Científic@
Multidisciplinary Journal
e-ISSN 2358-260X

PRODUCTION BEHAVIOR OF DIFFERENT SOYBEAN GENOTYPES IN THE WEST REGION OF PARANÁ

COMPORTAMENTO PRODUTIVO DE DIFERENTES GENÓTIPOS DE SOJA NA REGIÃO OESTE DO PARANÁ

Valéria Koschinski[1]*, Martios Ecco[2]

[1]Graduate student of the Agronomy course at the Pontifical Catholic University of Paraná (PUCPR), Câmpus Toledo, Avenida da União, 500, 85.902-532, Toledo, PR. e-mail: valkoschinski@gmail.com, contact telephone number: (44)99933-7110;
[2]Prof. Dr. of the Agronomy course at the Pontifical Catholic University of Paraná (PUCPR), Câmpus Toledo, Avenida da União, 500, 85.902-532, Toledo, PR. email: ecco.martios@pucpr.br

Info

Received: 11/2023
Published: 01/2024
DOI: 10.37951/2358-260X.2024v11i1.7178
ISSN: 2358-260X

Palavras-Chave
produtividade, Glycine max, tecnologias, clima, arquitetura.

Keywords:
technologies, Glycine max, productivity, climate, architecture.

Abstract

Agribusiness is responsible for the largest percentage of Brazilian GDP, yet agricultural activities have a low rate of return and a high cost risk. To meet the financial needs of producers and agribusiness sectors, the choice of the genotype to be implemented in commercial areas is one of the first decisions to be made. This work aimed to evaluate the production components of five different soybean genotypes in the western region of Paraná in the 2022/2023 harvest under standardized sowing conditions. The experimental design used was a randomized block design (DBC), with 5 treatments and 4 replications, totaling 20 experimental plots. The treatments consisted of sowing different soybean genotypes (M 6100 XTD, AS 3615 I2X, P 96R10 IPRO, DM 60IX64 RSF I2X and M 6110 I2X), all of indeterminate growth and an early cycle. The AS 3615 I2X, DM 60IX64 RSF I2X and M 6110 I2X genotypes have Intacta2 Xtend technology, while M 6100 XTD has Xtend technology Biotec and P 96R10 Intacta RR2 PRO technology. Additionally, all materials are from the relative maturity group (GMR) 6.1, with the exception of DM 60IX64 RSF I2X, which is from GMR 6.0. The parameters plant height (AP), number of racemes (NR), number of pods per plant (NVP), number of grains per pod (NGV), thousand grain mass (MMG), productivity (PROD) and index were evaluated. vegetative (IV). After measuring the aforementioned parameters, the results were subjected to the Tukey statistical test to compare the means, where significant differences ($p<0.05$) were observed between the genotypes (M 6100 XTD, AS 3615 I2X, P 96R10 IPRO, DM 60IX64 RSF I2X and M 6110 I2X) for the morphological and productive variables NGV, MMG and IV. For the NGV productive component, the P 96R10 IPRO genotype presented a lower average (2.32 grains per pod) compared to the others. However, the same genotype presented a higher mean MMG (153.59 g) than AS 3615 I2X and DM 60IX64 RSF I2X. The variables that showed a significant difference between the genotypes did not interfere in the final PROD of the genotypes in the experiment, as the evaluated genotypes have high productive capacity but different technologies. As there was no lack of control in chemical management, significant attacks by pests and diseases, or adverse weather conditions, all genotypes were able to develop their maximum productive capacity.

Resumo

O agronegócio é responsável pelo maior percentual do PIB brasileiro, ainda assim, as atividades agrícolas têm uma baixa taxa de retorno e um alto risco de custo. Para suprir as necessidades financeiras dos produtores e dos setores do agronegócio, a escolha do genótipo a ser implantado nas áreas comerciais é uma das primeiras decisões a serem tomadas. Este trabalho teve como objetivo avaliar os componentes de produção de cinco diferentes genótipos de soja na região oeste paranaense, na safra de 2022/2023, em condições padronizadas de semeadura. O delineamento experimental utilizado foi o de blocos casualizado (DBC), com 5 tratamentos e 4 repetições, totalizando 20 parcelas experimentais. Os tratamentos consistiram na semeadura de diferentes genótipos de soja (M 6100 XTD, AS 3615 I2X, P 96R10 IPRO, DM 60IX64 RSF I2X e M 6110 I2X), todos de crescimento indeterminado e ciclo precoce. Os genótipos AS 3615 I2X, DM 60IX64 RSF I2X e M 6110 I2X possuem a tecnologia Intacta2 Xtend, enquanto o M 6100 XTD possui a tecnologia Xtend Biotec e o P 96R10 a tecnologia Intacta RR2 PRO. Além disso, todos os materiais são do grupo de maturação relativa (GMR) 6.1, com exceção do DM 60IX64 RSF I2X, que é do GMR 6.0. Foram avaliados os parâmetros altura de planta (AP), número de rácemos (NR), número de vagens por planta (NVP), número de grãos por vagem (NGV), massa de mil grãos (MMG), produtividade (PROD) e índice vegetativo (IV). Após a mensuração dos parâmetros citados, os resultados foram submetidos ao teste estatístico de tukey, para comparação das médias, onde foi observado diferenças significativas ($p<0,05$) entre os genótipos (M 6100 XTD, AS 3615 I2X, P 96R10 IPRO, DM 60IX64 RSF I2X e M 6110 I2X) para as variáveis morfológicas e produtivas NGV, MMG e IV. Para o componente produtivo NGV, o genótipo P 96R10 IPRO apresentou menor média (2,32 grãos por vagem) em relação aos demais. No entanto, o mesmo genótipo apresentou maior média de MMG (153,59 g), quando comparado ao AS 3615 I2X e ao DM 60IX64 RSF I2X. As variáveis que apresentaram diferença significativa entre os genótipos não interferiram na PROD final dos genótipos do experimento, pois os genótipos avaliados apresentam alta capacidade produtiva, mas tecnologias diferentes. Como não houve descontrole no manejo químico, nem ataques expressivos de pragas e doenças, ou ainda intempéries climáticas, todos os genótipos puderam desenvolver sua máxima capacidade produtiva.

Introduction

In recent years, there has been a growth in the development of Brazilian agribusiness, both nationally and internationally. This sector corresponds to the largest percentage of the Brazilian gross domestic product (GDP), being responsible for more than 21% in the years 2020-2021, with emphasis on the cultivation of soybeans, which makes Brazil the main country in the production of this grain. However, agricultural activities have a low rate of return and a high cost risk (Oliveira, 2023).

Increases in income and reductions in costs and risks of failure are basic requirements for competitiveness. In regard to economic activity with such narrow profit margins, such as the current soybean farming practices in Brazil, there is no room for risks and dubious interpretations, no matter how insignificant they may seem (Farias et al., 2007).

The total cost of implementing soybean cultivation for the 2021/2022 harvest per hectare was estimated at R$4,678.39 for RR soybeans, R$4,685.65 for IPRO soybeans and R$4,901.81 for conventional soybeans (Richetti, 2021). In March 2022, the leveling productivity to pay off the COE (average effective operational production cost) was 33.1 bags of soybeans per hectare (CEPEA, 2022).

As of September 2022, the costs associated with soybean production in different states in Brazil show notable variations. In Paraná, the variable cost per bag of soybeans was R$100.61, with a fixed cost of R$22.77 per bag. In Mato Grosso, the variable and fixed costs were R$94.23 and R$21.88 per bag, respectively. In Rio Grande do Sul, variable costs reached R$82.24 per bag, while fixed costs were R$20.70 per bag. In Goiás, the variable cost per bag was R$93.01, with a fixed cost of R$17.33 per bag (CONAB, 2023). These differences highlight the variability in soybean production costs in different regions, influenced by factors such as inputs, logistics and agricultural technology.

In the 2022/23 harvest, the state of Mato Grosso led national production, producing 45,600.5 thousand tons and maintaining a productivity of 3,773 kg per hectare. Paraná has positioned itself as another major player, with a significant production of 22,384.9 thousand tons and a solid productivity of 3,860 kg per hectare. In contrast, Rio Grande do Sul faced productivity challenges, recording 2,214 kg per hectare, despite its production of 14,513.0 thousand tons (CONAB, 2023). These discrepancies reflect the diversity and complexity of the agricultural scenario in Brazil, with each state contributing in a unique way to national production.

In work by Menezes et al. (2023), commodity prices, currency devaluation against the dollar and the crisis generated by COVID-19 in global food supply and demand resulted in an increase of 31% in fixed costs and 24% in variable costs in soybean production. Among variable costs, seeds stood out, with an increase of 29%.

To meet the financial needs of families and agribusiness sectors, the choice of the genotype to be implemented in commercial areas is one of the first decisions to be made and requires much attention, as the grain yield potential of genotypes is influenced by factors of the genotype x environment interaction (Rocha et al., 2012). Among the main factors, there are predictable factors: photoperiod, soil type and fertility, aluminum toxicity, sowing time, and agricultural practices; unpredictable factors include rainfall distribution, relative air and soil humidity, atmospheric and soil temperature, pathogens and insects (Borem and Miranda, 2005). Because of this, the sowing time and plant population influence agronomic characteristics and, consequently, the final yield (Luiz, 2018).

Based on this interaction that influences the crop's ability to adapt, it is important to highlight that soy is cultivated in different countries on different continents, which results in a wide diversity of environmental factors. This diversity generates numerous combinations that have a significant influence on the grain productivity of the various cultivars (Vasconcelos et al., 2015). Therefore, it is extremely important to estimate this interaction to select the most appropriate cultivars for each location (Meotti et al., 2012; Colombari Filho et al., 2013), aiming for the continuous development of new cultivars with well-defined objectives, which allow you to circumvent or make the most of the specific biotic and abiotic conditions of each region. To achieve this objective, soybean improvement programs must seek cultivars with high productivity, production stability and adaptability to environmental variations in different growing regions (Almeida et al., 1999; Barros et al., 2010).

Sensitivity to photoperiod is a variable trait among cultivars, in which the range of adaptability can be restricted or broad across latitudes (Hamawaki et al., 2005). Because of this, soybeans only flower when the photoperiod of the growing environment becomes lower than the critical photoperiod (Mondine et al., 2001). It is worth noting that the number of days for maturation may vary according to the growing region, as it is influenced by latitude due to the sensitivity of soybeans to photoperiod (Rocha et al., 2012).

The interrelationships between chemical, physical and biological factors characterize a soil capable of meeting the needs of soybean cultivars with high productive potential. To define a genotype to be sown, it is necessary to check the Agricultural Climate Risk Zoning (ZARC) of the crop for a given location. The ZARC, governed by Decree No. 9,841/2019, is a study that allows each municipality to identify the best time for sowing crops in different types of soil and cultivar cycles, with the aim of minimizing risks related to adverse weather phenomena (Federal Government, 2022).

To define the ZARC, soils are classified according to available soil water (AD), being grouped into six classes: AD1, AD2, AD3, AD4, AD5, and AD6, which comprise AD from 0.34 to 1.84 mm cm $^{-1}$. Cases of AD below 0.34 mm cm $^{-1}$ only occur in excessively sandy areas and are therefore classified as high risk and unsuitable for agriculture and would correspond to class AD0 (Monteiro, 2022).

The relative maturity group (GMR) is understood as the duration of the soybean development cycle, that is, the number of days it takes for the crop to reach physiological maturity (Zanon, 2015). Each group fits best in a certain latitude range, depending on its response to the photoperiod, varying according to the number of hours/light to which it is exposed (Penariol, 2000). According to this influence of photoperiod on soybean plants, cultivars are distributed among 13 GMR: 000, 00, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 to 10, which are classified geographically based on plant growth and development. Brazil comprises GMRs 5 to 9, respectively, from the south to the north (Alliprandini et al., 2009).

Genetic improvement promoted significant changes in morphological and agronomic characteristics, developing genotypes with high yield potential and better grain quality. Furthermore, it developed genotypes with adaptability to each region, resistance or tolerance to pests and diseases, tolerance to biotic factors, shorter cycles, smaller plant stature, shorter and more erect leaves, and even resistance to lodging (Floss, 2022).

Another extremely important factor in choosing the genotype to be sown is the GMO (Genetically Modified Organisms) technology embedded in the material, allowing the producer to adopt criteria in choosing his genotype, according to his management difficulties encountered in the field, whether in the management of different species of weeds or pests. The INTACTA RR2 PRO ® technology has resistance to the main caterpillars that attack soybeans, provided by a Bt protein (Cry1Ac), and tolerance to glyphosate, which guarantees the health of the soybean crop and allows plant growth, even with the application of herbicides (Intacta RR2 PRO, 2023). On the other hand, the Intacta 2 XTEND ® technology allows for broader control of broadleaf weeds, as it has tolerance to glyphosate, present in the previous technology, and dicamba. Furthermore, it provides greater protection against the main soybean caterpillars, as it is based on the pyramiding of the proteins Cry1A.105, Cry2Ab2 and Cry1Ac and provides protection against two more species with relevant potential for damaging the production system, in addition to the four that were already targeted by Intacta RR2 PRO® technology. The XTEND ® varieties Biotec rely on non-Bt technology and are ideal for composing a refuge area with a high level of productivity (Plataforma Intacta 2 Xtend, 2023).

This study aims to evaluate the productivity of 5 different soybean genotypes in the western region of Paraná under standardized sowing conditions. The research aims to identify the genotypes that showed better aerial part formation and that present greater productivity per hectare based on the evaluation of their production components.

MATERIALS AND METHODS

The agricultural experiment was carried out on private property in the municipality of Tupãssi – PR, located between coordinates 24°34'29" S and 53°28'06" W, with an average altitude of 520 meters. According to the Köeppen climate classification, the region's climate is characterized as mesothermal humid subtropical, with hot summers and infrequent frosts (Caviglione, 2000). The soil in the experimental area is classified as a typical Distroferric Red Oxisol with a clayey texture (Andrade et al., 2010).

During the execution of the experiment, meteorological data on air temperature and rainfall were collected.

Prior to the installation of the experiment, soil was collected at a depth of 0 – 20 cm to assess fertility (Lana et al., 2016), presenting the following results: pH ($CaCl_2$) $_{5.10}$; 4.61 cmolc dm $^{-3}$ of H^+ + Al^{3+}; 6.29 cmol $_c$ dm $^{-3}$ of Ca^{2+}; 2.42 cmolc dm $^{-3}$ of Mg^{2+}; 0.55 cmol $_c$ dm $^{-3}$ of K^+; 13.87 cmol $_c$ dm $^{-3}$ cation exchange capacity (T); and 66.76% base saturation (V%).

The experimental design was randomized blocks (DBC), with 5 treatments and 4 replications, totaling 20 experimental plots. The area of each plot was 7.50 m x 15.0 m, with 112.50 m ^{2} consisting of 15 rows spaced 0.50 m apart (14 seeds m $^{-1}$). The soybean crop was sown in the first fortnight of September 2022 in an area in a direct sowing system under corn stubble cover from the previous harvest.

The seeder fertilizer used is from the PLANTI CENTER brand with 15 rows spaced 0.50 m apart, and the fertilization carried out was Yara fertilizer in the formulation 03-21-21 (NPK) at a dose of 300 kg ha $^{-1}$, together with sowing.

The 5 treatments consisted of sowing different soybean genotypes (M 6100 XTD, AS 3615 I2X, P 96R10 IPRO, DM 60IX64 RSF I2X and M 6110 I2X), all of indeterminate growth and early cycle (Table 1).

Table 1. Characteristics of the genotypes implemented in the productivity experiment of different genotypes in Tupãssi - PR – 2022/23 harvest.

	T1	T2	T3	T4	T5

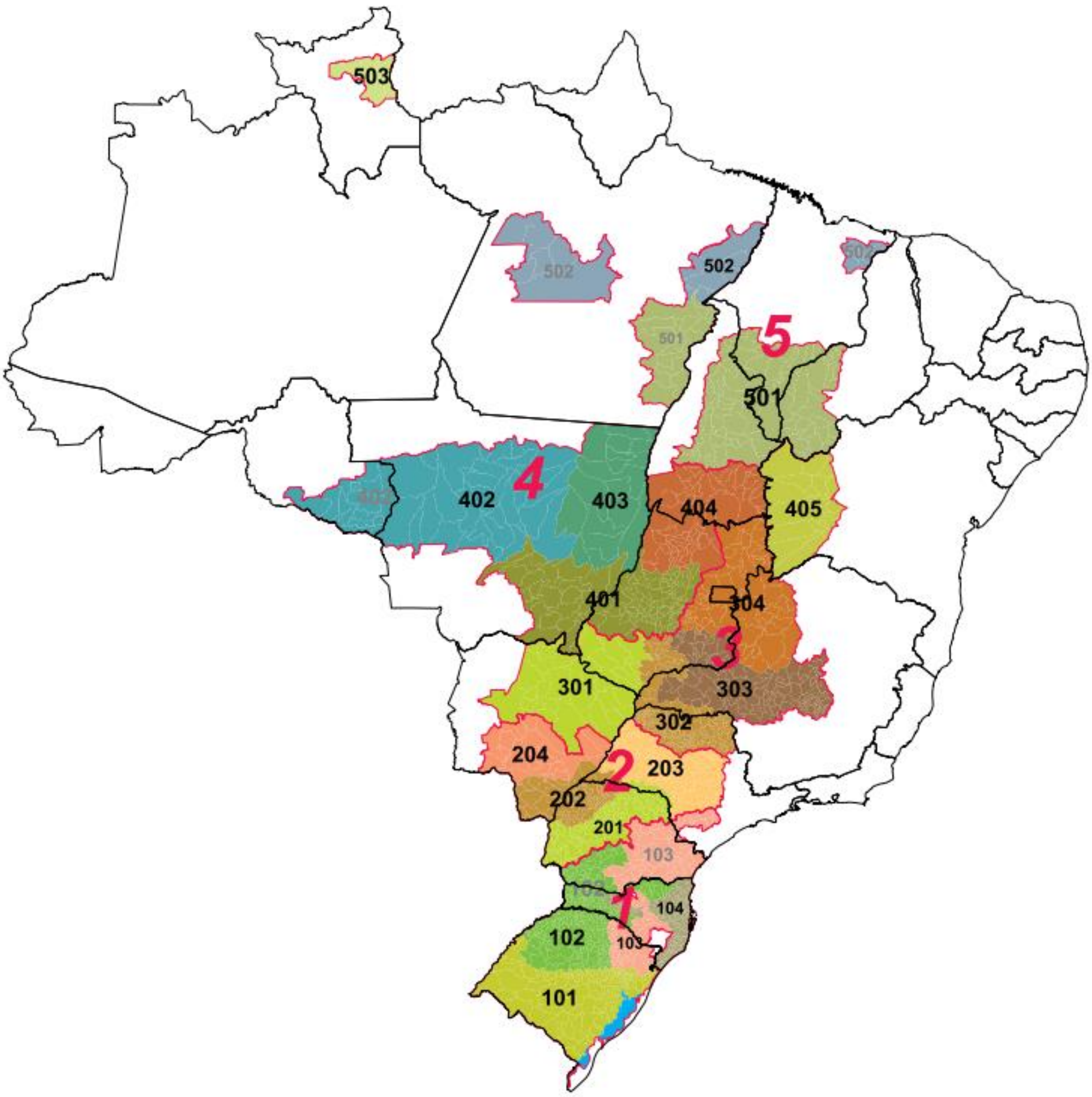
Genotypes	M 6100 XTD	AS 3615 I2X	P 96R10 IPRO	DM 60IX64 RSF I2X	M 6110 I2X
Technology	XTEND® BIOTEC –	INTACTA2 XTEND®	INTACTA RR2 PRO®	INTACTA2 XTEND®	INTACTA2 XTEND®
GMR	6.1	6.1	6.1	6.0	6.1
Cycle for region (days)	119	132	140 – 150	100	121
Disease tolerance	Bullseye, anthracnose, stem canker, frog's eye spot, bacterial pustule.	Target spot, anthracnose, stem canker, frog's eye spot, bacterial pustule, macrofomina	Cercosporiosis and stem canker	Stem canker, bacterial pustule, Phytophthora root rot , and *Meloidogyne gall Incognito* .	Target spot, bacterial pustule, frog's eye spot, white mold, anthracnose, stem canker
Bedding	2.7	1.8	Moderately susceptible	Resistant	4.9
Recommended soil and climate region	142 (Macro 1), 120 (301SP), 112 TO 118 (302/303)	101, 102, 201 High, 203 High, 204, 205, 301 SP	101, 102, 103, 201, 202, 203, 204, 301, 302, 303, 304, 401, 404	203, 201, 103, 104, 102, 101	201 High, 201 Low, 203 High, 203 Low, 301SP, 302, 303

Source: the author, 2023.

There are 5 different soybean macroregions (MRS) and 20 different edaphoclimatic regions (REC) (Figure 1), approved by MAPA, for research and indication of cultivars, considering the diversity of ecosystems, soil types and climate (latitude and altitude) in the country (Southern Foundation, 2023). The western region of Paraná is located in edaphoclimatic region 201.

When filling grains, ten plants were randomly collected from the useful area of each plot to evaluate: average plant height (AP), obtained by measuring between the soil and the stem end, number of racemes (NR) and number of pods per plant (NVP), counted one by one and divided by 10, and the number of grains per pod (NGV), obtained by counting pods with 1, 2, 3 and 4 grains, multiplying the number of pods by the number of grains, and then taking the average, dividing by 10.

Figure 1. Soybean macroregions (MRS) and edaphoclimatic regions (REC).



Source: Kaster and Farias (2011).

The management of weeds, pests and diseases in the experiment was standardized for the entire implementation area, carried out with a self-propelled 30 m boom (Table 2).

The Canopeo application quantifies the percentage cover of the canopy of live green vegetation using a cell phone camera.

After the maturation of the soybean crop, at 150 DAS, the 3 central lines were manually harvested, with a length of 5 meters, totaling 7.5 m2 for productivity analysis, discarding the borders of the experimental plot. The material was then threshed in a TC5090 harvester and collected by an elevator that takes the grains to the machine's bucket to avoid losses in the process. Humidity was determined using a digital electronic device in the PUCPR laboratory, where the results of harvesting the useful area of each plot were also weighed, corrected to 13% humidity and extrapolated to kg ha $^{-1}$. The mass of one thousand grains (MMG) was determined according to the Seed Analysis Rule (Brasil, 2009).

Table 2. Applications carried out in the management of soybean plots of different cultivars in Tupãssi - PR – 2022/23 harvest.

DAS	Date	Dose	Product	Active principle
1	17/09	1.7 L ha $^{-1}$	Dual Gold	Metolachlor
		0.1 L ha $^{-1}$	Tricho -turbo	*Trichoderma asperellum* BV10
31	10/17	0.4 L ha $^{-1}$	Iharol Gold	Mineral oil
		0.2 L and $^{-1}$	Select	Cletodim
		0.1 L and $^{-1}$	CoMo	Cobalt and Molybdenum
49	04/11	1.5 L and $^{-1}$	Crucially	Glyphosate
		0.165 L and $^{-1}$	Score Flexi	Propiconazole + Diphenoconazole
		1.65 L and $^{-1}$	Starter	Foliar fertilizer
64	11/19	0.4 L ha $^{-1}$	Progeny Detox	Foliar fertilizer
		0.5 L has $^{-1}$	Fox Xpro	Bixafem + Protioconazole + Trifloxystrobin
		0.2 L ha $^{-1}$	Select	Clethodim
83	08/12	0.6 L ha $^{-1}$	Vessarya	Picoxystrobin + Benzovindiflupir
		1.5 L. has $^{-1}$	Preventive	Chlorothalonil
		0.4 L ha $^{-1}$	hold	Fertilizer
		0.25 L ha $^{-1}$	Qualyfol Boró	Foliar Fertilizer
		0.2 L ha $^{-1}$	Iharol Gold	Mineral Oil
111	05/01	0.8 kg ha $^{-1}$	Proficient	Acephate
		0.2 kg ha $^{-1}$	Brit	Cypermethrin
		0.2 L ha $^{-1}$	Sphere Max	Trifloxystrobin + Cyproconazole
		0.25 L ha $^{-1}$	Qualyfol Boró	Foliar Fertilizer
118	01/12	0.7 L ha $^{-1}$	Curbix	Ethiprole
146	09/02	1.5 L ha $^{-1}$	Blowout	Diquate
		0.4 L ha $^{-1}$	Iharol Gold	Mineral Oil

Source: a author, 2023.
Note: DAS: days after sowing.

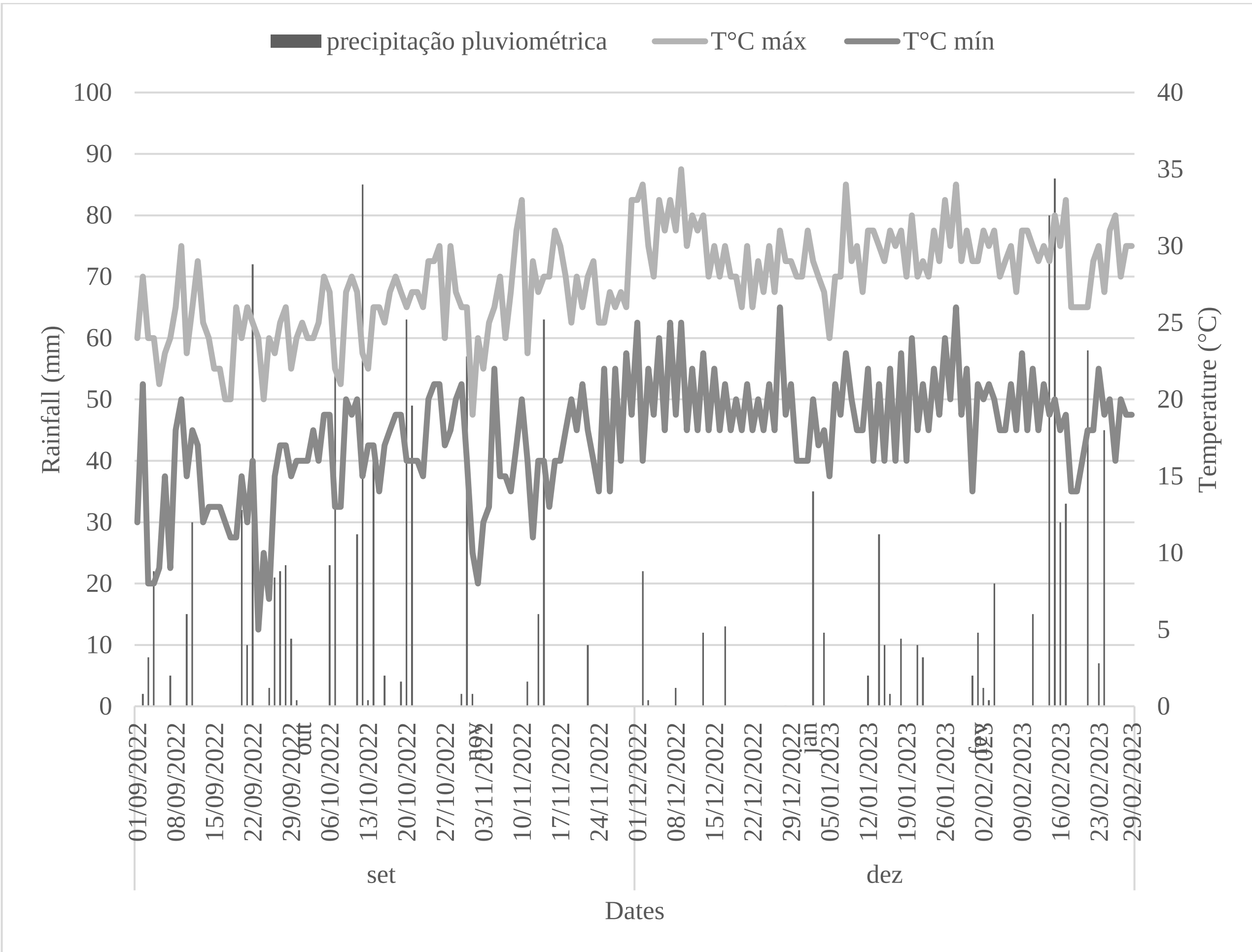
The data were tabulated and subjected to analysis of variance based on the 5% level of significance using the F test, and the qualitative means were subjected to the Tukey test at 5% probability. The analyses were performed using the statistical program SISVAR 5.6 - System for analysis of variance (Ferreira, 2011).

RESULTS AND DISCUSSION

The maximum and minimum temperature data presented averages of 28°C and 18°C, respectively, and accumulated rainfall of 936 mm (Figure 2), indicating that, during the experiment, meteorological conditions were suitable for the development of culture, since soybeans have a higher grain yield with air temperatures that are in the range of 20°C and 30°C and accumulated rainfall close to 700 mm during its cycle (Farias et al., 2007).

In general, there were significant differences ($p<0.05$) between genotypes (M 6100 XTD, AS 3615 I2X, P 96R10 IPRO, DM 60IX64 RSF I2X and M 6110 I2X) for the morphological and productive variables “number of per pods” (NGV) (Table 3), “thousand grain mass” (MMG) and “vegetative index” (IV) (Table 4), while “plant height” (AP), “number of racemes ” (NR), “number of pods per plant” (NVP) (Table 3), and “productivity” (PROD) (Table 4) did not differ between each other.

Figure 2. Meteorological conditions occurring during the soybean cycle. Data collected by the agro-industrial company Coamo Tupãssi Unit -PR, located 3 km from the productivity experiment of different genotypes – 2022/23 harvest.



Source: the author, 2023.

Table 3. Means, general average, F values, minimum significant difference (DMS) and coefficient of variation (CV) for the variables Plant Height (AP), Number of racemes (NR), number of pods per plant (NVP) and number of grains per pod (NGV) in soybean plants of different genotypes in Tupãssi - PR – 2022/23 harvest.

Source: the author, 2023.

GENOTYPES	AP	NR	NVP	NGV
	(cm)	no.	no.	no.
AS 3615 I2X	62.38	27.98	40.56	2.44 ab
P 96R10 IPRO	64.73	32.35	52.80	2.32 b
DM 60IX64 RSF I2X	69.03	34.88	54.78	2.35 ab
M 6100 XTD	69.10	33.15	45.70	2.51 to
M 6110 I2X	72.25	30.60	38.56	2.37 ab
			Overall Average	
	67.50	31.79	46.47	2.40
			F value	
	2.423 ns	1,443 ns	3.107ns –	3,872*
DMS	11.35	9.87	18.45	0.17
CV (%)	7.46	13.77	17.61	3.22

Note: ns: not significant at the 5% probability level using the F test; *: significant at the 5% probability level using the F test.

Table 4. Means, general average, F values, minimum significant difference (DMS) and coefficient of variation (CV), for the variables; thousand grain mass (MMG), productivity (PROD), and vegetative index (IV) in soybean plants of different genotypes in Tupãssi - PR – 2022/23 harvest.

GENOTYPES	MMG	IV	PROD
	(g)	(%)	(kg ha $^{-1}$)
AS 3615 I2X	135.40 bc	10.67 b	3693.18
P 96R10 IPRO	153.59 a	16.57 ab	4044.40
DM 60IX64 RSF I2X	125.33 c	0.62 c	3975.25
M 6100 XTD	144.23 ab	20.19 a	3538.63
M 6110 I2X	143.11 ab	17.57 a	4000.96
		Overall average	
	140.32	13.13	3850.48
		F value	
	13,713 *	26,852 *	0.785ns –
DMS	12.90	6.79	1131.71
CV (%)	4.08	22.96	13.04

Source: the author, 2023.

Note: ns: not significant at the 5% probability level using the F test; *: significant at the 5% probability level using the F test.

In relation to the NGV parameter, the M 6100 XTD genotype stood out in relation to the P 96R10 IPRO genotype; however, it was statistically equal to the other genotypes (Table 3). Furthermore, for the same parameter, the genotype P 96R10 IPRO presented a lower average (2.32 grains per pod) in relation to the other genotypes (Table 3). However, it presented a higher average MMG (153.59 g) than AS 3615 I2X and DM 60IX64 RSF I2X (Table 4). Therefore, it is observed that despite lower values for NGV, the P 96R10 IPRO compensated for its productivity in the MMG component. According to Deretti et al. (2022), with the reduction in the number of pods per soybean plant, there is a tendency for the size and, consequently, the mass of the grains to increase. According to Tourino (2002), in cases of high population density, there is an increase in MMG as the number of pods decreases, resulting in a decrease in physiological drains and an increase in the concentration of photoassimilates in a smaller number of grains.

According to Silva et al. (2020), the cultivar with the largest grain mass does not always have the highest productivity, as other productive characteristics interfere in this relationship, such as the number of pods per plant, number of grains per pod and number of grains per plant.

According to Carvalho (2023), the increase in NGV indicates a greater production potential; however, the individual grain mass can vary according to factors such as the size, weight and development of the grains. Grain growth depends on environmental factors, such as the availability of water, nutrients and sunlight, as well as the genetic characteristics of the plant. In some situations, a greater number of grains per plant can result in smaller, lighter grains, leading to a smaller 1000-grain mass.

For variable IV, the genotypes M 6100 XTD and M 6110 I2X did not differ significantly from each other but stood out in relation to AS 3615 I2X and DM 60IX64 RSF I2X. Furthermore, AS 3615 I2X stood out compared to DM 60IX64 RSF I2X (Table 4). Similar results were found in work by Zanon et al. (2015), where the reduction in the leaf index (LAImax) of the TEC5936 IPRO and Bragg genotypes can be explained by the greater sensitivity to photoperiod. Furthermore, in work by Yokoyama et al. (2018), the variations in IAF observed in the first harvest were also not reflected in productivity.

The DM 60IX64 RSF I2X genotype presented a lower IV (0.62%) compared to the others (Table 4), a result that can be explained by the difference in GMR in relation to the others, as its GMR is 6.0, while the others are GMR 6.1.

According to Kunz et al. (2014), the reduction in photoperiod results in a reduction in the period between seedling emergence and crop flowering, resulting in a shortening of the crop cycle. Vegetative shortening means that the reproductive period does not coincide with the recommended period, and the reproductive phase occurs in periods of lower availability of solar radiation (Sediyama, 1972), which results in lower production of photoassimilates and consequently lower accumulation of reserves in grains, affecting productivity components such as MMG (Santos, 2020). For photoassimilates to be stored in reserve organs (grains), they must be transported through the phloem. Phloem movement occurs due to the difference in photoassimilates between the source cells (leaf area) and the sink cells (grains) (Floss, 2011).

The variables AP, NR, NVP and PROD did not show a significant difference ($p>0.05$) between the genotypes (M 6100 XTD, AS 3615 I2X, P 96R10 IPRO, DM 60IX64 RSF I2X and M 6110 I2X). AP is directly related to GMR, with cultivars with a shorter cycle tending to have a shorter vegetative period, thus presenting the lowest height values (Tonini et al., 2023). NR influences the effect of seed vigor on plant development, as high vigor seeds produce plants with a greater number of racemes, consequently providing greater NVP (Kolchinski et al., 2005).

Production (PROD) is influenced by more than 50 factors and processes, such as the adoption of technologies, the selection of cultivars recommended for the region, sowing timing, soil fertility, seed quality, correct implementation of culture, fertilization and soil correction, water availability and other practices. Furthermore, there are factors that contribute to maintaining the PROD level, such as the effective control of diseases, pests and unwanted plants in crops. However, PROD is closely related to quantitative characteristics, such as yield, cycle length, plant height, number of pods, and quantity of grains per pod, which can be influenced by the management practices mentioned above.

In research by Tonini et al. (2023), carried out in Cafelândia-PR, the genotype M 6100 XTD presented the highest average of the 94 genotypes evaluated (7462.9 kg ha^{-1}). The genotypes M 6110 I2X, AS 3615 I2X, P 96R10 IPRO and DM 60IX64 RSF I2X were also present in the research and presented 7437.9, 6879.2, 6695.4 and 6588.5 kg ha -1, respectively. The genotypes M 6100 XTD, M 6110 I2X and AS 3615 I2X did not differ significantly and stood out from the others, which also did not differ statistically.

CONCLUSIONS

During the experiment, meteorological conditions were suitable for crop development.

Despite lower values for NGV, the P96R10 IPRO genotype compensated for its productivity in the MMG component.

The MMG production component did not interfere with PROD.

The AS 3615 I2X genotype showed greater sensitivity to photoperiod, as it suffered a relapse of IV compared to genotypes with the same GMR. This behavior proves the need for a correct recommendation of genotypes for a region.

At the time of evaluation, there was a difference between the developmental stage of DM 60IX64 RSF I2X in relation to the stage of the other genotypes due to its GMR being lower.

The variables that showed a significant difference between the genotypes did not interfere in the final PROD of the genotypes in the experiment.

The five genotypes in the experiment have high productive capacity; however, they have different technologies, which have resistance and tolerance to different pests and diseases and act with different mechanisms. As there was no lack of control in chemical management, significant attacks by pests and diseases, or even adverse weather conditions, all genotypes were able to develop high productivity, without differing due to this variable.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to all the people who made the completion of this Course Completion Work possible.

First, I want to thank God, the source of all wisdom and strength, for giving me the ability to learn, grow and overcome obstacles throughout this academic journey. His grace and mercy were evident at all times, and His wisdom guided me when I needed it most.

To my father, for his wise words and valuable advice, which guided me when I was lost. Your practical and financial help allowed me to dedicate myself to my study and research, making it possible to complete our TCC.

To my mother, for her unconditional love, unwavering support and constant encouragement. Your unwavering belief in my ability to achieve my goals was the driving force behind my academic success. Furthermore, his practical support, whether in the meals he prepared for me or in the moments he accompanied me in the field, demonstrated the trust and pride he feels in me.

To my sister, Bianca, for believing in me and my potential. Your practical help in reviewing the text was crucial for me to be able to complete this TCC with confidence and determination.

To my boyfriend, Matheus de Bortoli, who was a constant presence of love, support and encouragement. From the beginning of this course until its completion, you were by my side, always ready to teach and help me. Your practical help was fundamental to the success of this TCC.

To my grandparents, uncles and cousins. You have always been my safe haven, my advisors and my biggest supporters. This achievement would not have been possible without you by my side.

To my advisor, Martios Ecco, for his exceptional guidance, in-depth knowledge and unwavering commitment to the quality of this work. Your suggestions and insights were invaluable in the development of this project.

To my course mates, especially Camila, Diandra and Mariana, who shared with me the joys and challenges of academic life. Their discussions and exchanges of ideas enriched my knowledge and motivated me to seek excellence in my studies.

To my friends who have supported me emotionally throughout this journey, thank you for always being there in moments of doubt and celebration.

To the collaborators of this research, who dedicated their time and shared their experiences, thus contributing to the completion of this work.

Finally, I dedicate this TCC to everyone who believed in me and in the potential of this project. This work is the result of a collective effort and represents not only my dedication but also the trust that many have placed in me.

Thank you all!

REFERENCES

ALMEIDA, LA; KHIL, RA; Souza; MIRANDA, MAC; CAMPELO, GJA. Melhoramento da soja para regiões de baixas latitudes. In: QUEIROZ, MA.; GOEDERT, CO.; RAMOS, SRR. (Eds.). Recursos genéticos e melhoramento de plantas para o Nordeste brasileiro. Brasília: **Embrapa Recursos Genéticos e Biotecnologia,** Capítulo 5, p. 73-88, 1999.

ALLIPRANDINI, LF; ABATTI, C; BERTAGNOLLI, PF; CAVASSIM, JE; GABE; HL; KUREK, A; MATSUMOTO, MN; OLIVEIRA, MAR; PRADO, LC; STECKLING, C. Understanding soybean maturity groups in Brazil: environment, cultivar classification, and stability. **Crop Sci**. 49, 801-808. 2009.

ANDRADE, AP; REIS, TC; NEVES, AF; SANTOS, TS. Efeitos de fitotoxidade na soja RR tratada com formulações e dosagens de glifosato. Revista de Biologia e Ciência da Terra, v.1, n.1, p.34-43, 2010.

BARROS, HB; SEDIYAMA, T; CRUZ, CD; TEXEIRA, RC; REIS, MS. Análise de adaptabilidade e estabilidade em soja (*Glycine max* L.) em Mato Grosso. **Ambiência**, v. 6, n. 1, p. 75-88, 2010.

BORÉM, Aluízio; MIRANDA, Glauco Vieira. Melhoramento de Plantas. Viçosa: Editora UFV, 2005. 525p.

BRASIL. Ministério da Agricultura Pecuária e Abastecimento. Regras Para Análise de Sementes. Brasília, 2009, 399 p.

CARVALHO, RCS. Coinoculação com microrganismos promotores de crescimento de plantas no desenvolvimento e produtividade da soja. **Universidade Estadual Paulista (Unesp)**, 2023. Disponível em: <http://hdl.handle.net/11449/244322>. Acesso em: 25 set. 2023.

CAVIGLIONE, JH; KIIHL, LRB; CARAMORI, PH; OLIVEIRA, D; GALDINO, J; BORROZINO, E; GIACOMINI, CC; SONOMURA, MGY; PUGSLEY, L. **Cartas climáticas do Paraná.** Londrina: IAPAR, 2000.

CEPEA. **Gasto médio com fertilizantes para produção de grãos dobra em um ano**. Disponível em: <https://www.cepea.esalq.usp.br/br/opiniao-cepea/gasto-medio-com-fertilizantes-para-producao-de-graos-dobra-em-um-ano.aspx>. Acesso em: 09 set. 2022.

COLOMBARI FILHO, JM; RESENDE, MDV; MORAIS, OP; CASTRO, AP; GUIMARÃES, EP; PEREIRA, JA; UTUMI, MM; BRESEGHELLO, F. Upland rice breeding in Brazil: a simultaneous genotypic evaluation of stability, adaptability and grain yield. **Euphytica,** v. 192, n. 1, p. 117-129, 2013.

DERETTI, AFH; SANGOI, L.; MARTINS JÚNIOR, MC; GULARTE, PS; CASTAGNETI, V; LEOLATO, LS; KUNESKI, HF; SCHERER, RL; BERKIENBROCK, J; DUARTE, L; NUNES, M S. Resposta de cultivares de soja à redução na densidade de plantas no planalto norte catarinense. **Revista de Ciências Agroveterinárias**. Lages, SC. 2022.

DOS SANTOS, MS. Fotoperíodo e sua relação com a soja. **Mais Soja**, 2020. Disponível em: <https://maissoja.com.br/fotoperiodo-e-sua-relacao-com-a-soja/>. Acesso em: 15 dez. 2022.

FARIAS, JRB.; NEPOMUCENO, AL; NEUMAIER, N. Ecofisiologia da Soja. **Circular Técnica**. Londrina: Parará, 2007.

FERREIRA, DF. Sisvar: um sistema computacional de análise estatística. **Ciênc. agrotec**., Lavras/MG, v. 35, n. 6, p. 1039-1042, nov./dez., 2011.

FLOSS, EL. **Fisiologia das plantas cultivadas:** o estudo do que está por tras do que se vê. 5 ed. Passo Fundo: Ed. Universidade de Passo Fundo, P. 103-104, 2011.

FLOSS, EL. **Maximizando o rendimento da soja: "Ecofisiologia, nutrição e manejo"**. 3 ed. Passo Fundo: Aldeia Sul, Passografic, 2022.

FUNDAÇÃO MERIDIONAL. Indicação de cultivares por região edafoclimática. Disponível em: <http://www.fundacaomeridional.com.br/soja/regioes-edafoclimaticas>. Acesso em: 30 set. 2023.

GOVERNO FEDERAL. **Zoneamento Agrícola**. Disponível em: <https://www.gov.br/agricultura/pt-br/assuntos/riscos-seguro/programa-nacional-de-zoneamento-agricola-de-risco-climatico/zoneamento-agricola>. Acesso em: 06 jun. 2022.

HAMAWAKI, OT; SAGATA, E; HAMAWAKI, RL; MARQUES, MC; HAMAWAKI, CDL; CORREIA, WR. Desempenho de linhagens de soja de ciclo semiprecoce/médio e semitardio/tardio nas regiões do Triângulo Mineiro e Sul de Goiás. **Bioscience Journal**, v. 21, n. 3, p. 7-17, 2005.

INTACTA RR2 PRO. INTACTA RR2 PRO, 2023. INTACTA RR2 PRO. Disponível em: <https://www.intactarr2pro.com.br/intacta-rr2-pro>. Acesso em: 14 set. 2023.

KASTER, M; FARIAS, JRB. Regionalização dos testes de Valor de Cultivo e Uso e da indicação de cultivares de soja – Terceira Aproximação. Londrina: **Embrapa Soja**, 2011.

KOLCHINSKI, EM; SCHUCH, LOB; PESKE, ST. Vigor de sementes e competição intraespecífica em soja. **Ciência Rural**, Santa Maria, v.35, n.6, p.1248-1256. 2005.

KUNZ. J; CARLESSO, R; PETRY, M; CATTO, JC; AITA, R.; ANTONELLO, M. Cossetin. Simulação do Efeito da Temperatura e do Fotoperíodo na Fenologia da Cultura da Soja. **II Inovagri International Meeting.** Fortaleza. 2014.

LANA, MC; FRANDOLOSO, JF; FEY, R; RICHART, A; FONTANIVA, S. **Análise química de solo e de tecido vegetal:** metodologias analíticas. 2.ed. Cascavel: Edunioeste, 2016. 155p.

LUIZ, MCP. Efeito da época de semeadura e população de plantas sobre o potencial produtivo e caracteres agronômicos em soja. **Universidade Federal de Uberlândia**, Uberlândia/MG, 2018

MENEZES, BMB; FRANCO, C; MELO, SBX; ANDRADE, MGF. Os efeitos da pandemia de covid-19 nos custos de produção de soja transgênica nos municípios brasileiros. **SciELO Preprints**, 2023. Disponível em: https://preprints.scielo.org/index.php/scielo/preprint/view/6470. Acesso em: 13 set. 2023.

MEOTTI, GV; BENIN, G; SILVA, RR; BECHE, E; MUNARO, LB. Épocas de semeadura e desempenho agronômico de cultivares de soja. **Pesquisa Agropecuária Brasileira**, v. 47, p. 14-21, 2012.

MONTEIRO, JEBA; MONTEIRO, JEBA; VICTORIA, DC; FARIAS, JRB; BARROS, AHC; LIMA, EP; ARAUJO FILHO, JC; SILVA, FAM; EVANGELISTA, BA; TEIXEIRA, WG. Classes de água disponível do solo para uso no Zoneamento Agrícola de Risco Climático. Campinas: **Embrapa**, 2022. 6 p. (Comunicado técnico, 135).

MONDINE, ML; VIEIRA, CP; CAMBRAIA, LA. Época de semeadura: um importante fator que afeta a produtividade da cultura da soja. Dourados: Embrapa Agropecuária Oeste, 2001.

OLIVEIRA, JVD. Contabilidade e gestão de custos na agroindústria e produção de soja no brasil: uma revisão da literatura. Orientador: Prof. Dr. Sérgio Lemos Duarte. 2023. 47 f. Trabalho de Conclusão de Curso (Gradução) - Ciências Contábeis, Universidade Federal de Uberlândia, Uberlândia, 2023. Disponível em: < https://repositorio.ufu.br/handle/123456789/36885>. Acesso em: 13, set 2023.

PENARIOL, A. **Soja: cultivares no lugar certo**. Informações agronômicas n° 90, 2000. Disponível em: <http://www.ipni.net/PUBLICATION/IA-BRASIL.NSF/0/3D7AD150106A80E683257AA30069BE0F/$FILE/pages13-14-90.pdf>. Acesso: 28 abr. 2022.

PLATAFORMA INTACTA2 XTEND. PLATAFORMA INTACTA2 XTEND. Sobre a plataforma. Disponivel em: <https://plataformaintacta2xtend.com.br/sobreaplataforma>. Acesso em: 14 set. 2023.

RICHETTI, A. Viabilidade econômica da cultura da soja para a safra 2021/2022, em Mato Grosso do Sul. **Comunicado Técnico**. Embrapa. Dourados, MS. 2021.

ROCHA, RS; SILVA, JAL; NEVES, JA; SEDIYAMA, T; TEIXEIRA, RC. Desempenho agronômico de variedades e linhagens de soja em condições de baixa latitude em Teresina-PI. **Revista Ciência Agronômica**, Fortaleza, v. 43, n. 1, p. 154-162, 2012.

SEDIYAMA, CS. Influência do retardamento da colheita sobre a deiscência das vagens e sobre a qualidade e poder germinativo das sementes de soja. **Experientiae**, Viçosa, v. 14, p. 117-141. 1972.

SILVA, SM; AGUILA, LSH. **An importância da época de semeadura para o sucesso da cultura da soja**. XXIX Congresso de Iniciação Científica. Universidade Federal de Pelotas, 2020. Disponível em:<https://cti.ufpel.edu.br/siepe/arquivos/2020/CA_00541.pdf> Acesso em: 30 de set. 2023.

SILVA, ES; CARVALHO, MAC; DALLACORT, R. Cultivares de soja em função de elementos climáticos nos municípios de Tangará da Serra e Diamantino, MT. **Nativa**, Sinop, v. 8, n. 2, p. 157-164, mar./abr. 2020.

TONINI, V.; MADALOSSO, T; ROY, JMT; SOMAVILLA, J; CARVALHO, AG; PEREIRA, HV. Avaliação de desempenho agronômico de diferentes cultivares de soja safra 2022/2023 segunda época. **Relatório de Pesquisa Agrícola N°: 67/2023**. CPA Copacol. Cafelândia. 2023.

TOURINO, MCC; REZENDE, PM ; SALVADOR, N. Espaçamento, densidade e uniformidade de semeadura na produtividade e características agronômicas da soja. **Pesquisa Agropecuária Brasileira**, Brasília, v.37, n.8, p.1071-1077, 2002.

VASCONCELOS, ES, REIS, MS, SEDIYAMA, T; CRUZ, CD. Produtividade de grãos, adaptabilidade e estabilidade de genótipos de soja de ciclos precoce e médio. **Semina**: Ciências Agrárias, p. 1203-1214. 2015

YOKOYAMA, AH; RIBEIRO, RH; BALBINOT JUNIOR, AA; FRANCHINI, JC; DEBIASI, H; ZUCARELI, C. Índices de área foliar e SPAD da soja em função de culturas de entressafra e nitrogênio e sua relação com a produtividade. **Revista de Ciências Agrárias**, Londrina, 2018.

ZANON, AJ; WINCK, JEM; STRECK, NA; ROCHA, TSM; CERA, JC; RICHTER, GL; LAGO, I; SANTOS, PM; MACIEL, LR; GUEDES, JVC; MARCHESAN, E. Desenvolvimento de cultivares de soja em função do grupo de maturação e tipo de crescimento em terras altas e terras baixas. **Bragantia,** v.74, n.4, Campinas,2015.