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Research Article

Agronomic performance of soybean and its relation with the production environment

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Abstract

The objective of the work is to identify the agronomic performance of soybeans and correlate meteorological attributes with yield components. The study was carried out at the Escola Fazenda of the Regional University of the Northwest of the State of Rio Grande do Sul - UNIJUÍ, located in Augusto Pestana – RS. The experimental design used was randomized blocks, consisting of 10 genotypes and five replications. Descriptive analysis was performed using mean plus standard deviation for variables that presented a coefficient of variation greater than 35%; normality and homogeneity tests were also performed, as well as analysis of variance, Tukey mean comparison tests and linear correlations supported by the t-test. Soybean grain yield is closely linked to meteorological elements, which play a crucial role in the fluctuations and frustrations of soybean agricultural harvests in the municipalities of Rio Grande do Sul. The significant correlations between yield indicate that the water factor is what more affects production. The TMG7362IPRO cultivar had a higher yield with 73 bags per ha^{-1}. -Iin this context, the soybean GMR also influenced yield in relation to climatic relations and had a better positioning.

Keywords: *Glycine max*; selection; positioning; cycle; nutritional characteristics, food industry; biodiesel.

Introduction

Soybean (*Glycine max* L.), belongs to the Fabaceae family, is an erect, herbaceous annual plant with autogamous reproduction, which demonstrates a certain variability in some morphological characteristics influenced by the environment, such as the development cycle, with a variation of 75 to 200 days (Tejo, Fernandes, & Buratto, 2019). The appropriate temperature for its growth and development is between 20ºC and 30ºC, with 25ºC being the ideal temperature for rapid and uniform emergence and 30ºC being the ideal maximum limit (Norman, 1978).

The crop stands out as the main one in Brazilian agribusiness, which leads the ranking of its world production with 149.4 million tons, yield of 3.31 tons/ha and a planted area of 45.09 million hectares. The Rio Grande do Sul is the fourth largest producer in Brazil, as described by Coêlho (2024), based on production forecasts for the 2023/2024 harvest, developed by CONAB.

Due to its nutritional characteristics, it is widely used in the food industry due to its excellent fatty acid profile, composed of approximately 85% polyunsaturated fatty acids, with emphasis on linoleic acid and α-linolenic acid. Soy is composed of approximately 20% oil, 35% carbohydrates, 5% ash and 40% proteins, in addition to substances with structural, hormonal, attractive and chemopreventive functions, such as fibers, carotenoids and flavonoids (Callou, 2015). It can also be used as a raw material for the manufacture of soy milk, soy meat, tofu, sweets, soy oil, flour, animal feed and other products. Furthermore, it is used in chemical processes in the production of cosmetics, soap and biodiesel (Alvim & Fochezatto, 2020).

Over the years, technological advances have brought different characteristics to soybean cultivars. In addition to this, technological packages were inserted, such as the Roundup Ready cultivars, which carry the RR prefix, the IPRO event, configuring caterpillar control, the biotechnologies Enlist (E), Conkesta E3® and Intacta Xtend I2x, allowing use of other herbicides in post-emergence. We can say that soybean growth and yield are the result of the interaction between the cultivar used and environmental factors. Therefore, it is important to adjust the environment and cultural practices for high yield, when there are genotypes with high yield potential and adapted to the growing region, seeking to minimize the effects of environmental conditions that may affect yield (Silva *et al*., 2021).

It is essential to use cultural techniques to maximize the accumulation of biomass in plant tissues and, mainly, in the product to be harvested, the grain. The main cultural practices that can be adopted to increase soybean yield include: use of genotypes adapted to the region, choice of sowing time, management of plant populations, plant nutrition and soil fertility, control of diseases, pests and weeds, and reduced harvest losses (Vian, Bredemeier, Pires, Corassa, & Vanin, 2022). Therefore, the objective of the work is to identify the agronomic performance of soybeans and correlate meteorological attributes with yield components.

Materials and Methods

The study was carried out at the Escola Fazenda of the Regional University of the Northwest of the State of Rio Grande do Sul - UNIJUÍ, located in Augusto Pestana – RS, Brazil, under the geographic coordinates: 28°53'10" South and 52°59'55" West, and approximate altitude of 400 meters. In which the climate is type Cfa according to the Köppen climate classification (Dubreuil *et al*., 2018). The soil in the experimental area is classified as a typical dystroferric Oxisol, according to SiBCS (Brazilian Soil Classification System), with a deep profile, well drained, dark red color, with high clay content and a predominance of 1:1 and iron and aluminum oxyhydroxides.

The experimental design used was randomized blocks, consisting of 10 genotypes and five replications. The experimental unit consists of seven lines 15 m long, spaced 0.5 m apart. In this study, the qualitative characteristics of 10 commercial genotypes were evaluated, which are described in table 1.

Table 1. Qualitative description of the morphology of the genotypes.

GENOTYPES	FLOWER COLOR	HILO COLOR	PUBESCENCE COLOR	VEGETABLE COLOR	SEED SHAPE
95R70CE	Purple	Imperfect Black	Gray	Light Gray	Spherical
95R21E	Purple	Imperfect Black	Gray	Dark Gray	Elongated
95Y95IPRO	White	Light Brown	Gray	Dark Gray	Spherical
95R40IPRO	Purple	Black	Light Brown	Light Brown	Spherical
TMG1155RR	Purple	Gray	Gray	Light Gray	Spherical
TMG7362IPRO	White	Light Brown	Gray	Dark Gray	Spherical
TMG22X572101IPRO	NI[1]	NI	NI	NI	NI
19LB003529	NI	NI	NI	NI	NI
FPS1867IPRO	Purple	Imperfect Black	Gray	Dark Gray	Flattened Spherical
FPS2565IPRO	White	Light Brown	Gray	Light Brown	Spherical

[1]NI – not informed.
Source: Ministério da Agricultura de Pecuária [MAPA] (2024).

Sowing took place with a seeder-fertilizer and a population of 14 seeds per meter on November 8, 2023, and consequently the harvest on March 25, 2024. Prior to sowing and beginning of management, a soil analysis was carried out physical (Table 2) and chemical (Table 3), for diagnosing soil fertility.

According to physical analysis, the soil in the area is type 3, clay textural class, with a sand, silt and clay content of 22%, 19% and 59%, respectively. In the chemical analysis, it is observed that the soil pH is 5.2, however the ideal for soybean cultivation is between 5.5 and 6.0. With slightly acidic soil, it promotes an increase in aluminum content, which despite being at low levels (in this case with 0.1 cmolc/dm3), can still interfere with root growth, preventing it from seeking nutrients and water in depth, and causing a reduction in yield. As for macronutrients, both phosphorus and potassium are very high. Calcium and magnesium are high in the soil, as well as the micronutrients copper, zinc and manganese. Applications of herbicides, fungicides and insecticides were carried out at the different stages of soybean development, as shown in table 4.

Table 2. Physical analysis of the soil.

SAMPLE	Clay	Sand	Silt	Soil type	Textural class
	%				
	59	19	22	3	CLAY
Determinação da Água Disponível - AD[2]					
Predicted AD	AD Class	AD values greater than or equal to 0.80 and less than 1.06 millimeters of water per centimeter of soil			
1,05 mm. cm^{-1}	AD4				

Source: UNIJUÍ soil laboratory.

Table 3. Soil chemical analysis.

Index analyzed	Result obtained in the analysis	Interpretation of the result
Clay (%)	54	Class 3
pH	5.2	*
Index SMP	5.8	*
Organic Matter (%)	3.3	Medium
Aluminum	0.1	*
Calcium ($cmol_c/dm^3$)	5.3	High
Magnesium ($cmolc/dm^3$)	2.9	High
H + Al ($cmolc/dm^3$)	5.5	*
$CTC_{pH7,0}$	14.5	High
CTCeffective ($cmolc/dm^3$)	9.2	*
Sat CTC_{pH7} by bases (%)	62.3	*
Sat $CTC_{effective}$ by aluminum (%)	1.2	*
Copper (mg/dm^3)	12.0	High
Zinc (mg/dm^3)	4.6	High
Manganese (mg/dm^3)	35.1	High
Sulfur (mg/dm^3)	16.1	*
Sodium (mg/dm^3)	NB	*
	Result by crop: Soybean	
Phosphorus (mg/dm^3)	39.5	Very high
Potassium (mg/dm^3)	328	Very high

* No interpretation.
Source: UNIJUÍ soil laboratory.

To estimate the yield of these genotypes, 10 plants per block of each genotype at the stage of physiological maturity were randomly collected in the plots, totaling 50 plants evaluated. In all evaluations carried out, the plants were collected within the five internal lines (discarding the two external lines) randomly in the experimental units of each of the genotype blocks.

The variables analyzed in the reproductive period were: height of the productive zone (HPZ, cm); insertion height of the first vegetable (IHFV, cm); number of total nodes on the main stem (NTN_MS, No.); number of total nodes in the branches (NTN_B, No.); number of vegetables on the main stem (NV MS, No.); number of vegetables on the branches (NVB, No.); number of branches (NB, No.); branch length (BL, cm); root length (ROOT_L, cm); number of vegetables with one grain (NV1, No.); number of vegetables with two grains (NV2, No.); number of vegetables with three grains (NV3, No.); number of vegetables with four grains (NV4, No.); number of abortive vegetables (NV0, No.); percentage of disease incidence (PDI, %); percentage incidence of pest insects (PIPI, %); and percentage of incidence of invasive plants (PIIP, %).

In the post-harvest period, the following variables were analyzed: vegetable weight with one grain (VW1G, g); vegetable weight with two grains (VW2G, g); vegetable weight with three grains (VW3G, g); vegetable weight with four grains (VW4G, g); grain weight per plant (GWP, g); total grain yield (GY, kg ha^{-1}). Regarding meteorological attributes, they were obtained through the NASA Power platform (NASA POWER, 2022), these being: mean air temperature (Tmean, °C), minimum air temperature (Tmin, °C), maximum air temperature (Tmax, °C), precipitation (Prec, mm), relative air humidity (RH , %), growing degree days (GDD, C° day), number of hours of light (NLIGHT, hours), dew point (DP), radiation long wave (RAD_L, Mj m2 day-1), radiation short wave (RAD_S, Mj m2 day-1). Furthermore, the variables evapotranspiration (ETP, mm), wind speed (WV, m/s) were obtained using the Agricultural Decision Support System (SISDAGRO) database of the National Institute of Meteorology – INMET (Sistema de Suporte à Decisão na Agropecuária [SISDAGRO], 2022).

Table 4. Application of herbicides, insecticides and fungicides on the evaluated genotypes.

TIME OF APPLICATION	HERBICIDES	INSECTICIDES	FUNIGICIDES	MINERAL OIL	pH REDUCER
PRE-SEEDING 30 days before	Glyphosate (2L ha^{-1}) + 2,4D (1.5 L ha^{-1}) + Clethodim (0.6 L ha^{-1})	-	-	0.5L ha^{-1}	50 ml ha^{-1}
POST-SEEDING 2 days after	Diquat (2.5 L ha^{-1})	-	-	0.25L ha^{-1}	50 ml ha^{-1}
V4	-	Acetamiprid + Bifenthrin (200 g ha^{-1}); Diflubenzuron (60 g ha^{-1})	Difeconazole (250 ml ha^{-1})	0.25L ha^{-1}	50 ml ha^{-1}
R1	-	Thiamethoxam + Lambda-cyhalothrin (250 ml ha^{-1})	Benzovindiflupir + Ciproconazole + Difenoconazole (0.5 L ha^{-1})	0.25L ha^{-1}	50 ml ha^{-1}
R3	-	Acetamiprid + Bifenthrin (200 g ha^{-1})	Benzovindiflupir + Prothioconazole (0.5 L ha^{-1})	0.25L ha^{-1}	50 ml ha^{-1}
R5	-	Acetamiprid + Bifenthrin (200 g ha^{-1})	Azoxystrobin + Mancozeb + Prothioconazole (2.0 kg ha^{-1})	0.25L ha^{-1}	50 ml ha^{-1}

Regarding statistical methodology, discrepant values were removed, descriptive analysis was carried out using the mean plus standard deviation for variables that had a coefficient of variation greater than 35%, normality and homogeneity tests were also carried out, as well as analysis of variance, Tukey mean comparison tests and linear correlations supported by the t test. The analyzes were carried out using the R software (R Core Team, 2023).

Results and Discussion

In Figure 1, it is observed that from the moment of germination to the vegetative stage, temperatures were around 24ºC, in addition, in the reproductive stage scenario the averages were between 23ºC and 25ºC. Therefore, the mean temperature for soybean cultivation proved to be adequate, not presenting very high temperatures that could restrict plant transpiration and the quality of photosynthesis. According to Neumaier et al. (2020), soy adapts best in regions where temperatures vary between 20°C and 30°C, with the upper mean temperature being 35ºC, the medium mean temperature being 25ºC and lower mean temperature being 10ºC.

This result shows even more evidence of the quality of temperature on the development of the cycle when we analyze the maximum temperatures, which in the vegetative cultivation period were around 29ºC and in the reproductive stage remained similar, close to 31ºC. Although they were averages of the maximum temperature, the values were within temperature conditions that could be coherent with the plant's water osmotic balance capacity, being a favorable aspect with necessary conditions for adequate growth, development and grain filling.

Another important aspect is when it is analyzed the minimum temperatures that in the vegetative period temperatures were found to be around 18ºC, while in the reproductive stage they were around 19ºC. These conditions show significant minimum air temperature values compared to ideal temperatures, being favorable for the growth and development of the crop.

However, it is important to highlight that temperature alone is not the only determining factor in soybean yield. The availability of water in the production system is also crucial to facilitate the biological processes of growth and development. In this sense, in Figure 1, when evaluating the precipitation conditions, it is clear that throughout the cycle a volume of rain of 342mm was directed, this value being below the total water requirement that soybeans need to obtain maximum yield.

It is noteworthy that the greatest volume of precipitation occurred in the seedling emergence and vegetative phase, resulting in a range between 6 and 19mm/day in all growth stages over the months. It should be noted that, more important than the total volume of precipitation, is the frequency of precipitation throughout the cycle, as adequate regularity of precipitation is essential for the maintenance of biological processes.

According to Neumaier et al. (2020), the demand for water in soybean crops increases as the plant develops, reaching its peak during the flowering and grain filling phase (7 to 8 mm/day), decreasing after this stage. In general, the highest water consumption coincides with the period in which the plant reaches the greatest height and leaf area index. The total water requirement to obtain maximum yield in soybean crops varies between 450 and 800 mm per cycle, depending on climatic conditions, management and cycle length.

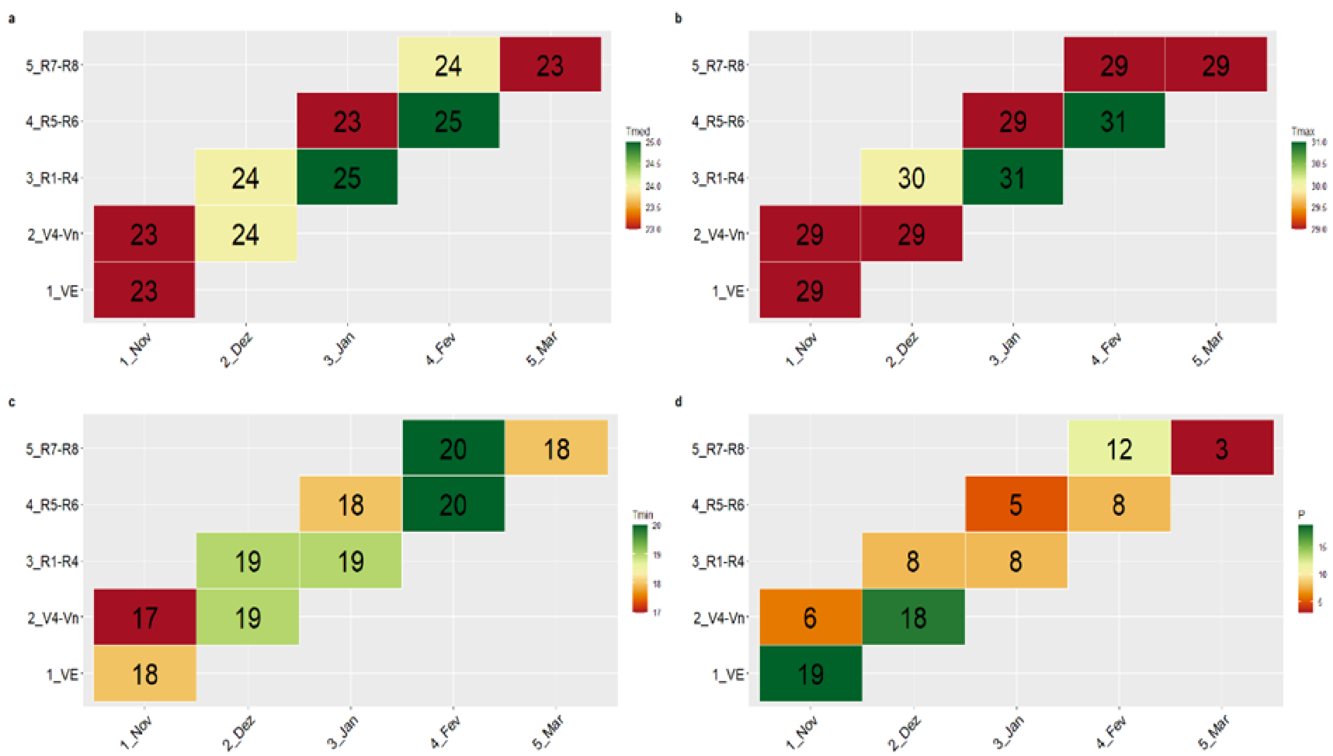

Figure 1. Mean air temperature measured in degrees of minimum (c), mean (a) and maximum (b) and daily precipitation (d) in the phenological stages of the soybean crop from November 2023 to March 2024.

In the summary of the analysis of variance in table 5, of the variables analyzed in the 10 genotypes under field conditions, only the variable number of vegetables with 3 grains (NV3) (not shown) was not significant. It is important to highlight that the coefficient of variation values were reduced, ranging between 7.12% and 25.59%, being considered low (less than 10%) and medium (between 10 and 20%) according to Pimentel-Gomes (2022), indicating good precision and experimental quality, and confers reliability on the results to be analyzed and interpreted. In this sense, statistical differences reinforce the need for a mean comparison test to analyze the average performance of genotypes in different traits.

Table 5. Summary of the analysis of variance of the expression of agronomic indicators in soybean genotypes.

SV[1]	DF	Mean Square				
		VW2G (g)	**VW3G (g)**	**GWP (g)**	**GY (g)**	**IHFV (cm)**
Treatment	9	18815*	29586*	57.47*	1854606*	102222*
Block	4	49.445	160.54	416.62	19819239	8.95
Residual	36	1.018	2.036	1.450	168353	17.839
Total	49					
CV%		16.02	14.91	7.12	12.10	19.03
SV	**DF**	**HPZ (cm)**	**NTN_MS (n)**	**NVMS (n)**	**ROOT_L (cm)**	**BL (cm)**
Treatment	9	259756*	259756*	326.14*	94778*	513.06*
Block	4	127.37	43.7	25.17	0.55	190.03
Residual	36	67.940	43.922	37.490	27.500	136.900
Total	49					
CV%		10.95	9.90	15.73	9.16	21.68

[1]SV- Source of variation; DF- Degree of freedom; CV%- Coefficient of variation; VW2G- Vegetable weight with two grains, g; VW3G- Vegetable weight with three grains, g: GWP- Grain weight per plant, g; GY- Total grain yield, g; IHFV- insertion height of the first vegetable, cm; HPZ - Height of the production zone, cm; NTN_MS- Number of total nodes of the main stem, No.; NVMS - Number of vegetables on the main stem, No.; ROOT_L - Root length, cm; and BL - Branch length, cm. The analysis of variance revealed significance at 5% probability using the F test.

In table 6 of the comparison analysis of means of expression of agronomic indicators in soybean genotypes, for the variable vegetable weight with 2 grains (VW2G), the genotypes TMG1155RR and TMG7362IPRO obtained the best means. In the analysis of vegetable weight with 3 grains (VW3G), TMG7362IPRO also showed better performance, followed by the 95Y95IPRO genotype. When the grain weight per plant (GWP) was analyzed, the TMG7362IPRO again continued to show better performance, even standing out from all the others. In the analysis of branch length (BL) and insertion height of the first vegetable (IHFV), FPS2565IPRO obtained higher performance.

Regarding the variable height of the production zone (HPZ), FPS1867IPRO presented the highest average. Regarding the variable number of total nodes on the main stem (NTN_MS), the TMG22X572101IPRO genotype stands out. In the analysis of the variable number of vegetables on the main stem (NVMS), it stands out again with the best average FPS1867IPRO followed by 95R70CE. In relation to root length (BL), the genotypes that obtained the highest value were TMG22X572101IPRO, FPS1867IPRO and FPS2565IPRO. For the grain yield (GY) variable, it is worth highlighting that of all the genotypes analyzed, TMG1155RR and TMG7362IPRO were the best performing.

According to Pearson's linear correlation analysis for meteorological factors in Figure 2, it is highlighted that there is a high correlation (r=0.60 to 0.95) between the dew point (DP) and the mean temperature (Tmean), growing degree days (GDD), radiation long wave (RAD_L) and minimum temperature (Tmin), all showing a positive correlation. Therefore, we can say that a higher dew point (DP) directs the elevation of these variables. It is also worth noting that the minimum temperature (Tmin) had a positive and high impact on the mean temperature (Tmean), growing degree days (GDD) and radiation long wave (RAD_L). Another point that draws attention is that the variable growing degree days (GDD) shows high relationships with the maximum (Tmax) and mean (Tmean) temperature.

Table 6. Comparison analysis of expression means of agronomic indicators in soybean genotypes.

Genotypes	VW2G	VW3G	GWP	BL	IHFV
95R70CE	7.0 b	7.7 bc	15.8 de	53.2 ab	18.0 cd
95R21E	5.9 bcd	7.3 bc	14.0 ef	46.4 ab	14.4 d
95Y95IPRO	3.9 d	130 a	18.4 bc	62.2 ab	26.6 abc
95R40IPRO	4.9 bcd	9.9 b	16.0 cde	64.4 ab	18.6 bcd
TMG1155RR	9.7 a	9.7 b	20.8 b	53.2 ab	23.4 abc
TMG7362IPRO	9.4 a	14.1 a	23.8 a	39.6 b	21.6 abcd
TMG22X572101IPRO	5.3 bcd	9.2 bc	15.8 de	46.6 ab	27.0 ab
19LB003529	4.7 cd	6.4 c	12.4 f	64.4 ab	20.8 abcd
FPS1867IPRO	6.4 bc	9.6 b	17.1 cd	42.2 b	22.6 abcd
FPS2565IPRO	5.3 bcd	8.3 bc	14.5 ef	67.4 a	29.0 a
Genotypes	**HPZ**	**NTN_MS**	**NVMS**	**ROOT_L**	**GY**
95R70CE	77.4 ab	23.0 abc	48.8 a	18.4 ab	3157.5 bc
95R21E	55.8 c	18.6 c	33.4 bc	15.2 b	2878.3 c
95Y95IPRO	77.2 ab	19.0 bc	41.2 ab	17.4 ab	3959.9 ab
95R40IPRO	79.2 ab	18.6 c	41.2 ab	17.6 ab	3071.0 c
TMG1155RR	78.4 ab	22.2 abc	35.2 bc	18.4 ab	4283.8 a
TMG7362IPRO	67.6 bc	18.8 c	31.2 bc	17.8 ab	4424.2 a
TMG22X572101IPRO	82.4 ab	24.6 a	43.6 ab	18.8 a	3073.8 c
19LB003529	72.6 abc	23.4 ab	42.2 ab	17.8 ab	2743.0 c
FPS1867IPRO	88.2 a	22.6 abc	49.0 a	19.0 a	3380.2 bc
FPS2565IPRO	74.0 ab	21.0 abc	23.4 c	20.6 a	2933.1 c

VW2G- Vegetable weight with two grains, g; VWG3- Vegetable weight with three grains, g; GWP- Grain weight per plant, g; BL- Branch length, cm; IHFV- insertion height of the first vegetable, cm; HPZ - Height of the production zone, cm; NTN_MS- Number of total nodes of the main stem, No.; NVMS- Number of vegetables on the main stem, No.; ROOT_L - Root length, cm; and GY- Total grain yield, kg. Means followed by the same lowercase letter in the column do not differ statistically from each other using the Tukey probability matrix at 5%.

These facts are important because growing degree days (GDD) have a direct impact on the effect of temperature, the higher the temperature accumulated during the days, the higher the growing degree days (GDD) recorded to define their sum. When analyzing the mean temperature (Tmean), a direct relationship with the maximum temperature (Tmax) is observed. A point that draws a lot of attention is the perfect correlation observed between evapotranspiration (ETP) and radiation short wave (RAD_S). According to Paranhos et al. (2014), the Pearson correlation coefficient varies from -1 to 1. The sign of the coefficient indicates the direction of the correlation (negative or positive), while the value indicates the magnitude. The closer to 1, the stronger the level of linear association between the variables. The closer to zero, the lower the association level.

According to Pearson's linear correlation analysis for morphological components and yield in Figure 3, a high correlation between the height of the production zone (HPZ) and the plant height (PH) is observed. Another correlation that draws a lot of attention is the grain weight per plant (GWP) with the variables vegetables weight with three grains (VW3G), vegetable weight with two grains (VW2G) and grain yield (GY), in this way we can say that the grain weight per plant (GWP) is reflected in the individual production of the plant, which characterizes, through the existing population in the area, greater yield per hectare. In addition, grain yield (GY) showed a high correlation with grain weight per plant (GWP), vegetable weight with two grains (VW2G) and vegetable weight with three grains (VW3G).

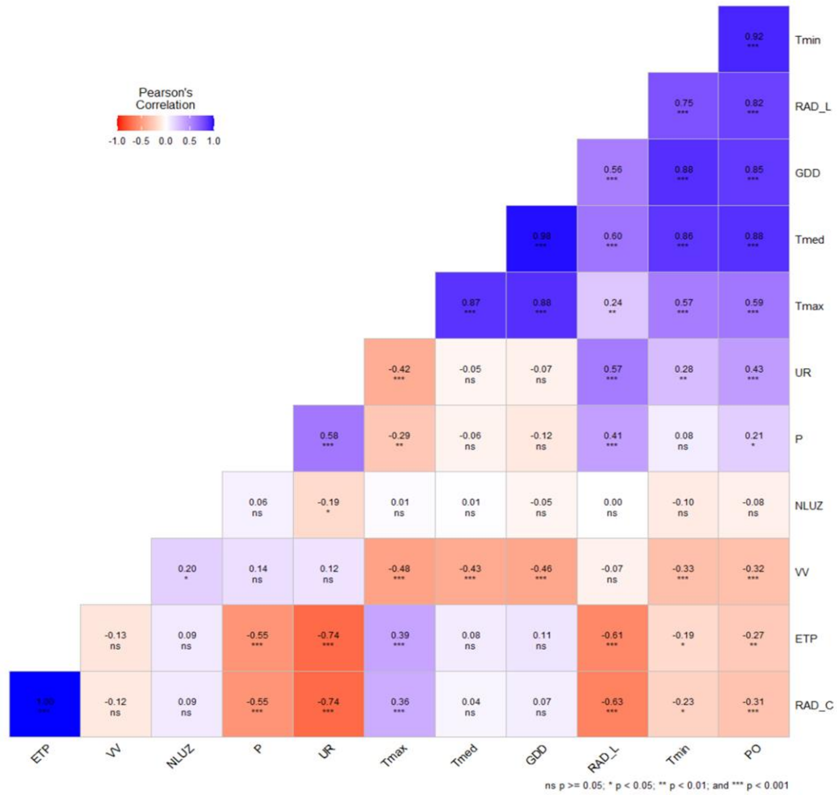

Figure 2. Pearson's linear correlation coefficients for meteorological factors. Significant Pearson's linear correlation coefficient at 5% probability by t test. ETP, mm- Evapotranspiration; WV- Wind speed, m/s; NLIGHT- Number of light hours, hours; P- precipitation, mm; RH- Relative humidity, %; Tmax- Maximum temperature, Cº; Tmean- Mean temperature, Cº; GDD- Growing degree days, Cº day; RAD_L-Radiation long wave, Mj m2 day-1; Tmin- Minimum temperature, Cº; DP- Dew point; RAD_S- Radiation short wave, Mj m2 day-1.

On the other hand, when the vegetable weight with four grains (VW4G) was evaluated, there was no effective relationship. Other agronomic traits that show high correlations are number of branches (NB) with number of total nodes on branch (NTN_B), number of vegetables on branch (NVB) with number of branches (NB) and number of total nodes on branch (NTN_B), these relationships with other characters linked to legumes are not directly linked to the effect of yield. In general, the table shows that the effects of yield are directly related to the grain weight per plant (GWP) and two and three vegetable weight per plant (VW2L; VW3L).

In order to understand the behavior of soybean genotypes, descriptive morphological analyzes were conducted. In table 7 of the descriptive statistics, it shows that the average of vegetable weight with one grain (VW1G) is 1.1 with a standard deviation of 0.6. In this scenario, it is observed that superiority was obtained only by the 19LB003529 genotype. Another variable, the vegetable weight with four grains (VW4G) with a mean of 2.3 and standard deviation of 6.3, was characterized as the highest genotype FPS1867IPRO. Within this scenario, it is also important to highlight the variable number of total nodes on the branch (NTN_B) and number of vegetables on the branch (NVB), identifying the 95R21E genotype as superior.

Furthermore, for the variable number of branches (NB), cultivars 95R70CE and 95R21E achieved the highest average. However, both for the number of vegetables with one grain (NV1) and for the number of legumes with two grains (NV2) the 95R70CE genotype showed superiority with averages of 5.5 and 24.1. For the variable number of vegetables with four grains (NV4), the genotype that was superior to the average plus one standard deviation was 19LB003529. Finally, for the variable number of abortive vegetables (NV0), 95R21E was highlighted.

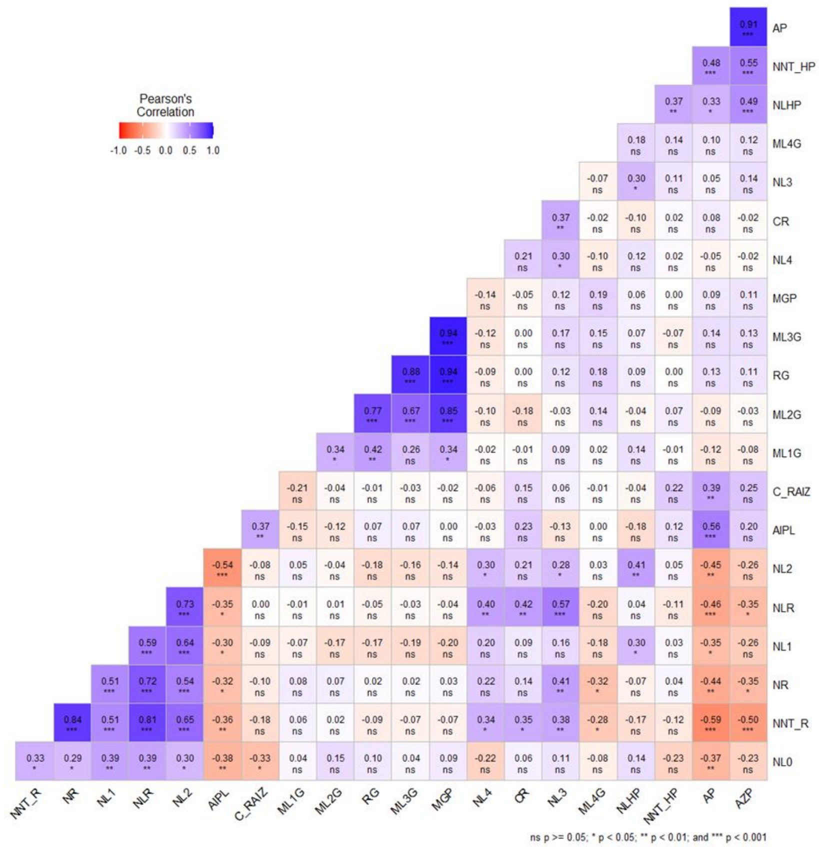

Figure 3. Pearson's correlation coefficients for morphological components and yield. Significant Pearson's linear correlation coefficient at 5% probability by t test. NTN_B- Number of total nodes in the branch, No.; NB- Number of branches, No.; NVB- Number of vegetables in the branch, No.; IHFV- Insertion height of the first vegetable, cm; ROOT_L- Root length, cm; BL- Branch length, cm; NVMS- Number of vegetables on the main stem, No.; NTN_MS- Number of total nodes of the main stem, No.; PH- Plant height, cm; HPZ- Height of the production zone, cm; NV1- Number of vegetables with one grain, No.; NV2- Number of vegetables with two grains, No.; NV3- Number of vegetables with three grains, No.; NV4- Number of vegetables with four grains, No.; VW1G- Vegetable weight with one grain, g; VW2G- Vegetable weight with two grains, g; GY- Grain yield, kg; VW3G- Vegetable weight with three grains, g; VW4G- Vegetable weight with four grains, g; GWP- Grain weight per plant, g.

In table 8 of the analysis of percentage incidence of diseases, insect pests and invasive plants, we can see that all genotypes presented an incidence of Asian rust (20%). For the percentage of macrophomina, the 95R70CE genotype had a 16% incidence of disease, while the 95R40IPRO and TMG1155RR genotypes had 8%. Regarding the percentage of anthracnose incidence, genotypes 19LB003529 and FPS1867IPRO had an 8% incidence of the disease.

Related to the incidence of insect pests, it is noted that the 95Y95IPRO genotype presented an 8% incidence of green belly stink bug and a 4% incidence of whitefly.

On the other hand, for the percentage of kitty incidence, the 95R70CE genotype showed 4% incidence. Regarding thrips, all genotypes showed incidence.

In the percentage of incidence of invasive plants, the 95R70CE genotype presented 12% incidence of morning glory, 8% of arrowleaf sida, 12% of pigweed, 4% of white-eye and 12% of horseweed. The 95R21E genotype showed an 8% incidence of pigweed and horseweed. On the other hand, genotypes 95R40IPRO and TMG22X572101IPRO had an 8% incidence of pigweed. Finally, the genotypes TMG1155RR (12%), TMG7362IPRO (8%) and FPS 2565IPRO (8%) had the incidence of horseweed.

Table 7. Descriptive statistics of agronomic variables not presented in previous tables of tested soybean genotypes.

Genotypes	VW1G (cm)	VW4G (cm)	NTN_B (n)	NVB (n)	NB (n)	NV1 (n)	NV2 (n)	NV4 (n)	NV0 (n)
95R70CE	0.9	0.1	32.0	33.2	5.0^S	11.6^S	34.8^S	0^I	7.0
95R21E	1.1	0	43.2^S	36.6^S	5.0^S	9.0	31.6^S	0.6	6.6^S
95Y95IPRO	0.5	0.9	26.0	30.0	4.4	7.6	22.4	1.2	1.0
95R40IPRO	0.9	0.2	21.0	27.8	2.4	4.2	24.6	0.4	3.8
TMG1155RR	1.1	0.2	24.2	27.0	3.6	2.8	18.0	1.4	0
TMG7362IPRO	1.4	0.2	24.8	18.2	3.6	4.4	20.6	0.4	0.8
TMG22X572101IPRO	0.6	0.6	20.2	11.8^I	3.8	3.8	19.2	0.4	0
19LB003529	2.5^S	0.4	31.6	34.8	3.6	8.8	31.0^S	1.8^S	0
FPS1867IPRO	0.6	20.3^S	5.8^I	3.2^I	1.2^I	1.6^I	22.4	0.4	0
FPS2565IPRO	0.7	0.0	26.4	21.4	3.2	1.2^I	16.6^I	0.2	0
Mean	1.1	2.3	25.5	24.4	3.6	5.5	24.1	0.7	1.9
Standard deviation	0.6	6.3	9.6	10.7	1.2	3.5	6.3	0.6	2.8
Mean + Standard deviation	1.7	8.7	35.1	35.1	4.7	9.0	30.4	1.3	4.7
Mean + Standard deviation	0.5	-4.0	15.9	13.7	2.4	2.0	17.8	0.1	-0.9

NV1- Number of vegetables with one grain, No.; NV2- Number of vegetables with two grains, No.; NV4- Number of vegetables with four grains, No.; NV0- Number of grain-free vegetables, No.; NVB- Number of vegetables in the branch, No.; NTN_B- Number of total nodes in the branch, No.; VW1G- Vegetable weight with one grain, g; VW4G- Vegetable weight with four grains, g.

Table 8. Percentage of incidence of diseases, insect pests and invasive plants.

Genotypes	*Phakopsora pachyrhizi*	*Macrophomina*	*Colletotrichum truncatum*
		%	
95R70CE	20	16	0
95R21E	20	0	0
95Y95IPRO	20	0	0
95R40IPRO	20	8	0
TMG1155RR	20	8	0
TMG7362	20	0	0
TMG22X572101IPRO	20	0	0
19LB003529	20	0	8
FPS1867	20	0	8
FPS2565	20	0	0

Genotypes	*Dichelops furcatus*	*Diabrotica speciosa*	*Bemisia tabaci*	*Thysanoptera*	*Chrysodeixis includens*
		%			
95R70CE	0	4	0	20	0
95R21E	8	0	0	20	0
95Y95IPRO	0	0	4	20	0

95R40IPRO	0	0	0	20	0
TMG1155RR	0	0	0	20	0
TMG7362	0	0	0	20	0
TMG22X572101IPRO	0	0	0	20	0
19LB003529	0	0	0	20	0
FPS1867	0	0	0	20	0
FPS2565	0	0	0	20	0

Genotypes	***Ipomoea sp.***	***Sida rhombifolia***	***Amaranthus sp.***	***Richardia brasiliensis***	***Conyza sp.***
			%		
95R70CE	12	8	12	4	12
95R21E	0	0	8	0	8
95Y95IPRO	0	0	0	0	0
95R40IPRO	0	0	8	0	0
TMG1155RR	0	0	0	0	12
TMG7362	0	0	0	0	8
TMG22X572101IPRO	0	0	8	0	0
19LB003529	0	0	0	0	0
FPS1867	0	0	0	0	0
FPS2565	0	0	0	0	8

Phakopsora pachyrhizi- Asian rust; *Macrophomina*- Macrophomina; *Colletotrichum truncatum*- Anthracnose; *Dichelops furcatus*- Green belly stink bug; *Diabrotica speciosa* – Cucurbit beetle; *Bemisia tabaci*– White fly; *Thysanoptera*- Thrips; *Chrysodeixis includens*- Soybean looper; *Ipomoea sp*.- Morning glory; *Sida rhombifolia* - Arrowleaf sida; *Amaranthus sp*.- Pigweed; and *Richardia brasiliensis*- White-eye.

Conclusions

Soybean grain yield is closely linked to meteorological elements, which play a crucial role in the fluctuations and frustrations of soybean agricultural harvests in the municipalities of Rio Grande do Sul. The significant correlations between yield indicate that the water factor is what more affects production.

The TMG7362IPRO cultivar had a higher yield with 73 bags per ha^{-1}; in this context, the soybean GMR also influenced yield in relation to climatic relations and had a better positioning.

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