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Influence of Chromolaena odorata Mulch on Amaranthus hybridus L. Yield Under Agro-ecological Conditions of Gbado-Lite, Democratic Republic of the Congo

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Abstract: *The aim of this study was to evaluate the effect of Chromolaena odorata mulch on the yield of Amaranth under the agroecological conditions of Gbado-Lite. The experimental design chosen was that of randomized complete blocks with 3 replications and each of these replications had 4 plots or 4 treatments. The treatments were as follows: T0: control plot (no amendment); T1: mulching at 18 kg per plot or 25 t/ha; T2: mulching at 36 kg per plot or 50 t/ha; T3: mulching at 54 kg per plot or 75 t/ha. The results show that with mulching, in the first trial, 6.7; 8.8; 16.5 tons per hectare were obtained; however, in the second trial, or by exploiting the residual effects, 1.8 tons per hectare were obtained; 15; 18.3; and 37.1 respectively for the control plots; plots mulched with 25 t/ha of Chromolaena odorata; with 50 t/ha of C. odorata and with 75 t/ha of C. odorata. The experiment demonstrated that mulching improves the yield of amaranth and especially its residual effects on the crop.*
Keywords: *amendment; structure; texture; amaranth; Gbado-Lite, Democratic Republic of the Congo*

I. Introduction

The center of origin and domestication of amaranth is in Central America and Mexico. The plant was introduced several centuries ago in tropical Africa and has diversified into a wide range of local cultivars (De Lannoy, 2001).

Amaranths are annual plants, some species of which are cultivated as vegetables, for their edible spinach-like leaves or for their seeds, and sometimes as ornamentals for their spectacular spike-like flowering (Gbessemehlan et al., 2022).

Amaranth is one of the most popular leafy vegetables in tropical Africa, sold at market level as bundled branches. The cooked leaves are consumed in many different ways according to local habits as a vegetable, soup or sauce. To avoid significant losses in vitamin C (De Lannoy, 2001).

The whole plant is a good fodder for poultry and yard animals. This plant is not traded internationally, but it also occupies an important place in the diet of the peoples of the coastal areas of the Gulf of Guinea, Benin, Nigeria, Congo and the Democratic Republic of Congo (CIRAD-GRET, 2007).

Soils change in appearance and function because they are born, then mature, i.e., they become richer, then older and finally poorer. Through their activities, human societies strongly influence these dynamics following direct interventions, by the farmer who clears and cultivates; but also, following indirect interventions through the channel of climatic modifications, the composition of the atmosphere and their consequences on biological activities (El Mazi et al., 2021).

In the tropics, communities have home gardens to grow vegetables and fruits. This provides healthy and affordable food, as vegetables are necessary foods for both children and adults. They balance the diet and make it more appetizing. They allow people not to depend regularly on stores and markets where the supply is insecure and the price very high, and on the other hand, the vegetable is the source of income (Dupriez, 2000; Waaijenberg, 2004).

However, tropical soils have a low organic matter content and high acidity that justify the low crop yields, especially of amaranth. To circumvent this gradual decline; many Western market gardeners' resort to mineral fertilizer which is expensive and presumed to be polluting; the others to the amendment method which allows to return to the soil the elements that are exploited by the crops by limiting the maintenance of soil productivity in the farming environment (Dupriez and De Leener, 2009; Ognalaga et al., 2015).

For this reason, this study is based on the use of Chromolaena odorata mulch, a plant invading the savannahs in the agro-ecological region of Gbadolite in order to restore the fertility of the garden soil and consequently, improve the yield of leafy vegetables in appreciable quantity (Ngbolua et al., 2019; Ngbangu et al., 2019).

The objective of the present study is to verify the influence of increasing dose of C. odorata mulch on amaranth yield. Specifically, whether the use of the residual effect of this mulch could improve vegetative parameters and consequently, increase leaf yield under the ecological conditions of Gbadolite.

II. Review of Literature

2.1. Setting

This study was conducted in Gbado-Lite, North Ubangi Province, Democratic Republic of Congo, at 50 Pangoma Villas for 2 months for the first trial and 19 days for the second trial. The geographical coordinates of the experimental field were taken by GPS and are as follows Latitude North 4° 15' 46" and Longitude East: 20° 59' 40"; at an altitude of 406 m.

The town of Gbado-Lite is located in the Aw2 climate, according to the Köppen classification, which has two seasons: The dry season: 4 months, from November 15 to March 15 and from June 15 to July 15 respectively, the long and short dry seasons. The rainy season: 8 months, from 15 March to 15 June and August to 15 November, the short and long rainy seasons respectively. The soil is generally of the sandy-clay type (IPAGRI North-Ubangi, 2015; Molongo et al., 2014).

The vegetation was once characterized by an evergreen rainforest; but under anthropogenic action, it has been replaced by a grassy Savanna with Imperata cylindrica, Penisetum purperum, Chromolaena odorata. The relief is composed of plateaus, hills and plains. Rainfall is relatively abundant with an annual average of over 1600 mm (Molongo et al, 2015).

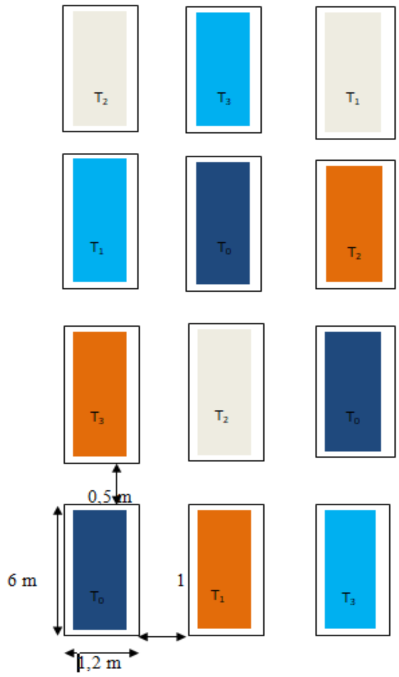
2.2 Material

The material that was the subject of this study consisted of the seed of amaranth from a farmer's field, a local variety and the straws were obtained from Chromolaena odorata, of the asteraceae family; a very invasive plant in the agricultural region of Gbadolite, North Ubangi in the Democratic Republic of Congo.

III. Research Methods

The experimental design chosen was that of randomized complete blocks with 3 replications and each of these replications had 4 plots or 4 treatments. The treatments were as follows: T0: control plot (no amendment); T1: mulching at 18 kg per plot, i.e. 25 t/ha; T2: mulching at 36 kg per plot, i.e. 50 t/ha; T3: mulching at 54 kg per plot, i.e. 75 t/ha.

The experimental set-up for illustration purposes is presented in Figure 1.



Legend: T0: control plot (without amendment); T1: mulch at 18 kg per plot, i.e. 25 t/ha; T2: mulching at 36 kg per plot, i.e. 50 t/ha; T3: mulching at 54 kg per plot, i.e. 75 t/ha.

Figure 1. *Experimental Device of the Test*

After delimitation, the following farming practices were adopted: mowing, plowing, preparation of transplanting seedbeds which are 7.2 m2 beds, i.e. 1.2 m wide and 6 m long . The flowerbeds were treated and mulched with C. odorata according to the respective doses after weighing using an electronic scale. The seedlings were transplanted after 15 days in the seedbed-nursery as shown in Figure 2.

Figure 2. *Ploughing, Weighing Straws, mulching with Chromolaena odorata, Watering and Transplanting*

2.4 The Parameter

Observations were made on:

The following vegetative parameters: diameter at the collar using calipers; plant height using tape measure; number of leaves by counting; length of leaves using tape measure as shown in Figure 3.

Yield parameters: plot yield in leaves (in kg/m2) by weighing with the precision balance and yield in tons per hectare.

Figure 3. *Plant height sampling, vigor of control subjects and subjects installed on plots mulched with Chromolaena odorata*

It is noted that this parameter was observed both on the effect of mulching and its residual effect.

2.5 Statistical Analysis

The data of this study were collected, processed and the results were treated with the software SPSS 20.0. They were analyzed using the Analysis of Variance a single criterion of classification without sampling; the F test of Snedecor and finally the test of Tukey in order to identify the difference between the treatments at the threshold of probability of 0.05.

IV. Discussion

4.1 Results

a. Diameter at the Neck (in cm)

The basal diameter of the plant in relation to the trials was taken and the results are presented by figure 4.

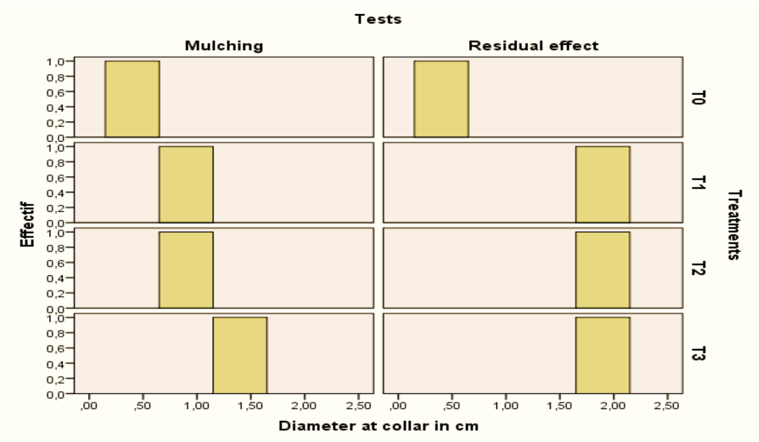


Figure 4. Diameter at the Crown (in cm)

From this figure 4, it can be seen that the smallest diameter was obtained from the control plot and the largest from plots mulched with Chromolaena odorata in both the first and second trials.

b. Plant Height

The plant height in this study was evaluated and the results are shown in Figure 5.

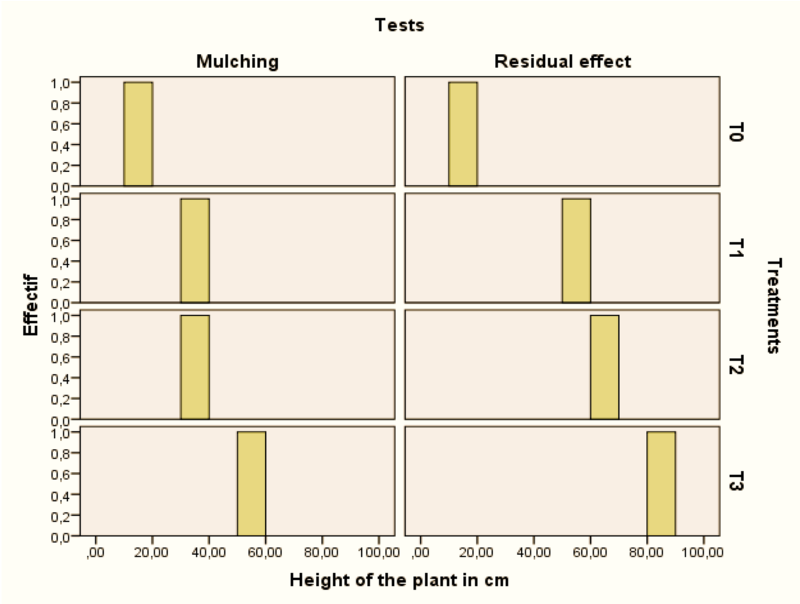


Figure 5. *Plant Height (in cm)*

With respect to Figure 5, height followed the same trend as basal diameter, which was one of the performance parameters. Taller plants were found on mulched plots; this growth was proportional to the increasing dose of straw. The extremes of height were 17 cm at 52.5 cm and 14 cm at 82.5 cm for the first and second trial height, respectively.

c. Leaf length (in cm)

Leaf length was measured and the results are plotted in Figure 6.

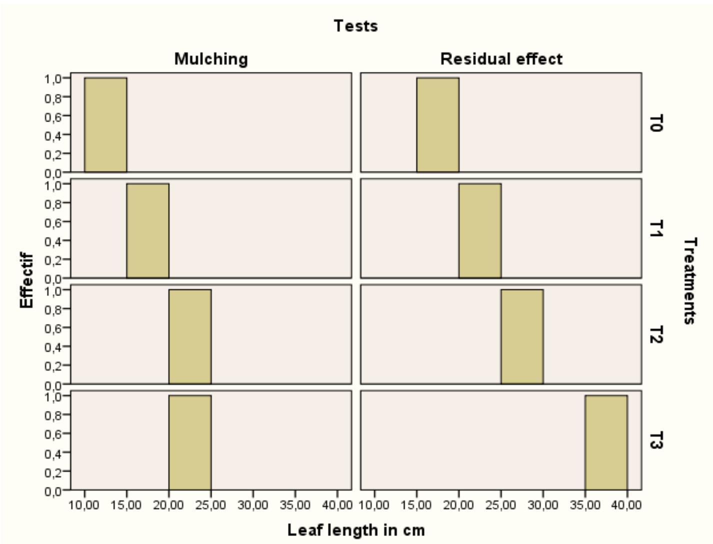


Figure 6. *Leaf length (in cm)*

d. Average Number of Leaves per Plant

The potentiality of leaf emission was evaluated and the results are recorded in Figure 7.

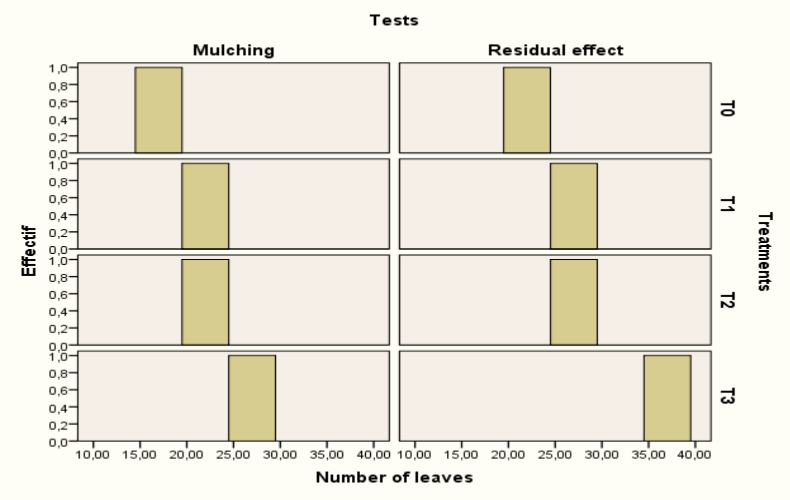


Figure 7. *Number of leaves per Plant*

It was stigmatized that the average number of leaves of the subjects was smaller than the subjects that received mulch.

e. Leaf Yield (in tons per hectare) at Mulching

The plot yields were extrapolated in tons per hectare and the results are presented in Figure 8.

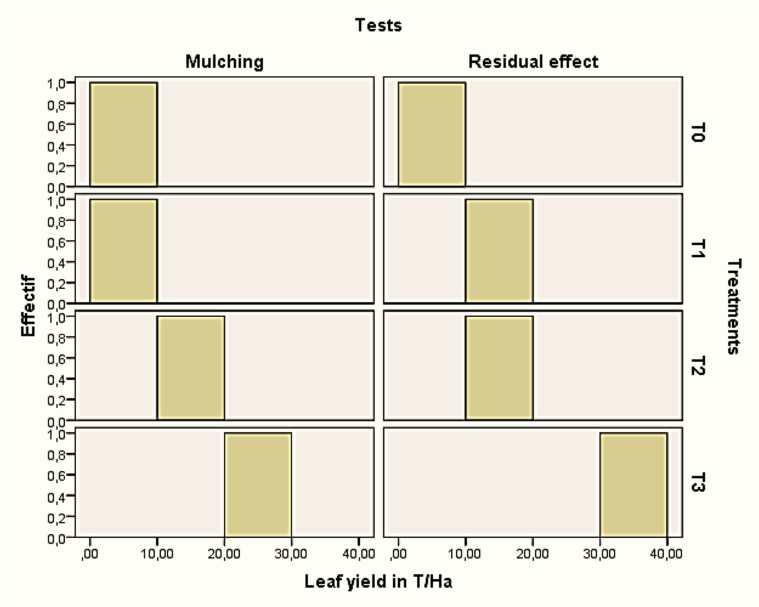


Figure 8. *Leaf Yield in Tons per Hectare*

It was obtained during this experimentation in the first trial, in ton per hectare, 6,7; 8,8; 16,5; however, in the second trial or exploiting the residual effects, 1,8; 15; 18,3; and 37,1 respectively for the control plots; plots mulched with 25 t/ha of Chromolaena odorata; with 50 t/ha of Chromolaena odorata and with 75 t/ha of Chromolaena odorata.

It is noticeable that the plots mulched with this plant species gave a higher yield and proportional to the quantity of straw. In addition, the residual effects were beneficial to the plant because it is a period that coincides with the moment of decomposition of these phytomasses useful to the physiology of the plant.

4.2 Discussion

The purpose of this study was to observe the influence of Chromolaena odorata mulch on amaranth yield under Gbadolite conditions.

a. Diameter at the Plant Collar

It was observed that the basal diameter regressed more in the second trial, on the other hand that of the mulched or treated plots took on the contrary the larger diameter. This situation is justified by the effect that in the second trial, the straws were completely decomposed and therefore they produced useful minerals to contribute to the increase of basal diameter. This increase was proportional to the dose of straw administered; thus, in the first trial we obtained 0.5 cm and 1.5 cm respectively for the control and for the mulched plot at 54 kg of biomass; in the second, we obtained 0.4 cm and 2.0 cm respectively for the control plot and for the residual effect of the mulched plot at the same dose as the first trial.

The basal diameter of amaranth at mulching was greater than 10.5 mm obtained by Mabwadi (2014) using the residual effect of hot compost; that is, in the first trial the phytomasses were in the humification stage, which does not allow them to release biogens in an optimal manner for their physiology (Dupriez and De Leener, 2009)

b. Height of the Plant

It was stigmatized that in the first trial, the plants were less tall than in the second. In all trials, the height of the plants was higher than 28.5 cm (Mabwadi, op. cit). This supports the contention that C. odorata is rich in nitrogen, which is responsible for the growth of the plant, especially the leaves, the stem and the dark green color of the foliage. In addition, vegetables grown for their leaves such as amaranths particularly require large amounts of nitrogen for soil improvement and to promote foliage growth (Waaijenberg, 2004).

Statistical analysis showed that the treatments were different, a decision such as T0 T1 T2 T3 resulted; that is, the best treatments were an amount of 75 t/ha and 50 t/ha followed by 25 t/ha during this experiment.

c. Length of the Leaves

It is apparent that the leaves in the first trial were shorter than in the first trial; in the second trial of this study, the leaf length was more than 18.6 cm and 20.7 respectively the leaf length of the residual effect and the primary effect of cold composts (Ngbolua et al., 2019).

In terms of number of leaves, the trend was similar to that of plant height according to Tukey's test.

d. Number of Leaves by the Plant

It was observed that the number of leaves correlated with the dose of straw. This number was greater than 14 to 16 found by Mabwadi (2014).

e. Yield

It is worth noting that the highest yields were obtained by mulching the plot at 54 kg and 36 kg on a 7.2 m2 plot. The best treatment in relation to these treatments were mulching at 36 kg and 54 kg per plot; yields greater than 25 t/ha for a single harvest but less than 50 t/ha for several harvests (CIRAD-GRET, 2007).

This situation is justified by the effect of mulching the soil, this technique has allowed to modify the physical state of the soil by acting on its degree of loosening, permeability and moisture because this soil was composed of clay which is a very fine particle, sand, coarser particles and humus, organic matter partially decomposed likely to improve the physical state of the soil by increasing the humus by bringing nutrients essential to crops (Birre, 1959).

Mulching consists of spreading a layer of straw, long straw manure, grasses, maize or millet stalks, etc., on the seedling soil and around the plants. After some time, the mulch rots and gives humus. Note that the mulch should never touch the stems of the plants to prevent them from rotting. Straw can attract termites. Do not mulch with materials that are infected with insects or diseases (Waaijenberg, 2004).

This technique is more or less perfected for making composts, which are very interesting for maintaining and improving soil structure (Dupriez and de Leener, 2009; Dupriez, 2000).

It was observed that the control plots in the first trial yielded more than the second trial in terms of crop response to the residual effect of mulching to C. odorata. This was consistent with the thesis that the crop affects initial soil fertility (Inckel et al., 2005).

Mulching is a very old practice that consisted in covering the soil with a material intended to protect it in order to increase production. Traditionally, straw is used in this case, the layer can be of a thickness varying from 5 to 10 cm. When a good mulch is used, shading is often not necessary. The mulch protects the plants from drought and is an important source of humus. This biological process of conversion and valorization of organic matter that are by-products of biomass, organic waste of biological origin; allows to have a stabilized, hygienic, potting soil-like substrate, rich in humic compounds (Edoukou et al., 2013).

This technique is one of the solutions to the problems of tropical agriculture because it controls weeds that it deprives of light; conservation of soil water through increased infiltration and decreased evaporation; contribution of organic matter and fertilizing elements. In addition, the data show the beginning of an improvement in carbon and nitrogen content under legumes, which improves certain key parameters such as cation exchange capacity (Inckel et al., 2005).

These results corroborate the thesis that organic manures not only enrich the soil with mineral elements, but also contribute to the improvement of the structure of vegetable soils (Ognalaga et al., 2015).

Straw as a soil cover, constitute carbon and nitrogen compounds that are easy to mineralize or form stable complexes with the clay fraction give rise to organic matter that play important functions such as participating in the alteration of rocks and minerals; to the migration of the constituents; to facilitate the aggregation of the constituents and the porosity of the assemblies; moreover, they are sources of food for the plants, they retain, then give back to the plants, the water and the fertilizing elements for their growth and their development (N' Dayegamiye and al. , 2005; CIRAD-GRET, 2007; Tshinyangu et al., 2017).

The statistical analysis yielded the following decision: T0 T1 T2 T3; mulching at 75 t/ha was different from those at 50 t/ha and 25 t/ha and these different from control both at primary mulching and residual effect.

V. Conclusion

This study was initiated to evaluate the effect of Chromolaena odorata mulching on the yield of amaranth (Amaranthus hybridus L.) under the agroecological conditions of Gbadolite.

The results suggest that with mulching, it was obtained in this first trial, in tons per hectare, 6.7; 8.8; 16.5; however, in the second trial or exploiting the residual effects, 1.8; 15; 18.3; and 37.1 respectively for the control plots; plots mulched with 25 t/ha of Chromolaena odorata; with 50 t/ha of Chromolaena odorata and with 75 t/ha of Chromolaena odorata.

The experiment demonstrated that mulching improves amaranth yield and especially its residual effects on the crop.

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