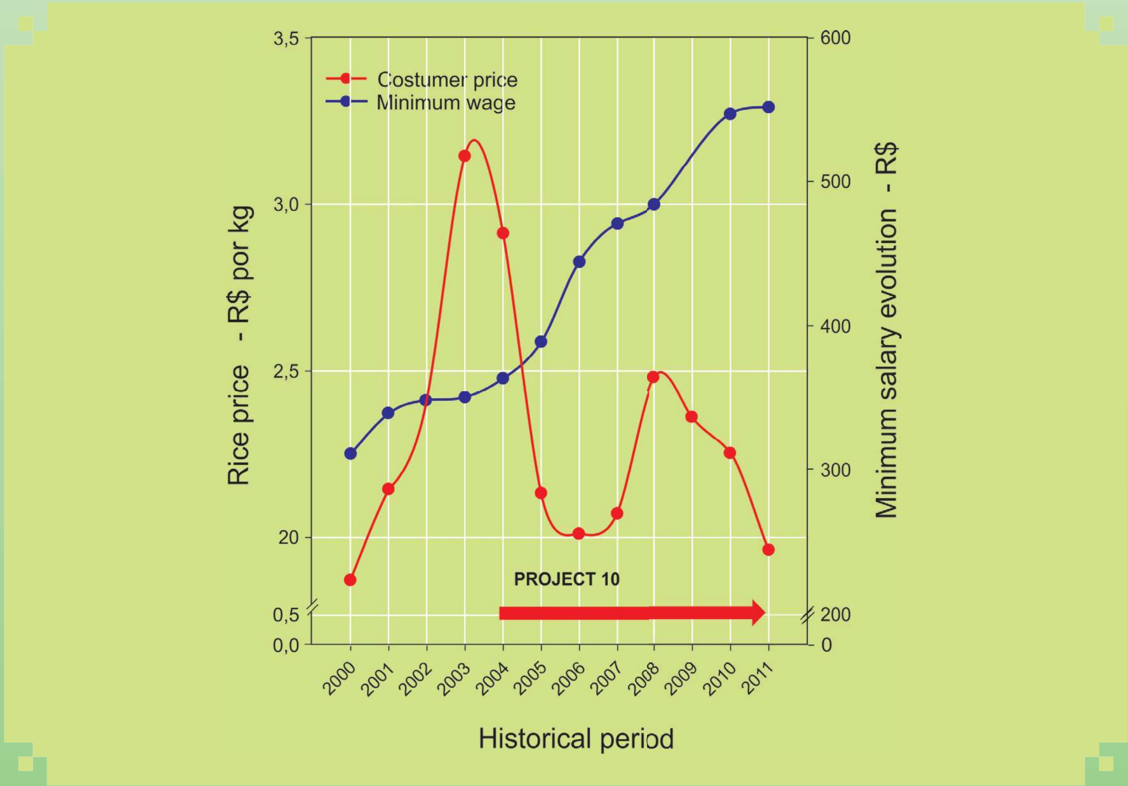


Figure 100. The greatest beneficiaries of the increased grain yield in rice crops in Rio Grande do Sul are Brazilians customers.

Source: IRGA (2012)

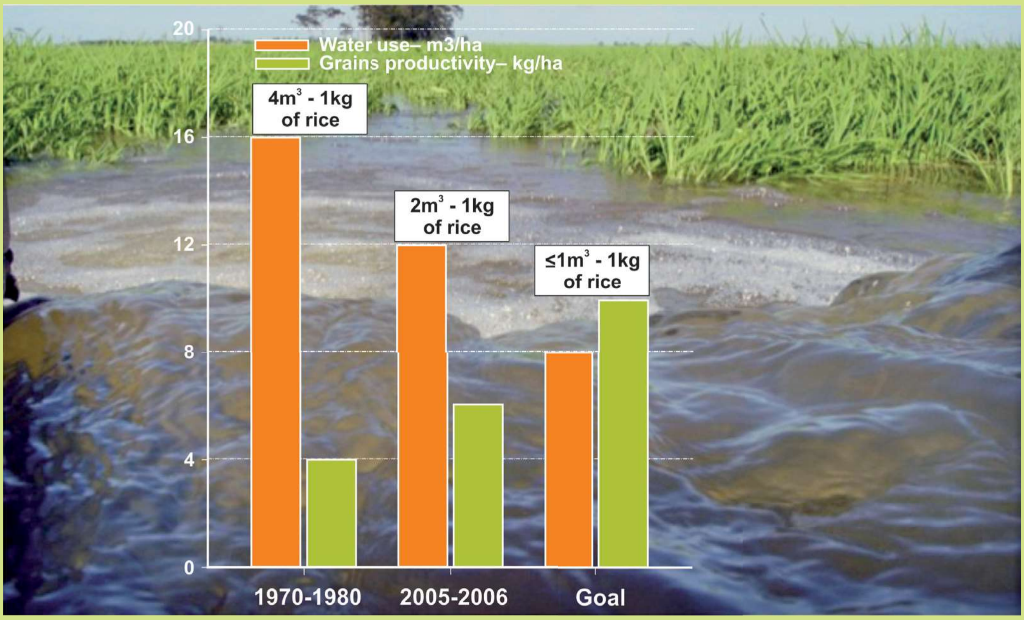


Figure 101. The water use efficiency has doubled with the Projeto 10 implementation. Less than 1 m^3 can to be used in order to produce 1 kg of rice, which is the goal to be achieved in rice fields in RS.

Source: Agronomy team, EEA/IRGA (2009)

ll their social role completely, which is to produce the highest quantity of food per unit of area, with less environmental impact.

4.2. Environmental adequacy

Rice cultivation modifies the natural ecosystem it is inserted. Then, another ecosystem using the natural resources available (soil, water, solar radiation and organisms) is created, with large human contribution. **This new ecosystem is not necessarily harmful to the existing natural resources if human actions are intended to keep them and even improve that environment with both the available technical and scientific knowledge.** The willingness of segments of our society in deeming rice crops as a highly pollutant activity needs to be revisited, once science shows that the proper management may reduce or eliminate possible negative effects of rice on natural resources and even improve them.

People who are used to walk along in the irrigated rice fields every day have a very different view from those who criticize it by looking it from distance. Fish, such as Astyanax, and a wide range of species of birds will not breed inside rice fields if they do not find conditions for so (Figure 102). This evidences that happens in rice crops in other countries, such as Italy, where rice farmers receive a subsidy of €960 per hectare, whereas corn farmers only receive €600, as authorities argue that rice flooded areas enables the development of birds and other animals. The Italian perception on the importance of irrigated agriculture has been around for long, when Leonardo Da Vinci projected the main irrigation channels to transport water from lakes formed from the mountains' ice.

Irrigated rice contributes with only 10% methane gas (CH_4) emissions to the atmosphere, and this figure is around four times lower than the emissions of this gas arising from animal production either directly or indirectly (BAYER & ZSCHORNAK, 2009). Research on greenhouse gas (GEE) is recent in the South of Brazil (10 years), but initial results have been encouraging and show that the adoption of technologies such as the minimum tillage system (Figure 103) and the use of high management levels (Figure 104) have high potential to mitigate methane gas significantly. **These research works also clearly show that the benefit is even higher when we express the emission of this gas per unit of produced rice** (Figures 103 and 104). **The increase in productivity and efficien-**

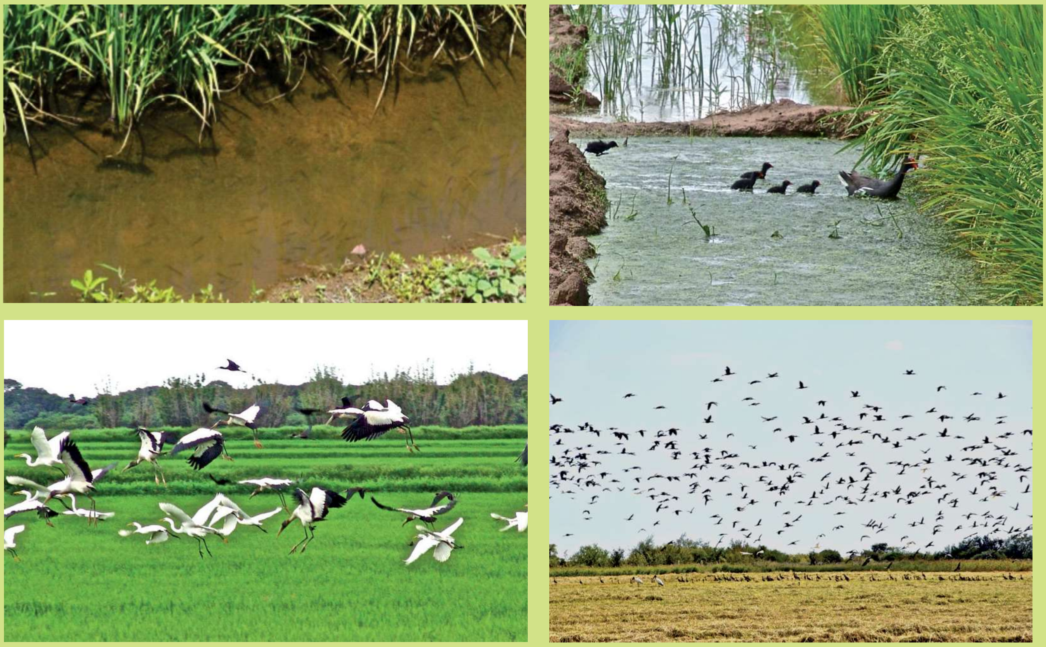


Figure 102. Rice fields, in their different stages, are a favorable habitat for the development of many species of fish and birds.

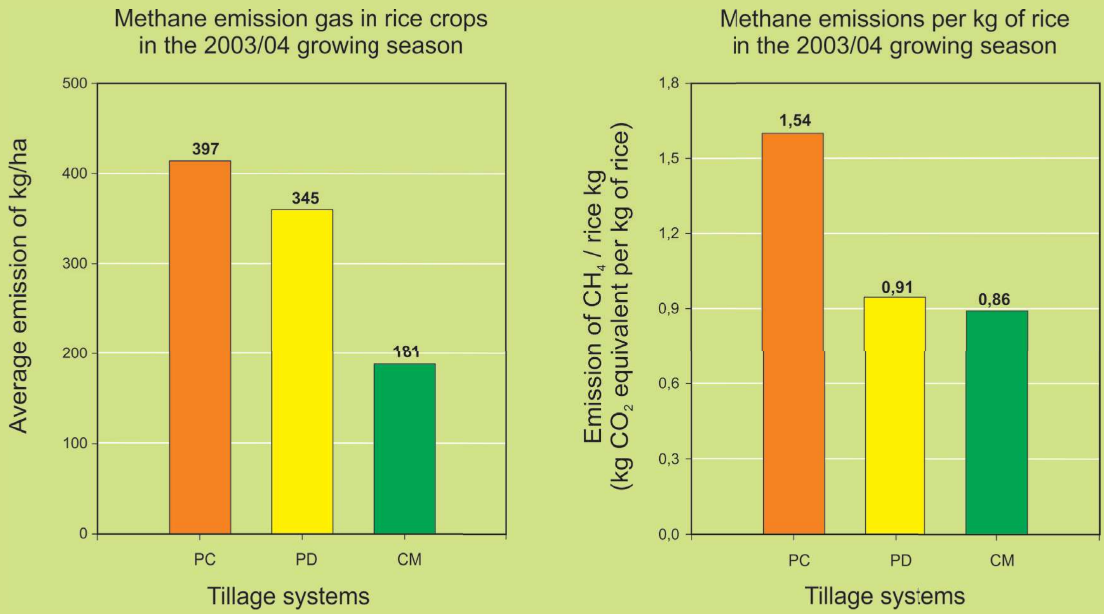


Figure 103. Methane emissions in irrigated rice fields are lower in the minimum tillage system.

Source: Bayer et al. (2009)

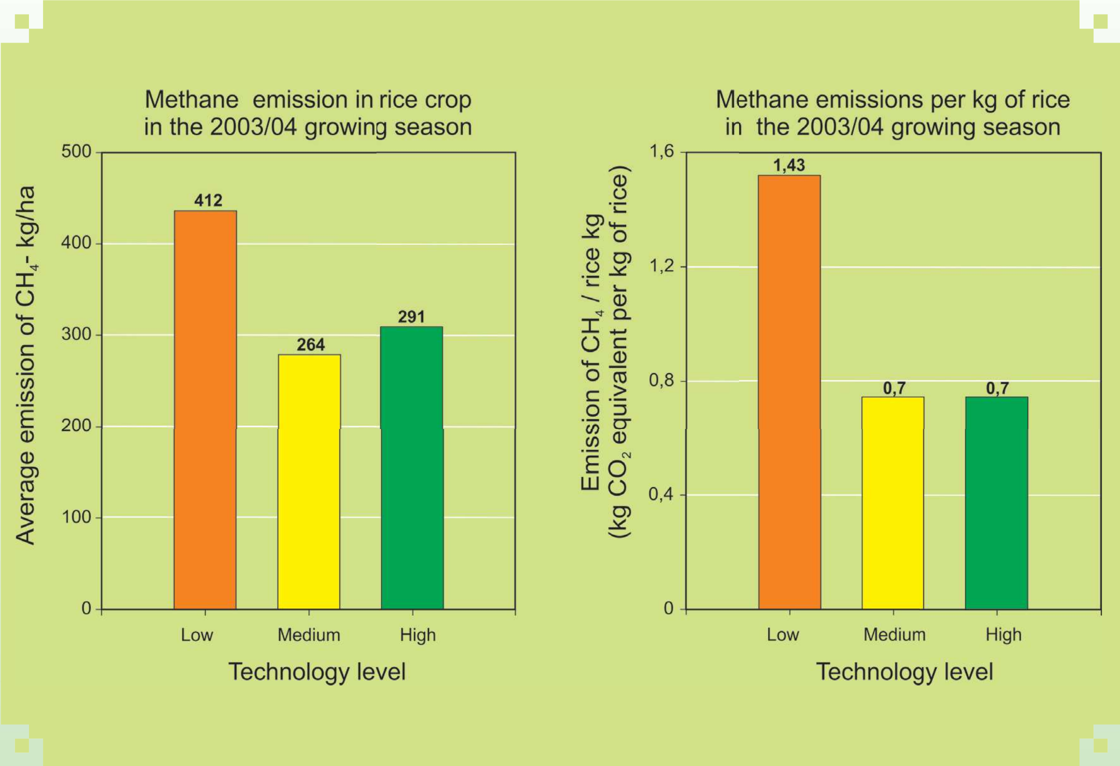


Figure 104. The high technology use in irrigated rice fields results in lower emissions of methane gas per kg of grains produced.

Source: Bayer et al. (2009)

cy in the use of applied inputs and natural resources reduce emissions of methane gas per unit of grains of irrigated rice.

IRGA has been working on a series of actions geared towards the use of Cleaner Technologies (MACEDO et al., 2008) and for the establishment of Good Agricultural Practices (MUNDSTOCK et al., 2011) suitable for the process of management of farms involved in rice production in Rio Grande do Sul. The Cleaner Technologies program recommends actions that benefit farmers and guarantee rice farm sustainability as it encourages adherence to environmental legislation, especially when it leads to rational use of natural resources and agricultural inputs, intended to provide a suitable use for the waste generated, conservation of fragile areas and safety and occupational health care. Among these actions, we can mention the monitoring of the quality of irrigation and draining water (through a partnership with UFSM - Federal University of Santa Maria), the increase in efficiency of use of water, biodiversity evaluation (through a partnership with Universidade do Vale do Rio do Sinos), the search for cultivation systems with low greenhuose gases emission (through a partnership with UFRGS - Federal University of Rio Grande do Sul), the implementation of the Selo Ambiental da Lavoura de Arroz do Rio Grande do Sul (Environmental Seal for Rice Production in Rio Grande do Sul), to recognize and value initiatives from farmers for the environmental adequacy of their projects, and the assistance from the Department of Public Prosecution for rice farmers to sign Environmental Agreement Terms (TCA) to rebuilt the ecological corridors of watersheds.

These actions are intended to develop an environmentally correct crop production system that contributes to ameliorations on the environment unlike the assumptions made on their negative effects on natural resources. Hence, IRGA strongly recommends a series of crop management practices (Integrated Management of Irrigated Rice), along with measures to be taken in the rice fields growing area with the intent of preserving natural resources and ecosystems near to the field crop. These policies are in accordance with the agronomic practices recommended by Projeto 10 (Item 3) and special cares to preserve the environment and improve living conditions of farmers, as presented in the "Good Agricultural Practices User Guide" (MUNDSTOCK et al., 2011).

5. PROJETO 10'S NEW CHALLENGES

Along this book we have presented the main strides in the production of irrigated rice in Rio Grande do Sul from the beginning of Projeto 10 in this State. Likewise, challenges to be pursued by IRGA over the coming years were pointed, so that rice productivity continues to grow within the precepts of crop sustainability and quality of the product. These new challenges will now be summarized to serve as a guide for planning of actions to be developed over the next years concerning Projeto 10.

1. Generation of data and regional information from the farmers' reality and demand

Eve n this process has considerably evolved, it should be strengthened even more, since the more the farmers take part in the process of definition of actions, higher will be the generation of information and suitable technologies to meet the demands and more they will be adopted by farmers.

2. Development of cultivars with higher tolerance to low temperatures during early plant growth

This higher tolerance will enable the conduction for sowing in the recommended period. The biggest challenges to be faced are, then, to develop cultivars that support environmental stresses, especially with medium cycle, lodging-resistant and cold-tolerant stems in the initial stage of development. Such cultivars will contribute greatly for the sowing during the entire recommended period and for making the production of rice in RS less vulnerable to environmental variables and less costly.

3. Continuation of the breeding program to develop CLEARFIELD® cultivars

Selection of new **Clearfield**® cultivars is important in areas infested with red rice fields resistant to phytotoxicity from imidazolinone herbicides. These genotypes must have higher productive potential and quality when compared to those that are currently being cultivated. Additionally, more research actions to find irrigated rice plants that are tolerant to other herbicides, with action mechanisms different from the current ones for red rice management.

4. Sowing 90% or more of rice area until until November 10th

Besides this goal has been reached in most rice production areas in the 2010/11 growing season, it must continue to be achieved in all cropped area of the State of RS. Hence, it is necessary to prepare the area in advance, dealing with aspects related to soil draining and tillage and the choice of the tillage system and area systematization.

5. Use of certified seeds

The goal to reach the use of certified seeds, despite the improvements observed throughout the development of Projeto 10, must be extended to most rice farmers in RS.

6. Management of herbicide-resistant weeds

The correct management of herbicide-resistant plants for the preservation of the **Clearfield**® technology must be disseminated as the main tool for the management of red rice.

7. Diagnosis improvement of rice nutritional status

It is necessary to develop and consolidate methodologies for foliar diagnosis (sufficiency ranges and/or balance between nutrients – DRIS) to improve the adjustments made in the fertilization recommendations, especially for micronutrients.

8. Projeto 10 and rice sustainability in the State of Rio Grande do Sul.

Even if the recommended practices by Projeto 10 take in consideration the Good Agricultural Practices, both in the cropping fields and in the farm as a whole, and there are initiatives available for tracking the product (Environmental Seal), the biggest challenge to be faced by rice farmers is still to produce large quantities of food with the highest level of efficiency and use of natural resources and inputs, with the lowest environmental impact possible and with the proper attention to ensure occupational safety and health.

9. Technology diffusion

Technology diffusion is still one of the biggest steps for the reduction of the productivity gap in the fields of irrigated rice and it will only be overcome with the increasing participation of the communities when defining problems to be addressed, both as extension and research works. The generation of knowledge at universities and research centers is compartmentalized. Hence, the integrated management for irrigated rice, looking the cropping system as a whole should be a strategy that enables farmers to increase productivity and reduce its environmental impact. The participation of researchers, extensionists and farmers as subjects in the process of technology and knowledge generation is essential for gathering higher economic, social and environmental sustainability in the rice production in the State. The provision of deeper insights into this process is essential for the crop to grow in a sustainable way over the coming years as a whole, and this is perhaps the biggest of the challenges.

6. RECORDING CROP EVENTS

Overall, in the agriculture business, it is not common to keep records of the activities and incidences during the whole growing season. Most part of what is done or happens is available only in the memory of the people involved in the production process. To rely upon the memory alone is a serious mistake for those who wish to implement rice production business. The events that take place in the beginning of the harvest are most of the time not even remembered. In the next harvest, it will be more difficult. Because of that, a detailed planning of all steps in the growing season and maintenance of records of all important data and facts have been strongly recommended.

Farmers and their cooperative members must pay special attention to all harvest stages, recording the main data, sowing period dates and the crop emergence and stand, amount of seeds and fertilizers, start and end of irrigation date, a list of products, doses and periods for weed control, pests, diseases among others, to find out about their reality. This information is extremely important for the planning and organizing the rice production process in the following harvest. In order to obtain more precise information, it is necessary to step over and inspect regularly the entire cropped area. Check for details by touring around it. Assess the development of plants and for the correct management. Count the number of rice seedlings, tillers and panicles. Record every occurrence of weeds, insects and diseases.

Having these events in your memory only is not a good way to record information, as they need to be registered. Recording results on paper or on an electronic way is a simple means to ensure that the information will be available in the future. Compare and identify results. Pinpoint the problematic areas and the crop's strengths. Improve management to overcome bad results and repeat management actions that have resulted in high productivities. **Use spreadsheets, as the one attached, to record data and information**.

7. PHOTO CREDITS

The most photos in this publication should be credited to the researcher Valmir Gaedke Menezes. In addition to him, some specific photos are credited to the following researchers, in the respective areas: Daniel Santos Grohs, in Disease Management, Thais Fernanda Stella de Freitas, in Insect Management and Elio Marcolin, in Irrigation Management.

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9. APPENDIX

9.1. Spreadsheet for recording crop events

PROJETO 10 - GROUP

IRGA – Institute of Rice of Rio Grande do Sul

1 REGISTRATION

Farmer's Name:	Property Name:
Address/Location:	City/State:
Telephone: ( )	Cell phone: ( )
Email address: @	Name:

2 REGISTRATION

Nº	Area		Seed		Base Fertilization		Sowing and Emergence				Weeds				Pests				Diseases				Irrigation	
	ha	Parcel	Cultivar	Density	Formula	Rate	Tillage system	Sowing date	Emergence date	Stand	Event 1		Event 2		Event 1		Event 2		Event 1		Event 2		Start Date	Stage
											Date	Stage	Date	Stage	Date	Stage	Date	Stage	Date	Stage	Date	Stage		
01																								
02																								
03																								
04																								
05																								
06																								
07																								
08																								
09																								
10																								

3 MANAGEMENT DATA

Nº	Date	Stage	Occurrence	Control (Commercial Product/Formulation)	Rate	Observation
01						
02						
03						
04						
05						
06						
07						
08						
09						
10						

9.1. Continuation...

4 CROP DATA

Nº	Top dressing fertilization						DPF	Flowering		End of Irrigation		Stimulated Losses			Harvest							Industrial Profitability	
	1st Application			2nd Application			Date	Date		End Date	Stage	Event	Date	Stage	Date	Panicles m^2	Sterility	Production (kg)	Impurity (%)	Drying (%)	Profitability (kg/ha)	Income/ Benefit	I/Q
	Formula	Rate	Stage	Formula	Rate	Stage		5%	80%														
01																							
02																							
03																							
04																							
05																							
06																							
07																							
08																							
09																							
10																							

5 OBSERVATIONS

6 DRAFT

Development stages of rice plant

The developent stages of rice plants are divided in three major phases: Seedling, Vegetative and Reproductive

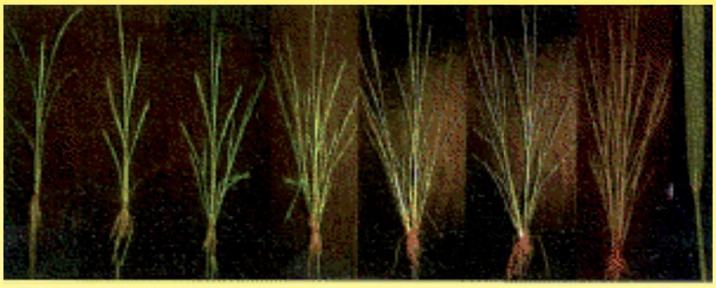
STAGES OF SEEDLING DEVELOPMENT

S0. Rice dry seed;
S1. Emergence of coleoptile or root;
S2. Emergence of coleoptile and root;
S3. Emergence of the coleoptile profile.

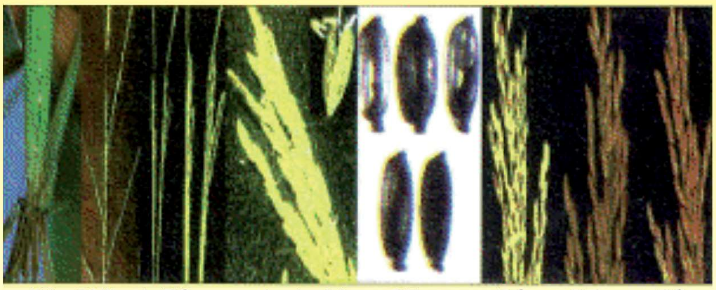
S0 S1 S2 S3 V1 V2 V3 V4 V5 V6

STAGES OF VEGETATIVE DEVELOPMENT

The stages are described with the letter "V" and the number below refers to the number of leaves fully development with the development of the collar.
V1. Collar formed in the 1st leave of the main stem;
V2. Collar formed in the 2nd leave of the main stem;
V3. Collar formed in the 3rd leave of the main stem;
V4. Collar formed in the 4th leave of the main stem;
V5. Collar formed in the 5th leave of the main stem;
V6. Collar formed in the 6th leave of the main stem;
V7. Collar formed in the 7th leave of the main stem;
V8. Collar formed in the 8th leave of the main stem;
V9 (VF-4). Collar formed in the 9th leave of the main stem. VF refers to the flag leaf and the following number refers to the number of the not preceding hte flag leaf.. **V10 (VF-3).** Collar formed in the 10th leave of the main stem, as 3 leaves are missing for the emergence of the flag leaf. **V11 (VF-2). Collar formed in the 11th leave of the main stem, as 2 leaves are missing for the emergence of the flag leaf. V12 (VF-1). Collar formed in the 12th leave of the main stem, as 1 leaf is missing for the emergence of the flag leaf. V13 (VF).** Collar formed in the flag leaf.



V7 V8 V9(VF-4) V10(VF-3) V11(VF-2) V12(VF-1) V13-VF(Flag)



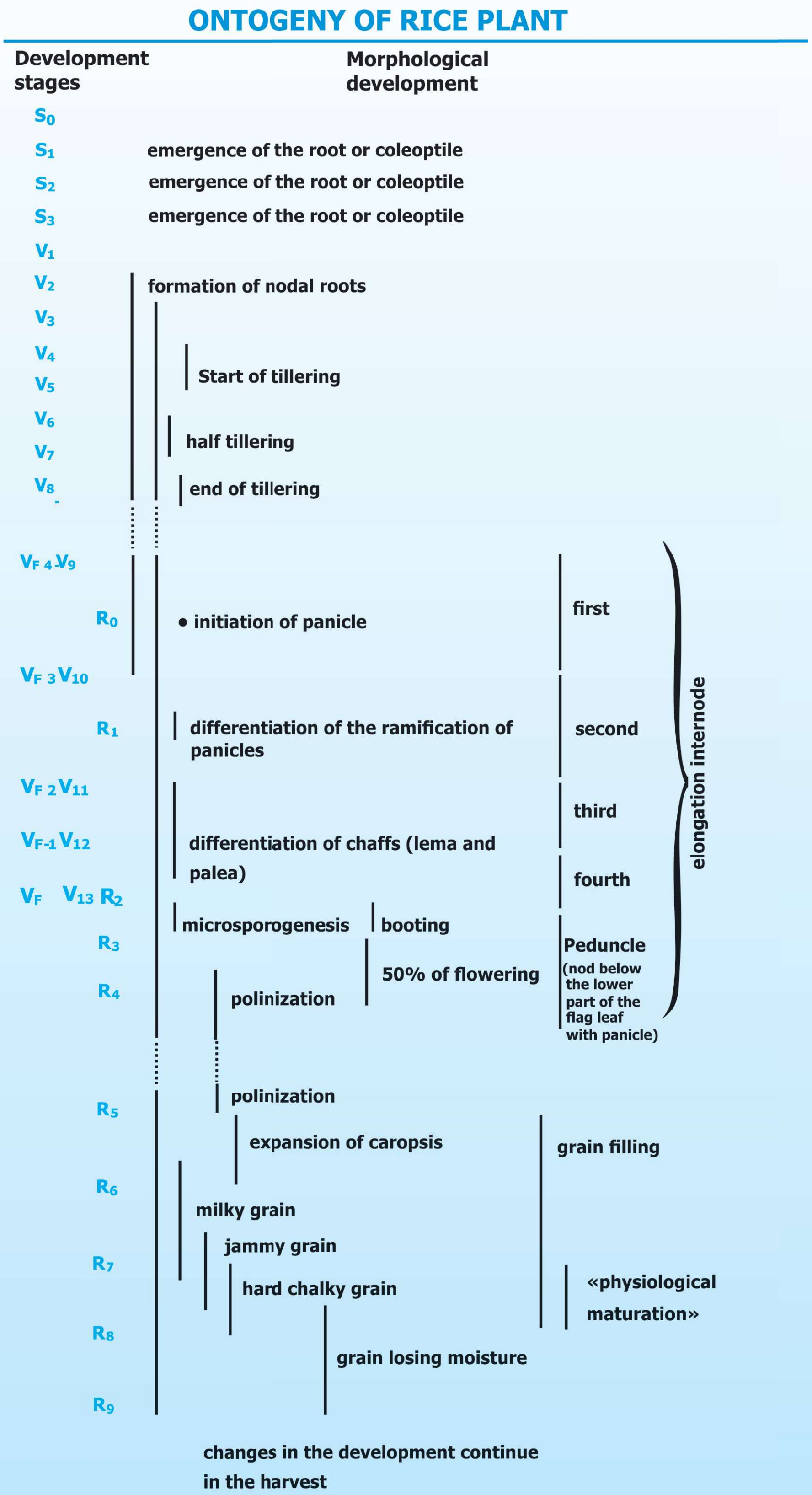
R1 R2(Boot) R3 R4(Anthenis) R5 R6 R7 R8

STAGES OF REPRODUCTIVE DEVELOPMENT

R0. Panicle initiation;
R1. Panicle differentiation;
R2. Formation of the collar of flag leaf;
R3. Exsertion of panicle;
R6. Anthesis (when one or more spikelets);
R5. Grain enlargement;
R6. Grain expansion;
R7. Maturation of a grain in the panicle;
R8. Complete panicle maturation.

Source: Counce et al. (2000)

9.3. Ontogeny of rice plant



Source: Counce et al. (2000)

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In the larger photo, an acknowledgment of the work of all extension workers who contributed to the success of Projeto 10. In the smaller photo, recognizing João Eloy Cordeiro for be the first extension worker of the IRGA to believe and to contribute to the implementation of the Project in Dom Pedrito. He had the best attribute of an extensionist: the confidence of growers in their work.