Acta Scientiarum
http://www.periodicos.uem.br/ojs/
ISSN on-line: 1807-8621
Doi: 10.4025/actasciagron.v46i1.66966

CROP PRODUCTION

Ecophysiological adaptability of rice sown on residual ridges of previous soybean cultivation

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ABSTRACT. The furrow-ridge system was designed to allow the cultivation of dryland crop species in lowlands, enabling rotation with rice. After harvesting the dryland species, farmers usually return with rice in the following cropping season, with costs associated with dismantling ridges before sowing rice. The possibility of sowing rice directly on residual ridges should be investigated to avoid these costs. The objective was to verify the ecophysiological adaptability of rice sown on residual ridges from the previous dryland crop in lowlands, and to identify possible factors impacting the physiological performance of rice plants in this new production system. The experiment was installed in the field in a randomized block design with 5 treatments and 12 replications. The treatments considered the plant's position in the field and in the irrigation furrow. The parameters of the growth analysis were calculated using the classical method. There was no significant damage to rice plants in any part of the field, and there was no difference between plants at the top or bottom of the furrow. Therefore, there is no need to dismantle residual ridges from previous dryland crops before planting rice in the succeeding cropping season in the lowlands of Rio Grande do Sul State, Brazil.

Keywords: growth analysis; irrigation system; *Oryza sativa*; production physiology.

Received on February 2, 2023.
Accepted on August 9, 2023.

Introduction

Rice (*Oryza sativa* L.) is one of the most consumed and cultivated cereals worldwide and plays an important economic and social role (Feitosa, Silva, & Oliveira, 2017). Brazil is among the 10 largest rice producers in the world and uses this product as a staple food (Gadal, Shrestha, Poudel, & Pokharel, 2019).

Due to farmer's economic failures in recent years as production costs have increased while market pricing stagnated, rice production has become unsustainable as a monocrop (Instituto Rio Grandense do Arroz [IRGA], 2020). The introduction of soybean and maize in rotation with rice in the summer (Silva, Vitorino, Souza, Gonçalvez, & Roscoe, 2006) is an alternative to modify the agricultural scenario in lowlands to achieve both economic and environmental sustainability. However, in most situations, excess water stress is a limiting factor for the good performance of dryland crop species in the lowlands (Pasley, Isaiah Huber, & Sotirios, 2020).

The furrow-ridge system has been designed to allow the cultivation of dryland crop species in the lowlands, enabling rotation with rice. The system makes it possible to improve the drainage of the root environment by implanting the dryland species on the ridge, as well as by irrigating the field through the furrows in times of water deficit (Silva, Winkler, Timm, Pfeifer, & Parfitt, 2016). In this way, it contributes to the viability of field rotation, and to the implementation of a more sustainable cropping system in lowland areas.

After harvesting dryland species, farmers usually return with rice, with costs associated with dismantling the residual ridges before sowing rice (Concenço et al., 2020). The possibility of sowing rice directly on residual ridges should be investigated to avoid these costs. For rice, the furrow-ridge system can contribute to increasing water use efficiency, reducing the need for labor, mitigating greenhouse gas emissions, and enabling better adaptation to climate risks (Silva, Parfitt, Theisen, & Pereira, 2006). In contrast, there could be major constraints to the ecophysiology of rice plants, resulting in grain yield reductions (Pinto et al., 2020).

When rice is sown directly on residual ridges, seedlings will establish in an environment with irregular topography in which part of it will remain more humid (the furrows) and part will be drier (the ridges). Thus, there is a risk of uneven distribution of water, which could result in phenomena such as uneven maturation since the lower water content in the soil ends up lengthening the rice cycle (Parfitt, Concenço, Downing, Larue, & Silva, 2017). In addition to affecting several biochemical, physiological, and morphological processes in plants, responses commonly depend on the rice genotype, plant developmental stage, and stress duration and severity (Falquetto, Cassol, Magalhães Júnior, Oliveira, & Bacarin, 2009; Parfitt et al., 2017). However, rice presents some adaptation and compensation mechanisms, such as the capacity for moderate water use by plants, the magnitude of leaf area, and the ability of roots to explore deeper soil layers (Uga et al., 2013), which could help deal with stress associated with the furrow-ridge system.

Therefore, rice plants are in different conditions of water availability, depending not only on their position in the furrow-ridge but also on their position in the field. The furrow-ridge system should be installed on previously smoothed fields, with 0.1 - 0.3% slope, where plants at the beginning of the field (higher portion) would eventually grow in a drier environment compared to plants at the end of the field (lower portion). Thus, basic ecophysiological aspects, such as the growth rate of the field as a function of the developmental stage, the usual level of water stress that the plant will face in the furrow-ridge system, the cycle length, and the partition of photoassimilates between plant organs, can be distinct among plants in different positions in the field.

This study had the following hypotheses: i) there are differences in the ecophysiological and productive performance of rice plants depending on their position in the residual furrow-ridge profile; and ii) the ecophysiological and productive performance of rice plants differ along the field, due to the differential availability of water as a function of the distance from the point of water entry into the furrow. The objective of this study was to verify the ecophysiological adaptability of the rice crop sown on residual ridges from the previous dryland crop and to identify the factors impacting the development of rice plants in this new rice production system.

Material and methods

The experiment was carried out in the 2021/2022 cropping season at *Embrapa Clima Temperado*, *Estação Experimental Terras Baixas*, Capão do Leão, Rio Grande do Sul State, Brazil, geographical coordinates −31.8153; -52.4698, 20 m. The soil of the experimental station is characterized as Solodic Eutrophic Hydromorphic Planosol (Santos et al., 2013), and the climate of the region is classified as Cfa (humid subtropical climate), according to the Köppen climate classification.

The cultivar BRS Pampa CL was chosen due to its high grain yield potential, disease resistance, tolerance to the herbicides associated with the Clearfield system, and ~15% lower water demand compared to cultivars with longer cycles. The sowing of rice cultivar BRS Pampa CL took place on residual furrows from the previous soybean cropping, which were spaced 0.90 m apart, with an average gap of 13 cm between the furrow base and the ridge top. The base and topdressing fertilization, as well as the cultural treatments, followed the recommendations for rice cultivation (Sosbai, 2018) for expectations of high grain yield.

The furrow-ridge system was irrigated using polytubes every third day. To measure the daily soil water tension, mechanical tensiometers were installed throughout the field, both at the base and top of the ridges. The entry of water into the field was allowed in all furrows until the water reached the end of the furrow (tension in the soil reached 0 kPa), at which point the entry of water into the field was closed, and irrigation only resumed after three days.

The furrow-ridge irrigation system provides differing water availability throughout the crop. This is due to the slope of the area stipulated in the smoothing project (varied rate slope), usually between 0.1 and 0.3%, to allow the drainage of water from excessive rainfall and during irrigation cycles. Due to the nature of area smoothing, which has a fixed direction, the blocks were arranged longitudinal to the slope of the area, and the plots of each treatment within the block were located along the block, corresponding to the treatments, with a minimum distance of 20 m between the blocks. Treatments were composed by factorials, where Factor A: two positions of the plant in the irrigation furrow: upper portion – ridge, and lower portion – furrow, at (Factor B): three different points along the field: near the water inlet (highest point in the smoothing project), center, and at the end of the field (lowest point) (Figure 1). At the lowest point, plants both at the top and at the base were pooled, as they were usually flooded, being considered as the test or the control treatment. From this, the design of the experiment was in randomized blocks with 5 treatments and 12 replications, in experimental units measuring 30 m^2.

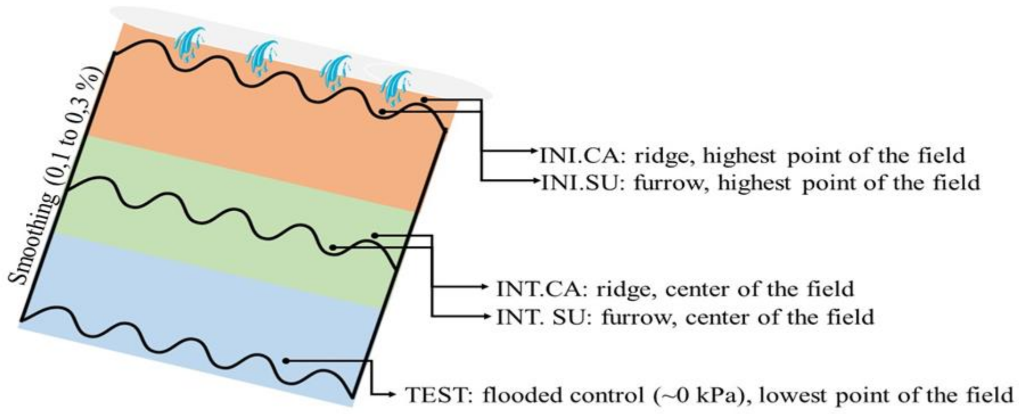

Figure 1. Schematic showing the position of treatments along the field: INI.CA (ridge, highest edge of the field), INI.SU (base of the furrow, highest edge of the field), INT.CA (ridge, center of the field), INT.SU (base of the furrow, center of the field), TEST (flooded control [~0 kPa], lowest edge of the field).

Fortnightly after seedling emergence, 12 plants were collected per treatment. The plants were separated into leaf, stem, and panicle, packed in properly labeled paper bags, and dried in an oven with forced air circulation at 65°C until reaching a constant mass. The shoot dry weight (DW) was determined. Plant height and the width and length of leaves (to estimate leaf area) were measured with a ruler, and the number of leaves per plant was also recorded. From these variables, the parameters associated with the analysis of plant growth were obtained, and the formulas in Table 1 were adopted (Lopes & Lima, 2015). Curves were adjusted to the data in the statistical environment CurveExpert Professional v.2.7, with treatments/curves compared by the respective 95% confidence intervals, according to Cumming (2013).

Table 1. Parameters used in the growth analysis, adapted from Gardner et al. (1985), Hunt (1990), and Lopes and Lima (2015).

Parameters	Abbreviation	Formula
Leaf area	LA	$LA = L \times W \times N \times f$
Leaf area index (cm^2 cm^{-2})	LAI	$LAI = \frac{LA}{S}$
Specific leaf area (cm^2 g^{-1})	SLA	$SLA = \frac{LA}{DWL}$
Leaf area ratio (cm^2 g^{-1})	LAR	$LAR = \frac{LA}{DW}$
Leaf weight ratio (g g^{-1})	LWR	$LWR = \frac{DWL}{DW}$
Culture growth rate (g cm^{-2} dia^{-1})	CGR	$CGR = \frac{1}{S} \times \frac{DW}{dT}$
Leaf area duration (days)	LAD	$LAD = \frac{(LAI2 - LAI1) \times (T2 - T1)}{2}$
Absolut growth rate (g dia^{-1})	AGR	$AGR = \frac{W1 - W2}{T1 - T2}$
Relative growth rate (g cm^{-2} dia^{-1})	RGR	$RGR = \frac{1}{Wt} \times \frac{DW}{dT}$
Net assimilation rate (g cm^{-2} dia^{-1})	NAR	$NAR = \frac{1}{LA} \times \frac{DW}{dT}$

*L-Leaf length, in cm; W-Width of the leaf, in cm; N-Number of leaves; f-Correction factor for rice (0.76); S-Soil surface occupied by the plant, in cm²; DW-Dry weight, g; dT-Time variation, days; W1 and W2-Dry weight 1 and 2, g; T1 and T2-Time 1 and 2, days. (As equações devem ser editadas com o Built Equation)

Results and discussion

Although rice has a high water demand, the identification or development of alternative managements, such as the furrow-ridge system, represents an economical and safe approach to sustain the grain yield of this crop. The furrow-ridge system provides different water availability throughout the crop, having a point with greater supply/accumulation of water (end of the tillage), an intermediate point (middle part of the tillage), and a point where less water may be available (beginning of the tillage). The growth analysis allowed for the characterization of the behavior of rice plants in these different tillage regions.

Plant height (Figure 2a and b) and total shoot dry weight (Figure 2c and d) of rice subjected to different water conditions along the furrow-ridge irrigation system showed near-expected behavior throughout the development cycle; that is, the control results were similar to those of the other treatments. The plant height increase maintained a constant rate for all treatments throughout the cycle. In experiments with rice under different water levels, Khairi, Nozulaidi, Afifah, and Jahan (2015) and Hossain et al. (2020) found similar results.

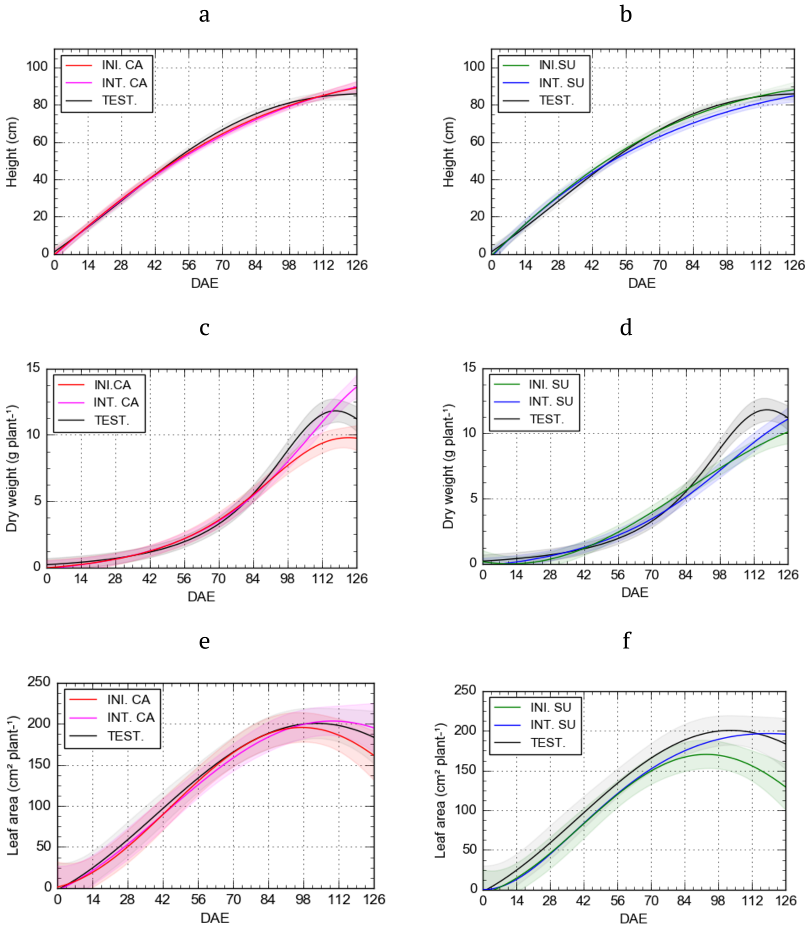

Figure 2. Plant height (A and B), shoot dry weight (DW) (C and D), and leaf area (LA) (E and F) of rice plants cv. BRS Pampa CL in different positions in the field: INI.CA (ridge, highest edge of the field), INI.SU (base of the furrow, highest edge of the field), INT.CA (ridge, center of the field), INT.SU (base of the furrow, center of the field), and TEST (flooded control [~0 kPa], lowest edge of the field). Embrapa, Estação Terras Baixas, Capão do Leão, Rio Grande do Sul State, Brazil, 2021/2022.

The shoot dry weight accumulation was slow, compared to over the cycle, until approximately 40 days after emergence (DAE). However, from this period onward, there was a rapid increase in dry weight until 115 DAE for the TEST and until the last evaluation (126 DAE) for the other treatments. The DW showed no difference for treatments, either in relation to the position in the field or the position of the plant in the furrow or on the ridge for most of the cycle. The results demonstrated the high capacity of rice to accumulate mass after an initial phase with naturally slow growth rates.

Plants subjected to water stress or reduced water availability can undergo a variety of physiological changes, consequently decreasing their growth (Hossain et al., 2020). From this information, it is possible to say that the furrow-ridge system did not affect rice growth to the point of decreasing its growth based on the values obtained by the DW variable. Similarly, Jahan, Khanif, and Sinniah (2013) did not report lower productivity or changes in components under five different water conditions.

The leaf area (LA) and leaf area index (LAI) were influenced by the treatments. Leaf area is known to be highly related to grain yield since the photosynthetic process depends on the interception of light energy by the leaves (Wimalasekera, 2019). LAI, a parameter that relates the leaf area to the area of soil shaded by the leaves, is also a consistent indicator of this relationship (Zanon et al., 2015). Treatments located in the middle section of the field (INT.CA and INT.SU) showed a peak of LA (Figure 2e and f) 112 DAE and for LAI 90 and 112 DAE and obtained values equal or very close to the control. Treatments INI.CA and INI.SU showed a maximum value at 98 DAE for LA and at 90 DAE for LAI. These treatments showed LAI values below the control, indicating damage to those established in the furrow. The control showed its maximum LA and LAI at the same time of the cycle, ~98 DAE.

Despite having great importance in the absorption of solar radiation, the field yield does not increase indefinitely with increasing LA or LAI due to self-shading. Thus, a part of the plant receives light and carries out photosynthesis (the upper portions), while the lower and more shaded portion ends up working below the light compensation point. The lower leaves remain alive at the expense of the photoassimilates produced by the most illuminated part of the canopy. Thus, increasing LA and LAI beyond an optimum level may lead to a reduction in grain yield. The ideal LAI for most annual crops is 4 to 7, that is, when 95% of the solar radiation is absorbed. In this case, the control reached this LAI level between ~90 and 112 days (Figure 3a), and the INT.SU treatment reached it between 98 and 110 days (Figure 3b). The other treatments showed a peak LAI of around 3.5.

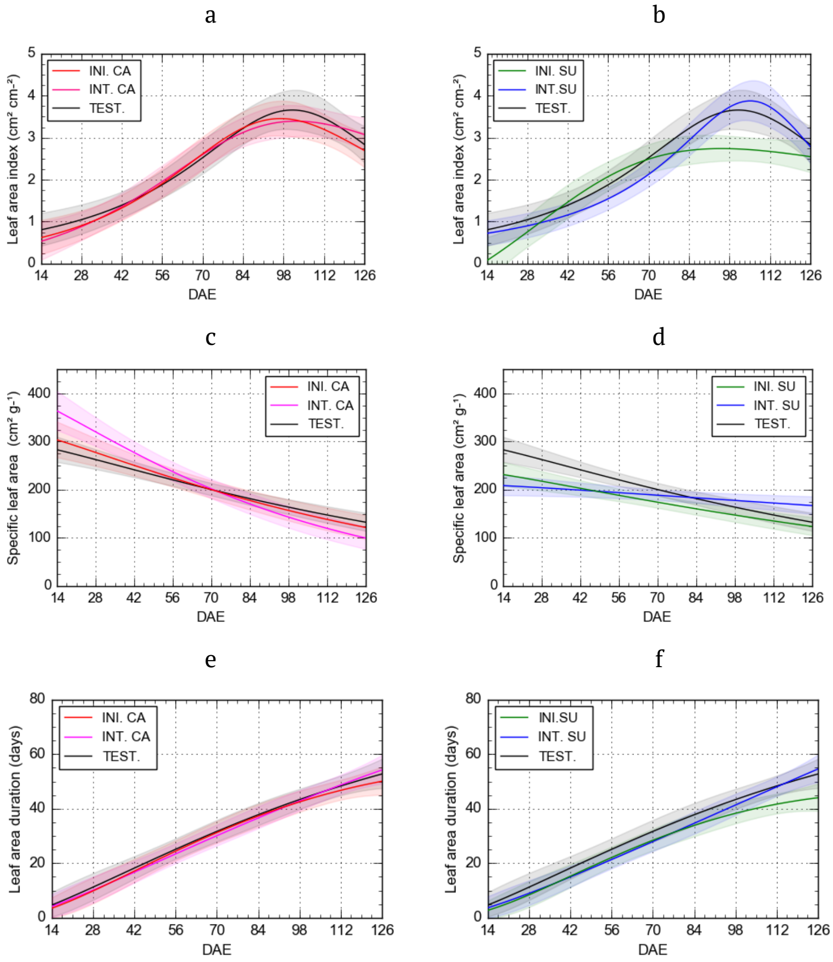

Figure 3. Leaf area index (LAI) (A and B), specific leaf area (SLA) (C and D), and (E and F) leaf area duration (LAD) (E and F) of rice cv. BRS Pampa CL. in different positions in the field: INI.CA (ridge, highest edge of the field), INI.SU (base of the furrow, highest edge of the field), INT.CA (ridge, center of the field), INT.SU (base of the furrow, center of the field), and TEST (flooded control [~0 kPa], lowest edge of the field). Embrapa, Estação Terras Baixas, Capão do Leão, Rio Grande do Sul State, Brazil, 2021/2022.

One of the reasons LAI may be less than ideal for most treatments is the reduction in water availability. Working with the adaptation of irrigated rice varieties under mechanized sprinkler irrigation, Parfitt et al. (2017) reported a reduction in the size and leaf area of rice plants but without a proportional reduction in grain yield. These results agree with those found by Sudhir-Yadav, Humphreys, and Kukal (2011), who reported a decrease in rice LAI in an environment with lower soil hydration. Water stress can affect several biochemical, physiological, and morphological processes in plants, and the responses commonly depend on the genotype, plant developmental stage, and stress duration and severity. Characteristics of drought tolerance in rice are related to the capacity for moderate use of water by the plants, which is related to the reduction in the leaf area index (Terra, Leal, Rangel, and Oliveira, 2015).

The specific leaf area (SLA) showed similar behavior for all treatments, depending on the position in the field, but it differed between plants established at the top of the ridge or in the furrow (Figure 3c and d). At the beginning of the field, the values were higher for plants grown at the top of the ridge (~320 cm^2 g^{-1}) compared to those located in the furrows (~250 cm^2 g^{-1}), but over time, there was compensation. The rate of reduction in the SLA of plants on the ridge was greater than that reported for those grown in the furrow, resulting in equivalent averages in SLA throughout the field cycle.

SLA is a morphoanatomical component of the leaf area ratio, as it relates the surface (morphological component) to the dry weight of the leaf itself (anatomical component) (Floss, 2011). The decline in SLA with advancing plant age is a result of the reduction or stoppage of LA expansion (Figure 2e and f) combined with the increase in DW (Figure 2c and d), resulting in greater leaf thickness. This may be a consequence of the lower leaf area expansion, which is typical when rice is grown in water-restricted systems. According to Floss (2011), several studies carried out in different cultures show that grain yield is related to SLA, but this is only true for adequate plant densities, as SLA shifts to compensate for the level of available sunlight.

Leaf area duration (LAD) indirectly expresses the leaf turnover rate. Plants under stress, for example, in the case of foliar disease, will abort the affected leaves and emit new, uncontaminated leaves. This process demands energy from the plant, which ends up expending photosynthates for the emission of the new leaves instead of storing them for later use during grain filling. However, healthy and stress-free plants do not need to renew their leaves as often, saving energy and increasing the duration of their leaf area (Hussain & Ali, 2015). The LAD increased in an approximately linear way and did not show any difference between treatments until 98 DAE, when the INI.SU treatment, which was located at the beginning of the field and therefore had less water availability, showed a reduced LAD compared to the others (Figure 3f). It was expected that the INI.CA treatment would have similar behavior to INI.SU, but although this behavior occurred, the confidence intervals did not indicate a difference from the other treatments.

When comparing rice in irrigated and dryland environments, differences can be observed in LAD. In the irrigated treatments, the leaf area was larger, and the leaves lasted longer; consequently, the LAD was higher, as was the grain yield (Santos & Costa, 1996). The LAD may vary according to the cultivar due to genetic factors and may have characteristics that delay leaf senescence and thus increase the grain-filling phase. In addition, the LAD depends on climatic conditions, such as water availability, nutrients, luminosity, and temperature (Floss, 2011).

The leaf area ratio (LAR) represents the assimilatory surface per unit of total shoot dry weight, allowing inferences about the efficiency of translocation and photoassimilate partitioning (Floss, 2011). The LAR reached a maximum value at 14 DAE for all treatments, except INT.SU, whose peak was reported at around 20 DAE. The INT.CA, once again, presented the highest value in relation to the others in the initial phase, being around 250 $cm^2 g^{-1}$, and the lowest value in the initial phase of growth was reported for INT.SU (150 $cm^2 g^{-1}$). However, after the first 20 days of field development, no differences were observed between the position of the plant in the field or even in the furrow-ridge profile (Figure 4a and b).

The leaf weight ratio (LWR) (Figure 4c and d) behaved similarly to that reported for LAR; however, there was no increase in LWR, as reported for LAR in the first 20 days at the beginning of the development cycle, starting at ~0.6 $g g^{-1}$ and ending the cycle with ~0.15 $g g^{-1}$. However, there was a treatment effect of up to approximately 28 DAE, depending on the position of the plant in the field, both for those located at the top of the ridge (Figure 4c) and at the base of the furrow (Figure 4d). In this time interval, treatments in the furrow (INT.SU and INI.SU) presented lower values than those on the top of the ridge (INT.CA and INI.CA), and all treatments obtained lower values than the control until 28 DAE (~0.65 $g g^{-1}$).

The LWR increased sharply at the beginning of the development cycle, characterizing a phase of great leaf growth with photoassimilates allocating mainly to the leaves. This behavior shows that, initially, the largest fraction of the assimilates is converted into leaves to increase the photosynthetic apparatus to capture the available solar radiation (Pereira & Machado, 1987). After the increase in LWR, there may be leaf abscission, the appearance of non-assimilatory tissues that compete decisively with vegetative structures for the assimilates produced, inducing leaf senescence and a decrease in LWR. In addition, the LWR can decrease due to interference of the upper leaves with the lower ones (self-shading), with a decrease in useful leaf area (Santos, Stone, Heinemann, & Santos, 2017), which occurs when the LAI is greater than the ideal value.

The net assimilation rate (NAR) showed the same behavior for all treatments, with no differences as a function of the position of the plant along the crop or in the ridge profile (Figure 4e and f). In the initial phase of the cycle, growth was observed up to 70 DAE, stabilizing at values of ~0.0008 $g cm^{-2} day^{-1}$ and then declining to ~0.0003 $g cm^{-2} day^{-1}$ at the end of the cycle. The NAR of a plant is the increment of the biomass rate per unit of leaf area; that is, it expresses the net photosynthesis rate, excluding respiration and photorespiration from gross photosynthesis in terms of shoot dry weight produced per unit of LA.

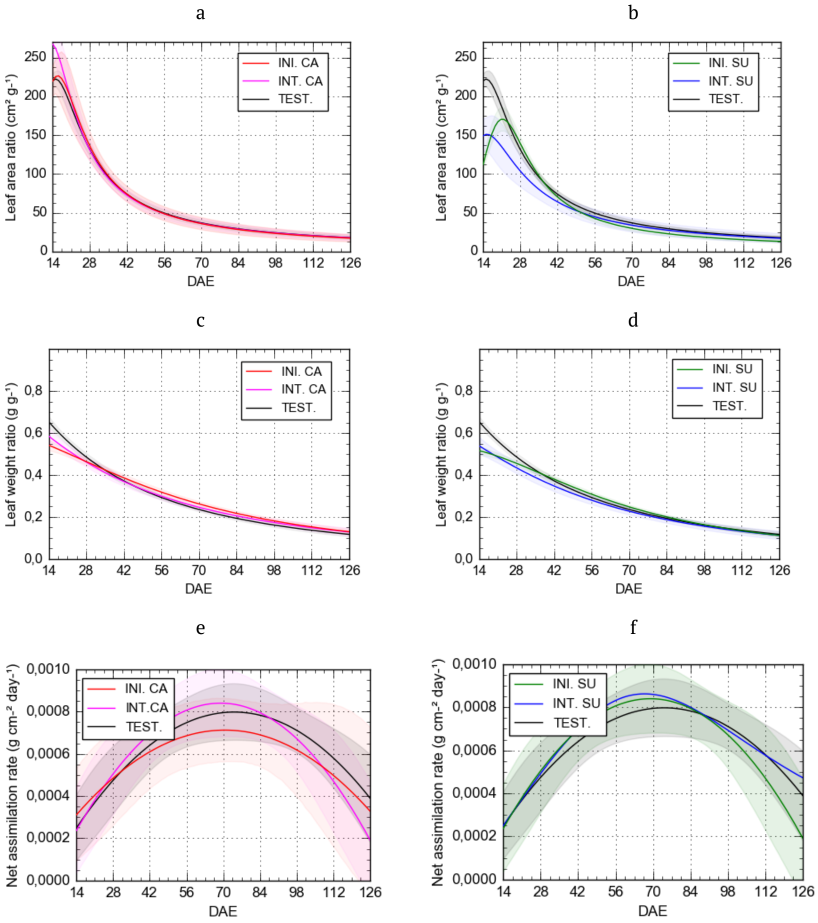

Figure 4. Leaf area ratio (LAR) (A and B), leaf weight ratio (LWR) (C and D), and net assimilation rate (NAR) (E and F) of rice cv. BRS Pampa CL in different positions in the field: INI.CA (ridge, highest edge of the field), INI.SU (base of the furrow, highest edge of the field), INT.CA (ridge, center of the field), INT.SU (base of the furrow, center of the field), and TEST (flooded control [~0 kPa], lowest edge of the field). Embrapa, Estação Terras Baixas, Capão do Leão, Rio Grande do Sul State, Brazil, 2021/2022.

Due to the increase in the mutual shading of the leaves, NAR may eventually be negatively correlated with LAI and, consequently, with all factors that induce an increase in LAI (nitrogen, planting density, high level of water supply, among others). In this case, the NAR decreased during plant development. This can happen due to the size of the leaf area, length of the growing season, distribution of the leaves in the canopy, leaf angle, and translocation and partitioning of assimilates.

Treatments showed similar results for the absolute growth rate (AGR), both between different positions along the field (beginning, middle, or flooded control) and between positions in the ridge profile (furrow or top of the ridge) at all times throughout the cycle (Figure 5a and b). The AGR was incipient until ~ 28 DAE, when it started to increase until 98 DAE (~ 0.15 g^{-1} day^{-1}) and then decreased to ~ 0.08 g^{-1} day^{-1} at the end of the cycle.

AGR disregards the initial size of the plant (Larcher, 2004), and must therefore be considered carefully so that it is used in conjunction with the relative growth rate (RGR) (Concenço, Staut, Correia, & Silva, 2015). Thus, when we compare both, the results report that the highest AGR coincides approximately with the grain filling period, while the relative growth rate is higher at the beginning of the vegetative cycle in the field establishment phase.

The RGR was linear up to 20 DAE for all treatments (Figure 5e and f), and after this period, there was an approximately exponential decrease. This decrease was observed by the initial output of values of approximately 0.07 g g^{-1} day^{-1}, reaching 0.01 g g^{-1} day^{-1} at the end of the cycle. INT.SU showed lower values than the control throughout the cycle, and INI.CA showed a reduction at 56 DAE; both lower treatments obtained final values below 0.01 g g^{-1} day^{-1}. As previously mentioned, unlike the AGR, the RGR considers the pre-existing biomass.

The decrease in RGR with plant age is, in part, a result of the increase in non-photosynthetic tissues with the approach of senescence (Lopes & Lima, 2015), allowing inferences about the efficiency of plants in DW conversion. For all treatments, the RGR showed a reduction with the advancement of the rice cycle. This is due to the loss of the relative ability to produce new biomass throughout the plant's development (Falqueto et al., 2009).

Similar to AGR, the crop growth rate (CGR) showed a slow initial growth up to ~40 DAE, a rapid growth range from 40 to 90 DAE with a peak of ~0.0037 g cm^{-2} day^{-1}, and a decrease at the end of the field cycle (Figure 5c and d). TEST, in general terms, presented a higher peak and, later, a more accentuated decrease in CGR until the end of the cycle compared to the other treatments. The maximum CGR of the field is mostly reached at the maximum LAI (Santos & Costa, 1996).

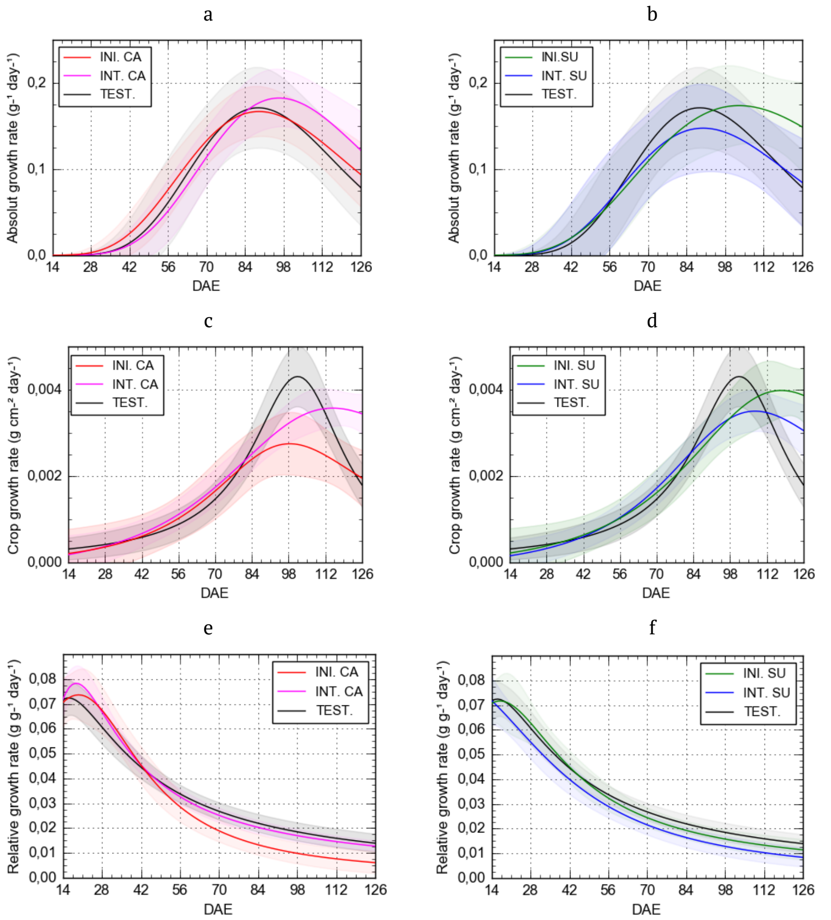

Figure 5. Absolute growth rate (AGR) (A and B), crop growth rate (CGR) (C and D), and relative growth rate (RGR) (E and F) of rice cv. BRS Pampa CL in different positions in the field: INI.CA (ridge, highest edge of the field), INI.SU (base of the furrow, highest edge of the field), INT.CA (ridge, center of the field), INT.SU (base of the furrow, center of the field), and TEST (flooded control [~0 kPa], lowest edge of the field). Embrapa, Estação Terras Baixas, Capão do Leão, Rio Grande do Sul State, Brazil, 2021/2022.

The CGR is the sum of the growth rates of the various plant components and represents the crop's primary yield (Pereira & Machado, 1987). A slight difference was observed between treatments, with the control having the highest CGR observed, but as seen before, this difference did not affect the other parameters or even the DW.

The proportion of photoassimilate partitioning between sources (exporting organ, typically a fully expanded adult leaf) and drains (young leaves, roots, shoot tips, and fruits) can influence plant growth and, consequently, productivity (Thomas, Murray, & Murphy, 2017). The dry weight of leaves and stems (DWL and DWS) followed a similar behavior for all treatments, reaching a maximum peak at a given moment of the cycle and declining at the end until the last evaluation. The estimated curves followed the expected pattern, with similar curves, and for DWS and DWL, an increasing behavior until the appearance of the panicle, 95 DAE, when there was an inversion in the distribution of photoassimilates from the vegetative to the reproductive organs (Figure 6).

All treatments had a greater investment in the vegetative phase for stalk production. INI.CA and INT.CA (Figure 6a and c) were the ones that most concentrated dry weight in the stem at full tillering (~52 DAE), around 72%. However, INT.SU (Figure 6d) invested most of its reserves in dry weight in the leaves, reaching 37.65%. This shows the difference between treatments as a function of the position in the ridge profile. Corroborating the principle of photoassimilate partitioning in annual plants, the largest possible proportion is first destined for the formation of leaves that participate in production and increase plant absorption (Floss, 2011).

At the end of the cycle (126 DAE), there was a reversal in the results. INT.SU, which had the highest DWL at full tillering, ended the cycle with the lowest mass for this variable, an increase in DWS, and the lowest percentage for the dry weight of the panicle (DWP). INT.CA had the highest rate of DWP (~65.93%), as the panicle was of the greatest interest at this time of the cycle, followed by DWS (~27.1%) and DWL (~6.96%). TEST (Figure 6e) showed similar behavior to the treatments INI.CA and INI.SU, with a DWP of ~60%, DWS of ~31%, and DWL of ~8%, showing that at the end of the cycle there was no difference as a function of the position in the field or in the ridge profile.

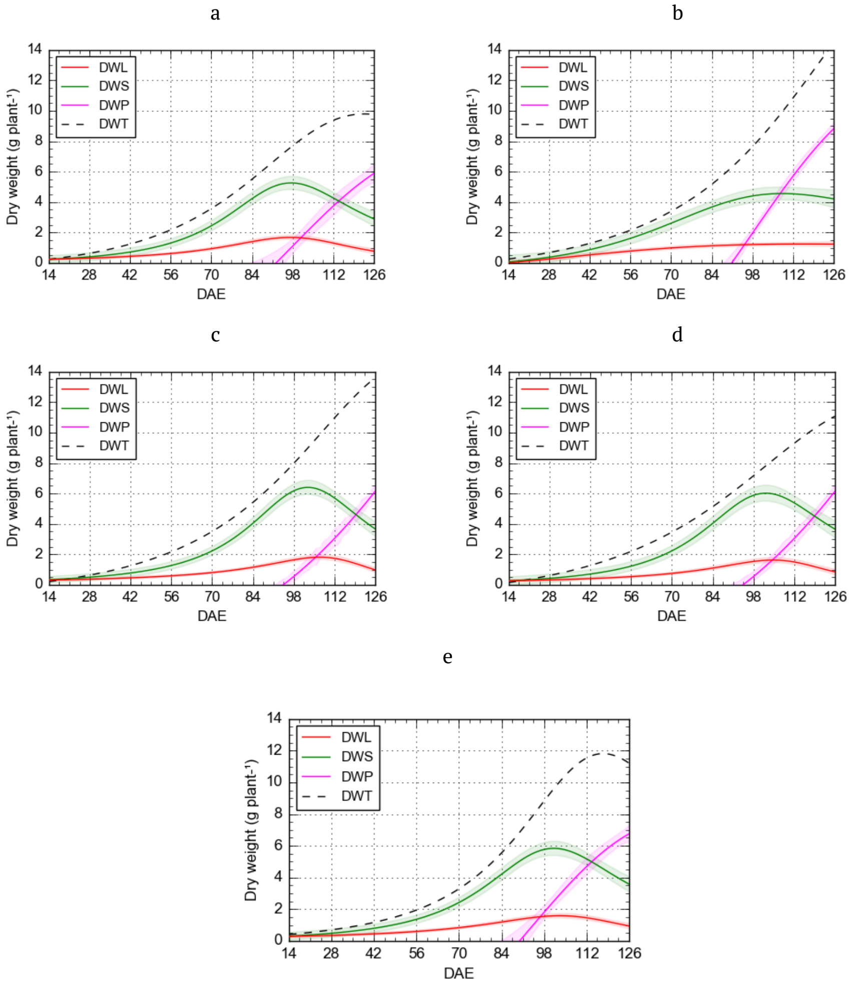

Figure 6. Photoassimilate partitioning: dry weight of leaf (DWL), dry weight of stem (DWS), dry weight of panicle (DWP), and dry weight total (DWT) of rice cv. BRS Pampa CL in different positions in the field: (a) INI.CA (ridge, highest edge of the field), (b) INI.SU (base of the furrow, highest edge of the field), (c) INT.CA (ridge, center of the field), (d) INT.SU (base of the furrow, center of the field), and (e) TEST (flooded control [~0 kPa],lowest edge of the field). Embrapa, Estação Terras Baixas, Capão do Leão, Rio Grande do Sul State, Brazil, 2021/2022.

Rice plants showed an increase in DWS and DWL accumulation rates in the initial phase of their development. From this period onwards, there were subsequent decreases due to the leaf senescence rate exceeding the rate of emission of new leaves. In addition, due to the transition from the vegetative to the reproductive phase, there is a great capacity for mobilization of assimilates exerted by panicles and seeds, which are preferential metabolic drains (Larcher, 2004). Furthermore, Falqueto et al. (2009) reported that the percentage of shoot dry weight destined for panicles at the end of the reproductive cycle was around 30%, similar to those found in the present study.

Panicle emission occurred at the same time for all treatments under study; that is, in the vegetative period, the remobilization of photoassimilates from a stronger organ, such as leaves, to the reproductive organs, panicles, occurred simultaneously in the three tillage positions and the top and base of the ridge. This is a great indicator that the level of water stress imposed on rice plants in the furrow-ridge system, with irrigation cycles every third day, is relatively low, as Parfitt et al. (2017) reported that water stress in rice ends up lengthening the rice crop cycle. This was not reported in the present study at significant levels.

Conclusion

The ecophysiological and productive performance of rice plants was little affected as a function of their position in the residual furrow-ridge profile or their position in the field. Differences observed between treatments were restricted to some parameters and were mostly later compensated during a certain moment of the cycle. There seems to be no need to dismantle residual ridges from the previous dryland cropping season before planting rice in the following cropping season in the lowlands of Southern Rio Grande do Sul State, Brazil.

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