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Environmental Adaptability and Rock Dust Concentrations in Lettuce Cultivars

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Abstract

The purpose of this work is to analyze lettuce cultivars different responses to environmental adaptability and rock dust concentrations in agroclimatic conditions in the south-west region of Goiás state. The work was conducted in the county of Mineiros, Goiás. The experimental area soil's was classified as quartzarenic NEOSOL. In experiment number 1, was used experimental design in random blocks in factorial 5 × 2, corresponding to five rock dust concentrations (0, 100, 200, 300 and 400 kg ha^{-1}), in two lettuce cultivars of Crespa and Americana lettuce. In experiment number 2 was applied experimental design in randomized blocks, which were constituted by 7 lettuce cultivars (Hanson, Simpson S. Preta, Baba de Verão, Maravilha de Inverno, Grandes Lagos, Crespa Palmas, and 4 Estação). The data results were analyzed 45 days after seeds transplant. The results were submitted to variance analysis and Turkey's regression and test at a 5% probability. The 400 kg ha^{-1} rock dust dose didn't have any effects in lettuce cultivars Crespa and Americana, once that, rock dust nutrients mineralization occurs very slowly, not interfering in the lettuce first cycle. 4 Estação cultivar presented good environmental adaptability to Goiás south-west agroclimatic conditions, more specifically in Mineiros, where it is recommended lettuce cultivation in summer-fall.

Keywords: *Lactuca sativa*, stonemal, competition test

1. Introduction

There was a devaluation of natural and biological processes in agriculture modernization process, prioritizing, mainly, high solubility mineral fertilizers use (Santi et al., 2013), causing a bigger production cost, that most part of the times is unnecessary, which increases researches with other materials (Rezende et al., 2013).

To Delprete et al. (2016), non-conventional inputs become attractive due to low cost and improvement of soil properties and increasing vegetal production, which is what happens in basalt rock dust. In this aspect, natural fertilizers, for example phosphates rock, gypsum, vegetables cake and manure are important inputs in fertilization for being macro and various micronutrients source, which are essential to plants nutrition (Nunes et al., 2009).

In Brazil there are still very few references of basalt sedimentary rock use in agriculture commercial scale, however in Europe, it's using can be considered a very conventional practice to a lot of farmers (Rezende et al., 2013). Besides that, rock dust experiences use as a nutrient source needs to transform and adapt soil's fertility conditions, in a way that maintains production patterns in large scale (Theodoro et al., 2006).

Rock dust use is a alternative technology to conventional inputs, it can become a easily practice used by farmers, because of its principles and, specially, it's low purchase cost. Besides that, we have to better take care of our soils, because it is a extremely important resource to human survival, which makes necessary to search for alternatives that can propose better using of this resource in a sustainable way, especially in food production.

Food production pursuance involving vegetables and fruits commonly called HFs (HortiFruit) in South west Goiás region still very insipid, because attention is mainly focused on grains like soy and maize, however lettuce

cultivation has been gaining attention in local agribusiness. Researches in this pursuance focusing in vegetal nutrition and insertion of genetic material have become necessary to productive chain development.

Nowadays, there is a huge diversity of lettuce cultivars in market, which explores different types of plants in shape, size and color (Suinaga et al., 2013). With advances in lettuce genetic development, new cultivars have been constantly made available to producers. (Domingos Neto et al., 2014). According to Sala and Costa (2012), there are about six varietal types (crespa, lisa, americana, mimosa, romana e vermelha) of predominant lettuce in the country cultivation that attends the huge demand from the consumer market.

Although the producer has all this technology on his favor with new cultivars releasing that are resistant to various factors that potentialize the cultures income, often the cultivars doesn't adapt to the diverse conditions of a certain region, which makes necessary doing cultivars development tests to make it easier to choose the cultivars that better adapts to market demand and rural producer necessities.

Success examples have been seen with lettuce improvement programs developed in Brazil by some national companies and research institutions, aiming cultivars obtention and liberation adapted to growing conditions (Sala & Costa, 2012). Blind and Silva Filho (2015), suggest that it is essential to choose cultivars that attend qualitative requirements by local consuming market.

In Goiás southwest region, more specifically in Mineiros there are very few or none existent works that involve lettuce cultivars climatic adaptation tests and it's behavior when submitted to rock dust use as a nutritional alternative, showing how unpublished this work is and it's importance to others involved in lettuce crop. According to what was exposed, the work aims analyze different lettuce cultivars answers to environmental adaptability and rock dust concentration in Goiás South West agroclimatic conditions.

2. Method

The study was made in Experimental Farm Luiz Eduardo de Oliveira Sales, in Mineiros-Goiás state, located between geographic coordinates 17°34′10″ South latitude and 52°33′04″ west longitude, with 760 meters average height. Average temperature is 22.7 °C, the average annual precipitation is 1695 mm occurring mainly in spring and summer. The experimental area is classified as Aw climate type (hot and dry) (Köppen & Geiger, 1936). Experimental area soil was classified as quartzarenic NEOSOL, with light texture, smoothly wavy to flat topography and also good drainage (Embrapa, 2013).

Before the experiment installation was made a soil analysis in a 0-20 cm layer, which the following features were verified: hydrogen potential 5.7; calcium 3, magnesium 0.8, aluminum 0.2, hydrogen + aluminum 2, cation exchange capacity 5.9 in $cmol_c\ dm^{-3}$; potassium 53, phosphorus 59, sulfur 1.7, boron 0.2, copper 1.4, iron 51, manganese 23, zinc 8.3, sodium 1.5, in mg dm^{-3}; clay 223, silt 50, sand 728, organic matter 20 and organic carbon 12, in g dm^{-3}. As well as in aviary bed: nitrogen 3, magnesium 1.1, phosphorus pentoxide 3, potassium oxide 4.6, sulfur 0.45, Organic Matter 65.1, calcium 5.3, 16.7 Moisture at %; Cobalt 0.1 and Molybdenum 0.1, in ppm. The data were taken according to methodology from (Embrapa, 2009).

In experiment number 1 was used experimental design in random blocks in factorial 5 × 2, which corresponds to five rock dust concentrations (0, 100, 200, 300 and 400 kg ha^{-1}), in two lettuce cultivars Crespa (Vanda) and Americana (Lucy Brown), in four repetitions. Rock dust doses were applied in 12/09/2016, the same day that plants seedling were also transplanted.

In experiment number 2 was applied experimental design in casual blocks with 4 repetitions, which were constituted by 7 lettuce cultivars (Hanson, Simpson S. Preta, Baba de Verão, Maravilha de Inverno, Grandes Lagos, Crespa Palmas, 4 Estação). Plants seedlings were transplanted in 13/03/2017.

To both experiments the soil preparation was made in a conventional system with plowing and harrowing. Each parcel in bed was dimensioned at 0.80 m long by 1.20 m wide and 0.10 m high. On these, it was incorporated poultry litter on a 0-5 cm 40 m^3 $hectare^{-1}$ layer, 7 days before seedlings transplant. Seedlings developed polystyrene trays with 200 cells, filled with commercial substrate Plantmax®. On the beds was used dry vegetable stubble as mulch. Seedlings were transplant 20 days after sowing. Parcels were composed by 15 plants each, spaced in 0.3 × 0.3 m.

Data results were analyzed 45 days after seedlings transplant using 5 central plants from each parcel where it was analyzed: Experiment 1: stem length (cm), leaves number (unit), head diameter (cm) head fresh weight (g) and yield (t ha^{-1}). Experiment 2: head diameter (cm), head fresh weight (cm), commercial leaves number (unit), stem height (cm) and yield (t ha^{-1}). To theese it was followed Benincasa (2004) methodology.

The results were submitted to ANAVA variance analysis. Experiment 1: on the basis of rock dust concentrations, performing polynomial regression and testing linear quadratic models and choosing significant models that presented the greatest correlation with average, watching test F significance. Experiment 2: was performed ANAVA variance analysis using F test and when significant, cultivars were compared by Tukey test at a 5% probability. All analysis were made with Variance Analysis System statistical program – SISVAR (In Portuguese: Sistema para Análise de Variância) (Ferreira, 2014).

3. Results and Discussion

3.1 Experiment 1

Rock dust doses didn't made effect to leaves number, head diameter, head fresh weight and lettuce cultivars Crespa (Vanda) and Americana (Lucy Brown) yield, with the only exception in stem length with quadratic effect to the last one ($p < 0.05$). Different from Groth et al. (2017) growing lettuce in rock dust presence incorporated to soil presented significant increment in the plant's structure, root system and dry matter growth when compared to control, however, differences in stem diameter and root system volume were not observed.

Curly cultivar length stem presented a 6.61 (cm) average (Figure 1A). Equivalent information to Pontes et al. (2005) who reported a non-significant influence in length stem, possibly due to short space of time between rock dust application and harvest, aggravated by slow nutrients availability and Ehlers et al. (2014) that obtained a indicative result that dock dust treatment didn't contribute to height increment, possibly due to low porosity and aeration in substrate, generated by large amount of rock dust. However, it was observed that Americana cultivar answered longer length stem to 202.59 kg ha^{-1} dose which corresponded to 6.10 cm length from such characteristic (Figure 1A). Close results to Nunes et al. (2009) after testing different cabbage cultivars in function of slow release fertilizers reached different answers from cultivars about manure. Lettuce plants with very high stem can reflect mainly climatic stress, early change from vegetative stage to reproductive stage which it is not a appreciable characteristic for lettuce crop producers, furthermore, it's leaf end up with a bitter taste, depreciating it to consumer market.

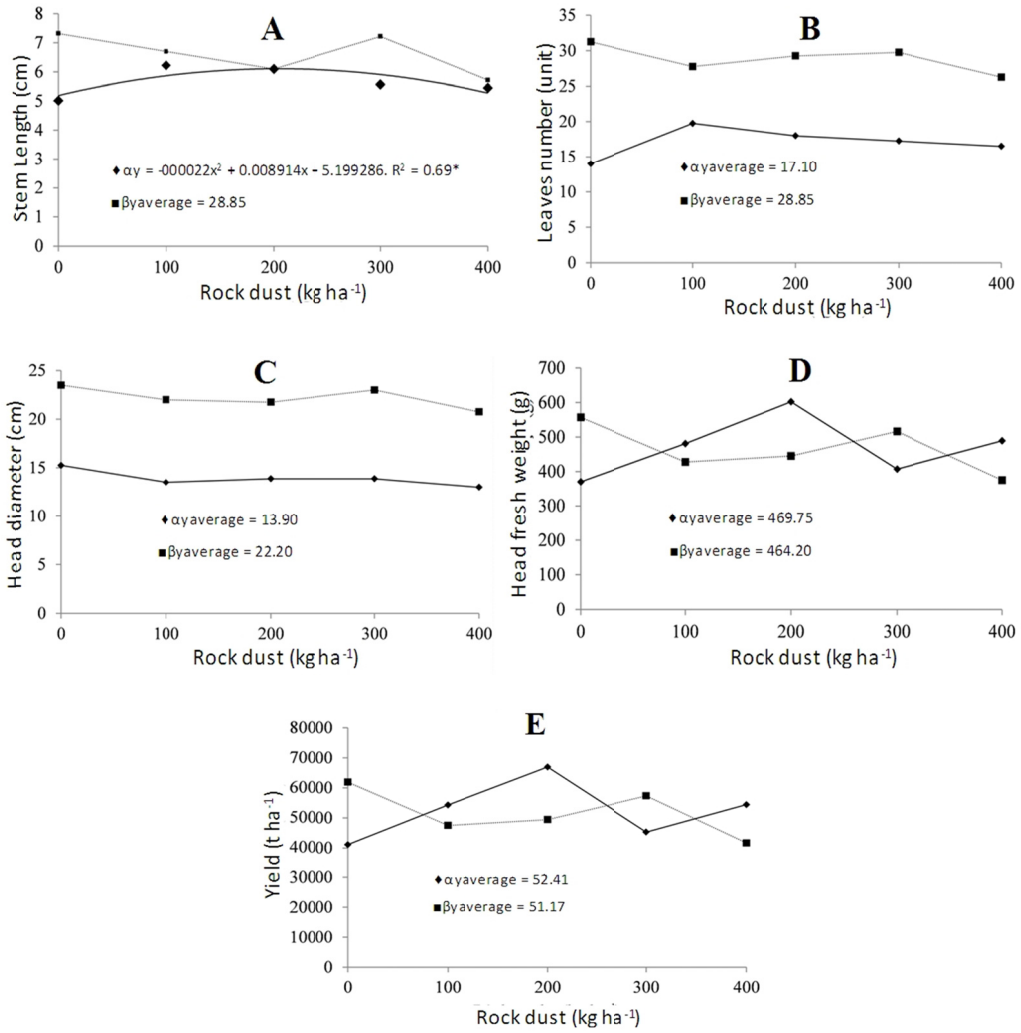

Figure 1. Stem Length (A), Leaves Number (B), Head Diameter (C), Head fresh weight (D) and yield (E) of Americana (α) and Crespa (β) lettuce cultivars in function of rock dust fertilization.
UNIFIMES, Mineiros-Goiás, 2019

It was noticed that average value in leaves number question per plant didn't change when exposed to rock dust dose, presenting 17.10 average to Americana cultivar and 28.35 to Crespa cultivar (Figure 1B). Similar result to Rezende et al. (2013) after observing that lettuce cultivars leaves number fertilized with organic matter associated with rock dust, didn't show significant differences. Probably this feature it's too associated to genetic factors and, therefore, it is not influenced by treatments or environmental factors (Mascarenhas et al., 2008).

In head diameter Americana and Crespa cultivars didn't show difference in it's average compared to rock dust ones, presenting respective values of 13.89 and 22.20 cm (Figure 1C). This information corroborates with Santi et al. (2013), Dalestra et al. (2016), besides Rezende et al. (2013) after evaluating rock dust fertilizing efficiency in lettuce culture, verified that such fertilizer, used in isolation or associated to organic matter, was inefficient to culture nutrition in the tested doses.

To head fresh weight (Figure 1D) and yield (Figure 1E) it was observe that Americana and Crespa cultivars didn't show difference in it's average with rock dust dose and it was verified the following average values 469.75 and 464.20 g and 52.441 t ha^{-1} and 51.577 t ha^{-1}, respectively. Such data are similar to Tessaro (2013) that after trying different substrates to Chinese cabbage production and reached the best results referring to aerial part, although it's average were not differed, that probably occurred due to compound chemical and physical properties, allied to rock dust originate nutrients greater supply. Inferior result was obtain by Santi et al. (2013) with fresh matter of the head of 354.9 g. Delprete et al. (2016) with different rock dust concentrations in organic

compound mixtures verified that green pepper seedlings growth was presented in all evaluated parameters, which shows rock dust use efficiency as substrates in seedlings production in the studied culture.

However the main point observed in this experiment is that in short period of time, very few or inexpressive rock dust action in lettuce culture, which open possibilities to longer tests with input, or even in other agriculture fields. For example Groth et at. (2017) suggest that basalt rock dust can be used as a compound to supply soil's mineral needs to lettuce cultivation, as also, provides a phytophagous insects population decline in the culture, which helps in protection against insects pest attack.

3.2 Experiment 2

All lettuce cultivars presented average variation ($p < 0.05$) of head diameter. (Figure 2A), head fresh weigth (Figure 2B), commercial leaves number (Figure 2C), stem diameter (Figure 2D), stem height (Figure 2E) and yield (Figure 2F).

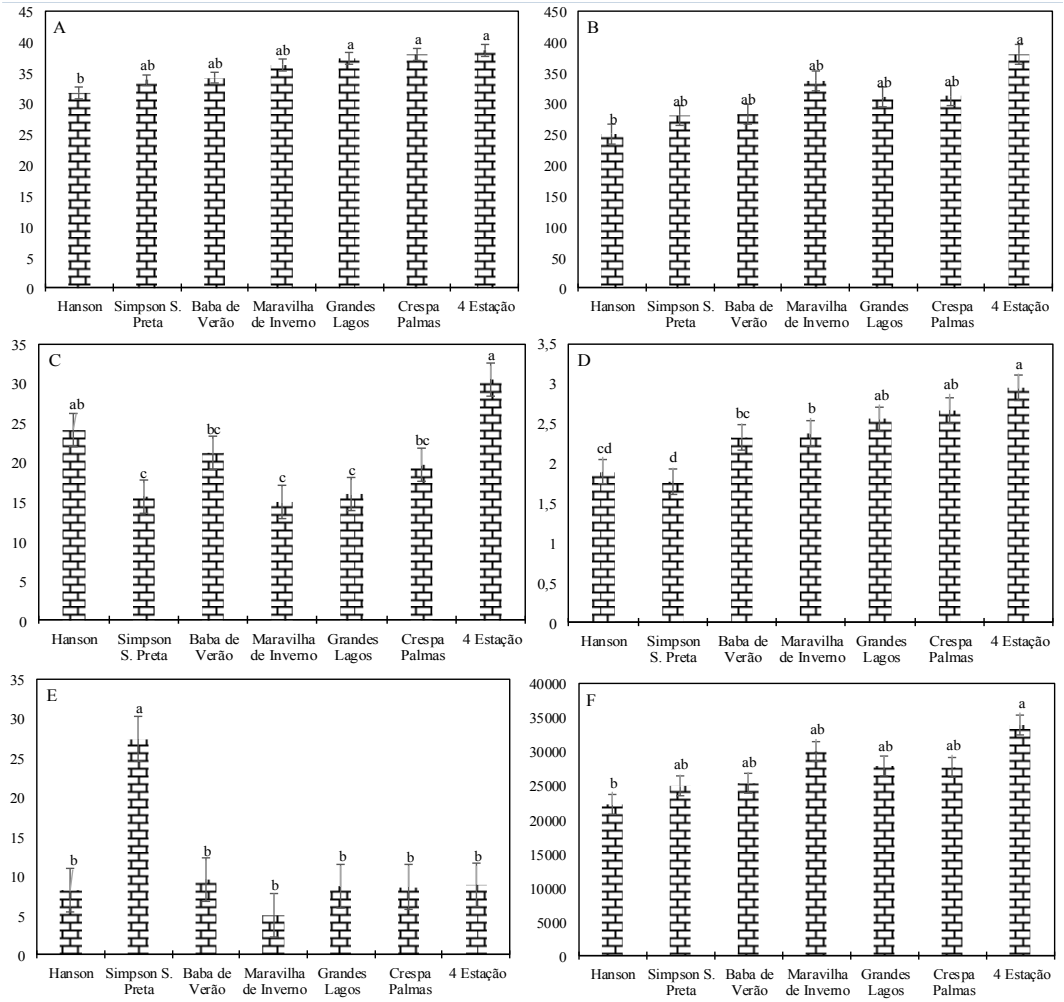

Figure 2. head diameter average (A), head fresh weight (B), Commercial leaves number (C), stem diameter (D), stem height (E) and yield (F) of lettuce cultivars in South West region in the Goiás states. Mineiros-Goiás, UNIFIMES, Brazil, 2019

Note. Averages followed by the same letter in variable do not differ among each other by Turkey test, at a 5% probability.

Cultivars Grandes Lagos, Crespa Palma, and 4 Estação presented higher averages related to head diameter, however, did not differ from Simpson S. Preta, Baba de Verão and Maravilha de Inverno. Hanson cultivar provided lowest average 31.70 cm (Figure 2A). Values obtained in this experiment were equivalent to the ones observed by Domingues Neto et al. (2014), who observed larger head diameter compared to the others in

Grandes Lagos cultivar. Lower results were obtained in Brzezinski et al. (2017) with four Americana lettuce cultivars, getting average of only 14 cm. Taking into account the diameter size importance to commercial environment, the highest average will provide better sales, because in hardwoods vegetative vigor has a positive influence in yield culture levels.

The head fresh weight, was the highest in cultivar 4 Estação with 380 g (Figure 2B). Similar average was found in Suinaga et al. (2013) who evaluated productive performance in lettuce cultivars. Hanson cultivar obtained lowest weight with 250 g. Other cultivars presented intermediate averages (Figure 2B). Fresh matter production per plant varying from 187.87 to 297.05 g plant^{-1}, was found by Schumacher et al. (2012), according to lettuce commercial fresh matter authors, associated with it's commercialization value, are among main parameters which influence on this vegetable consumer choice, therefore the cultivars which present highest fresh matter are the ones which are preferred by the consumer. Coloration and texture, variables not analyzed in this study, are also definitive in consumer evaluation.

About leaves number, cultivar 4 Estação obtained highest average 30, 50 unit, similar to Hanson cultivar, in the same, other cultivars did not differ among themselves, presenting lower averages varied from 14.93 to 24.12 unit (Figure 2C). Close result were found in Blind and Silva Filho (2015) competition test, with 24.9 leaf plants^{-1}. Higher leaf quantities were found in Domingues Neto et al. (2014) work, who evaluated lettuce cultivars agronomic development with 52.66 leaves average. According to Santos et al. (2009), indicates that environment together with genetic compounds, are great responsible for plants physiological and morphological changes, besides growth.

The largest stem diameter was verified in cultivar 4 Estação, however it didn't differ from Grandes Lagos and Crespa Palmas averages. Lowest diameters were found in Hanson and Simpson S. Preta (Figure 2D). Corroborating with Brzezinski et al. (2017) who found stem diameter of 2.77 cm and Santana et al. (2012). More robust diameters allow greater sap circulation and more efficient communication with root system, which makes the plant more resistant to leaves wilting, providing longer shelf life.

Simpson S. Preta cultivar presented highest average when it came to stem height characteristic (27.38 cm), other cultivars did not differ among each other, (from 4.97 to 9.51 cm) (Figure 2E). Absence in stem height variation was also reported by Cruz et al. (2012) and Domingues Neto et al. (2014), after working various lettuce cultivars. According to Santos et al. (2009), cultivars with high stem length present lower performance in characteristic as (dry and fresh matter, plant diameter and leaves number), which may be related to higher susceptibility to precocious bolting, due to climatic conditions in which they were grown.

Cultivar 4 Estação presented highest yield 33.89 t ha^{-1}, however, it didn't statistically differ from Simpson S. Preta, Baba de Verão, Maravilha de Inverno, Grandes Lagos, Crespa Palmas, yet, the cultivar which provided lowest average related to yield was Hanson 22.18 t ha^{-1} (Figure 2F). Values obtained in this experiment were inferior to the ones observed by Domingues Neto et al. (2014), in cultivar Grandes Lagos, with 59.20 t ha^{-1}. It was also checked in Schumacher et al. (2012) experiment, who evaluated productive behavior in six lettuce cultivars in Jataí-Goiás conditions, that highest yield was obtained by cultivar Veneranda (297.05 g plant^{-1}).

The two first canonic variables allowed to explain 93.5% of variance contained in lettuce cultivars original variables, which Can1 was responsible for 80.4% and the second, Can2, was responsible for 14.9% of the data variations (Figure 3). Therefore, the first two main compounds effectively summarize total sample variance and can be used to the study of data set (Hongyu et al., 2016). according to Rencher (2000), at least 70% of total variance must be explained by first and second main compounds.

According to first canonic variable the most prominent feature was DIAC that along with DC and PRODT presented positive and similar contributions to Can1, applied to cultivars Crespa Palmas, Grandes Lagos and Maravilha de Inverno (Figure 3). This was verified by variables which have longest length vector and which were closer to axis Can1 (Hongyu et al., 2016), besides forming sharp angles among each other, which features high correlation existence.

The NF presented associations close to 4 Estação, Baba de Verão and Hanson. The ALTCAU was only associated to Simpson S. Preta and with great contrast with other variables (Figure 3).

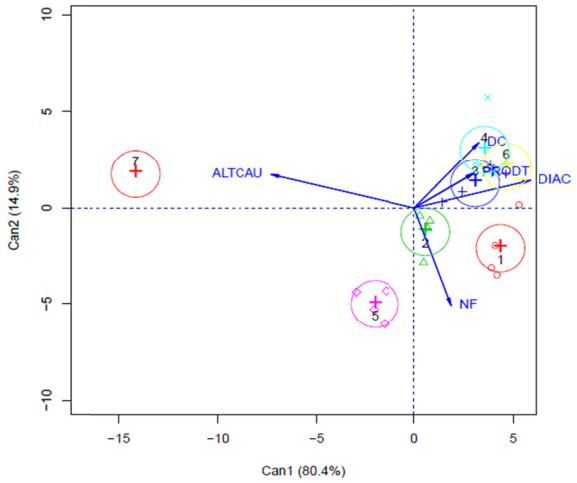

Figure 3. DIAC average canonic variable analysis: ALTCAU: stem height; DC: head diameter; NF: leaves number; PRODT: productivity. In lettuce cultivars 1: 4 Estação; 2: Baba de Verão; 3: Crespa Palmas; 4: Grandes Lagos; 5: Hanson; 6: Maravilha de Inverno; e 7: Simpson S. Preta. Mineiros-Goiás, UNIFIMES, Brazil, 2019

In the correlation network analysis it can be observed that there wasn't any negative interaction among variables, and that head fresh weight and productivity presented highest correlation and positive magnitude among variables (Figure 4).

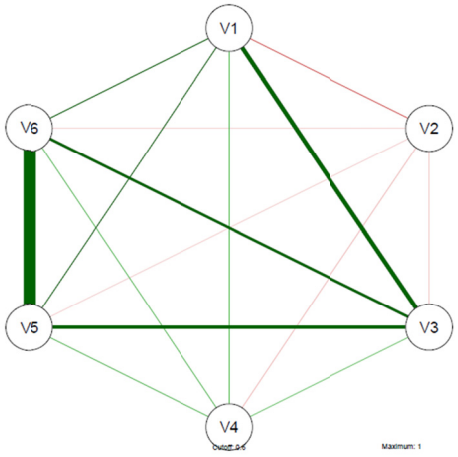

Figure 4. Lettuce features phenotypic correlations network. The red lines represent negative correlations and the green ones represent positive correlations. The line thickness is proportional to correlation magnitude. The highlighted line present in higher module than 0.6. Variables = V1: stem diameter; V2: stem height; V3: head diameter; V4: leaves number; V5: head fresh weight; and V6: productivity. Mineiros-Goiás, UNIFIMES, Brazil, 2019

Amogn lettuce cultivars, analysed in similarity dendrograms, 5 groups were observed, highlighting the ones individually formed by 4 Estações, Maravilha de Inverno and Hanson (Figure 5). Lettuce groups formation is opportune to producers, because assertive options in decision making at cultivar choice are extremely important to activity success.

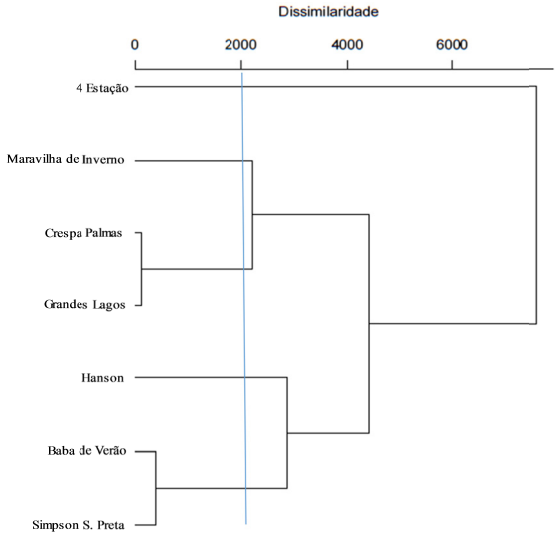

Figure 5. Representative similarity dendogram among evaluated lettuce cultivars, obtained by nearest neighbor technique, based on Euclidian distance. Mineiros-Goiás, UNIFIMES, Brazil, 2019

4. Conclusion

The 400 kg ha^{-1} rock dust dose didn't make any effect in lettuce cultivars Solta Crespa (Vanda) and Repolhuda Americana (Lucy Brown). However, new studies must be done, or even, conducted for a longer period of time, once that, rock dust nutrients mineralization occurs very slowly, not interfering in lettuce first cycle.

Cultivar 4 Estação presented good environmental adaptability to agroclimatic conditions in Goiás South West, more specifically in Mineiros, recommending it's cultivation in Summer-fall, moment this experiment was developed. However, new studies must be developed aiming to identify new potential materials to the region, providing genetic amplitude to the producer.

Multivariate analysis is an efficient strategy to explain lettuce culture phenological cultivars variability.

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