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Effect of Maggot Production Residue on Amaranth Growth Parameters

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Abstract

Amaranth is one of the most consumed vegetables in Niger Republic because of its nutritional values. However, the production of this plant requires nutrient-rich soils that are becoming scarce in most agricultural soils in Niger. This study aims to evaluate the fertilizing potential of the maggot production residue of *Musca domestica* L. 1758 and bovine excrement on the agronomic parameters of *Amaranthus cruentus* L., 1759. To do this, four densities (50, 100, 150, 200 g) of maggot production residue and bovine excrement were tested. Stem length, neck diameter and leaf number were strongly influenced by the interaction of the type of treatment (maggot production residue and bovine excrement) and dose. Dose 50 and dose 150 gave the best performance in length and diameter respectively for residue (length = 42.24 ± 8.98 cm; diameter = 0.88 ± 0.17 cm) and bovine droppings (length = 39.29 ± 8.10; diameter = 0.98 ± 0.77). On the leaf number side, no significant differences were observed between the doses for the residue. For bovine excrement, this number was higher at the 150 g dose (28.12 ± 4.98). The effect of the residue and bovine excrement on each corresponding dose shows that, for the stem length, only the 50 g dose was statistically influenced by the latter ($P < 0.001$). On the neck diameter side, only the 50 g and 100 g doses were statistically influenced by bovine residue and excrement (dose 50 g: $P < 0.001$; dose 100 g: $P < 0.001$). For each of these doses, the residue recorded the best performance both for the length of the rod and for the diameter at the collar. On the leaf number side, only the dose 50 g and 150 g varied statistically according to the type of fertilizer. At the 50 g dose, the residue recorded the largest number of leaves (27.10 ± 11.15), but the residue recorded the lowest number of leaves at the 100 g dose (21.01 ± 5.99). Foliar and root biomass varied statistically according to the dose within each fertilizer (foliar biomass: residue: $P = 0.040$; bovine excrement: $P < 0.001$; root biomass: residue: $P < 0.001$; bovine excrement: $P < 0.001$). The highest leaf biomass was obtained with doses 50 and

150 respectively for residue (155.00 ± 33.91 g) and bovine excrement (123.20 ± 20.57 g). The 150 g dose gave the best root biomass performance for the residue. For bovine excrement, the dose of 150 g and 200 g gave (without any significant difference between them) the best performance in root biomass with 21.80 ± 5.48 g and 21.50 ± 4.74 g respectively. The effect of residue and bovine excrement on each corresponding dose shows that, for foliar biomass, dose 50 and 100 g were statistically influenced by the latter (dose 50: $P < 0.001$; dose 100: $P < 0.001$). At each of these doses, the residue recorded the highest leaf biomass. For root biomass, each dose was statistically influenced by the type of fertilizer except dose 200 ($P = 0.616$). For each of these doses, maggot production residue gave better root biomass performance than bovine excrement except for dose 200 where no difference between the two fertilizers was observed (residue = 20.50 ± 3.97 g and dung = 21.50 ± 4.74 g). It appeared from this that the 50 g dose was to be the optimal dose of maggot production residue to bring for a better growth of amaranth plants. Whereas, this optimal dose is 150 g for the bovine droppings used in the present study.

Keywords

Musca domestica, Maggot Residue, Amaranth, Fertilization, Niger

1. Introduction

Vegetables occupy an important place in the diversification of diets of populations in developing countries and are one of the main sources of nutrients. Regular consumption of vegetables contributes to improving the health of populations through the richness of protein and fiber but especially micronutrients such as certain minerals, vitamins and antioxidants [1] [2] [3] [4] [5]. In West Africa, cereals are the staple diet in which vegetables complement the nutritional value of the dishes consumed [6] [7] [8]. The Amaranthaceae family, native to temperate and tropical regions, offers a range of leafy vegetables of which the most widely grown in West Africa is the fast-growing amaranth (*Amaranthus cruentus* L., 1759) with large leaves [9]. Amaranth is grown intensively in urban and peri-urban market gardens for its leaves, which are rich in beta-carotene, protein, carbohydrates, calcium, iron, and vitamin C [10] [11]. Consumption of its leaves in sauce is highly recommended for children, lactating women and people suffering from malnutrition and is one of the most consumed vegetables in Niger Republic, both in urban and peri-urban areas [9]. However, amaranth production requires nutrient-rich soils, which are becoming increasingly scarce in Niger [9]. Drought and high population growth (3.3%), which adversely affect 2.5%, have led to a series of food crises (1973, 1984, 2001, 2005, 2010), resulting in increased pressure on the environment and a change in ecological balance and land degradation due to over-exploitation, often beyond the real capacity of ecosystems [12]

Most agricultural soils in Niger Republic (especially those used for rainfed cultivation) are tropical ferruginous and brown sub-arid soils characterized by sand contents varying between 80% and 90%, clay between 1% and 8%, and silt from 2% to 6% [13]. Their water retention capacity is very low, with a field capacity between 5% and 12%. They are generally acidic with a pH (water) ranging from 4.5 to 7, low in organic matter (0.15% to 0.7%), low in assimilable phosphorus (0.4 to 9.4 mg/kg soil) and low in nitrogen [14] [15] [16] [17] [18]. These are soils that are severely deficient in nutrients due in part to poor cropping practices and require an integrated system to manage their fertility. One of the methods to fertilize the soils is the application of chemical fertilizers, which are expensive and have adverse consequences on the environment and human health when misapplied [12] [19] [20].

In addition, the application of chemical fertilizers is generally only effective during the first few years of continuous application. Indeed, a decline in crop yields is observed after a few years due to the degradation of soil properties [15] [21] [22] [23].

Many insects can be used for recycling organic byproducts allowing for a reduction of organic byproducts in the environment while producing a food resource for animals and/or humans and a livestock residue considered as biofertilizer [24] [25] [26] [27]. Housefly maggots (*Musca domestica* L. 1758) are one of the best mechanisms for recycling organic waste [24] because it grows rapidly on a wide variety of organic byproducts [28]. There are very few studies on the capacity of the maggot production residue of *Musca domestica* as an organic fertilizer in crop improvement. This study main purpose of this research is *to evaluate* the fertilizer potential of *Musca domestica maggot* production residue produced on wheat bran in combination with cattle dung on the agronomic parameters of *Amaranthus cruentus.*

2. Materials and Methods

2.1. Plant Material

The plant material used is *Amaranthus cruentus* which is one of the most consumed leafy vegetables in the sub-region as it is an important source of nutrients.

2.2. Presentation of the Site

This study was conducted in the V district of the city of Niamey in an experimental plot of the Faculty of Agronomy of the Abdou Moumouni University of Niamey. The climate of the site is Sahelian with high temperatures between April and June and low temperatures between December and January. Rainfall varies from 400 to 600 mm per year, except for a few years when cumulative rainfall exceeds 700 mm. The soil of this site is generally sandy.

2.3. Origin of Maggot Production Residue and Cow Manure

The maggot production residue of *M. domestica* came from a rearing unit of the

Faculty of Agronomy of the Abdou Moumouni University (Niamey, Niger). Indeed 25,000 *M. domestica* pupae were placed in three rearing cages (75 × 75 × 115 cm; Bug Dorm, Mega View Science, Taiwan) which correspond to a stocking density of about 2.8 cm^3 per fly [29]. Cotton dipped in a mixture of powdered milk and granulated sugar (1:2 ratio), plus cotton dipped in sugar water (2:1) placed in plastic containers served as food for adult flies. The cages were placed in a room with a photoperiod of 12 h of light and 12 h of dark (12:12 L:D), a temperature of 27˚C ± 2˚C, and a relative humidity (RH) of 60% - 70% [29] [30]. Five days after adult emergence, plastic containers (83 mm diameter and 3 cm height) containing a mixture of water, wheat bran, and granulated sugar (7:2:1; moisture content) covered with filter paper (grade:50, circular, porosity:2.7 µm; Wattman, La Chapelle-sur-Erdre, France) were placed in cages, the cages (containing adult flies) as an oviposition medium [28]. The oviposition substrate was placed inside the cages for 8 hours (8.00 to 16.00 hours) to allow the flies to oviposit. The eggs were collected from the filter papers with a brush and incubated directly in trays containing the larval development substrate of wheat bran. After 6 days of larval development, the maggots were sieved, and the residue of the substrate was collected and packed in bags for further use.

The cow dung was collected from a cow shed of a cattle breeder in the city of Niamey. The sand used in the pots was collected on the river beaches and transported to the experimental field. As this sand was strongly leached by the river water, the hypothesis for its use is that it was poor in nutrients.

2.4. Chemical Analysis of Maggot Residue Samples and Cow Dung

After drying the maggot production residue and cow dung samples and grinding them, the following analyses were performed: organic matter, organic and total carbon, total nitrogen, total phosphorus, potassium and pH. After drying and grinding the samples of maggot production residues and cattle manure, different analyses were performed on the samples (Organic matter, organic carbon total carbon, total nitrogen, total phosphorus, potassium and pH). Organic matter (OM) and organic carbon (OC) were performed following the method of [31]. Total Carbon (C), total nitrogen (N), total phosphorus (P-total), total potassium (K-total) and pH (H_2O), of cow manure and maggot production residue (MPR) were determined. The pH was determined according to the ratio 1/2.5 by a suspension of substrate sample in distilled water [32]. Total carbon was determined by [33] procedure. Total N and total P were determined by the Kjeldahl digestion method [34]. Total K was determined using a flame photometer after mineralization of organic substrate samples.

2.5. Experimental Device

The trial lasted from June 23 to September 7, 2020. To set up the trial, an experimental plot of 6.00 m × 4.10 m (24.60 m^2) was delineated. Plastic containers (30 cm length and 33 cm diameter) were used. The spacing between rows and between containers in the same row was 20 cm. These pots were manually filled with sand (2/3 of the volume of the pots). The sand used was collected on the river beaches and transported to the experimental field. This sand was strongly leached by the river water, and the hypothesis is that it is poor in nutrients. The setup was a completely randomized block design with 10 replications.

Maggot production residue and cattle droppings were tested at 4 rates: 50 g; 100 g, 150 g and 200 g. The maggot production residue and cattle manure were placed in the containers and watered 24 h before sowing.

Every day, watering was done (1 liter of water per container) except on rainy days. Regular weeding was done to remove weeds in the perimeter. Weeding was performed on the 10^{th} day after seedling emergence, leaving 2 plants per container. The trial lasted for two and a half months.

2.6. Effects of Maggot Production Residue and Cow Dung on Pigweed Growth

Observations were made on plant size measured from the crown to the terminal bud, leaf count, by counting the number of leaves for all plants in each container, and crown diameter measured with a caliper. Fresh leaf biomass and fresh root biomass were also measured.

2.7. Statistical Analysis

All statistical analyses and graphs were performed on the R environment version 4.0.3. A two-factor ANOVA (α = 0.05) was used to test the effect of two fixed factors (dose and treatment) on the different measured variables (crescent parameters, leaf and fresh root biomass). Duncan's test-based comparison of means was performed to compare the means of the variables measured on the different doses according to each treatment as well as to compare the means of the treatments of these same variables according to each dose. Principal component analysis (PCA) was used to determine the relationship between growth parameters (stem length, collar diameter, number of leaves) on the discrimination of dose and treatment combination. The following R packages, agricolae and Factoshiny, were used in the analyses respectively: for univariates analysis and multivariate analysis.

3. Results

3.1. Chemical Characteristics of Maggot Production Residue and Cow Dung

The chemical composition of the organic cow dung and maggot production residue is presented in Table 1.

3.2. Effect of Dose and Treatments (Production Residue and Cow Dung) on Growth Parameters

The two-factor analysis of variance (Table 2) shows that stem length, collar

Table 1. Chemical composition of fertilizers.

Parameters	Cow dung	Maggot production residues
pH	8.49 ± 0.16	7.56 ± 0.18
Ash (%)	16.39 ± 1.22	14.23 ± 0.43
Total nitrogen (%)	4.43 ± 0.13	4.04 ± 0.18
Organic carbon (%)	4.00 ± 0.94	3.05 ± 0.06
Organic matter (%)	6.37 ± 0.23	5.27 ± 0.10
Total phosphorus (mg/l)	0.06 ± 0.01	0.02 ± 0.01
Total potassium (mg/l)	0.10 ± 0.01	0.08 ± 0.01
Total Calcium (mg/l)	0.044 ± 0.02	0.037 ± 0.01
Magnesium (mg/l)	0.03 ± 0.01	0.02 ± 0.01

Table 2. Summary of the two-factor analysis of variance.

Parameter	Factors	DF	F	P-value
Stem length	Treatment	1	4.961	0.027
	Dose	4	49.964	P < 0.001
	Treatment: dose	4	13.223	P < 0.001
Diameter at the collar	Treatment	1	2.498	0.011
	Dose	4	15.969	P < 0.001
	Treatment: dose	4	5.169	P < 0.001
Number of sheets	Treatment	1	0.166	0.684
	Dose	4	18.357	P < 0.001
	Treatment: dose	4	7.940	P < 0.001

diameter, and leaf number are strongly influenced by the interaction of treatment type and rate.

Stem length and collar diameter varied significantly with the rate applied for each fertilizer (**Table 3**—vertical comparison). For the number of leaves, no significant variation was observed as a function of the dose for the maggot production residue (P = 0.621) in contrast to the bovine manure (P < 0.001).

For residue, the highest stem length was obtained at the 50 g dose (42.24 ± 8.98 cm) and the lowest at the 200 g dose (29.83 ± 10.66 cm). For cattle dung, the stem length was highest at the 150 g dose (39.29 ± 8.10) and lowest at the 50 g dose (24.36 ± 5.29 cm)

For the residue, the diameter at the collar was higher at the 50 g dose (0.88 ± 0.17 cm) and lower at the 200 g dose (0.72 ± 0.18 cm). For cattle manure, the diameter is larger at the 150 g dose (0.98 ± 0.77) and smaller at the 50 g dose (0.56 ± 0.06). As for the number of leaves, there is no significant difference between the doses for the residue. For cattle manure, the number of leaves was

Table 3. Variation in length, collar diameter and number of leaves as a function of dose and fertilizer.

Parameter	Dose (g)	Residual maggot production	Cattle manure	Statistics
Stem length (cm)	0	13.45 ± 5.01 c		
	50	42.24 ± 8.98 a (a)	24.36 ± 5.29 ab (b)	P < 0.001; Df = 1; F = 59.27
	100	35.02 ± 7.54 ab (a)	29.80 ± 10.13 ab (a)	P = 0.07; Df = 1; F = 3.412
	150	34.47 ± 9.94 ab (a)	39.29 ± 8.10 a (a)	P = 0.10; Df = 1; F = 2.825
	200	29.83 ± 10.66 b (a)	35.06 ± 9.51 a (a)	P = 0.11; Df = 1; F = 2.677
	Stat	P = 0.005; Df = 1; F = 124.8	P < 0.001; Df = 1; F = 91.51	
Diameter at the neck (cm)	0	0.40 ± 0.06 c		
	50	0.88 ± 0.17 a (a)	0.56 ± 0.06 bc (b)	P < 0.001; Df = 1; F = 56.7
	100	0.80 ± 0.15 ab (a)	0.63 ± 0.10 b (b)	P < 0.001; Df = 1; F = 17.21
	150	0.77 ± 0.13 ab (a)	0.98 ± 0.77 a (a)	P = 0.24; Df = 1; F = 1.403
	200	0.72 ± 0.18 b (a)	0.69 ± 0.08 b (a)	P = 0.55; Df = 1; F = 0.355
	Stat	P < 0.001; Df = 1; F = 0.54	P < 0.001; Df = 1; F = 14.20	
Number of leaves	0	14.16 ± 4.28 a		
	50	27.10 ± 11.15 a (a)	19.30 ± 4.91 ab (b)	P = 0.006; Df = 1; F = 8.201
	100	20.05 ± 5.83 a (a)	18.04 ± 4.26 ab (a)	P = 0.22; Df = 1; F = 1.52
	150	21.01 ± 5.99 a (b)	28.12 ± 4.98 b (a)	P = 0.015; Df = 1; F = 6.245
	200	18.61 ± 4.91 a (a)	19.58 ± 6.48 ab (a)	P = 0.596; Df = 1; F = 0.286
	Stat	P = 0.621; Df = 1; F = 15.65	P < 0.001; Df = 1; F = 20.23	

Legend: italicized value indicates significant tests (P < 0.05) and letters in parentheses are comparisons between fertilizer types. Letters are from Duncan comparison at $\alpha = 0.05$ threshold.

higher at the 150 g rate (28.12 ± 4.98) with no significant difference between the other rates.

The effect of residue and cattle dung on each corresponding dose shows that, for stem length, only the 50 g dose was statistically influenced by them (P < 0.001;

(Table 3—horizontal comparison). At this dose, the highest stem length was obtained on residue (42.24 ± 8.98 cm) and the lowest on cattle dung (24.36 ± 5.29 cm). As for the diameter at the neck, only the 50 g and 100 g doses were statistically influenced by the residue and the bovine dung (50 g dose: P < 0.001; 100 g dose: P < 0.001). At both doses, the residue recorded the largest diameter with 0.88 ± 0.17 cm and 0.80 ± 0.15 cm for the 50g and 100g dose, respectively. For the number of leaves, only the 50 g and 150 g doses varied statistically according to the type of fertilizer. At the 50 g dose, the residue recorded the highest number of leaves (27.10 ± 11.15), but the latter recorded the lowest number of leaves at the 100 g dose (21.01 ± 5.99).

3.3. Effect of dose and Residue of Production and Cow Dung on Fresh Leaf and Root Biomass

Fresh leaf and root biomass are strongly influenced by the different doses and

Table 4. Summary of the two-factor analysis of variance.

Parameter	Factors	DF	F	P-value
Fresh leaf biomass	Treatment	1	6.564	P < 0.001
	Dose	4	59.858	P < 0.001
	Treatment: dose	4	30.611	P < 0.001
Fresh root biomass	Treatment	1	54.563	P < 0.001
	Dose	4	35.986	P < 0.001
	Treatment: dose	4	11.535	P < 0.001

Leaf and root biomass varied strongly with applied rate (**Table 5**—vertical comparison) for each fertilizer (leaf biomass: maggot residue: P = 0.040; cattle dung: P < 0.001; root biomass: maggot residue: P < 0.001; cattle dung: P < 0.001).

type of treatment applied and by the interaction of these two factors (**Table 4**).

The highest leaf biomass was obtained with doses 50 and 150 for residue (155.00 ± 33.91 g) and cattle dung (123.20 ± 20.57 g) respectively. On the other hand, the lowest leaf biomass was obtained with doses 200 and 50 for residue and cattle dung respectively. The 150 g dose gave the best performance in root biomass for the maggot production residue. For cattle manure, the 150 g and 200 g dose gave (without any significant difference between them) the best performance in root biomass with 21.80 ± 5.48 g and 21.50 ± 4.74 g respectively.

The effect of residue and cattle dung on each corresponding dose shows that, for leaf biomass, dose 50 and 100 g were statistically influenced by the latter (dose 50: P < 0.001; dose 100: P < 0.001; **Table 5**—horizontal comparison). At each of these doses, the residue recorded the highest leaf biomass with 155.00 ± 33.91 g and 129.20 ± 31.82 g for dose 50 and 100 respectively. For the other corresponding doses, no difference was observed between the residue and the cattle dung. For root biomass, each dose was statistically influenced by the type of fertilizer (**Table 5**—horizontal comparison) except dose 200 (P = 0.616). For each of these doses, maggot production residue gave the best performance in root biomass than bovine dung except for dose 200 where no difference between the two fertilizers was observed (residue = 20.50 ± 3.97 g and dung = 21.50 ± 4.74 g).

3.4. Principal Component Analysis

The first axis alone explains 91.34% of the total variability. Stem length, collar diameter, and number of leaves (**Figure 1**) are positively correlated with dimension 1 (length: correlation coefficient = 0.979 and P < 0.001; diameter: r = 0.974 and P < 0.001; number: correlation coefficient = 0.911 and P < 0.001. These parameters were positively correlated with each other. In other words, amaranth plants with the highest length also have the largest diameter and number of leaves.

4. Discussion

Fertilizer applications (maggot production residue and cow dung) had different

Table 5. Variation in fresh leaf and root biomass with dose and fertilizer.

Parameter	Dose	Residual maggot production	Cow Dung	P-value
Fresh leaf biomass (g)	0	33.8 ± 8.09 c		
	50	155.00 ± 33.91 a (a)	54.00 ± 11.49 bc (b)	P < 0.001; Df = 1; F = 79.56
	100	129.20 ± 31.82 ab (a)	63.00 ± 19.88 b (b)	P < 0.001; Df = 1; F = 31.11
	150	119.20 ± 15.76 ab (a)	123.20 ± 20.57 a (a)	P = 0.632; Df = 1; F = 0.238
	200	96.50 ± 8.51 b(a)	92.00 ± 10.32 b (a)	P = 0.302; Df = 1; F = 1.130
	Stat	P = 0.040; Df = 1; F = 3.89	P < 0.001; Df = 1; F = 67.63	
Fresh Root Biomass (g)	0	7.7 ± 1.82 c		
	50	27.50 ± 8.24 ab (a)	10.50 ± 3.68 c (b)	P < 0.001; Df = 1; F = 35.39
	100	28.50 ± 5.79 ab (a)	15.40 ± 4.29 b (b)	P < 0.001; Df = 1; F = 32.64
	150	31.50 ± 8.18 a (a)	21.80 ± 5.48 a (b)	P = 0.006; Df = 1; F = 9.68
	200	20.50 ± 3.97 b (a)	21.50 ± 4.74 a (a)	P = 0.616; Df = 1; F = 0.261
	Stat	P = 0.003; Df = 1; F = 9.464	P < 0.001; Df = 1; F = 81.19	

Legend: italicized value indicates significant tests (P < 0.05) and letters in parentheses are for comparisons between substrate types. Letters are from Duncan comparison at $\alpha = 0.05$ threshold.

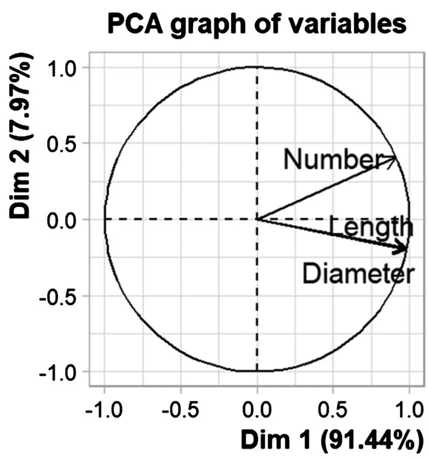

Figure 1. Correlation circle of the variables.

effects on pigweed development depending on the dose. The application of fertilizer generally improved plant growth in contrast to the no-fertilizer control. These results reveal the importance of fertilization in production [35] [36] [37] [38].

For the maggot production residue, as the residue application rate increased, growth and yield parameters (except root fresh biomass) of amaranth decreased. In other words, the lowest dose (50 g) of the residue had a greater effect on all observed parameters than the higher doses. Indeed, several studies have shown that the residue from maggot production is a bio-fertilizer rich in nutrients (especially N and P) easily accessible to the plant. The application of high doses of this residue could lead to an excess of N and P that would result in decreases in plant growth and leaf yield [39] [40] [41]. Moreover, [42] also show that improvement very rich in nitrogen, induced a weak growth of Roselle plants (*Hibiscus sabdariffa* L., 1753) explained by a too high abundance of fertilizing elements (N and P especially). In *Hibiscus sabdariffa*, [43] conclude that the application of a high dose of 100 kg N per hectare induced a decrease in seed yield and calyx harvest index.

For bovine manure, the parameters observed increase as the dose applied increased until the maximum limit of 150 g above which these parameters decreased. This implies that the lower doses did not contain the nutrients required by the plant and that the higher doses might constitute an improvement in excess of the plant's nutritional requirements [44] [45] [46] [47]. In their work on *M. oleifera*, [48] find that cattle dung alone sufficiently improved plant growth compared to NPK fertilizer. These authors explain this result by the ability of cattle dung to enrich the soil with nitrogen naturally.

For best amaranth production, a spacing of 20 cm × 20 cm (i.e. 250,000 bunches/ha) and 10 t/ha of well-decomposed manure is recommended [9]. The doses of 50 g, 100 g and 150 g used in the present study corresponded respectively to 12.5 t/ha, 25 t/ha, 37.5 t/ha of localized application (micro-dose) of residue under the same experimental conditions. Thus, the results obtained show that the dose of 50 g of maggot rearing substrate residue corresponding to 12.5 t/ha gave the best yields for all the parameters studied (stem length, collar diameter and fresh leaf biomass) except for root biomass where the dose of 150 g (37.5 t/ha) gave the best yield. For cattle manure, the 150 g dose (37.5 t/ha) gave the best yields. The effect of the residue and the cattle manure on each corresponding dose showed that, for the doses with a statistical difference, the residue gave the best performance than the cattle manure. However, it should be noted that a broadcast fertilization will consume more fertilizer than the localized pot fertilization used in this study. These results can be explained by the fact that the residue of maggot production already constituted a kind of compost, thus making the necessary nutrients available to the plant more quickly [39] [41]. Indeed, the cattle manure used for this trial was not previously mineralized (composting) which reduced the availability of nutrients for the plant [49]. The latter admits that the 3-month prior mineralization process made the cattle manure more efficient by making the nutrients needed by the plant more rapidly bioavailable. This mineralization lasted at least for 2 months for organic manures in general [50] [51]. In this study, because the trial lasted for two months, the cattle manure did not reach the stage of complete mineralization that would have made its nutrients available to the amaranth plants more quickly and sufficiently.

The use of composts produced from organic waste was known to increase soil fertility [52] [53] by improving soil structures, water and nutrient holding capacities, and microbial activity [54]. Furthermore, the viability of a land depended primarily on its humus richness [55], which made the use of animal manure a common practice in agriculture and constituted a valorization of livestock by-products highly appreciated in organic farming [56].

5. Conclusion

This study addresses for the first time in Niger Republic the use of maggot production residue for amaranth fertilization. The results indicate that this residue allows an improvement of the growth of the amaranth compared to the various kinds of fertilizers commonly used. In this pot experiment, 50 g (12.5 t/ha) appears to be the optimum dose of maggot-producing residue for improved amaranth plant growth. For the cattle manure used, the optimal dose is 150 g or 37.5 t/ha. Moreover, for each corresponding dose, the maggot production residue was more efficient than the cattle manure used. Thus, these treatments can be recommended to growers for better pigweed production. The medium- and long-term promotion and resilience of soil fertility can be promoted by maggot production residues. In this study no physicochemical parameters were measured at the soil level. Further study in this direction could better highlight the capacity of this residue to improve soil fertility and its ability to improve the availability and preservation of minerals in plants. In addition, studies on the effect of these organic fertilizers on the nutritional quality of amaranth as well as on their economic profitability on amaranth production are needed to better exploit these results.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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