Available online at http://www.journalijdr.com

IJDR

ISSN: 2230-9926

International Journal of Development Research
Vol. 13, Issue, 03, pp. 62102-62105, March, 2023
https://doi.org/10.37118/ijdr.26485.03.2023

RESEARCH ARTICLE OPEN ACCESS

MONITORING OF WATER USE FOR IRRIGATED RICE CULTIVATION ON THE SOUTHERN COAST OF SANTA CATARINA, BRAZIL

***Álvaro J. Back**

Empresa de Pesquisa Agropecuária e Extensão Rural de Santa Catarina (Epagri), Estação Experimental de Urussanga

ARTICLE INFO

ArticleHistory:

Received 10th January, 2023
Received in revised form
19th February, 2023
Accepted 26th February, 2023
Published online 28th March, 2023

KeyWords:

Irrigação; Arroz irrigado; Rizicultura; Recursos hídricos.

****Correspondingauthor: Álvaro J. Back***

ABSTRACT

Rice growing is the main agricultural activity on the southern coast of Santa Catarina. The cultivation system used is flood irrigation with planting in the pre-germinated system. The activity is characterized by the high demand for water use, and thus there are water use conflicts and also impacts on water quality. Irrigation is carried out based on natural water availability and there are no structures for measuring the volumes used. This study aimed to monitor and evaluate the use of irrigation water in a collective system of irrigation association of rice producers. The inflow and outflow were monitored with Parshall and CTR gutters equipped with level sensors with hourly readings, for one period and three consecutive harvests. Water consumption for irrigated rice cultivation averaged 9894 m^3ha^{-1}. The need for irrigation showed mean values of 0.78 $L.s^{-1}.ha^{-1}$ with peak values of 1.10 $L.s^{-1}.ha^{-1}$. Rainfall makes an important contribution. It was found that it is possible to increase the efficiency of the irrigation system and reduce the value of water used for irrigation.

Citation: ***Álvaro J. Back, 2023.*** "Monitoring of water use for irrigated rice cultivation on the southern coast of santa catarina, brazil". *International Journal of Development Research*, 13, (03), 62102-62105.

INTRODUCTION

Rice growing has outstanding economic and social importance for the state of Santa Catarina (Oliveira *et al*., 2016), with a planted area of around 150,000 hectares, involving more than 5,000 rural producers in 93 municipalities (Hickel and Vale, 2022). It is the main crop for several municipalities in the southern region of Santa Catarina and especially in the Araranguá River Basin. This hydrographic basin is considered one of the most important basins on the southern coast of Santa Catarina (Dantas *et al*., 2005), which has a large part of the water resources with water quality compromised by coal mining (Cardoso *et al*., 2022).The great demand for water used in irrigation contributes to conflicts of use and the degradation of water quality in the Araranguá River basin. According to Profill (2015), these areas required intervention so that there is compatibility between the demand for water and the existing water availability, thus allowing that improvement and control measures can be implemented, according to the needs of each sector and in accordance with the watershed management units. Considering the large volumes demanded by the irrigation sector and the fact that the activities are more significant, the Water Resources Plan for the Araranguá River Basin points to the need to seek means that allow these economic activities to be carried out with greater security and water viability (Profill, 2015).

For the implementation of Water Resources Management instruments, it is necessary to know the water demands and availability. Despite the long tradition of irrigated rice cultivation, there is little information about the actual use of water in irrigated rice cultivation. Most properties do not have a system for monitoring and measuring the collected flow. Even in collective systems and Irrigation Associations, normally there is no monitoring structure, and irrigation is managed basically according to the natural availability of water in the watercourse, therefore there are conflicts in times of drought. Back and Lucietti (2022) highlight the lack of local information on the use and efficiency of irrigation in the rice crop for the climate, soil, and management conditions adopted in Santa Catarina. Some studies were carried out based on experimental plots and, therefore, do not represent the conditions of collective systems, where the water drained from a property can be used in the property located downstream. There is also information on water consumption for irrigation systems other than those used in the southern region of Santa Catarina. Thus, this study aimed to monitor the use of water in irrigation in a collective irrigated rice irrigation system on the southern coast of Santa Catarina.

MATERIALS AND METHODS

The research was carried out at the Núcleo Gava Drainage and Irrigation Association (Adinga), located in the municipalities of

Siderópolis and Nova Veneza, in the south of Santa Catarina (Figure 1). This Association was created to manage an irrigation system for rice cultivation in an area of 304 ha, distributed in 40 agricultural properties, with an average irrigated rice cultivation area of 7.6 ha. In the delimitation of the area, cultivation areas were identified between the properties of Adinga's partners, with that the cultivation area was considered to be 399 ha. The climate in the region is Humid subtropical with hot summer (Cfa) (Alvares *et al*., 2013). The average monthly temperature ranges from 14.2°C in June to 23.0°C in February. The monthly averages of minimum temperatures vary from 9.6 to 19°C and monthly averages of maximum temperatures vary between 19.6 and 28.6C. The average annual precipitation is 1704 mm (Back, 2020). The study area is located downstream of the São Bento River Dam and captures water by gravity directly from the São Bento River. The water is conducted through a main channel, which feeds the rice fields of different properties, always by gravity. With the implementation of the São Bento River Dam, in 2003, an agreement was made with the community guaranteeing the flow for rice cultivation to Adinga and also areas of other irrigation associations located in the São Bento River basin.

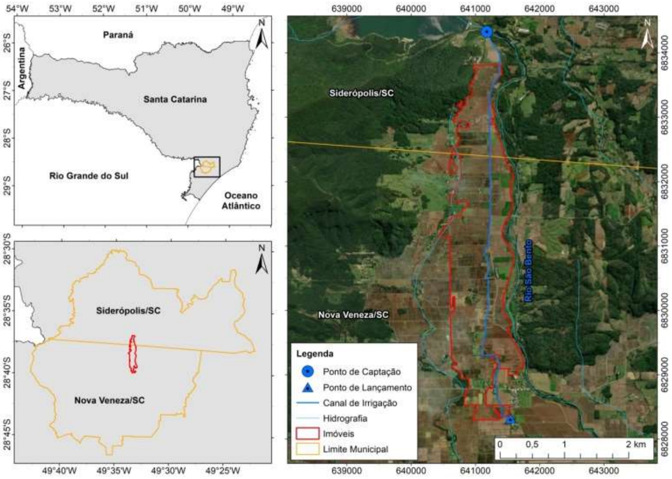

Figure 1. Location of the study area

The rice cultivation system adopted is by flooding, with planting in the pre-germinated system, in which the area is systematized in level. Flooding occurs in the soil preparation phase and sowing is carried out with pre-germinated seeds in blocks with water depths of approximately 5 cm. Flooding occurs 25 to 30 days before the scheduled sowing date (Oliveira and Vale, 2022).To monitor the flow of water entering the Adinga irrigation system, a Parshall flume was built in concrete. The monitoring of the water level in the flume was carried out with a level sensor with records of the water height at hourly intervals. Anatmospheric pressure sensor with hourly readings was also used for compensation and correction of the level sensor measurement. Figure 2 represents the monitoring model adopted.

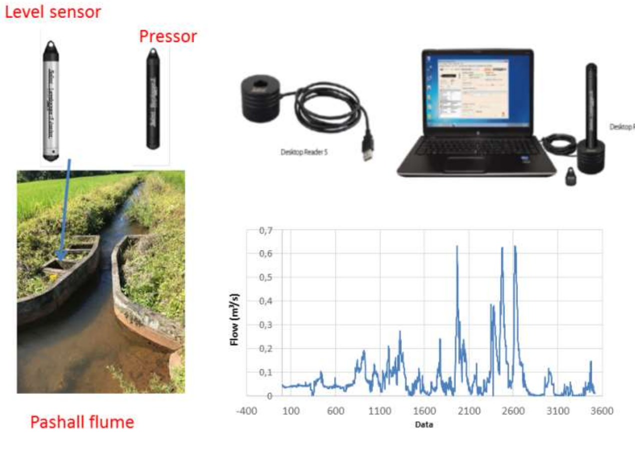

Figure 2. Outflow monitoring scheme

Excess water was monitored with the construction of a CTR model flume (Back, 2015) also equipped with a level sensor. This flume was installed in the irrigation channel at a point located after capturing the last property. Precipitation and evapotranspiration were monitored at the São Bento River Dam Meteorological Station, located approximately 600 m from the beginning of the Adinga area. To measure the flow rates of the CRT flume, measurements were made with a hydrometriccurrent meter and the rating curve was adjusted. Monitoring was carried out in the 2019/20, 2020/21 and 2021/22 harvests during the period from August 1 to February 15.

RESULTADOS E DISCUSSÃO

Tables 1 to 3 show, respectively, the precipitation data, evaporation from the Class A Tank (ECA), and the irrigation volume and flow values for the three monitored crops. The monitoring period was from August 1st to February 15th, totaling 199 days. It is noteworthy that mid-cycle cultivars have a crop cycle duration ranging from 121 to 135 days, and for late-cycle cultivars, the cycle duration is 136 to 150 days (Marschalek *et al*., 2022). As irrigation starts approximately 25 days before planting and is suspended 20 days before harvest, the irrigation period is approximately equal to the cultivation cycle. Pandolfo *et al*. (2022) point out that for the southern coastal region of Santa Catarina, late-cycle cultivars have a 140-day cycle. The duration of the monitoring period of 199 days is justified by the planting schedule, since some farmers start sowing earlier. This practice of staggering planting is encouraged in the region as a way of distributing the demand for water use and reducing conflicts during periods of drought. As this Association has relatively little consumption and is located downstream of the São Bento River dam, it is in a relatively comfortable situation in terms of water availability. In other Associations, there is a greater concern with scheduling planting as a way of reducing conflicts and increasing irrigation efficiency. The Ministry of Agriculture, Livestock and Supply, based on climate zoning, recommends that planting be carried out between September 15th and October 15th. Pandolfo *et al*. (2022) point out that the best time for sowing on the southern coast of Santa Catarina, for most cultivars, is between October 15 and November 15. In practice, it is observed that many farmers anticipate planting, justifying this anticipation by several factors such as greater availability of harvesting machines, better use of the July and August rains for soil preparation, and less risk of storms in the summer.

The total precipitation in the three seasons was respectively 860 mm; 1152 mm and 941 mm, with an average of 984 mm. Evaporation from the class Atank averaged 792 mm, which is 20% less than average precipitation. These data reinforce the great contribution of rainfall to meeting water demand. Back and Lucietti (2022) highlight that for the conditions of Santa Catarina, rainfall is one of the main components related to water supply, contributing to about 40% of the demand for the crop. Parfitt *et al*. (2018) point out that the continuous flood irrigation system, as currently practiced in southern Brazil, does not allow the direct use of rainwater in rice cultivation, although, during the irrigation period, rainfall in the rice regions of Rio Grande do Sul is, on average, 46% of the water evapotranspired by rice (Mota *et al*., 1990). Water use in the three harvests was respectively 9,396 $m^3.ha^{-1}$, 10,001 $m^3.ha^{-1}$ and 10,285 $m^3.ha^{-1}$with an average of 9,894 $m^3.ha^{-1}$. According to SosbaI (2018), the traditional irrigation system has a high water requirement that can vary from 6,000 to 12,000 $m^3.ha^{-1}$, for an average irrigation period of 80 to 100 days, depending on the cultivar used. Back and Lucietti (2022) state that the average requirement per hectare per harvest ranges from 7,000 to 10,000 m^3. Back and Just (2018) evaluated water consumption in two harvests in an Irrigation Association with an area of 3,000 ha located near Adinga and found lower values. The higher values of water use in Adinga show that the irrigation system can be more efficient. As the irrigated area is located between the São Bento River and the River Sanga, there are several points of water loss, with drainage for these rivers. The problem is relativized by the fact that part of the water returns to the watercourse, and thus is used in other irrigated areas.

Table 1. Use of irrigation water at the Adinga Irrigation and Drainage Association in the 2019/20 harvest

Period	Rainfall (mm)	ECA (mm)	Volume (hm³)			Use m³ha^{-1}	Flow rate (L.s^{-1}.ha^{-1})		
			Input	Output	Use		Input	Output	Use
Aug.	32	92	0.259	0.075	0.184	460	0.24	0.07	0.17
Sep.	39	76	0.461	0.197	0.264	661	0.45	0.19	0.26
Oct.	243	132	0.974	0.232	0.742	1858	0.91	0.22	0.69
Nov.	144	127	0.728	0.105	0.624	1564	0.70	0.10	0.60
Dec.	91	141	1.088	0.176	0.912	2286	1.02	0.16	0.85
Jan.	303	108	1.126	0.248	0.877	2199	1.05	0.23	0.82
Feb.	79	114	0.395	0.248	0.146	367	0.76	0.48	0.28
Total	931	790	5.031	1.282	3.749	9396	0.73	0.19	0.55

Table 2. Use of irrigation water at the Adinga Irrigation and Drainage Association in the 2020/21 harvest

Period	Rainfall (mm)	ECA (mm)	Volume (hm³)			Use m³ha^{-1}	Flow rate (L.s^{-1}.ha^{-1})		
			Input	Output	Use		Input	Output	Use
Aug.	77	92	0.516	0.123	0.393	986	0.48	0.11	0.37
Sep.	143	76	0.810	0.178	0.633	1586	0.78	0.17	0.61
Oct.	75	132	1.051	0.174	0.877	2197	0.98	0.16	0.82
Nov.	139	127	0.983	0.202	0.781	1959	0.95	0.19	0.76
Dec.	239	141	0.955	0.337	0.618	1549	0.89	0.32	0.58
Jan.	308	108	0.996	0.462	0.534	1338	0.93	0.43	0.50
Feb.	171	122	0.279	0.124	0.154	387	0.54	0.24	0.30
Total	1152	798	5.590	1.600	3.990	10001	0.81	0.23	0.58

Table 3. Use of irrigation water at the Adinga Irrigation and Drainage Association in the 2021/22 harvest

Period	Rainfall (mm)	ECA (mm)	Volume (hm³)			Use m³ha^{-1}	Flow rate (L.s^{-1}.ha^{-1})		
			Input	Output	Use		Input	Output	Use
Aug.	39	87	0.720	0.095	0.625	1567	0.67	0.09	0.59
Sep.	213	104	0.688	0.264	0.424	1063	0.67	0.26	0.41
Oct.	111	98	0.801	0.293	0.508	1272	0.75	0.27	0.47
Nov.	114	125	0.942	0.188	0.754	1890	0.91	0.18	0.73
Dec.	109	127	0.907	0.180	0.726	1821	0.85	0.17	0.68
Jan.	222	120	1.131	0.235	0.896	2246	1.06	0.22	0.84
Feb.	133	126	0.349	0.179	0.170	426	0.67	0.35	0.33
Total	941	788	5.538	1.434	4.104	10285	0.81	0.21	0.60

In Figure 1, it is possible to observe that next to the study area there are irrigated rice cultivation areas that take advantage of this drained water.The consumption of 9,894 m³.ha^{-1}is compatible with values mentioned in the literature. Porciúncula *et al*. (2019) cite values of 12,000 m³.ha^{-1}for the irrigation district of ArroioDuro, in the municipality of Camaquã–RS, with approximately 45,782 hectares of irrigated rice. Research works measuring water consumption in rice crops in the pre-germinated system found water consumption ranging from 9,300 and 11,200 m³.ha^{-1}. Also Petrini *et al*. (2013) determined the use of 9,489 and 12,127 m³.ha^{-1}of water during the rice cultivation cycle, without considering the rainfall that occurred during the experiment. Based on field observations, it can be concluded that it is possible to increase irrigation efficiency with the adoption of some practices, such as reinforcing and increasing the height of the rammed earth, avoiding rupture, lateral losses, and better use of rainwater. The construction of lateral channels for the drainage and reintroduction of water in the irrigation system allows for better use and increased efficiency of the irrigation system. A relatively easy measure to be adopted is also highlighted, which consists of better control.A relatively easy measure to be adopted also stands out, which consists of better controlling the entry of water into the irrigation system, by closing the gate or reducing the inflow in periods of lower demand or excessive rainfall, and thus reducing loss due to excess water. The inflow had an annual average of 0.78 L.s^{-1}.ha^{-1}, with peak demand values of 1.06 L.s^{-1}.ha^{-1}. The inflow had an annual average of 0.78 L.s^{-1}.ha^{-1}, with peak demand values of 1.06 L.s^{-1}.ha^{-1}. According to Irga (2001), in Rio Grande do Sul, in the system of contoured trays, to meet the need for water during the average irrigation period of 80 to 100 days for conventional cultivation systems, minimum cultivation and no-tillage is recommended. the use of continuous flows of 1.5 to 2.0 L.s^{-1}.ha^{-1}. Correa *et al*. (1997) estimated the consumption of water through the water balance, not considering the losses in the conduction of water in the channels nor the continuous exit to the drain, that is, irrigation was consideredwith static water slide.

nor the continuous output to the drain, that is, irrigation with static water was considered. Under these conditions, water consumption ranged from 1.15 to 1.76 L.s^{-1}.ha^{-1}., or from 0.77 to 1.02 L.s^{-1}.ha^{-1}. The lower flow values observed in Adinga are due in part to the contribution of rainwater. Rosso and Back (2008), simulating the water balance in a flood irrigation crop under the climatic conditions of southern Santa Catarina, observed that the effective precipitation meets, on average, 51% to 33% of the demand, with the remainder provided by irrigation. The highest irrigation values occur in the soil preparation phase with flows ranging from 1.0 to 1.2 L.s^{-1}.ha^{-1}., according to the percolation rate. For the period of 160 days, the average flows were between 0.44 and 1.0 L.s^{-1}.ha^{-1}., similar to the values observed in Adinga.

CONCLUSION

Water consumption for irrigated rice cultivation in Adinga averaged 9894 m³.ha^{-1}. The need for irrigation showed mean values of 0.78 L.s^{-1}.ha^{-1} with peak values of 1.10 L.s^{-1}.ha^{-1}. Rainfall makes an important contribution to meeting the demand for water and therefore practices that allow greater use of rainwater should be used in order to reduce the need for supplementary irrigation. The efficiency of the irrigation system can be improved with the reduction of lateral losses and better use of rainwater, better control of the gate by regulating the inlet flow according to demand.

REFERENCES

Alvares, C.A.; Stape, J.L.; Sentelhas, P.C.; Gonçalves, J.L.M and Sparovek, G. 2013. Köppen's climate classification map for Brazil. Meteorologische Zeitschrft, b.22, n.6, p.711-728.

Back, Á.J and Lucietti, D. 2022. Manejo da água em arroz irrigado. In: Vale, M.L.C. and Hickel, E. R. Recomendações para a produção de arroz irrigado em Santa Catarina: Florianópolis: Epagri, p.50-54.

Back, Á.J. 2015. Hidráulica e hidrometria aplicada (com programa Hidrom para cálculo). Florianópolis: Epagri, 398p.

Back, Á.J. 2020. Informações climáticas e hidrológicas dos municípios catarinenses (com programa HidroClimaSC). Florianópolis: Epagri, .157p.

Back, Á.J. and Just, M.C. 2018. Consumo de água em lavouras de arroz irrigadas em sistema coletivo. *Revista Tecnologia e Ambiente,* v.24, p. 133-145.

Cardoso, A.L.T., Fan, F.M., Frasen, M., Simão, G. and Troian, G.C. 2022. Recursos hídricos superficiais da região sul de Santa Catarina – Background geoquímico da região afetada pela mineração de carvão. *Revista Brasileira de Recursos Hídricos*, v.27, https://doi.org/10.1590/2318-0331.272220220084

Correa. N. I. 1997. Consumo de água na irrigação do arroz por inundação. *Lavoura Arrozeira*, v.50, n.432, p.3-8.

Dantas, M.E., Goulart, D.R., Jaques, P.D., Almeida, I.S. and Krebs, A.S.J. 2005. Geomorfologia aplicada à gestão integrada de bacias de drenagem: Bacia do rio Araranguá, SC, Zona Carbonífera Sul-Catarinense. CPRM. 74p.

Empresa de Pesquisa Agropecuária e Extensão Rural de Santa Catarina -Epagri. 2013. Publicações: Relatórios Síntese Anual da Agricultura de Santa Catarina. Santa Catarina.

Instituto Rio Grandensedo Arrroz –IRGA 2001. Arroz irrigado: recomendações técnicas da pesquisa para o sul do Brasil. Porto Alegre, 2001. 128 p.

Marschalek, R., Andrade, A.de, Wickert, E., Terres, L.R. and Oliveira, D.G. de. 2022. Cultivares de arroz irrigado. In: vale, m.l.c.; hickel, e.r. Recomendações para a produção de arroz irrigado em Santa Catarina: Florianópolis: Epagri, p.55-58.

Mota, F.S., Alves, E.G.P. and Becker, C.T. 1990. Informação climática para planejamento da necessidade de água para irrigação do arroz no Rio Grande do Sul. *Lavoura Arrozeira,* v.43, n.392, p.3-6

Oliveira, D.G. and Vale, M.L.C. 2022. Sistemas de cultivo. In: Vale, M.L.C. and Hickel, E.R. Recomendações para a produção de arroz irrigado em Santa Catarina: Florianópolis: Epagri,p.27-34.

Oliveira, E.D. de, Biz, J.B. and Salvaro, G.I.J. 2016. A trajetória de modernização da cultura do arroz no município de Turvo – Santa Catarina, Brasil. Agroalimentaria, v.22, n.43, p.135-150.

Pandolfo, C., Vianna, L.F.N., Lucietti, D. and Vale, M.L.C. 2022. Caracterização do ambiente de cultivo. In: Vale, M.L.C. andHickel, E.R. Recomendações para a produção de arroz irrigado em Santa Catarina: Florianópolis: Epagri, p.11-14.

Parfitt, J.M.B., Silva, J.T. da, Bueno, M.V., Timm, P. De A, Campos, A. D. S. De; Aires, T. D. A. and Timm, C. 2018. Quantificação da Demanda Hídrica na Cultura do Arroz em Função do Manejo da Irrigação por Inundação. Boletim de Pesquisa e Desenvolvimento n 313. Pelotas, RS: Embrapa Clima Temperado,17p.

Petrini, J.A., Azambuja, I.H.V.; Magalhaes Junior, A.M. De, Fagundes, P.R.R., Winkler, A.S. and Kuhn, R. 2013. Estratégias de irrigação para redução do uso da água em arroz irrigado. In: CONGRESSO BRASILEIRO DE ARROZ IRRIGADO, 8., 2013, Santa Maria. Anais... Santa Maria: SOSBAI,p. 1180-1183;

Porciúncula, G.S., Stefanello, G., Chafgs Net, M.C.C. and Cardoso, L.P. 2019. Estudo para avaliação e revitalização do Perímetro de Irrigação do Arroio Duro. Expressa Extensão, v.24, n.3, p.161-176, 2019.

PROFILL. 2015. Plano de Recursos Hídricos da Bacia Hidrográfica do Rio Araranguá. Porto Alegre. 2015.

Rosso, J.C. and Back, Á.J. 2008. Necessidade de água para irrigação do arroz no cultivo pré-germinado nas condições climáticas do sul de Santa Catarina In: Taller Internacional RedRiegos CYTED, 2008, Florianópolis. Taller Internacional RedRiegos CYTED, p.1 – 13.

Sociedade Sul-Brasileira de Arroz Irrigado -Sosbai**.** 2018. Arroz Irrigado: recomendações técnicas da pesquisa para o Sul do Brasil/32. XXXII Reunião da Cultura do Arroz Irrigado. – Farroupilha, RS - Cachoeirinha: Sociedade Sul-Brasileira de Arroz Irrigado, 2018. 205p.

Vale, M. L.C. and Hickel, E. R. 2022. Recomendações para a produção de arroz irrigado em Santa Catarina.

******