agrometeoros
REVISTA DA SOCIEDADE BRASILEIRA DE AGROMETEOROLOGIA

ISSN 2526-7043 www.sbagro.org.br DOI: http://dx.doi.org/10.31062/agrom.v31.e027266

Growth and grain yield of canola overseeded on soybean

Mateus Leonardi[1(*)], Arno Bernardo Heldwein[1], Jocélia Rosa da Silva[2], Paulo Eugenio Schaefer[1], Astor Henrique Nied[1] and Andressa Janaína Puhl[1]

[1]Universidade Federal de Santa Maria. Av. Roraima, nº 1000, Cidade Universitária Bairro Camobi, CEP 97105-900 Santa Maria, RS, Brazil.
E-mails: mateus-leonardi@hotmail.com, arno.heldwein@ufsm.br, pauloeugenioschaefer@gmail.com, astor.nied@ufsm.br and andressa.puhl@hotmail.com
[2]Irriga Global, Rua. João Goulart, nº 165, Camobi, CEP 97105-220, Santa Maria, RS, Brazil. E-mail: joceliarosa.s@gmail.com
(*)Corresponding author.

ARTICLE INFO

Article history:
Received 24 March 2023
Accepted 28 June 2023

Index terms:
Brassica napus
crop system intensification
crop deployment
germination
overseeding

ABSTRACT

The overseeding technique allows the establishment of a crop before the harvest of an overseeded crop at the end of the cycle. It aims at making a better use of more favorable seasonal climatic conditions and the intensification of cultivation systems, with the possibility of obtaining another harvest in less time. This work aimed to verify if it is possible to establish the *Brassica napus* crop in overseeding with the phenological stages at beginning of grain filing (R5) and beginning of soybean physiological maturation (R7) in the Central region of the state of Rio Grande do Sul. The study was performed in a Humid Subtropical climate, in Santa Maria, RS. A randomized block design was used, in a 4 x 2 factorial arrangement with 4 replications, with four seed *Brassica napus* densities (3, 6, 12, and 18 kg ha^{-1}) and two developmental stages of the soybean crop (R5 and R7), in addition to the control treatment sown in rows directly on the straw right after soybean harvest (3 kg ha^{-1} - standard). The plant density, yield components, and grain yield were measured. The canola crop is not established when overseeded in the soybean stage R5. The seed density of 6 kg ha^{-1} achieved the recommended plant density for the canola overseeded in stage R7 of the soybean crop. The 6 kg ha^{-1} density stood out as the best treatment performed in the R7 stage of the soybean crop.

Introduction

In the South region of Brazil, after the harvest of the summer crops, producers adotam the sowing of winter cereal crops, such as wheat, barley, oat, besides forage crops, and, more recently, canola. This oilseed has been highlighted among winter and spring crops, due to the wide range of uses associated with its grain, with a high protein impact and oil administration rate, of which human food, bioenergy, pharmaceutical industry and animal feed stand out. (Tomm et al., 2009; De Mori et al., 2014; Estevez et al., 2014). The high added value of the commercialization of the grain, similar to soybeans, in comparison to the wheat crop, and the great impact of climatic conditions on the final quality of the cereal grains, are other preponderant factors in the choice of the crop in the insertion for succession the main commodities for cultivation in summer, soybeans and corn (De Mori et al., 2014; Gularte et al., 2020).

The introduction of crops after soybeans, specimens, besides the socioeconomic question (Canalli et al., 2020), represents an important agronomic role in agricultural production systems associated with crop rotation. It has favorable effects in the obtainment of better plant health, weed control, soil conservation, and soil nutrient cycling, as well as in the obtainment of different root architectures and their positive effect on soil structure, accumulation of organic matter, and improvement in the way and intensity of the use of agricultural machinery (Silva et al., 2006; Weisberger, et al., 2019; Santos et al., 2019; Manfron et al., 2022). Therefore, given the uncertainty of profitability associated with the climatic risks typical of winter, sowing at this time of the year is indispensable considering such indirect benefits.

Overseeding is a traditional practice for the establishment of autumn/winter crops, aiming primarily at preventing the soil from lying fallow with the introduction of crops in a crop rotation system and/or in the formation of pastures (Manfron et al., 2019; Manfron et al., 2022; Pires & Cunha, 2022). Regardless of the crop on which it is performed, overseeding brings the advantage of anticipating soil covering in up to three weeks in areas destined for grazing, being widely used in southern Brazil (Pacheco et al., 2008; Manfron et al., 2022) to obtain a better food supply for animals during autumn and winter. This practice demands a higher amount of seeds compared to sowing in rows since, out of the seeds that are thrown on the straw of the previous crop, only part of it comes into direct contact with the soil surface, with the remainder being subjected to be deposited over the plant remains, more exposed to weather and predators compared to the seeds that are incorporated into the soil (Silva et al., 2013; Volf et al., 2021).

The practice of overseeding can ensure soil covering and the formation of straw with the predominance of desirable species in the desired time interval, for this, it is necessary to observe some aspects, such as the choice of the ideal time for its realization and incident edaphoclimatic conditions, which can be optimized in managed areas with irrigation control, since absences rainfall or insufficient levels can delay the seed germination process (Manfron et al., 2022).. Observing the soybean crop as an antecedent, overseeding should be performed at the beginning of the fall of leaves in order to favor that the greatest possible number of seeds is in direct contact with the soil, and as the abscission of senescent leaves occurs, these may come to cover the deposited seeds, forming a favorable microenvironment for the process of germination and initial seedling establishment (Pacheco et al., 2008; Correia & Gomes, 2016; Voft et al., 2021).

For the traditional sowing using rows using traction seeders-fertilizers after harvesting the predecessor crop, two problems may occur in implantation, in this period: the first relates to the eventual superposition or competition in the use of part of the machinery, equipment, and manpower between the operations of sowing and harvest; the second is the possibility of the occurrence of delays in the establishment of the crop subsequent to the summer crop, in years with excessive or prolonged rainfall that may prevent the operation with sowing machines right after harvest. Therefore, the interest in the use of overseeding among rural producers relates to the agronomical benefits associated with this practice, in which the agility of the broadcast sowing process and the speed of the sowing process are highlighted observed in prototypes and/or equipment adapted for its realization, such as tractored grain spreaders, agricultural drones and sprayers.

Longer time periods between the harvest of the summer crop and the sowing of the autumn/winter crop, caused by the eventual need to wait for favorable meteorological and soil water conditions and/or availability of machinery, increase the exposure time of both soil and straw. This condition can contribute to the decrease of the straw cover on the surface, a permanent concern related to soil conservation. The emergence and establishment of the plants of the succeeding crop, still with the preceding crop in its stage of maturation, allows maintaining a better soil cover in the transition between crops since the straw volume of the senescent crop is still available, associated with an emergent plant stand of the succeeding crop. This process also increases the speed of soil covering by the succeeding crop and the suppression of invasive weeds due to the fast occupation of the space and greater interception of solar radiation provided by the species of interest. Concerning this benefit, the establishment of a sufficient plant population to protect and improve the soil, in general, has been obtained with the practice of overseeding of forage turnip on soybean, intercropped or not with a grass species (Tiecher, 2016).

However, for overseeding on soybean using the canola crop, there is a lack of basic information and also no data on this operation under Brazilian conditions, especially related to the seed density required for overseeding that allows the establishment of a plant population that better relates to the competitive ability of this species, within the biotic and abiotic adversities at this time of the year. Likewise, there is no direct information regarding the phenological stage of the soybean crop that better favors the initial establishment of the overseeded canola crop. To obtain part of these data, this study aimed to verify if it is possible to establish the canola crop in overseeding with the phenological stages in beginning of grain filing and physiological maturation beginning of the soybean crop in the Central region of the state of Rio Grande do Sul.

Materials and Methods

The experiment was conducted in the experimental area of the Department of Phytotechnics of the Federal University of Santa Maria (UFSM) (29° 43' 23'' S; longitude: 53° 43' 15'' W; 95 m a.n.m.). The climate of the region, according to the classification by Köppen, is a typical Cfa, characterized as humid subtropical with hot summer and normal rainfall (1,712 mm) distributed evenly throughout the four seasons of the year (Kuinchtner & Buriol, 2001; Beldwein et al., 2009). In the period from April to September, which comprises most of the canola cycle in the state of Rio Grande do Sul (Tomm, 2007), water deficits are little frequent and usually small, with a predominance of water excess (Cardoso, 2005; Buriol et al., 1980).

The soil of the experimental area belongs to the São Pedro Mapping Unit, being classified as a sandy dystrophic Red Argisol (Santos at. al, 2013). In this soil, the acidity was corrected to pH 6.0, according to the results of the chemical analysis and the recommendation (SBCS, 2016). Soil preparation was performed with scarification and harrowing, aiming at leveling the surface and conferring good conditions for the establishment of the soybean crop. The soybean was sown on November 21, 2017, with a no-till seeder, in a 0.5 m spacing between rows, using the cultivar NA 5909 RG, which presents an undetermined growth habit. The seeds were inoculated with nitrogen-fixing bacteria in the liquid formulation. Ground and topdressing fertilization followed the recommendation for the soybean crop (SBCS, 2016). After the emergence of the plants, weed control and disease prevention and control were performed according to the technical recommendations for the soybean crop (Salvadori et al., 2016) to keep the good health of the leaf area, providing better agronomical conditions for the subsequent establishment of the canola crop, in overseeding.

Canola overseeding was performed by manual broadcasting when the soybean reached stages of beginning of grain filing (March 1, 2018) and beginning of the physiological maturation of de culture (March 21, 2018), according to the scale by Fehr and Canivess (1977). The soybean harvest was performed on April 12, 2018, by occasion of the physiological maturation of the crop, with the aid of a specific motorized machine for this operation. Four days after, the canola sowing was performed in rows to compose the standard control treatment. The management of chemical fertilization was performed in its totality via topdressing, according to soil analysis results, following the indications of the manual for fertilization and liming of the canola crop (SBCS, 2016).

The experimental design employed was in randomized blocks, with four replications per treatment, in a 4x2 factorial arrangement, with four densities, namely 3 kg ha^{-1} (recommended for the crop in the no-tillage method), 6 kg ha^{-1}, 12 kg ha^{-1}, and 18 kg ha^{-1}, all in overseeding, and two developmental stages of the soybean crop (R5 and R7). In the block, a control treatment sown in rows was also implanted, following the recommendation for the canola crop, after the soybean harvest, totaling 36 experimental units, each with an area of 15 m^2 (3 m width x 5 m length). The plots were arranged side by side in the north-south direction, with a useful area of 8 m^2.

During the development cycle of the canola plants, phenological observations and phenometric determinations were performed in two plants per experimental unit to identify possible differences in crop growth and development. The phenological evaluations were performed by registering the occurrence dates of the main phenological stages of the crop, such as emergence (E), rosette formation (FR), beginning of flowering (IF), end of flowering (FF), and physiological maturation (C), following the phenological scale described by Iriarte and Valetti (2008). For the phenometric variable, the leaf area was determined (AF; cm^2) through a mathematical model developed by Tartaglia et al. (2016), to which the largest dimension of the leaf blade (L; mm) of each leaf of the plant was measured in the field. With the sum of the leaf area of each plant e respective special area occupied (AS), the leaf area index (IAF) was calculated for each treatment, applying the formula IAF: AF/AS.

The micrometeorological evaluations comprised the evaluation of the transmittance of photosynthetically active radiation (RFA) through the soybean canopy. For this measurement, bars with amorphous silicon solar cells covered with a measuring filter (RFA) were installed at ground level for the prediction of the photosynthetically active radiation transmitted (RFAt), and bars outside the soybean canopy were installed for the determination of the incident photosynthetically active radiation (RFAinc), both installed at the sowing of the canola crop on soybean and kept until the emergence of the plants. The data of RFAt and RFAinc were measured every 30 seconds and stored in means at every 30 minutes in a Campbell Scientific® datalogger CR200 series. For the determination of transmittance and/or transmissivity of the RFA, the following expression was used: (Γ_{RFA}, % = RFAt/ RFAinc). Meteorological information was also collected at the automatic station belonging to the 8th

Meteorology District of INMET, located at UFSM within a radius of 50 m from the experiment site, which included air temperature (Tar, °C), precipitation rainfall (P, mm day-1) and global solar radiation (Rg, MJ m-2 h-1).

For the determination of the total dry matter (MSPA) of the shoot part of the canola plants, at harvest, two plants were collected per experimental unit, stored in paper bags, and taken to dry in a forced-air circulation oven at 60°C for 72 hours, until reaching constant weight; afterward, the samples were weighed in a precision balance with 1 mg resolution.

The harvest to evaluate the grain yield and yield components of the crop occurred manually when the grains presented a color alteration from green to brown in the intermediate portion of the raceme. For the determination of the yield components, two random plants were collected in the experimental unit, from which the following variables were determined: dry mass of twenty siliques (MS20S, g), number of grains per silique (NG), number of siliques per plant (NS), 100-grain mass (M100G, g), and silique length (CS, cm). For the determination of the grain yield (GY), a composite sample composed of 0.25 m^2 was collected in the central part of the useful area of each parcel. These plants collected were air-dried in an open shed until reaching approximately 10% of moisture, being then subjected to manual processing and separation of impurities, after this procedure, weighing was carried out on a precision scale and the grain yield of the culture was determined for a final moisture of 10%.

The data on the initial plant stand and leaf area at the full flowering stage, number of siliques per plant, number of grains per silique, dry matter of 20 siliques, and 100-grain mass were subjected to analysis of variance and, upon verifying a significant effect, the means of the qualitative variables were compared by the Scott-Knott test at 5% of error probability, using the SISVAR® statistical software. The quantitative data were subjected to regression analysis. The productivity data were subjected to orthogonal contrasts at 5% of error probability to compare this variable determined in the plots of the treatments for the sowings in R5 and R7 with the control and between the densities of the same time, in which:

C1 = contrast of the overseedings in R5 and R7 with the control;

C2 = contrast between R5 and R7;

C3 = contrast of the treatment 3 kg ha^{-1} in R5 with 6, 12, and 18 kg ha^{-1} in R5;

C4 = contrast of the treatment 6 kg ha^{-1} in R5 with 12 and 18 kg ha^{-1} in R5;

C5 = contrast of the treatment 12 kg ha^{-1} in R5 with 18 kg ha^{-1} in R5;

C6= contrast of the treatment 3 kg ha^{-1} in R7 with 6, 12, and 18 kg ha^{-1} in R7;

C7 = contrast of the treatment 6 kg ha^{-1} in R7 with 12 and 18 kg ha^{-1} in R7;

C8 = contrast of the treatment 12 kg ha^{-1} in R7 with 18 kg ha^{-1} in R7.

To complement the productivity analysis, Scheffé's test at 5% of probability was used to compare the sowing in R5 with the control and the sowing in R7 with the control.

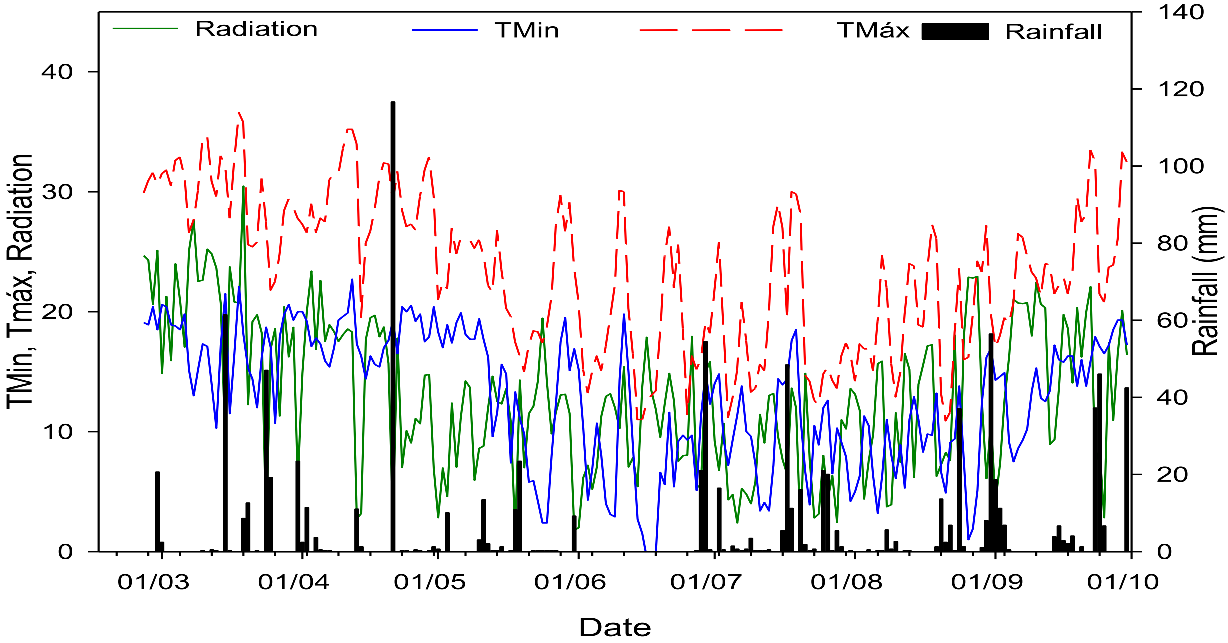
Results and Discussion

The meteorological conditions of the period from overseeding until emergence were more favorable for the germination and initial establishment of the canola plants when the overseeding on soybean was performed in the R7 phenological stage, considering that, in this stage, there was rainfall in the day after overseeding, whereas, for the overseeding on soybean in the R5 stage, rainfall only occurred 10 days after (Figures 1).

The fact that rainfall only occurred 10 days after the overseeding performed in stage R5 led the canola seeds to germinate only after this favorable moisture condition, when the soybean crop was then in the R6 stage (March 14, 2018). As for the overseeding on soybean in the phenological stage R7, the rainfall, although presenting a low index, occurred one day after sowing, allowing the canola plants of this overseeding time to germinate and emit cotyledons within only three days (24/03/2018), resulting in a faster initial establishment and a more even plant distribution.

The phase after the germinative process in overseeding systems is also essential since the plants can be exposed to stresses of higher or lower intensity as a function of the photosynthetically active radiation caused by the shading provided by the soybean canopy. In this phase, the young canola plants from the first overseeding were subjected to greater competition for light since the soybean already exhibited a higher number of leaves. In the first two days after the emergence of the canola plants overseeded on soybean in the R5 stage, the seedlings received only 7% of the incident RFA on the canopy of the crop, and in 10 out of the 12 days subsequent to germination, the RFA transmitted was lower than 1.0 MJ m^{-2} day^{-1} (Figure 3). With this RFAt insufficiency below the soybean canopy, the canola plants underwent an excessive elongation of the main stem aggravated by the shading and did not present the characteristics rosette shape for the phenology of the plant (Figure 2A). This etiolation was visualized in the treatments with overseeding in R5, throughout their cycle, in which the plants presented winding in the base of the stem (Figure 2B). The high competition for solar

Figure 1. Minimum (Tmin; ºC) and maximum daily air temperatures (Tmax; ºC), global solar radiation (MJ m^{-2} day^{-1}) and rainfall in the period from 5 days before the first overseeding on soybean (March 1, 2018; soybean in stage R5) until the last canola harvest (October 1, 2018), in Santa Maria, RS.



radiation affects the architecture of the canola plants (Jacob Junior et al., 2012) since the low luminosity leads the plant to present a quick stem prolongation towards solar radiation (Gommers & Monte, 2018), destining a significant part of its reserves and converted energy for this process. Etiolation was also verified by Almeida et. al. (2014), in a study in which they verified this condition in excessively shaded soybean plants intercropped with eucalyptus. Etiolation is a negative response since it results in smaller stem diameter and in plants that are more susceptive to lodging, generating problems especially at harvest, negatively affecting the yield and quality of canola grains.

In the canola plants originated from the overseeding on soybean in R7, although no clear rosette formation has been observed, no winding of the base of the stem was verified (Figure 2C), probably because the insufficient RFA, lower than 1.0 MJ m^{-2} day^{-1}, occurred only in the first three days after emergence, gradually increasing its availability in the later period (Figure 3). In general, it may be inferred that the lower etiolation in the plants of the second overseeding date occurred because the soybean began to lose leaves from stage R7, allowing a gradual increase of RFA transmissivity through the canopy and greater availability for the canola plants.

The difference in plant etiolation can be explained by the availability of RFAt to the canola plants emerged under the soybean canopy (Figure 3). It is verified that the RFAt in stage R5 was lower than 10% of the photosynthetically active radiation incident in the entire crop, remaining with low values for a relatively long period, even with a high incidence of photosynthetically active radiation on top of the soybean canopy. For the canola plants from the overseeding in R7, there was higher RFA transmissivity through the soybean canopy, reaching 40% on March 27, 2018 (Figures 3 and 4), at the beginning of soybean maturation. However, due to the lower RFA availability from March 19 to March 27, 2018, the canola plants overseeded on soybean in R7 only received very low RFAt (RFAt < 1.0 MJ m^{2} day^{1}) in the first three days after emergence. For the canola plants from the overseeding in soybean in R5, this insufficient RFA condition lasted for 12 days after their normal emergence (Figures 3 and 4), with this being the probable cause of the low number of remaining plants after soybean harvest.

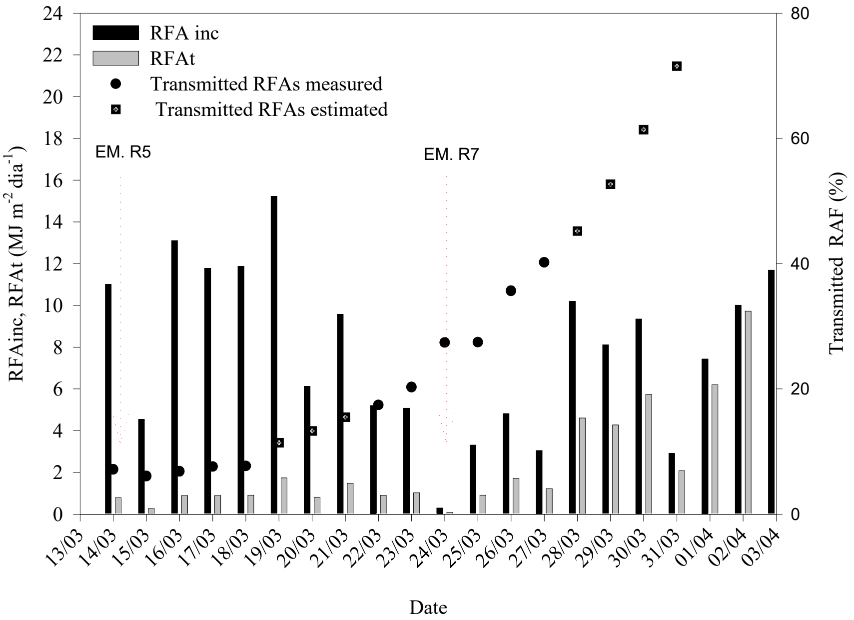
The increase of the RFA transmitted from March 23, 2019 (2nd day after emergence for the canola in the second stage of overseeding) is due to the fall of leaves that the soybean crop presents when maturation is approaching the end of the cycle, a characteristic the provides a better development of the canola plants originated from overseeding.

The density of the canola plants after soybean harvest presented, as resulted in the analysis of variance, a significant interaction between the two soybean stages in the overseeding and density of the canola seeds distributed. In the first overseeding (soybean in R5), the mean number of plants was below three plants per

Figure 2. Canola plants with excessive elongation of the main stem aggravated by shading, presenting no rosette stage (A); winding of the base of the stem in canola plants in the stage of elongation of the floral stem when overseeded on soybean stage R5 (B); and base of the stem in canola plants in the state of elongation of the floral stem when overseeded on soybean stage R7 (C); Santa Maria, RS, 2018.

Source: Authors.

Figure 3. Photosynthetically active radiation incident on top of the soybean canopy (RFAinc); RFA transmitted through the soybean canopy and incident on the canola plants (RFAt); RFA transmissivity measured and estimated (RFAt/RFAinc; %) for the days 19/03, 20/03, 21/03, 28/03, 29/03, 30/03, 31/03, and 01/04 in the period subsequent to the emergence (EM) of the canola crop overseeded on soybean in stages R5 and R7, in Santa Maria, RS.



square meter, which means a plant density well below the indicated for the canola crop in the state of Rio Grande do Sul (RS), which is 40 plants m^{-2} for sowing in rows and at the adequate time for the canola crop to express its maximum productive potential in RS (Tomm, 2007). This low plant density may be linked, in addition to the reduction in soil moisture observed to the detriment of water restriction, also to the reduction of senescent leaf mass available to cover the seeds at this stage, which has an influence on their germination. (Volf et al., 2021).

The number of 40 Pl m^{-2} was only reached in the overseeding performed when the soybean was in the R7 stage, at the seed density of 6 kg ha^{-1} or higher (Figure 5A). As for the seed density of 3 kg ha^{-1}, only 10 Pl m^{-2} were counted, on average, for this second overseeding, whereas in the treatments with 12 and 18 kg ha^{-1}, it was 67 and 81 Pl m^{-2}, respectively. This unnecessarily high number, according to Angadi et al. (2003), does not present a significant increase in canola productivity in the comparison of a population of 40 Pl m^{-2} with one of 80 Pl m^{-2} and, therefore, it is inferred that seed densities of 12 kg ha^{-1} or higher are too much, even when the

Figure 4. Minimum (Tmin, ºC) and maximum daily air temperatures (Tmax, ºC), global solar radiation (Rg, MJ m-2 day-1), and rainfall in the period between the overseedings (S) in stages R5 and R7 of the soybean crop, with the indication of the respective emergence dates of the canola plants (EM) in R5 and R7 of the soybean crop until soybean harvest (April 12, 2018), in Santa Maria, RS.

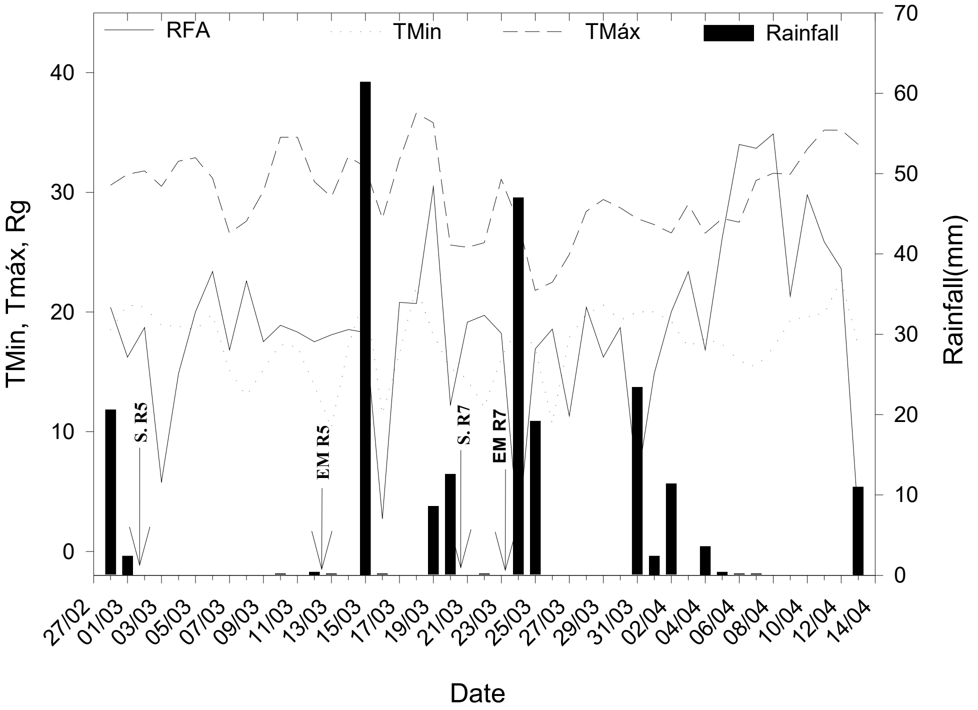
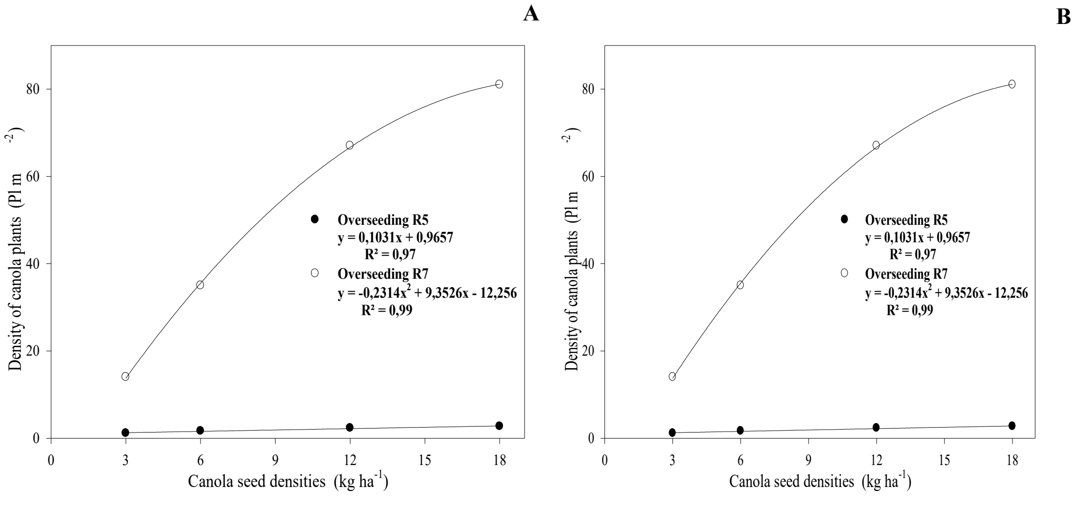


Figure 5. Density of canola plants after soybean harvest in plots where overseeding occurred in stages of beginning of grain filing and beginning of the physiological maturation of the soybean crop, at the canola seed densities of 3, 6, 12, and 18 kg ha^{-1} (A); leaf area index (IAF) of the canola plants at full flowering, as a function of the seed densities of 3, 6, 12, and 18 kg ha^{-1} (B), in two overseeding times on soybean in stages R5 and R7, in Santa Maria, RS.



implantation of the crop occurs through overseeding.

Among the phenometric variables, the IAF measured in the full flowering stage of the canola plants presented a significant interaction between the soybean stage at overseeding and the density of the distributed seeds. In the first overseeding, the IAF of the canola crop remained practically constant for all sowing densities (Figure 5B), keeping under 0.3. The low IAF value can be explained by the low plant stand and their initial etiolation during their establishment in the management of overseeding performed in the R5 stage of the soybean crop.

With the canola overseeding on soybean in R7 (time 2), the IAF increased with the increase in the seed densities employed in the overseeding process, until reaching the maximum value at the seed density of 12 kg ha^{-1}, a treatment that resulted in a count of 62 canola plants m^{-2}

Table 1. Density of established canola plants (DP), plant height (Height), shoot dry matter per plant (MSPA), dry matter of twenty siliques (MS20S), number of grains per silique (NGs), number of siliques per plant (NSpl), and 100-grain mass (M100G) of canola plants overseeded in two developmental stages of the soybean crop.

Overseeding Soybean Stage	DP (Pl m^{-2})	Height (m)	MSPA (g Pl^{-1})	MS20S (g)	NGs (nº Pl^{-1})	NSpl (nº Pl^{-1})	M100G (g)
Grain filing	1.97b	1.14 a	153.1 a	2.03 b	17.4 b	912 a	0.44 a
Maturation	48.36a	1.06 a	37.8 b	2.34 a	19.1 a	210 b	0.40 b
Mean	25.16	1.10	95.4	2.18	18.2	561	0.42
CV (%)	24.3	9.37	43.7	9.4	10.8	48.7	8.9

Means followed by different letters in the column differ significantly from each other by the Scott-Knott test at 5% of error probability, CV-coefficient of variation.

at the moment of soybean harvest (Figure 5B). This result is congruent with the results found by Bandeira et al. (2013), who obtained the highest IAF at the density of 60 Pl m^{-2}, also observing a decrease in the IAF at the density of 18 kg ha^{-1}, demonstrating that the canola established within high plant densities can be exposed to significant intraspecific competition. The results related to the IAF, obtained with the overseeding performed in R7, also serves to ratify that the initial establishment of the canola plants can be perfectly viable with seed densities within 6 and 12 kg ha^{-1}.

For the variables of plant height, yield components, and dry matter of the plants, there was no interaction between sowing densities and overseeding stages, which indicates that these factors act independently. For the factor of plant densities, there were also no significant differences between the different overseeding densities, and therefore, the results are presented only for the factor of soybean stages at overseeding, verifying that this variable did not differ (Table 1). Although in the conditions of the first overseeding, there was etiolation in the early stages of the crop, this response did not provide a higher or lower final plant height.

The MSPA variable per plant presented a reduction of 75.3 % (Table 1) in the comparison of the means obtained with the overseeding in R5 and compared with R7, due to the low plant density obtained in R5. Since there was no intraspecific competition because the plants were isolated, the plants probably did not compete for solar radiation, water, and minerals, thus showing that the canola plants exhibit high phenotypic plasticity, compensating the lack of plants with the emission of a higher number of branches and, consequently, a higher number of siliques per plant. The reduction trend of the shoot dry matter in canola plants, due to competition, also occurs for forage canola. Ahmadi, Rad, and Delkhosh (2014) verified that, in the subperiod of stem elongation, the plants reached the highest dry matter mass at the density of 150 Pl m^{-2}, and from this density, the dry matter per plant decreased to a minimum of 22% at the plant density of 200 Pl m^{-2}.

The MS20S also presented a significant difference between the canola plants originated from sowing in different stages of the soybean crop, at overseeding. The overseeding performed in R7 resulted in the highest mean, probably because the plants allocated more photoassimilates in the grains, unlike the plants from the overseeding in R5, which presented a higher production of MSPA, accumulating less photoassimilates in the grains. A significant difference was also verified between the two canola overseedings for the number of siliques per plant. The plants of the overseeding in stage R5 of the soybean crop presented higher NSpl means that those of stage R7 (Table 1), with no seed density differences between treatments. The higher NSpl in the plants from the overseeding on soybean in the R5 stage is linked to the spatial distribution in the plots, indicating little competition between the plants, thus obtaining more space for the emission and development of branches and a higher number of siliques per plant. Krüger et al. (2011) verified that, with a lower plant density, there is a trend towards higher silique production per plant. The same authors obtained NSpl values of 572 and 186 for the densities of 20 and 40 Pl m^{-2}, respectively, indicating the existence of intraspecific competition and a drastic reduction of NSpl with the duplication in plant density.

The mean number of grains per silique (NG) presented no significant interaction between the levels of the soybean stage at overseeding and seed density, with a difference occurring only between stages, being superior in the overseeding of the R7 soybean stage (Table 1). The number of grains per silique is directly linked to flower pollination, which may be affected by factors such as meteorological conditions and availability of pollinators (Halinski et al., 2018). The fact that the overseeding in R5 had lower NG values than R7 may be related with the flowering period, since it extended from May 2 until August 26, 2018, for the overseeding in R5, whereas the canola plants from the overseeding on soybean in R7 kept in flowering from May 20 until July 30, 2018. Therefore,

Table 2. Orthogonal contrasts for the grain yield (GY) of the canola crop overseeded on soybean in stages of beginning of grain filing and beginning of the physiological maturation of de culture at different seed densities and control treatment, Santa Maria, RS.

Treatment	GY (kg ha-1)	C1	C2	C3	C4	C5	C6	C7	C8
3 kg R5	261	1	1	3	0	0	0	0	0
6 kg R5	332	1	1	-1	2	0	0	0	0
12 kg R5	348	1	1	-1	-1	1	0	0	0
18 kg R5	368	1	1	-1	-1	-1	0	0	0
3 kg R7	1,92	1	-1	0	0	0	3	0	0
6 kg R7	2,527	1	-1	0	0	0	-1	2	0
12 kg R7	2,722	1	-1	0	0	0	-1	-1	1
18 kg R7	2,548	1	-1	0	0	0	-1	-1	-1
Control	1,302	-8	0	0	0	0	0	0	0
Estimation		613.0	-8,407.3*	-265.0	-53.0	-20.3	-2,037.3*	-215.3	173.5

C1= contrast of the overseedings in R5 and R7 with the control; C2 = contrast between R5 and R7; C3= contrast of the treatment 3 kg R5 with 6, 12, and 18 kg in R5; C4 contrast of the treatment 6 kg R5 with 12 and 18 kg in R5; C5 contrast of the treatment 12 kg R5 with 18 kg in R5; C6= contrast of the treatment 3 kg R7 with 6, 12, and 18 kg in R7; C7 contrast of the treatment 6 kg R7 with 12 and 18 kg in R7; C8 contrast of the treatment 12 kg R7 with 18 kg in R7; * significant at 5% of error probability by the F-test.

the flowering period of the overseeding in R7 was smaller, and the meteorological conditions were better for pollination, with less rainy days (Figure 1).

The M100G variable was significantly higher in the canola plants overseeded on soybean in R5 (Table 1). However, although significantly higher, this difference of only 0.04 grams can be explained by a higher translocation of photoassimilates to a lower number of canola grains in the plants originated from the overseeding on soybean in R5, due to the absence of intraspecific competition, as a consequence of the low plant density.

For the evaluation of yield, the means comparison test by orthogonal contrasts (Table 2) showed significance for a few contrasts only, probably due to the great plant density variability originated by the overseeding procedure performed manually and the probable greater spatial variability of the germination conditions of the canola seeds on the soil compared to the variability that occurs when the sowing is performed in planting rows.

When comparing the two overseeding times with the control treatment (Contrast 1), the analysis of variance by orthogonal contrasts indicated that there is no significant difference (Table 2), evidencing that the overseeding technique on soybean can be indicated and it shall not bring yield losses if the density of established plants is at least 36 Pl m^{-2}.

Contrast 2 compared the yield for the overseeding in two developmental stages of the soybean crop (R5 and R7), registering best yields in the experimental units in which overseeding was performed when the soybean was in stage R7 (Table 2), with a higher value than the mean yield of 1,343 kg ha^{-1} of the state of Rio Grande do Sul in 2018 (CONAB, 2018). This yield was similar to that obtained in the control treatment, sown in rows right after the soybean harvest at the density of 3 kg ha^{-1}, that is, 26 days after the canola overseeding performed when the soybean was in R7.

In contrasts 3, 4, and 5, which compared the different seed density treatments in the overseeding in R5 regarding the yield, with each other, there was no significant difference, which is explained by the low remaining population of canola plants after soybean harvest (Figure 5a) and the consequently lower IAF (Figure 5b) than in any of the seed densities distributed. The main cause of this drastic yield reduction was, therefore, the insufficiency in the availability of solar density below the soybean canopy for the canola overseeded on soybean in R5 (Figure 3), even if the availability of solar radiation measured outside the canopy was above 18 MJ m^{-2} day^{-1} in 77% of the 12 days after the emergence of the plants (Figure 3), compromising the initial establishment of the canola crop due to the strong shading caused by the soybean canopy.

Contrast 6 indicated a significant difference (Table 2), by which the comparison between the yield of the treatment with 3 kg ha^{-1} of canola seeds overseeded in

Table 3. Scheffé's test for the grain yield of the canola crop (kg ha^{-1}) overseeded on soybean in stages R5 and R7 at different seed densities and control treatment, sown 4 days after soybean harvest, in Santa Maria, RS.

Contrast	Estimation	Scheffé Estimation	p - Value
X1 = T1+T2+T3+T4 – T9	974	1,089	0.110
X2 = T5+T6+T7+T8 – T9	1,128	1,089	0.038*

T1 = 3 kg ha^{-1} in R5, T2 = 6 kg ha^{-1} in R5, T3 = 9 kg ha^{-1} in R5, T4 = 12 kg ha^{-1} in R5, T5 = 3 kg ha^{-1} in R7, T6 = 6 kg ha^{-1} in R7, T7 = 9 kg ha^{-1} in R7, T8 = 12 kg ha^{-1} in R7, T9 = control sown in row with 3 kg ha^{-1} of canola seeds after soybean harvest; * significant at 5% of error probability by Scheffé's test.

stage R7 of the soybean with the remaining densities overseeded in R7 showed to be inferior to the treatments with 6, 12, and 18 kg ha^{-1}.

When compared the yields of the treatments 6 kg ha^{-1} with 12 and 18 kg ha^{-1} and 12 kg ha^{-1} with 18 kg ha^{-1} with each other, in contrasts 7 and 8 respectively, no difference in yield was verified, thus allowing to recommend the 6 kg ha^{-1} density as sufficient and adequate for the initial establishment of the canola crop when overseeding is performed in the R7 stage of the soybean crop, considering that there are proper moisture conditions for the germination of canola seeds.

The sowing in R5 did not differ statistically from the control treatment when compared by Scheffé's test at 5% of error probability (Table 3). When comparing the overseeding in R7 with the control, the yield of R7 was significantly better due to the meteorological conditions of the flowering period, which favored fertilization and grain filling for the plants overseeded in R7. The overseeding in R7 allowed a time gain in the civil calendar since the harvest was performed on August 23, 2018, with approximately 156 days of total cycle, whereas the plants originated from the overseeding on soybean in R5 and the control were harvested on September 28, 2018, with approximately 212 and 166 days of the cycle, respectively, resulting in 36 days of real gain in harvest anticipation with the overseeding procedure performed on soybean in stage R7. This cycle duration was very similar to that found by Luz et al. (2012), who obtained a cycle duration of 162 days for the cultivar Hyola 433 sown on April 3, in Santa Maria, RS.

The increase in the cycle of the canola overseeded in R5 can be attributed to the low competition with other canola plants since they were completely isolated in the plots. This condition induced the canola plants to emit more branches for a longer period, which prolonged the total cycle, resulting in a higher shoot dry mass and, consequently, a higher number of siliques per plant (Table 1). Therefore, the canola crop has the ability to establish and develop in the overseeding system when this practice is performed in the developmental stage R7 of the soybean crop. This finding has great agronomic and economic importance since it can allow the organization of the succession system from annual crops to eventual 5 cultivation cycles in two agricultural years, under favorable conditions, which is usually not possible with traditional sowing methods. Furthermore, the overseeding of canola on soybean could be one of the advantages to promote the cultivation of canola as a rotation option for winter cereals, in production systems.

Conclusions

Canola overseeding should not occur in the developmental stage R5 of the soybean crop or while the excessive shading caused by the soybean crop is within levels that inhibit the initial establishment of the canola plants.

Canola has the ability to establish and develop in the overseeding system when this practice is performed in the developmental stage R7 of the soybean crop.

The time gain of canola harvest in the civil calendar was 36 days in the canola overseeded on soybean in the R7 stage, which may allow the implantation of the subsequent crop with more antecedence, allowing the intensification of cultivation systems in agricultural enterprises.

The best plant density of canola seeds to perform overseeding in Santa Maria, RS, was 6 kg ha^{-1}, overseeded in stage R7 of the soybean crop.

The grain yield of the canola overseeded on soybean in stage R7 was higher than that of the canola sown in row right after soybean harvest, in Santa Maria, RS.

Acknowledgments

To the Coordination for the Improvement of Higher Education Personnel (CAPES) and the National Council for Scientific and Technological Development (CNPq) for the concession of scholarships, and to Professor Dr. Alessandro Dal'Col Lúcio for his collaboration in the statistical part of this study.

Author contributions

M. LEONARDI and P. E. SCHAEFER conception of article, writing of the article, acquisition and analysis of data and review of the article. A. B. HELDWEIN conception of article, writing of the article, analysis of data. J. R. SILVA and A. J. PUHL conception of article, writing of the article, acquisition and analysis of data. A. H. Nied conception of article and analysis of data.

References

AHMADI, B.; RAD, A. H. S.; DELKHOSH, B. Evaluation of plant densities on analysis of growth indices in two canola forage (*Brassica napus* L.). **European Journal of Experimental Biology**, vol. 4, n 2, p. 286-294, 2014.

ALMEIDA, F.L.; CALONEGO, J.C.; TIRITAN, C.S.; ARAÚJO, F.F.; SILVA, P.C.G. Produtividade de soja em diferentes posições entre renques de eucalipto em cultivo consorciado. **Colloquium Agrariae**, v. 10, n. 1, p. 33-44, 2014.DOI: https://doi.org/10.5747/ca.2014.v10.n1.a098

ANGADI, S.V.; CUTFORTH, H.W.; MCCONKEY, B.G.; GAN, Y. Yield adjustment by canola grown at different plant populations under semiarid conditions. **Crop Science**, v. 43, p. 1358-1366, 2003. DOI: https://doi.org/10.2135/cropsci2003.1358

BANDEIRA, T.P; CHAVARRIA, G; TOMM, G.O. Desempenho agronômico de canola em diferentes espaços entre linhas e densidades de plantas. **Pesquisa Agropecuária Brasileira**, v.48, p.1332-1341, 2013. DOI: https://doi.org/10.1590/S0100-204X2013001000004

BURIOL, G.A.; ESTEFANEL, V.; SACCOL, A.V.; HELDWEIN, A.B.; SCHNEIDER, F.M. Disponibilidades hídricas do solo possíveis de ocorrerem no estado do Rio Grande do Sul. **Revista do Centro de Ciências Rurais**, v.10 (suplemento), p.1-141,1980.

CANALLI, L. B. S.; COSTA, G. V.; VOLSI, B.; LEOCÁDIO, A. L. M.; NEVES, Carmen S. V. J.; TELLES, T. S. Production and profitability of crop rotation systems in southern Brazil. **Semina.** V. 41, n. 6, p. 2541-2554, 2020. DOI: 10.5433/1679-0359.2020v41n6p2541.

CARDOSO, C.D.V. **Probabilidade de ocorrência de deficiência hídrica nos solos da região Central do Estado do Rio Grande do Sul**. 2005. 162 f. Tese (Doutorado em Agronomia) - Universidade Federal de Santa Maria, Santa Maria, 2005.

CONAB - Companhia Nacional de Abastecimento. **Acompanhamento de safra brasileira: grãos, décimo segundo levantamento, setembro 2018** / Companhia Nacional de Abastecimento. – Brasília: Conab, 2018. Disponível em:< https://www.conab.gov.br/info-agro/safras/graos/boletim-da-safra-de-graos/item/9983-12-levantamento-safra-2017-18> Acesso em: 23 de mar. de 2023.

CORREIA, N. M.; GOMES. L. J. P. Sobresemeadura de soja com Urochloa brizantha e Panicum máximo e a formação de palha em sistema plantio direto. **Semina**: Ciências Agrárias, v. 37, n. 3, p. 1209-1218, 2016. DOI: 10.5433/1679-0359.2016v37n3p1209.

DE MORI, C.; TOMM, G. O.; FERREIRA, P. E. P. **Aspectos econômicos e conjunturais da cultura da canola no mundo e no Brasil.** 149. ed. Passo Fundo: Embrapa Trigo, 2014. 36 p. (Embrapa Trigo. Documentos online, 149). Disponível em < http://www.cnpt.embrapa.br/biblio/do/p_do149.htm> . Acesso em: 20 jul. 2021.

ESTEVEZ, R. L.; DUARTE, J. B.; CHAMBO, A. P. S.; CRUZ, M. I. F. A cultura da canola (Brassica napus var. oleifera). **Scientia Agraria Paranaensis**, v. 13, n. 1, p. 1-9, 2014. DOI: 10.18188/1983-1471/sap.v13n1p1-9.

FEHR, W.R.; CAVINESS, C.E. **Stages of soybean development.** Ames: lowa State University of Science and Technology, 1977. 11p.

GOMMERS, C.M.M.; MONTE, E. Seedling establishment: a dimmer switch-regulated process between dark and light signaling. **Plant Physiol** 176: 1061–1074, 2018. DOI: https://doi.org/10.1104/pp.17.01460

GULARTE, J. A.; MACEDO, V. G. K.; PANOZZO, L. E. Canola seed production and market in Brazil. **Applied Research e Agrotechnology**, v. 13, n. 1, e5834, 2020. DOI: 10.5935/PAeT.V13.e5834. DOI: 10.5935/PAeT.V13.e5834

HALINSKI, R.; SANTOS, C. F. dos; KAEHLER, T. G.; BLOCHTEIN, B. Influence of wild bee diversity on canola crop yield. **Sociobiology**, v. 65, n. 4, p. 751-759, 2018. DOI: https://doi.org/10.13102/sociobiologia.v65i4.3467

HELDWEIN, A.B.; BURIOL, G.A.; STRECK, N. A. O clima de Santa Maria. **Ciência & Ambiente**, v. 38, p. 43-58, 2009.

IRIARTE, L.B.; VALETTI, O.E. **Cultivo de Colza. Buenos Aires: Instituto Nacional de Tecnologia Agropecuária** – INTA. 2008. 156p.

JACOB JUNIOR, E.A.; MERTZ, L.M.; HENNING, F.A.; RODRÍGUEZ QUILÓN, I.; MAIA, M.S.; ALTISENT, J.M.D. Changes in canola plant architecture and seed physiological quality in response to different sowing densities. **Revista Brasileira de Sementes**, Londrina-PR, v. 34, n.1, p.14-20, 2012. DOI: https://doi.org/10.1590/S0101-31222012000100002

KRÜGER, C.A.M.B.; SILVA, J.A.G.; MEDEIROS, S.L.P.; DALMAGO, G.A.; SARTORI, C.O.; SCHIAVO, J. Plant Arrangement in the Expression of Yield Components of Canola. **Pesquisa Agropecuária Brasileira**, 46, 1448-1453, 2011. DOI: http://dx.doi.org/10.1590/S0100-204X2011001100005

KUINCHTNER, A; BURIOL, G.A. Clima do estado do Rio Grande do Sul segundo a classificação climática de Köppen e Thornthwaite. **Disciplinarum Scientia**. Série: Ciências Exatas, S. Maria, v.2, n.1, p.171-182, 2001.

LUZ, G. L. da; MEDEIROS, S.L.P.; TOMM, G.O.; BIALOZOR, A.; AMARAL, A.D.do.; PIVOTO, D. Temperatura base inferior e ciclo de híbridos de canola. **Ciência Rural**, Santa Maria, v. 42, n. 9, p. 1549-1555, set. 2012. DOI: https://doi.org/10.1590/S0103-84782012000900006

MANFRON, A. C. A.; FONTANELI, R. S.; SANTOS, H. P.; ZENI, M.; SILVA, D.; PAZINATO, J. F. Sobressemeadura, uma alternativa entre safras para alimentação animal e palhada. **Revista Plantio Direto & Tecnologia Agrícola**, v. 29, n. 172, p. 19-24, 2019.

MANFRON, A. C. A.; BONDAN, C.; FONTANELI, R. S.; ZENI, M. Sobressemeadura de forrageiras na entressafra de grãos no Brasil. **Research, Society and Development**, v. 11, n. 5, e10111527914, 2022, DOI: 10.33448/rsd-v11i5.27914.

PACHECO, L.P.; PIRES, F.R.; MONTEIRO, F.P.; PROCÓPIO, S. de O.; ASSIS, R.L. de; CARMO, M.L. do.; PETTER, F.A. Desempenho de plantas de cobertura em sobressemeadura na cultura da soja. **Pesquisa Agropecuária Brasileira**, Brasília, DF, v. 43, n. 7, p. 815-823, 2008. DOI: https://doi.org/10.1590/S0100-204X2008000700005

PIRES, J. L. F.; CUNHA, G. R. **Sistemas de produção de lavouras extensivas em Plantio Direto: cereais de inverno**. In: GASSE, D N et al. Sistema plantio direto no Brasil. Passo Fundo: Aldeia Norte Editora, 2022, p. 174-204. ISBN: 978-65-87818-01-6.

SALVADORI, J. R.; BACALTCHUK, B.; DEUNER, C. C.; LAMAS JUNIOR, G. L. C..; RIZZARDI, M. A.; LANGARO, N. C.; ESCOSTEGUY, P. A. V.; BOLLER, W. (Org.). **Indicações Técnicas para a Cultura da Soja no Rio Grande do Sul e em Santa Catarina**, safras 2016/2017 e 2017/2018. Passo Fundo, RS: Editora UPF, 2016. 128 p. ISSN: 978-85-7515-994-1

SANTOS, H.G. dos; JACOMINE, P.K.T.; ANJOS, L.H.C. dos; OLIVEIRA, V.A. de; LUMBRERAS, J.F.; COELHO, M.R.; ALMEIDA, J.A. de; CUNHA, T.J.F.; OLIVEIRA, J.B. de. **Sistema brasileiro de classificação de solos**. 3.ed. rev. e ampl. Brasília: Embrapa, 2013. 353p.

SANTOS, H. P.; FONTANELLI, R. S.; SPERA, S. T.; DALMAGO, G. A.; PIRES, J. L. F.; SANTI, A**. Sistemas de produção para cereais de inverno: três décadas de estudos**. 1ed. Brasília: Embrapa, 2019, 307p.

SBCS - SOCIEDADE BRASILEIRA DE CIÊNCIA DO SOLO. Comissão de Química e Fertilidade do Solo - RS/SC. **Manual de adubação e calagem para os Estados do Rio Grande do Sul e Santa Catarina.** 10a. Ed. Porto Alegre, 2016.

SILVA, A.A.; SILVA, P.R.; SUHRE, E.; ARGENTA, G.; STRIEDER, M.L.; RAMBO, L. Estratégias de manejo de coberturas de solo no inverno para o cultivo do milho em sucessão no sistema semeadura direta. **Ciência Rural**, v. 36, n. 3, p. 1011-1020, 2006. https://doi.org/10.1590/S0103-84782006000300049

SILVA, W. B.; PETTER, F. A.; LIMA, L. B.; ANDRADE, F. R. Desenvolvimento inicial de Urochloa ruziziensis e desempenho agronômico da soja em diferentes arranjos espaciais no cerrado Mato-Grossense. **Bragantia**, v. 72, n. 2, p. 146-153, 2013. DOI: 10.1590/S0006-87052013000200006.

TARTAGLIA, F.L.; RIGHI, E.Z.; ROCHA, L DA, LOOSE, L. H.; MALDANER, I.C.; HELDWEIN, A. B. Modelos não destrutivos para determinação da área foliar em canola. **Revista Brasileira engenharia agrícola e ambiente**, v.20, n.6, p. 551-556, 2016. DOI: https://doi.org/10.1590/1807-1929/agriambi.v20n6p551-556

TIECHER, T. **Manejo e conservação do solo e da água em pequenas propriedades rurais no sul do Brasil: práticas alternativas de manejo visando a conservação do solo e da água.** Porto Alegre, RS: UFRGS, 2016. 186 p. disponível em: <https://www.lume.ufrgs.br/bitstream/handle/10183/149123/001005239.pdf?sequence=>1 Acesso em: 23 de mar. de 2023.

TOMM, G. O. **Indicativos tecnológicos para produção de canola no Rio Grande do Sul**. Embrapa Trigo, pp.14, 2007. Disponível em:< http://www.cnpt.embrapa.br/culturas/canola/p_sp03_2007.pdf.> Acesso em: 23 de mar. de 2023.

TOMM, G. O. et al. **Tecnologia para produção de canola no Rio Grande do Sul**. 113. ed. Passo Fundo: Embrapa Trigo. p. 1-39, dez, 2009. (Documentos online). ISSN 1518-6512.

VOLF, M. R.; CRUSCIOL, C. A. C.; CUSTÓDIO, C. C.; BOSSOLANI, J. W.; MACHADO, F. G.; WRUCK, F. J.; COSTA, C. H. M.; RIBEIRO, J. F.; SILVA, L. S. Interseeding of ruzigrass into soybean: Strategies to improve forage cultivation in no-till systems. **Annals of Agricultural Sciences**, v. 66, n. 1, p. 16-24, 2021. DOI: 10.1016/j.aoas.2021.02.003.

WEISBERGER, D.; NICHOLS, V.; LIEBMAN, M. Does diversifying crop rotations suppress weeds? A meta-analysis. **Plos One**, v. 14, n. 7, p. e0219847. DOI: 10.1371/journal.pone.0219847.

CITATION

LEONARDI, M.; HELDWEIN, A. B.; SILVA, J. R.; SCHAEFER, P. E.; NIED, A. H.; PUHL, A. J. Growth and grain yield of canola overseeded on soybean. **Agrometeoros**, Passo Fundo, v.31, e027266, 2023.

agrometeoros
REVISTA DA SOCIEDADE BRASILEIRA DE AGROMETEOROLOGIA

ISSN 2526-7043 www.sbagro.org.br DOI: http://dx.doi.org/10.31062/agrom.v31.e027266

Crescimento e rendimento de grãos da canola sobressemeada à soja

Mateus Leonardi[1(*)], Arno Bernardo Heldwein[1], Jocélia Rosa da Silva[2], Paulo Eugenio Schaefer[1], Astor Henrique Nied[1] e Andressa Janaína Puhl[1]

[1]Universidade Federal de Santa Maria. Av. Roraima, nº 1000, Cidade Universitária Bairro Camobi, CEP 97105-900 Santa Maria.
E-mails: mateus-leonardi@hotmail.com, arno.heldwein@ufsm.br, pauloeugenioschaefer@gmail.com, astor.nied@ufsm.br e andressa.puhl@hotmail.com
[2]Irriga Global, Rua. João Goulart, nº 165, Camobi, CEP 97105-220, Santa Maria. RS. E-mail: joceliarosa.s@gmail.com
(*)Autor para correspondência.

INFORMAÇÕES

História do artigo:
Recebido em 24 de março de 2023
Aceito em 28 de junho de 2023

Termos para indexação:
Brassica napus
sistema de implantação
intensificação de cultivos
sobressemeadura

RESUMO

A técnica da sobressemeadura possibilita o estabelecimento de uma cultura antes da colheita da cultura sobressemeada em final de ciclo. Visa aproveitar melhor as condições climáticas sazonais mais favoráveis e a intensificação dos sistemas de cultivo, podendo-se obter mais uma safra em menos tempo. Este trabalho teve como objetivo verificar se é possível estabelecer a canola em sobressemeadura nos estádios fenológicos de início do enchimento de grãos (R5) e início da maturação fisiológica da soja (R7) na região central do Rio Grande do Sul. O estudo foi realizado em clima Subtropical úmido, em Santa Maria, RS. Utilizou-se o delineamento blocos casualizados com 4 repetições, em esquema fatorial 4x2, para a densidade de sementes de *Brassica napus* na parcela (3, 6, 12 e 18 kg ha^{-1}) e o estádio de desenvolvimento da cultura da soja (R5 e R7), além de uma testemunha adicional semeada em linha diretamente na palha logo após a colheita da soja (3 kg ha^{-1} – método padrão). Mensurou-se a densidade de plantas, os componentes de rendimento e a rendimento de grãos. A canola não se estabelece quando sobressemeada no estádio R5 da soja. Com a densidade de sementes de 6 kg ha^{-1} foi alcançada a densidade de plantas recomendada para a canola sobressemeada no estádio R7 da soja. Destacou-se como melhor tratamento, a sobressemeadura de 6 kg ha^{-1} realizada no estádio R7 da soja.

REFERENCIAÇÃO

LEONARDI, M.; HELDWEIN, A. B.; SILVA, J. R.; SCHAEFER, P. E.; NIED, A. H.; PUHL, A. J. Growth and grain yield of canola overseeded on soybean. **Agrometeoros**, Passo Fundo, v.31, e027266, 2023.