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Research Article

PERFORMANCE OF DIFFERENT ORGANIC FERTILIZERS ON THE PRODUCTION OF THE AMARANTH *(AMARANTHUS HYBRIDUS L) ON SANDY SOIL IN THE SOUTH OF BENIN*

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A B S T R A C T

The urban and suburban farming takes place very widely on sandy soils in the south Benin. In this activity, producers are confronted to problems, diseases, parasitic attacks and soil fertilization particularly. However, this farming needs organic material to improve the soils and maintain their fertility under intensive crops/cultures. The goal of the survey conducted at Sèmè-Podji on sandy soil in South Benin is to assess the performance of five (5) sources of organic fertilizers (compost with guano and ruminant's litter, poultry droppings, cow dung, the combination compost/poultry droppings and the compost/cow dung) on the growth, the yield and the parasitic attacks on the cultivation of the *Amaranthus hybridus.* The experimental arrangement/mechanism/system put in place is a two factors split-plot. The first factor is the type of crop used (Amaranth) and the five sources of organic fertilizers represent the second factor. Thus we have, the sample included, six (06) treatments that are repeated four (04) times; which gives 24 experimental units. The results showed that the poultry droppings and the compost with guano and ruminant's litterhave had a sensitive effect on the growth in number of the amaranth leaf. On the other hand, all treatments have significantly influenced the growth in height of the amaranth seedlings. So the different organic fertilizers have influenced the yield of the amaranth with a significant difference at the threshold of 5% contrary to the sample. But the poultry droppings and the compost with guano and ruminant's litter have had a yield in weight higher than the other treatments. Besides, the compost has sensitively reduced the pest attacks. So the compost has been identified as the fertilizer qualified to improve the soil fertility and also a good fertilizer for the plant.

INTRODUCTION

For several years now, the soil fertility in market gardening areas decreases because of the progressive reduction of their rates of organic material and their unprofitable mineral balances (Dagbenonbakin, et al, 2012). The soil fertility management implies the use of chemical fertilizers, organic or a combination of the two (02) kinds of fertilizers. Malhi *et al,* (2006) notices that the valorization of the crop residue can contribute in a determining way to ensure the keeping of the fertility of the cultivated soils. Likewise, the sustainability of the culture systems relies on/is based on the rational management of the soil fertility (Crozier *et al,* 2004; Girma *et al.*2007; Ouattara *et al.*2006; Igué *et al.*2008; 2010).

In Benin, several authors have studied the effects of the compost based on plants, droppings and animals' manure on the vegetable crops. Cédric (1997) has used the compost made of household garbage and manure on the amaranth and the radish grown on ferriferous/ferralitic/iron-bearing type soil following the input of three organic fertilizers. Kounde (1998) has applied to the head cabbage, compost made of bush hay, cattle's manure and organic waste of household garbage. Mallouhi (1993) has tested the compost made of peat and poultry droppings on peanut. Assogba-Komlan (2007) identified three types of organic fertilizers as the main sources of organic materials used by the market gardeners of the south Benin, in the production of leafy vegetables: poultry droppings, cow dung and household garbage. The direct application without composting of those different kinds of organic materials is the most observed practice. But the usage of the composts produced by a combination of those organic materials and of plant materials also improves the soils' properties, nourishes the crops and protects them from diseases.

The usage of compost supplies nutrients and micronutrients in a good proportion to the plants for them to use. It's a natural

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fertilizer for the plantings and the vegetable crops, (Guérin, 2007). It plays an important role in the durability of the fertility, and thus for a lasting farming production. However, the study is called on regarding the knowledge of the needs of different crops in nutritive elements, and the levels of soils in those elements, the fertilizing properties of biological fertilizers, and the mineralizing of the organic material, in order to determine the most suitable fertilizing method. The goals of the present study, realized on sandy soils in Sèmè-Podji in South-Benin from July 2014 to December 2014 are the following:

1. Estimate the effect of five (05) organic fertilizer sources on the growth of the *Amaranthus hybridus,*
2. Study the effect of five (05) fertilizer sources on the yield of the *Amaranthus hybridus,*
3. Assess the risk of parasitic attacks according to five (05) organic fertilizer sources.

Location of the Study Site

The study has been realized in the municipality of Sèmè-Podji, on the vegetable/market gardening village of Sèmè of AMAP-Benin. Located between 6°22' and 6°28' of North latitude and 2°28'and 2°43' of East longitude, the Municipality of Sèmè-Podji is in the Department of Ouémé, at the South-East of the Republic of Benin, on the Atlantic coast. (Figure1)

The municipality has a Sudanese-Guinean weather characterized by two (02) dry seasons (December to February and August to September) and two (02) raining seasons (April to July and October to November).

Composting

The compost made of ruminant's litter and guano manufactured anaerobically has been produced by APAP-Bénin. According to the results of the analyses carried out in the Laboratory of Sciences Of Soils, Waters and Environment(LSSEE), this compost rich in organic material (46%) and presenting contents in N of 3,85; in P of 0,69%; in K of 0,51%, in Ca of 2,71% and in Mg of 0,73%, can be considered to have good chemical characteristics. In addition to the compost, four (04) other fertilizers have been used for the experimentation. These are the poultry droppings (F), the cow dung (B), the combination compost/poultry droppings (C+F), composed of 50% of compost C and 50% of droppings F; the combination compost/cow dung (C+B), composed of 50% of compost C and 50% of dung B.

Soil

A composite sample of soil that has not received any spreading of compost or fertilizers has been collected between 0 and 20cm depth before the setup of the test by means of auger and analyzed in the Laboratory of Soils Sciences (LSS) of the National Institute of Agricultural Research of Benin (INRAB) for their physicochemical characteristics according to the methods of Tran Vin An (1978). Those analyses consisted in the determining of the grain size (5 fractions), realized by the international method modified by the use of the Robinson's pipette; of carbon defined by the method of Walkley and Black, of the total nitrogen defined by the method of Kjeldahl, of the pH level of water (pH_{water}) with the help of the pH-meter

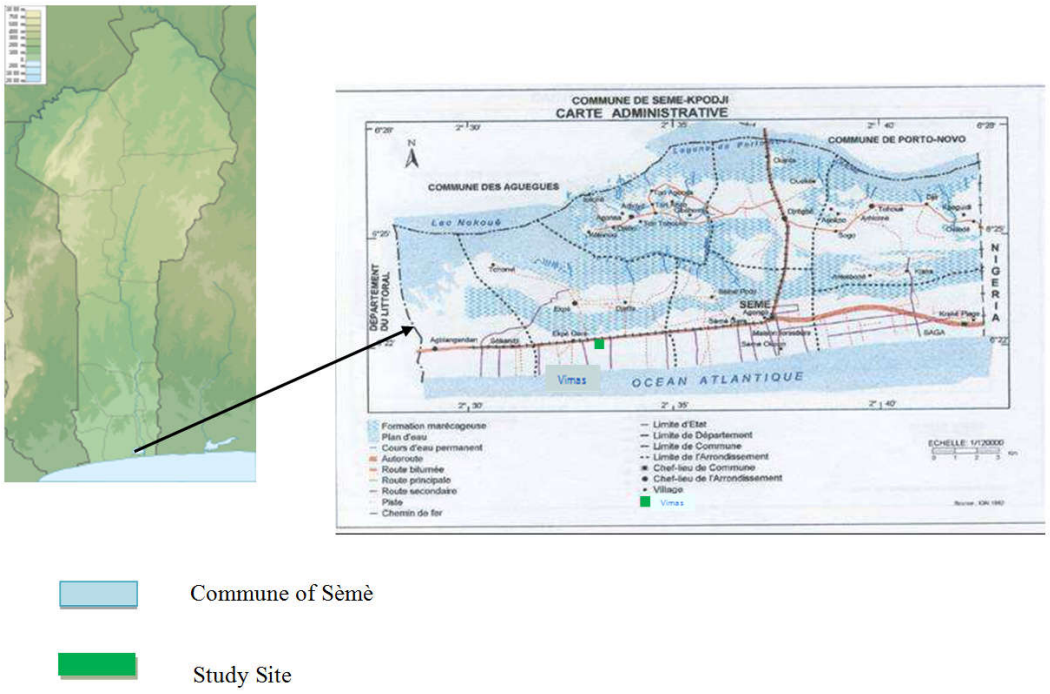

Figure 1 Administrative Map of the Commune of Sèmè-podji

Equipment and Methods

Plant material

The plant material used in the context of this study consists of a local variety of *Amaranthus hybridus*. The seeds have been bought from a company named « Bénin semence ».

with (1/2,5) as ratio soil-water, the capacity of cationic exchange (CEC), by the extraction at the level of 10% of KCI, then distillation by the method of Kjeldahl.

Experimental set-up

The experimental set-up is a split-plot with four repeated measures. The main factor is the studied crop: the amaranth.

The secondary factor is the type of fertilizer applied on the experimental units. Which gives five (05) levels (compost (C); poultry droppings (F); cow dung (B); combination compost/poultry droppings (C+F); combination compost/cow dung (C+B)). Six (06) treatments have thus been constituted and repeated four times. Then we have 6*4 = 24 experimental units (panels). The planks have a size of $2m^2$ (2m long x 1m wide) and alleys (gaps) of 0.5m are left between the planks and around the big plot.

The collected data and the setting of charts have been carried out by the Excel spreadsheet, whereas, the analyses of variance (average, structuring of the averages) have been carried out by the software Rversion 3.1.0.

RESULTS

The number of amaranth leaves, the height of the amaranth seedlings the root-collar diameter of the amaranth seedlings, the yield, the number of leaves and the number of seedlings attacked while under the application of the compost, of fertilizers, and of compost + fertilizers have been the parameters being measured through the experiment.

Effect of the five organic fertilizer sources on the number of the amaranth leaves

The number of amaranth leaves (Table 1) shows that the different types of organic fertilizers have highly significant effects (P<0,01) on the number of amaranth leaves. From that same table, it stands out that fertilizerssuch as the droppings, the compost, the compost/droppings, the compost/dung and dung have shown an identical effect on the parameter 'number of leaves'.

Table 1 Analysis of variance (values of P) of the number of leaves of the *Amaranthus hybridus*

Fertilizer	Average number of leaves	Groups
F	24,7525	A
C	24,1300	A
CF	23,0425	A
CB	22,9425	A
B	16,9275	AB
T	13,1875	B
P	6,913**	

The numbers with the same letter are significantly identical and those with different letters are significantly different.
**: Difference highly significant at the threshold of 1%

Effect of the five organic fertilizer sources on the height of the amaranth seedlings

The table 2 informs us that the different types of treatments haven't had a significant effect on the growth in height of the seedlings (P 0,001). The reading of that same table indicates that all the fertilizers are equal in terms of influence on the growth in height of the seedlings. Comparatively to the control plot, none of the used organic fertilizers allows a difference in height.

Table 2 Analysis of variance (values of **P**) of the height of the seedlings of the *Amaranthus hybridus*

Fertilizer	Average Height (cm)	Groups
F	6,4350	A
CB	6,2425	A
C	6,0350	A
CF	5,8975	A
B	5,0950	A
T	4,1000	A
P	7,951 ns	

The numbers with the same letter are significantly identical and those with different letters are significantly different.
ns = non significant

Effect of the five organic fertilizer sources on the root-collar diameter of the amaranth seedlings

From the reading of the table 3 it comes out that the different types of organic fertilizers applied to the amaranth seedlings have had very highly significant effects on the growth in root-collar diameter of the seedlings (P 0,001). So, the table reveals that the root-collar diameters observed at the seedlings on the plots that have received organic fertilizers are identical. But they are significantly different comparably to the control plot.

Table 3 Analysis of variance (values of**P**) of root-collar diameter of the seedlings of the *Amaranthus hybridus*

Fertilizer	Average diameter (mm)	Groups
F	4,8950	A
C	4,6125	A
CF	4,6025	A
CB	4,5925	A
B	3,8600	AB
T	3,3425	B
P	12,506***	

The numbers with the same letter are significantly identical and those with different letters are significantly different.
***: Difference very highly significant at the threshold of 0,1%

Effects of the five fertilizer sources on the yield of the Amaranthus hybridus

The reading of the table 4 shows that the organic fertilizers have had significant effects (P 0,05) on the yield in weight of the seedlings at the harvest; the average yield of the *Amaranthus hybridus* under the effect of the different types of organic fertilizers used. From this table, it stands out that the droppings, the compost and the combinations: compost/ droppings and compost/dung give identical yields. On the other hand, the droppings and the compost allow having a good yield comparatively to the dung and to the control plot.

Table 4 Analysis of variance (values de **P**) of the yields of the seedlings of the *Amaranthus hybridus*

Fertilizer	Average yield (g)	Groups
F	815,00	A
C	730,00	A
CF	650,00	Ab
CB	612,50	Ab
B	196,25	B
T	190,00	B
P	4,3192*	

The numbers with the same letter are significantly identical and those with different letters are significantly different.
*: Difference significant at the threshold of 5%

Effect of the five organic fertilizer sources on the parasitic attacks of the amaranth

Assessment of the number of leaves attacked per seedlings: Case of Tetranychus spp

The analysis of variance established in the table 13 shows that the different organic fertilizer sources haven't had significant effects (P<0,01) on the number of leaves attacked per *Tetranychu sspp*. From that same table, it is to be noticed that the different types of organic fertilizers used show an identical behavior when it comes to the number of leaves attacked.

Table 5 Analysis of variance (values of**P**) of the number of attacked leaves per *Tetranychus spp*

Fertilizer	Average number of attacked leaves	Groups
T	4,0700	A
CB	4,0550	A
B	3,9100	A
CF	3,8125	A
F	3,5400	A
C	3,2975	A
P	4,9986 ns	

ns = non significant

Assessment of the number of leaves attacked per seedlings: Case of Spoladea recurvalis

The number of leaves attacked per *Spoladea recurvalis*(Table 6) shows that the different organic fertilizer sources used, have highly significant effects (P<0,01). Indeed, the plots that received the dung, the combinations: compost/droppings, compost/dung and the control as treatment have had a similar behavior face to the attack of the leaves per *Spoladea recurvalis*. On the contrary the plot that received the combination compost/dung has been the most attacked as opposed to those that received compost and droppings that are the least attacked.

Table 6 Analysis of variance (values of P) of the number of leaves attacked per *Spoladea recurvalis*

Fertilizer	Average number of leaves attacked	Groups
CB	3,1400	A
B	2,9350	Ab
T	2,9000	Ab
CF	2,5625	Ab
C	2,4275	B
F	2,3800	B
P	7,2052 **	

**: Difference highly significant at the threshold of 1%

Assessment of the number of seedlings attacked per plank: Case of Tetranychus spp

The results of the analysis of variance (Table 7) reveal that the different fertilizers used have no significant effect on the number of seedlings attacked. So, irrespective of the treatment, the seedlings of the amaranth show an identical behavior confronted to the attack per *Tetranychus spp*.

Table 7 Analysis of variance (values of**P**) of the number of seedlings attacked per*Tetranychus spp*

Fertilizer	Average number of seedlings attacked	Groups
B	0,875	A
T	0,862	A
CB	0,860	A
CF	0,845	A
F	0,820	A
C	0,807	A
P	1,1608 ns	

ns = non significant

Assessment of the number of seedlings attacked per plank: Case of Spoladea recurvalis

It is noted that the different fertilizer sources used (Table 8) have not had a significant effect (P<0,05) on the amaranth seedlings. The reading of that same table reveals that all the six treatments have then an identical effect on the parameter 'number of seedlings attacked on the amaranth.

Table 8 Analysis of variance (values of**P**) of the number of seedlings attacked per *Spoladea recurvalis*

Fertilizer	Average number of the seedlings attacked	Groups
B	0,8000	A
CB	0,7850	A
T	0,7475	A
CF	0,7125	A
C	0,7050	A
F	0,6925	A
P	3,0118 ns	

ns = non significant

DISCUSSION

The different organic fertilizers have had a highly significant effect at the threshold of 1% on the growth of the amaranth. Among all the fertilizers used for the purpose of our study, only the poultry droppings and the compost with guano and ruminant litter have presented the highest number of leaves comparatively to the other fertilizers and to the control. These two fertilizers have then had a sensitive effect on the growth in number of leaves of the amaranth. This result is also observed at the growth in height and that of the root-collar diameter at the threshold of 0,1%. A similar work done by Agbossou et al 2003 on the carrot showed that the input of organic material has for effect to stimulate the rate of growth. These results are due to the high rate of nitrogen of those two fertilizers, such as 4% and 3,85% for the droppings and the compost respectively. According to the classification established by the CIRAD 2006, those rates are 40kg/t of nitrogen and 38.5kg/t of nitrogen respectively, which characterize organic matter rich in nitrogen. These results match those of Biaou (2009) and of Assea (2012), who have found that the fertilizers rich in nitrogen induce an increase of the number of leaves.

However, it is to be noticed that the combination compost/droppings have given best results on the growth of the amaranth compared to the combination compost/cow dung and to the cow dung. This is due to the high nitrogen content in the droppings and the compost. According to the CIRAD 2006, the cattle dung contains 6.2kg/t of nitrogen, which classifies it in the category of the organic matters with average nitrogen content: hence a low fertilizing ability.

In the light of those results, it stands out that the input of organic matter plays 2 roles: it increases the organic matter content of the soil by improving the physicochemical fertility (ability of water retention, the soil structure, the humus content, the ability of cationic exchange) and biologic (biodiversity), and fertilize the crops with the provided elements such as the nitrogen, the phosphorus and the potassium. So the nitrogen stimulates the vegetation and accelerate the formation and the growth of the vegetative organs od the seedlings (Aho et Kossou, 1997).

The different organic fertilizers have influenced the yield of the amaranth with a significant difference at the threshold of 5% contrarily to the control without fertilizer application. Which means that the production of the amaranth depends on the fertilizer application. This result is in conformity with the result of Houenou (2012) on the production of the big nightshade. But the highest yield of the amaranth has been registered with the poultry droppings (0.815g) comparably to the four other fertilizers. These results are justified by the richness in nitrogen of the droppings, which is another determining factor of the yield of the plants (Magnan, 2006). So the C/N of the poultry droppings is close to 10 McClintock, (2005) and the CIRAD 2006 indicate C/N of 4 to 8 corresponding to a rapid mineralization of the nitrogen, which besides being present in sufficient quantity, will quickly be available for the plants. The plant, having its needs satisfied, will be able to have a quick growth and a high yield. The input of compost had superior results on the yield of the amaranth, contrary to the control. Those results match those of Fassinou (1996) and Amadji (2001), which have highlighted the positive effect of the compost on the production of vegetable crops and on the subsistence crops. They are also similar to those of Chitou (2003) who compared the impact of composts on the yield of apples and the fresh biomass. The author shows that the compost based on household garbage made with the cotton grains and chicken droppings provide high results. Furthermore, the compost has been able to provide at the scale of one plank, a higher yield compared to the droppings. This result is to correlate with a development of the seedlings superior to the one of the droppings, despite a slower growth at the beginning. Not to forget the post-test observations, which indicate a stronger fertilizing ability two weeks after the harvest. Which is due to the nitrogen contents of the compost residual in the soil and confirms the analyses of Assogba (2007), which say that the aftereffects allow the increase of the number of leaves and provide higher yields.

Moreover, the best fertilizing combination is the one of the compost combined with the droppings, which gave 0.650g comparably to the combination compost/cow dung, which gave 0.612g and of the control without fertilizer with 0.190g. This result is obtained through the influence of the compost and the poultry droppings that have high fertilizing abilities. Similar studies published by the Bulletin of Agronomic Research of Benin (Bulletin de la Recherche Agronomique) (2012) on a test where the compost combined to the complex N14P23K14S5B1 has been used, show that the fertilized plots present yields superior to those of the non fertilized control. Likewise the cow dung gave a good result compared to the control without fertilizer application, although those results are mediocre compared to the other organic fertilizers. This is probably due to the low content in fertilizing elements. In fact, from the CIRAD 2006, the cattle manure contains 6.2kg/t of nitrogen, which classify it in the category of the organic matters with average nitrogen content, hence a low fertilizing ability. Also its C/N is comprised between14 and 18, which indicates a mineralization speed lower than the compost and the poultry droppings. Thus, the low content in fertilizing elements of the dung is not quickly available to the plant.

The statistical analysis revealed for the attack of *Tetranychus spp*on the six treatments, a same number of leaves attacked, but the compost had the lowest number of leaves attacked. Which means the use of the compost reduced the attacks of the number of leaves attacked per *Tetranychus spp*. Besides the different organic fertilizers had no effect on the number of seedlings attacked per *Tetranychus spp.* So all the treatments had a same number of seedlings attacked. The same way, the compost revealed the lowest number of seedlings attacked. The usage of compost reduced then the number of leaves and seedlings attacked per *Tetranychus spp*comparably to the other organic fertilizers.

In the case of the attacks of the *Spoladea recurvalis,* the application of the poultry droppings reduced the number of leaves and seedlings attacked.

In general, the compost made possible to reduce the attack of the seedlings and leaves per *Tetranychus spp.* As for the droppings, it made possible to reduce the attack of the leaves and seedlings per *Spoladea recurvalis.* The effects of the microorganisms present in the organic matter, on the soil and on the plant, could explain this. In fact, from Dagbenonbakin (2013), the plants that grow on the soil that received only compost are more resistant to diseases than those that grow on the soil that received only chemical fertilizers. So the organic matter favors the reinforcement of the soil and plants by improving the structure and the soil properties.

CONCLUSION

The effects of different organic fertilizers used allow summarizing that the best fertilizer that ensure a durable management of soils, and favors an ecologically durable agriculture is then the compost. The latter improves the physicochemical and biological fertility of soils, while being a good fertilizer for the plants. It remains to determine the best efficient dosage for the producers.

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