Agronomy Science and Biotechnology

Research Article

Environmental stimulus in lettuce genotype in agroecological cultivation system

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Citation: Bester, A. U., Argenta, C., Lucchese, O., Carvalho, I. R., Bianchi, C. A. M., Schiavo, J., Bubans, V., Sfalcin, I. C., & Loro, M. V. (2024). Environmental stimulus in lettuce genotype in agroecological cultivation system. *Agronomy Science and Biotechnology*, 10, 1-10 https://doi.org/10.33158/ASB.r197.v10.2024

Received: August 14, 2023.
Accepted: August 30, 2023.
Published: November 23, 2023.

English by: Ivan Ricardo Carvalho

Abstract

Vegetable production system has presented and developed strategies to increase the level of sustainability of production, adding information that expands agroecological production, resulting in better use of different components necessary for production. This study aims to evaluate the effect of different coverages in relation to the expression of the genotype in three crops of different agricultural years, enabling the best use of natural resources, bringing effective subsidies for a more sustainable production. The study was conducted in three growing seasons, in 2017, 2018 and 2019 crop years, in a randomized block design with four replications, using three soil covers (corn silage residue, elephant grass straw and soil without vegetation cover) and a lettuce cultivar (Lettuce "Iceberg"). It was possible to observe through the analysis of variance that only the year variable promoted alterations on the analyzed characters, with no effect of the different coverages. The highest production occurred in 2019 for all variables analyzed. Regarding the estimate of Pearson's linear correlation, it was possible to obtain significance at 0.01% of probability for the variables average total weight and productivity, with a significance of 1% of probability for the variables average diameter, average longitudinal diameter and productivity. There was no effect of soil cover for the variables of lettuce production and productivity, possibly related to excess water from precipitation in 2017, 2018 and 2019. In addition, the complementary effect of irrigation in the years of the experiment was, possibly, superior to the demand of the crop by reducing the effect of ground cover on soil water dynamics.

Keywords: *Lactuca sativa* L; organic fertilization; vitamin; mineral; crop system; small farmer.

Introduction

Lettuce (*Lactuca sativa* L.) originated from wild species, still found in temperate regions, southern Europe and western Asia (Filgueira, 2003). It is characterized as an annual plant belonging to Asteraceae family, being one of the most consumed vegetables in Brazil and in the world (Henz & Suinaga, 2009; Andrade, Andrade Júnior, Perini, Andrade, & Miglioranza, 2016; Silva et al., 2019). The species is considered a good source of vitamins and minerals, highlighting its high content of vitamin A, in addition to containing vitamins B1 and B2, vitamins C, calcium and iron (Fernandes, Martinez, Pereira, & Fonseca, 2002). Lettuce cycle is short, facilitating its production throughout the year, and in recent decades many cultivars have been developed, which may differ in terms of cycle duration, directly influencing plant development and crop system productivity. Several researches are being developed with the culture, with the aim of improving the cultivation and the expression of desirable characteristics (Monteiro et al., 2017).

The production of vegetables in an Agroecological system is an activity that has been showing great growth in the world, due to the protection of the health of producers and consumers and of productive viability and preservation of the environment (Sediyama et al., 2014). In addition, this cultivation strategy makes it more stable and profitable, especially for small farmers with little available area. Agroecological production systems are guided by organic agricultural production, whose main advantage is production without the use of pesticides and synthetic inputs (Melo & Serra, 2019; Hoshino et al., 2023; Pradebon et al., 2023).

However, there are a large number of biotic and abiotic factors in the production chain of this vegetable, which make production difficult and affect its productivity; among these factors, temperature and photoperiod are the main ones (Oliveira, Sediyama, Pedrosa, Garcia, & Garcia, 2004; Blat, Sanchez, Araújo, & Bolonhezi, 2011; Loro et. al., 2024; Meotti, Carvalho, Loro, Silva, & Lautenchleger, 2024). This determines different growing seasons for cultivars in the most varied regions, resulting, according to Carvalho et al. (2020), in different genotypes x environments relationships. In this sense, the demand for water in vegetable systems is an important factor in obtaining productivity and quality.

Thus, despite the great potential of this vegetable crop, it demands large amounts of water, so in Brazil lettuce is the most important vegetable produced in a hydroponic NFT-laminar nutrient flow system. However, this system can be difficult to access for some farmers, due to its high cost of implantation, technologies and information necessary for its implantation and conduction. Thus, the cultivation of lettuce in the field is still developed by many producers, even though this system is sensitive to environmental conditions, especially when it comes to water management (Carvalho, Pinto, Monte, Mello, & Sousa, 2016).

In this perspective, aiming at the optimization of water consumption, the use of different types of soil cover can lead to greater productive efficiency in the field cultivation of this species. Therefore, this study aims to evaluate the effect of different coverages in relation to the expression of the genotype in three crops of different agricultural years, enabling the best use of natural resources, bringing effective subsidies for a more sustainable production.

Material and Methods

The experiment was carried out in the field in three seasons, in the agricultural years of 2017, 2018 and 2019 at Instituto Regional de Desenvolvimento Rural (IRDeR) located in the municipality of Augusto Pestana, RS, Brazil (28° 26' 30" latitude S and 54° 00' 58" longitude W). The soil of the experimental area is classified as a typical dystroferric red latosol (Santos et al., 2013) and the climate of the region, according to the Köppen classification, is Cfa, with hot summers without a dry season.

In the experimental area, prior to the implantation of the culture, a soil analysis was carried out and the needs for fertility correction were identified. Considering the agroecological-based cultivation, it was decided to use laying hen litter and bovine urine to fertilize the soil. The laying hen litter has dry matter (DM) equal to 1.6% of nitrogen, 4.9% of phosphorus and 1.9% of potassium, with an efficiency index of these nutrients, respectively, equal to 0.5, 0.8 and 1.0. Thus, the following formula was used to determine the amount of solid fertilizer to be applied:

$A= QD/((B/100)x(C/100) \times D)$, where:

QD is the amounts available;
A is the dose of the organic fertilizer to be applied to the soil (kg ha^{-1});
B is the dry matter content of the fertilizer (%);
C is the nutrient concentration (%); and
D is the efficiency index of each nutrient, thus, according to the Soil Chemistry and Fertility Commission – RS/SC (2016).

Thus, the initial recommendation was 3 kg m^{-2} of layer bedding in order to supply the nutrient demand required by the culture, in relation to the soil conditions. However, only 1.5 kg m^{-2} of layer litter was applied and the remainder was supplied in a fractional way throughout the crop cycle with bovine urine, based on nitrogen to establish the fertilization proposal.

The experiment was carried out in a 3x4 factorial scheme, considering years of cultivation (2017, 2018 and 2019) and soil cover (corn silage residues, elephant grass straw and soil without vegetation cover), in a randomized block design with four replications, using the cultivar Lettuce "Iceberg".

The cultivar used was Lettuce "Iceberg". It has a cycle of 70 days (summer) and 90 days (winter), and can be grown in all regions of Brazil and sown at any time of the year, genetics developed for hot regions, large plant, early and uniform, the crispy leaves are another outstanding feature, it is the cabbage type, with curly green leaves with a cream center.

The seedlings were produced in polystyrene trays, containing specific substrate for horticulture (H). The seedlings were conducted in a protected environment, until they reached three to four true leaves, when they were transplanted to the field with a spacing of 30 cm x 30 cm. The transplant dates occurred in the month of October of the respective years 2017, 2018 and 2019. The duration of the cycle was computed in days after transplanting (DAT), and its cycle or from 39 to 49 DAT.

The irrigation system was by sprinkler, and the gross water depth applied was the estimated gross water depth (WD) of water required by the crop per day. To obtain the irrigation volume, the formula LB=Kc.Eto/Ea (Andriolo, 2002) was used, with Kc being the crop coefficient (Santana, Celso, & Ribeiro, 2016), the reference evapotranspiration (Eto) obtained from the meteorological station from Regional Institute for Rural Development (IRDeR/UNIJUÍ) and the application efficiency (Ea) of 0.85 for the system used. Thus, considering the applied water depth (mm/min) by each sprinkler, the necessary irrigation time was estimated to reach the LB required by the culture per day.

When necessary, the phytosanitary management of the agroecological-based crop was carried out, aiming to monitor and control damages resulting from this species. When the lettuce reached the point of harvest, four central plants were collected to carry out the evaluations. In this way, the lettuce yield and quality indicators were quantified by the variables average lettuce weight in grams (AWG), average diameter in cm (AD) and average longitudinal diameter in cm (ALD). At the end, the total productivity per hectare in kilograms (P) was estimated.

Data were evaluated through analysis of variance (ANOVA) to detect the presence or absence of interaction between the study factors. Then, based on this information, the comparison test of means for cultivars and coverings was performed using Tukey model at a level of 5% error probability and Pearson correlation. In all analyses, the GENES Software was used.

Results and Discussion

In the analysis of variance, it was observed that only the year variation source promoted changes on the characters analyzed by the F test at 5% probability (Table 1 and Table 2). For coverage, and the interaction between year and coverage, there were no effects on average lettuce weight (ALW), productivity (P), diameter (D) and dorsal diameter (DD).

Table 1. Analysis of variance of yield variables and production indicators, considering year and soil cover factors for lettuce "iceberg" cultivar.

Source of Variation	DF	Mean square			
		Average weight per plant	Productivity	Average diameter	Average longitudinal diameter
Block	2	3	3	2	2
Year	2	4*	4*	6*	6*
Cover	2	5	5	3	4
Year*Cover	4	6	6	5	3
Residue	16	2	2	4	5
Total	22				
CV (%)		26,06	26,06	8,27	6,62

*significant at 5% probability of error, by Tukey's test.

Table 2. Mean comparison test for productivity and quality variables, considering the year. IRDeR/UNIJUÍ, Augusto Pestana/RS, 2020.

YEAR	ALW[1] (g/plant)	P (kg/ha)	AD (cm)	ALD (cm)
2017	311.76 b[2]	6852.0 b	24.14 b	42.19 b
2018	412.23 ab	9060.0 ab	17.00 c	33.78 c
2019	441.97 a	9713.7 a	34.19 a	51.89 a

[1]Average lettuce weight in grams (ALW), productivity per hectare of lettuces evaluated in kilograms (P), as well as average diameter in cm (AD) and average longitudinal diameter in cm (ALD). [2]Means followed by the same lowercase letter in the column do not differ by Tukey test at 5% probability for year and coverage.

In figure 1, it is noted that in 2017 and 2018 there was well-distributed rainfall during the cycle. In 2017, on 3, 21 and 30 DAT there were voluminous precipitations. Which, in a way, did not happen in 2018, when the occurrence of rain was concentrated in a greater number of days at the beginning, middle and end of the cycle. The rainfall during the crop cycle, in 2019, was not well distributed and with lower rainfall. The rainfall was 104 mm throughout the cycle.

The development of vegetables is strongly influenced by soil moisture conditions, so the water supply by irrigation systems is a decisive factor for the success of horticulture, which promotes productivity and quality gains when the application is adequate (Silva et al., 2019). The use of ground cover reduces the incidence of weeds, contributes to maintaining soil temperature and humidity at levels suitable for plant development, providing better conditions for plant development (Reis et al., 2015).

In this context, like most vegetables, lettuce has its development influenced by soil water conditions. So, the experiment was carried out with a sprinkler irrigation system, as this irrigation system is a technique that aims to meet the water demand of the culture by the fractionation of a jet of water in drops launched on the surface of the ground, simulating a uniform precipitation. The use of water via irrigation allows adequate nutrition for plants, because for the plant to absorb nutrients in the correct amount there must be water, if there is a water deficiency in the root system, there will also be a deficiency in the absorption of nutrients by the plant. However, excess water can cause a microclimate favorable to the development of diseases, impairing the productivity and quality of vegetables.

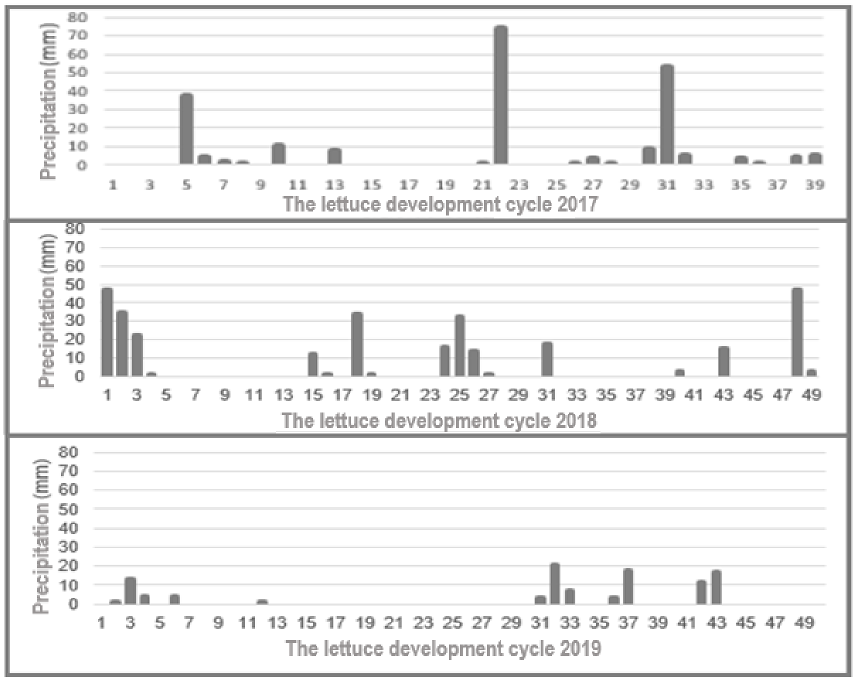

Figure 1. Precipitation during the lettuce field development cycle in the three years of conducting the experiment. IRDeR/UNIJUÍ meteorological station, Augusto Pestana/RS 2017, 2018, 2019.

Therefore, the irrigation management carried out, sought to reconcile the water need of the crop with the water availability in the different agricultural years, in view of the non-uniformity of precipitation visualized in Figure 1. It is also important to highlight that in the first weeks the daily demand per crop water increases slightly with plant growth. Taking into account, the irrigation management adopted in this study, it is possible that the amount of water needed was applied in the initial third. However, it was found that the water depth applied was greater than necessary in all the years evaluated, which may have compromised the development of lettuce. This fact may have occurred considering the methodology used to obtain the value of the gross water depth that did not consider the water storage capacity in the soil.

The voluminous precipitation of 245 and 299 mm that occurred in the crop cycle in 2017 and 2018, respectively, could have promoted excess water for the development of the lettuce crop, being one of the possible justifications for the lack of ground cover significance, since the value of water consumption can reach a maximum of 170 mm

(Andrade Júnior & Klar, 1997).

The hypothesis is also raised that the ground covers may not have been effective in reducing demand, as there was no water restriction established, as described by Andriolo (2002). In addition, silage and straw coverings hold more moisture in the soil, as there is less absorption of shortwave radiation, reducing the temperature and evaporation of water in the soil, contributing to the maintenance of moisture (Meneses, Moreira, Souza, & Bianchini, 2016). In relation to the soil without vegetation cover or control, a higher incidence of invasive plants was observed, which could affect the performance of the species to be commercialized.

In this way, it can be seen that coverings with straw or silage residue visibly reduce the emergence of invasive plants in relation to bare soil. This fact can be explained by the fact that coverage changes the conditions for germination, making emergence difficult due to the lower incidence of light and soil thermal amplitude between day and night, release of allelochemicals and the physical barrier imposed by the coverings (Meneses et al., 2016).

Taking into account this information and aiming to explain the results found, it can be seen that the different types of cover did not present significance, since both the bare soil and the soils with vegetation cover had limiting factors in their performance.

Regarding the agricultural years, they were significant, so from the average test it was found that the best year for all the variables analyzed (Total weight, Average diameter, Average longitudinal diameter and Average weight per plant) was the year of 2019.

One of the possible reasons for the year 2019 to have obtained the best averages is that this year it reached the lowest accumulated precipitation index (104 mm). Unlike the years 2017 and 2018, which reached high rainfall during the crop cycle, resulting in greater accumulation of water and consequently less crop development and greater probability of low productivity. Due to excess water, it impairs the development of the culture, by reducing the availability of O_2 in the roots, preventing respiration, lowering biochemical activity, which will lead to a drop in photosynthetic rate and an increase in reactive oxygen species (ROS).

According to studies, soil management practices are the ones that promote greater changes in agroecosystems. In this conception, the physical-chemical environment has been pointed out as the main regulator of crop production, both by physical changes caused by soil preparation and management and, or, by irrigation, and by chemical changes, with the addition of nutrients through of fertilizers. Mainly from the 1990s onwards, the concept of biological soil management was strengthened with the recognition of the regulatory role of populations of organisms and their activities on soil fertility. In this aspect, emphasis should be given to management practices that increase or enhance the biological activities of the soil (Lima, Moura, Sediyama, Santos, & Moreira, 2011).

Fertilization under the organic paradigm assumes that soil fertility must be maintained or improved, using natural resources and biological activities. As far as possible, local resources should be used, as well as organic by-products that provide a broad and diversified supply of nutrients, prioritizing the cycling of nutrients through cultural residues, organic compounds and residues and green manures with legumes. or spontaneous plants (Lima et al., 2011; Sediyama et al., 2014). Therefore, over the years, there may have been an improvement in the soil microbiota, for the development of the crop in the year 2019.

Recent studies such as those by Ferreira et al. (2020a) and Ferreira et al. (2020b) have addressed the study of linear relationships between lettuce characters, in order to highlight relationships that can be used strategically to maximize agronomic performance and genetic improvement of the crop. Not only lettuce, but in several crops such as corn (Olivoto et al., 2016), quinoa (Vergara et al., 2021), soybean

(Nardino et al., 2016) and wheat (Loro et al., 2021), the correlation between characters has been used and has promoted great genetic advances in breeding programs.

In this context, Figure 2 shows the results of Pearson's correlation coefficients, for the linear correlations between yield characteristics in the three soil covers, as a function of *Lactuca sativa*. Regarding the linear correlation analysis, associations were obtained, of which four pairs were significant at 0.01% probability and two pairs were significant at 1% probability by the T test. A positive association with total weight (TW) in the three coverages. This is because one is linked to another, where the total weight is the sum of the average weights. In the silage ground cover, there was a positive correlation between the mean diameter (MD) and the mean longitudinal diameter (MLD). Therefore, for the two interactions, the higher the DM value, the higher the MLD.

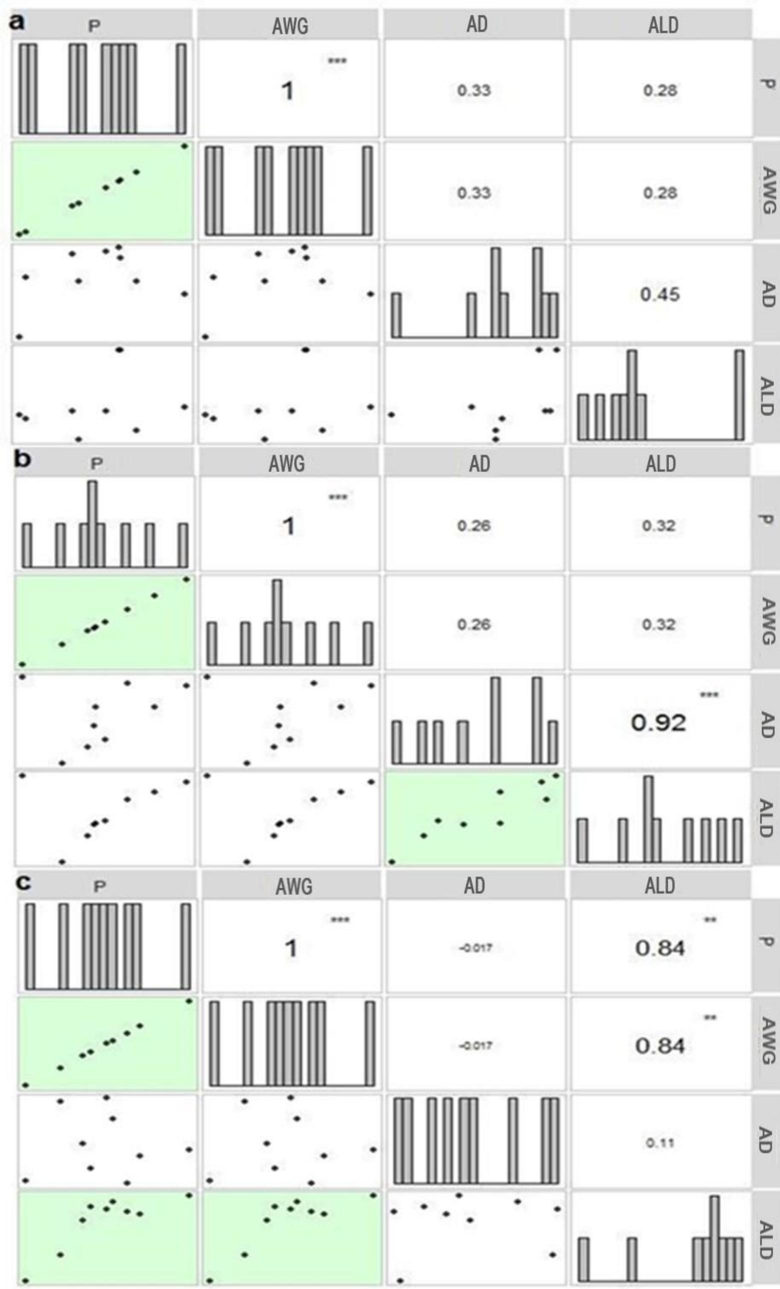

Figure 2. Pearson linear correlation estimates for four characters of agronomic interest measured in three soil covers (a) straw, (b) silage, (c) soil without vegetation cover) in the lettuce crop). IRDeR/UNIJUÍ, Augusto Pestana/RS, 2020.

The correlation coefficients for the characteristic mean longitudinal diameter showed a positive correlation with total weight and for the mean longitudinal weight. Therefore, the greater the weight will consequently increase the size proportionally, this for soil without vegetation cover.

Thus, attention is recommended regarding the supply of water for the crop, strictly observing the field capacity in the estimation of water consumption, in higher rainfall regimes, of plastic tunnels for soil cover, and that the soil covers can be used, in a first moment, to contain the development of competing plants rather than to reduce the effect of water maintenance in the soil.

Conclusion

There was no effect of soil cover for the variables of lettuce production and productivity, possibly related to excess water from precipitation in 2017, 2018 and 2019. In addition, the complementary effect of irrigation in the years of the experiment was, possibly, superior to the demand of the crop by reducing the effect of ground cover on soil water dynamics.

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