Soil mulch in control of soil temperature and incidence of weeds in the production of crisphead lettuce

Cobertura morta no controle da temperatura do solo e na incidência de plantas daninhas na produção de alface americana

Mantillo para controlar la temperatura del suelo y la incidencia de malezas en la producción de lechuga

Received: 10/28/2020 | Reviewed: 11/02/2020 | Accept: 11/06/2020 | Published: 11/11/2020

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†In Memoriam
Abstract

It was evaluated the effects of different types of mulching of soil in the cultivation of crisphead lettuce (*Lactuca sativa* L.), cultivar “Lucy Brown”, in the spring period, on weed control, soil temperature and productivity. The experiment was arranged in a randomized block design with four treatments and five replications in plots of 14.0m². The following coverages were studied: *Pennisetum glaucum* L., *Avena strigosa*, *Brachiaria ruziziensis*, plus the control treatment (soil without mulching). The use of mulching of soil, *P. glaucum* and *B. ruziziensis*, proved to be a beneficial practice, reducing the soil temperature by up to 5ºC. There was a lower incidence of weeds with the use of the *P. glaucum* and *A. strigosa* coverages. The use of mulch did not provide a significant gain in productivity, however, there was a gain regarding the quality of the product, since the coverage with *P. glaucum* provided an increase in the size of the head (fresh mass of the commercial head).

**Keywords:** *Lactuca sativa* L.; Straw; Productivity.

Resumo

Avaliaram-se os efeitos de diferentes tipos de cobertura morta de solo no cultivo da alface americana (*Lactuca sativa* L.) americana, cultivar “Lucy Brown”, sobre o controle de plantas daninhas, a temperatura do solo e a produtividade. O delineamento experimental utilizado foi o de blocos casualizados, com quatro tratamentos e cinco repetições em parcelas de 14,0m². Estudaram-se as seguintes coberturas: milheto (*Pennisetum glaucum* L.), aveia preta (*Avena strigosa*), ruziziensis (*Brachiaria ruziziensis*), mais o tratamento controle (solo sem cobertura morta). A utilização da cobertura morta de solo, milheto e ruziziensis, mostrou-se como uma prática vantajosa, reduzindo a temperatura em até 5ºC. Houve menor incidência de plantas daninhas com o uso das coberturas milheto e aveia. O uso de cobertura morta não proporcionou um ganho significativo na produtividade, no entanto, houve ganho quanto a qualidade do produto, visto que a cobertura com milheto proporcionou um aumento no tamanho da cabeça (massa fresca da cabeça comercial).

**Palavras-chave:** *Lactuca sativa* L.; Palhada; Produtividade.

Resumen

Se evaluaron los efectos de diferentes tipos de mantillo de suelo sobre el cultivo de lechuga americana (*Lactuca sativa* L.), cultivar “Lucy Brown”, sobre el control de malezas, temperatura del suelo y productividad. El diseño experimental utilizado fue de bloques al azar, con cuatro tratamientos y cinco repeticiones en parcelas de 14.0 m². Se estudiaron las
siguientes coberturas: mijo (\textit{Pennisetum glaucum} L.), avena negra (\textit{Avena strigosa}), ruziziensis (\textit{Brachiaria ruziziensis}), más el tratamiento testigo (suelo sin mantillo). El uso de mantillo de tierra, mijo y ruziziensis, resultó ser una práctica ventajosa, reduciendo la temperatura hasta en 5°C. Hubo una menor incidencia de malezas con el uso de cobertura de mijo y avena. El uso de mantillo no proporcionó una ganancia significativa en la productividad, sin embargo, hubo una ganancia en términos de calidad del producto, ya que la cobertura de mijo proporcionó un aumento en el tamaño de la cabeza (masa fresca de la cabeza comercial).

**Palabras clave:** \textit{Lactuca sativa} L.; Paja; Productividad.

1. Introduction

The lettuce \textit{(Lactuca sativa} L.) is a leafy vegetable of mild climate that belongs to the family Asteraceae. It is one of the most important vegetables grown in the world and in Brazil, certainly one of the most popular and consumed, being an important source of minerals, mainly calcium and vitamins (Filgueira, 2013).

It is estimated that the area planted of vegetables in Brazil is 5,1 million hectares, having as production the value of R$ 36 billion, and the volume, more than 53 million of tons (Anuário, 2019).

Brazil has an area of approximately 39,000 hectares for intensive production of lettuce, through cultivation in small areas and by small producers with family farming (up to 10 hectares) concentrated close to major centers and contributing to the generation of employment and income (Heredia Zárate et al., 2010; Vilela & Luengo, 2017)

In Brazil, the lettuce marketed can be classified into six groups according to the type of leaf lettuce: butterhead lettuce; crisphead lettuce (American); loose-leaf lettuce; green-leaf lettuce; mimosa lettuce and romaine lettuce (Filgueira, 2013). Among the types of lettuce grown today, the type iceberb has been highlighted, aiming at fulfilling mainly the fast foods chains.

The temperature and photoperiod are the main factors that interfere with the cultivation of lettuce, directly affecting their development. High temperatures affect the texture of the lettuce leaves, making them more fibrous, cause the burning of edges of the outer leaves, affecting the proper formation of head (Filgueira, 2013). High temperatures also stimulate the tasseling, which is intensified to the extent that the same increases (Luz et al., 2009).
To mitigate the effect of high temperatures on cultivations, in recent decades, new cultivation techniques have been used, such as the use of soil cover. The mulching induces less loss of water through evaporation and reduction of the oscillations of temperature, soil, it is used commonly for the lettuce cultivation, providing a microclimate that is more favorable to the development of the cultivation, so it has the capacity to express better their genetic potential (Kosterna et al., 2014).

The advantages presented by this system are: Improvement of the soil structure, increase of the infiltration and soil water retention, improvement on the root system of the invasive plants control, keeping the soil temperature milder (Gilley et al., 1990; Derpsch et al., 1991; Marouelli et al., 2008).

However, the high temperatures are still one of the main problems faced by producers of lettuce in the State of Mato Grosso do Sul. High temperatures during most of the year are marked characteristics of the climate of the region and interfere and affect the production of the cultivation. Considering that use of stubble straw can soften the soil temperature, the objective of this work was to evaluate the effects of the use of plants mulching on the incidence of weeds and soil temperature in the cultivation of crisphead lettuce, cultivar "Lucy Brown", in Campo Grande - MS during the spring, as well as the effects of this system of cultivation on the productivity and the quality of the lettuce.

2. Material and Methods

The study was carried out between May and November of 2014 in the experimental area at the Anhanguera Uniderp University in Campo Grande – MS (20°26’16.62”S, 54°32’16.07”W). The climate of the region, according to the Köppen (1948) classification system, is Aw, humid tropical climate with the rainy season in the summer and dry in winter. Average annual climatic variables are: rainfall 1500mm and temperature 26°C (Brasil, 1992).

The coverages were through solid seeding, being used the following cultivation densities: 80kg.ha⁻¹ of A. strigosa, 20 seeds.m⁻¹ of P. glaucum and 16kg.ha⁻¹ B. ruziziensis, as recommended by Embrapa (2006).

At 91 days after seeding (DAS), evaluations were conducted on the fresh mass of the coverages, using a square frame of iron of 50cm/side placed in the center of each experimental plot, where it was cut the fresh mass in the area bounded by the square, weighed on precision scale, and, after drying in oven to 60 - 70°C until constant mass, it was measured the dry mass; and the values were extrapolated to kg.ha⁻¹.
The evaluation of weeds infestation was performed immediately before the chemical desiccation of the experimental area, which was performed at 92 DAS, with application of glyphosate in the dose of 1.44 kg of a.i..ha\(^{-1}\). It was used the method of visual evaluation according to methodology of Research Method in Weed Science (1997): 100 (full control), 90 - 99 (excellent control), 80 - 89 (acceptable control), 50 - 79 (not acceptable control), 0 - 49 (insufficient control to no effect).

The seedlings of lettuce cultivar "Lucy Brown", were produced in a greenhouse, transplanting was done manually 30 DAS, on the desiccated plants, with a spacing of 0.30 m between rows and between plants. The corrective and coverage fertilizations were performed based on the soil analysis of the area and following the recommendations of Ribeiro et al. (1999). The water supply was performed daily by means of a system of sprinkler irrigation.

It was evaluated the soil temperature by means of daily measurements, before the beginning of the irrigation, always at 14 hours to a depth of five centimeters below the surface of the soil.

At 42 days after transplanting the lettuce plants were harvested, washed and separated into the aerial part and the root. Subsequently, the following ratings were performed: fresh weight of the head (FW), fresh weight of the commercial head (FWC), dry weight of the commercial head (DWC), losses (L), head diameter (HD), diameter of compact head (DCH), number of leaves (NL), fresh weight of the root (FWR), dry weight of the root (DWR), root diameter (RD), root length (RL), commercial productivity (PROD).

This is an experimental research qualitative and quantitative, with visual assessments of weed infestation and collection and statistical analysis of the data measured in lettuce plants (Pereira et al., 2018).

The experimental design adopted was in randomized blocks with four treatments (mulching) and five replications, totaling 20 experimental units. The experimental units had the dimensions of 7.0 m long and 2.0 m wide, where 116 seedlings of lettuce were planted. As useful plot 10 plants were harvested.

The treatments were characterized by the soil coverage: planting of lettuce on *P. glaucum*, *A. strigosa* and *B. ruziziensis* mulching, plus the control treatment with planting of lettuce in soil without plant coverage (spontaneous vegetation).

The data were interpreted statistically through analysis of variance, and the averages were compared among themselves through Tukey test at 5% probability; using the statistical program Genes (Cruz, 2013). The statistical model adopted was the following:
\[ Y_{ijk} = \mu + t_i + b_j + e_{ij} \]

Where: \( \mu \) = general average of treatments \( t_i \) = fixed effect of the \( i \)-th treatment (\( i = 1, 2, 3, 4 \)) \( b_j \) = end of the \( j \)-th block (\( j = 1, 2, 3, 4 \)); \( e_{ij} \) = experimental error associated with the observation \( Y_{ij} \).

### 3. Results and Discussion

The materials, millet and oats, used as mulching on the lettuce cultivation were equally effective and with significantly different results from the lack of coverage on maintenance for the soil temperature (Table 1). On average, these covers kept the soil with a temperature gradient of approximately 5°C below the control (without coverage). The use of mulching in other vegetables show similar results. According to Resende et al. (2005), in the culture of carrots the use of mulching has reduced the gradient temperature gradient at 3.5°C. In the garlic cultivation, the mulching provides greater insulating effect on the soil surface and contributes to milder temperatures (Costa et al, 1997).

**Table 1.** Averages of soil temperature during the lettuce cycle, cultivar “Lucy Brown”, cultivated on different soil mulching. Campo Grande, Mato Grosso do Sul, Brazil.

| Soil coverage               | Temperature (°C) |
|----------------------------|------------------|
| Control treatment          | 33.25a           |
| *Pennisetum glaucum* L.    | 26.25c           |
| *Avena strigosa*           | 30.50ab          |
| *Brachiaria ruziziensis*   | 28.75bc          |

Means followed by the same letters in columns do not differ (Tukey test, \( p \leq 0.05 \)). Source: Authors.

The temperature range between the control and treatment coverage more efficient in reducing the gradient was 7, *Pennisetum glaucum* was the most efficient coverage in reducing soil temperature.

In Table 2 are the weed species identified in the experiment, as well as their respective densities. The highest densities of weeds were the species of *Gamochaeta coarctata* and *Cenchrus echinatus*. 
Table 2. Averages of density of weeds on different soil mulching. Campo Grande, Mato Grosso do Sul, Brazil.

| Soil coverage | Gamochaeta coarctata | Cenchrus echinatus | Emilia fosbergii | Eleusine indica |
|---------------|----------------------|--------------------|-----------------|----------------|
| Control treatment | 72.90 a | 9.90 a | 6.30 a | 7.20 a |
| P. glaucum | 8.10 b | 1.10 b | 0.70 b | 0.80 b |
| A. strigosa | 4.05 b | 0.55 b | 0.35 b | 0.40 b |
| B. ruziizensis | 62.90 a | 2.20 b | 5.60 a | 1.60 b |

| Soil coverage | Amaranthus viridis | Richardia brasiliensis | Solanum sisymbriifolium | Coronopus didymus |
|---------------|-------------------|------------------------|--------------------------|------------------|
| Control treatment | 5.40 a | 5.40 a | 2.70 a | 4.50 a |
| P. glaucum | 0.60 b | 0.60 b | 2.40 b | 0.50 b |
| A. strigosa | 0.30 b | 0.30 b | 1.80 c | 0.25 b |
| B. ruziizensis | 1.20 b | 1.20 b | 0.60 d | 1.00 b |

| Soil coverage | Solanum americanum | Sida cordifolium | Commelina benghalensis | Total |
|---------------|--------------------|-----------------|------------------------|-------|
| Control treatment | 3.70 a | 3.60 a | 3.60 a | 125.20 a |
| P. glaucum | 0.45 b | 0.40 b | 0.45 b | 16.10 c |
| A. strigosa | 0.15 b | 0.20 b | 0.25 b | 8.60 c |
| B. ruziizensis | 0.80 b | 0.80 b | 0.70 b | 78.60 b |

Means followed by the same letters in columns and for each weed do not differ (Tukey test, \( p \leq 0.05 \)).

Source: Authors.

The soil cover provided by the \( P. \) glaucum, \( A. \) strigosa and \( B. \) ruziizensis coverings reduced weed infestation by 93, 87 and 37\%, respectively. The coverings \( P. \) glaucum and \( A. \) strigosa are the most efficient in controlling weeds.

The millet and oats mulching and oats have significantly reduced the total number of \( Gamochaeta \) coarctata plants in relation to bare soil and to ruziizensis mulching (Table 3). The weed control through vegetation coverage can occur both through physical effect, preventing the luminous incidence, as through allelopathy effects (Theisen et al., 2000; Favero et al., 2001; Monquero et al, 2009; Favarato et al, 2017).
Table 3. Efficiency of *Gamochaeta coarctata* control on different soil mulching. Campo Grande, Mato Grosso do Sul, Brazil.

| Soil coverage       | Notes of visual evaluation |
|---------------------|----------------------------|
| Control treatment   | 0 b                        |
| *P. glaucum*        | 100 a                      |
| *A. strigosa*       | 100 a                      |
| *B. ruziziensis*    | 15 b                       |

Means followed by the same letters in columns do not differ (Tukey test, \( p \leq 0.05 \)). Source: Authors.

The coverage provided by *B. ruziziensis* was not efficient for the control of *Gamochaeta coarctata*, the other coverages were effective in suppressing the weed.

Trezzi; Vidal (2004), emphasize the ability to weed suppression through millet cultivation. The authors found average reductions of 91, 96 and 59% of the infestation of *Brachiaria plantaginea*, *Sida rhombifolia* and *Bidens pilosa*, respectively, in areas covered millet stubble. The literature reports that the straw in decomposition can release allelochemicals, which, in turn, can be associated to reduce the emergence of plants seeds (Trezzi; Vidal, 2004; Souza et al., 2006; Carvalho et al, 2016).

Jacobi; Fleck (2000), claim that the allelopathic action of some oat genotypes is attributed to its ability to exude scopoletin. Scopoletin. is a secondary product from the class of coumarins and has an inhibitory effect on root growth of plants. Hagemann (2010) reports allelopathic potential of oats on the germination and the weeds development.

The allelopathic effect of mulching is so much more intense as the greater the amount of dry matter produced, thus ensuring a sufficient concentration of toxins to lethal action on the seeds or weeds seedlings (Almeida; Rodrigues, 2018). In Figure 1, it is possible to see the data of fresh and dry mass produced by mulches. It is observed that the coverage oats provide the greatest amount of fresh matter, whereas at *B. ruzizienses* the largest dry mass. In organic cultivation, under direct seeding, it is recommended that the pre-cultivation of species that have large amount of straw, allowing the soil cover, reducing then the undesirable or invasive plants (Vaz de Melo et al., 2007).
Figure 1. Averages of fresh and dry weight of different plants used as soil mulching. Campo Grande, Mato Grosso do Sul, Brazil

Bars followed by the same letter - capital letter to fresh weight and small letters for dry weight - do not differ (Tukey test, p ≤ 0.05). Source: Authors.

*B. ruziizenses* was the covering with the best mass production, the largest amount of dry mass provided a greater reduction in the temperature gradient in the soil, however, it was not efficient for the suppression of weeds.

For most of the characteristics related to productivity, showed no difference between treatments, i.e., there was no significant effect of different coverage on the productivity of the lettuce, a fact that can be attributed to the high degree of adaptability to high temperature conditions of this cultivar (Sala; Costa, 2012). There were significant differences only for two variables: dry mass of the commercial head and the fresh mass of the root of lettuce (Table 4). The mass of commercial head, however, is an important feature for the *producer*, because the remuneration, in this case, occurs according to the mass of the head. It is also important, as it affects yield during processing.
Table 4. Averages of dry weight of the commercial head (DWC) and of fresh weight of roots (FWR) in lettuce, cultivar “Lucy Brown”, cultivated on different soil mulching. Campo Grande, Mato Grosso do Sul, Brazil.

| Treatments       | DWC     | FWR    |
|------------------|---------|--------|
| Control treatment| 10.15ab | 8.75b  |
| P. glaucum       | 21.65a  | 19.55a |
| A. stigosa       | 13.55ab | 8.72ab |
| B. ruiziensis    | 10.00b  | 6.25b  |

Means followed by the same letters in columns do not differ (Tukey test, \( p \leq 0.05 \)). Source: Authors.

4. Conclusions

The use of soil mulch is a beneficial practice for lettuce cultivation, improving the soil temperature and reducing the incidence of invasive plants. The soil coverage with P. glaucum and B. ruiziensis stood out in reducing the soil temperature gradient, while with P. glaucum and A. strigosa reduced the incidence of weeds.

The coverage with P. glaucum has also provided an increase in the fresh mass of the commercial head, causing an improvement in product quality.

It is suggested, as a continuation of the studies, new experimental research with other leafy vegetable plants, and other cover crops in order to meet other advantageous possibilities for cropping systems.

Acknowledgments

The authors acknowledge the Fundação Manoel de Barros by their partnership.

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