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Vegetative Growth in Cucumber as Influenced by False Yam (*Icacina oliviformis*) Tuber Compost

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Abstract

Continuous cropping has led to nutrient depletion in the soils. To amend the soil, this study explored 12, 14, and 16 weeks (W) false yam (*Icacina oliviformis*) compost combined with topsoil in ratios (false yam: topsoil) of 1:1(T1), 1:2(T2), and 2:1(T3) and topsoil (T4) served as control. After assessing for effectiveness, false yam at 12 weeks at 2:1 topsoil: false yam (most effective) was integrated with animal manure (cow dung and pig droppings) as follows: topsoil: false yam: cow dung (FYCD)- (2:1:1), topsoil: false yam: pig droppings (FYPD)- (2:1:1), topsoil: false yam: cow-dung: pig droppings (FYCDPD)- (2:1:1/2:1/2) and topsoil: false yam (FY)- (2:1) as the benchmark. The four treatments for each set were evaluated using cucumber as the test crop and were replicated three times in CRD. FY and FYCD recorded similar results in the leaf area, followed by FYCDPD, and FYPD. FY and FYCD recorded similarly in plant girth at 2 weeks after planting (2WAP) and 4WAP. FYCD and FY recorded pH values of 5.57 and 5.61 respectively. These indicated that the period of decomposition had a significant effect on the performance of the test crop. Also, false yam compost combined with cow dung offered positive support to crop performance although not significantly different from false yam compost (12W) only. This indicates that decomposed false yam tuber within 12W with or without cow dung may be used to amend the soil for better performance with better physical medium characteristics.

Keywords: Animal manure; compost; continuous cropping; nutrient depletion; false yam.

1. Introduction

The production of crops and wholesome food for the world's expanding population depends on plant nutrients. Crops are cultivated on a piece of land. The crops obtain their nutrient requirement from the soil and continuous cultivation of crops on the same piece of land has led to the depletion of nutrients in the soil [1, 2].

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To amend the soil, chemical fertilizers, manure, mulch, and compost have been used for this purpose [3–5]. The use of chemical fertilizers increases the cost of production and expensive for rural farmers. Routine usage of chemical fertilizer and compost was a vital component of soil management in arable crop production systems and these amendments were used mostly to raise nutrient availability to plants, but they can also affect soil microorganisms [6]. Today's soil management techniques rely primarily on inorganic chemical fertilizers, which pose a major risk to both human health and the environment and in sustainable farming, bio-fertilizer has been found as an alternative for boosting crop productivity and soil fertility [7]. The benefits of using compost in maintaining soil quality have been increasingly recognized [8]. The chemical, physical and biological fertility of a plant growth medium as suggested by the authors in [9] are controlled by the organic matter found in the growth medium and thus should be supplied through the application of manure and crop residues, to either maintain or elevate the organic matter content in the growth medium. False yam (*Icacina oliviformis*) is a small, drought-resistant shrub forming dense stands in the West African and Central African savannas [10]. It belongs to the family Icacinaceae and indigenous to the west and central Africa [11]. The tuber is said to possess advantageous agronomic and nutritional features that are similar when compared to soil [12]. Composting was employed to transform false yam tuber into a biologically stable, hummus-like substance excellent for soil amendment. The usage of animal manure in organic farming is geared towards improved crop yields, improved soil fertility, and water holding capacity to optimum levels. In view of this, the issue of poor soils contributing to the decreased crop yield in Northern Ghana [13], which is negatively affecting the development of agriculture can be curbed [14] . This study seeks to evaluate the effectiveness of false yam tuber (*Icacina oliviformis*) compost on crop growth performance as a cheap and nutrient-rich organic medium using cucumber as a test crop.

2. Materials and methods

2.1. Experimental Area

The experiment was carried out at the mechanization field and at the plant house of the University for Development Studies, Nyankpala campus, Tamale. According to the Savanna Agricultural Research Institute's (SARI) report in 2001, the location lies on latitude 9^0 25^1 45^1N and longitude 0^0 58^1 42^1 N at latitude 182m above sea level characterized as a hot dry savannah zone. The pattern of rainfall in this area is a mono-modal which occurs in April to October followed by the dry season which sets in from November to March [12]. The temperature of the area ranges between 19^0C (minimum) and 42^0C (maximum). A report by SARI in 1998 stated that the average annual rainfall is 1060mm.

2.2. Experimental design and analysis

Four treatment levels were applied for two sets of experiments. The first set was false yam compost at week 12 and topsoil in a ratio of 1:2 combined with animal manure in a Completely Randomized Design with only false yam compost as control. Both sets were replicated three times. The decomposed false yam mixed with animal manure were included as follows; false yam tuber compost and cow dung (FYCD), false yam tuber compost and pig dropping (FYPD) decomposed false yam plus cow dung and pig dropping (FYCDPD), and false yam tuber compost only (control). The second set was false yam compost mixed with topsoil in ratios of 1:1, 1:2, and 2:1

(false yam: topsoil) at 12 weeks, 14 weeks, and 16 weeks after composting and topsoil as control (Set-up 2) laid in a Randomized Complete Block Design (RCBD).

Table 1: Treatment combinations of false yam compost and topsoil at 12 weeks, 14 weeks, and 16 weeks after decomposition (Experiment 1)

Treatment	False Yam Compost	Topsoil
T1	1	1
T2	1	2
T3	2	1
T4	-	1

Table 2: Treatment combinations of false yam compost and animal manure (Experiment 2)

TREATMENTS	COMPOSITION RATIO			
	FALSE YAM	TOPSOIL	COW DUNG	PIG DROPPING
FYCD	1	2	1	-
FYPD	1	2	-	1
FYCDPD	1	2	1/2	1/2
FY	1	2	-	-

Data collected were subjected to analysis of variance (ANOVA) using Genstat statistical package, 4th edition at a significance level of ($P<0.05$). Data were taken on plant girth, the number of leaves per plant, plant height, and leaf area for the two sets except for pH which was taken in the second experiment.

Source and Preparation of Test Crop

Cucumber (*Cucumis sativa*) was used as a test crop for the experiment. Cucumber seeds were sourced from a Tamale agrochemical shop in the northern region of Ghana and screened off all foreign and non-viable seeds.

Preparation of false yam tuber and animal manure to serve as a substrate

Fresh false yam (*Icacina oliviformis*) tubers were harvested within the Nyankpala Campus of the University for Development Studies, Tamale - Ghana. Harvested false yam tubers were chopped into pieces about 2cm and buried in compost pits of dimensions 152cm×61cm×91cm and covered with black polythene bags. Watering to moist condition and turning was done for proper aeration every week. Composting process was for a period of twelve weeks, fourteen weeks, and sixteen weeks. Planting and data collection started in October and ended in

December 2015. The plastic experimental pots used had an approximate volume of 7067cm^3 with perforations at the bottom. The experiment was set up in a plant house.

Figure 1: Experimental set-up. (1-3) Harvesting and chopping of false yam into smaller size for decomposition. (4-5) Chopped false yam buried in pit and covered to keep required temperature for microbial decomposition. (6) Matured false yam compost. (7-9) Establishment of test crop and growth parameters evaluation.

3. Results and discussion

3.1. Substrate pH

Table 3 indicates highly significant differences in substrate pH values for all treatments resulting in the different performances of the test crops subjected to the different treatments.

Table 3: Substrate pH of the treatment

Treatment	**pH**
FYCD	5.57
FYPD	5.36
FYCDPD	4.69
FY	5.61
P-Value	**<0.001**

This may be owing to the difference in resident ions in the treatments resulting in dissimilar nutrient and water uptake among the test crops. Cucumbers are sensitive to acidic soils hence a pH of 5.5 to 6.7 is optimum [15]. Organic fertilizer improves the capacity of growth medium to buffer changes in pH and cation exchange capacity and serves as a reservoir of elemental constituents such as N, S, P, and many minor elements [16–21]

3.2. Plant Girth

Figure 2 reveals that there was a significant difference (P<0.05) in the four treatments for two (P=0.008) and four (P=0.019) weeks after planting. These exist between, FY and FYPD; FY and FYCDPD; FYCD and FYPD for two weeks after planting and FYCD and FYPD; FY and FYPD for four weeks after planting. However, at six weeks after planting (P=0.177), there was no significant difference in plant girth for all the treatments. This may be attributed to the differences in nutrient content and supply by treatments to the test crop at the earlier stages of the experiment. This is in line with the findings of the authors in [22] who stated that crop development generally, is wholly determined by the nutrients present in the medium. Authors in [23–25], reported that organic manure inputs improve the vegetative development of vegetables, attributing it to an increase in soil nutrients and microbial biomass associated with the use of organic matter.

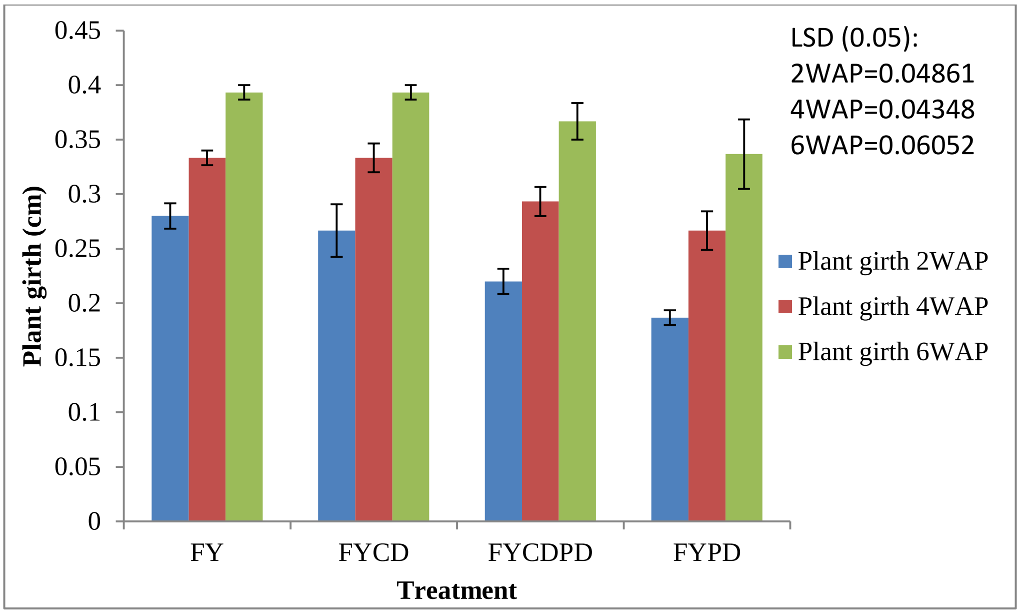

Figure 2: Plant girth of test crop (Set-up 1)

However, no significant difference existed between FY and FYCD and may be said that FY and FYCD supplied similar nutrient elements essential for plant girth development. At 6 WAP, no significant difference existed in plant girth measurements for all treatments, and this may be an indication of the depletion of plant nutrient sources essential for vegetative growth and as well the inherent decrease in vegetative growth of crops near maturity. Results in Set-up 2 (figure 3) revealed a significant difference among treatments (P<0.05) for all the weeks of decomposition.

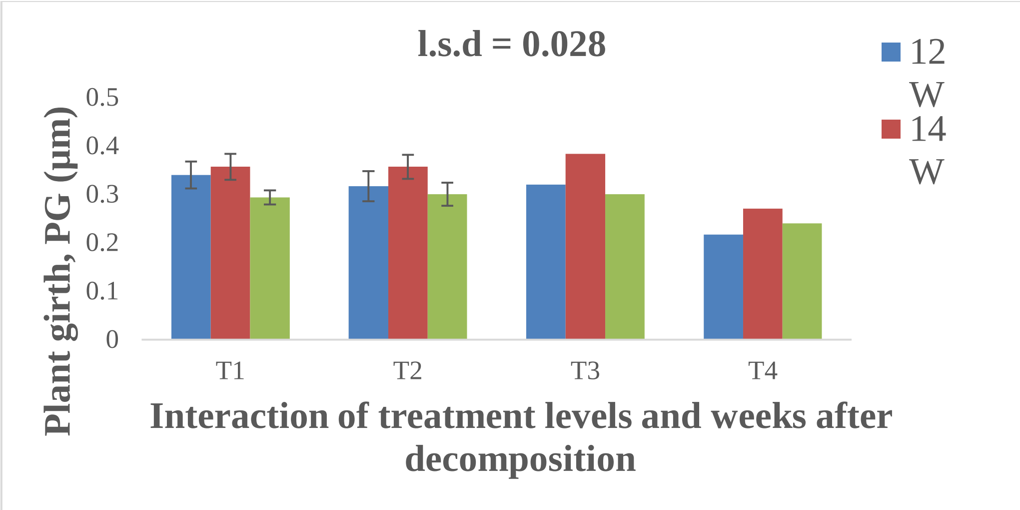

Figure 3: Plant girth of test crop (Set-up 2)

This may be attributed to the fact that nutrients were released from decomposed false yam into the growth media. Also, the information revealed that 12W and 14W were not different from each other at T1 and T2 but differed at 16W. It may perhaps be that enough nutrients were released at 12W and 14W hence an increase in performance than 16W, a finding relating to a report by authors in [26], that general crop development is wholly determined by the nutrients available in the media. However, 12W was not different from 14W.

3.3. Leaf Area

Results of Figure 4 showed no significant difference (P>0.05) in leaf area in the four treatments for two (P=0.106), four (P=0.210), and six (P=0.172) weeks after planting.

Figure 5 indicated no statistical differences in measurements for the various treatments.

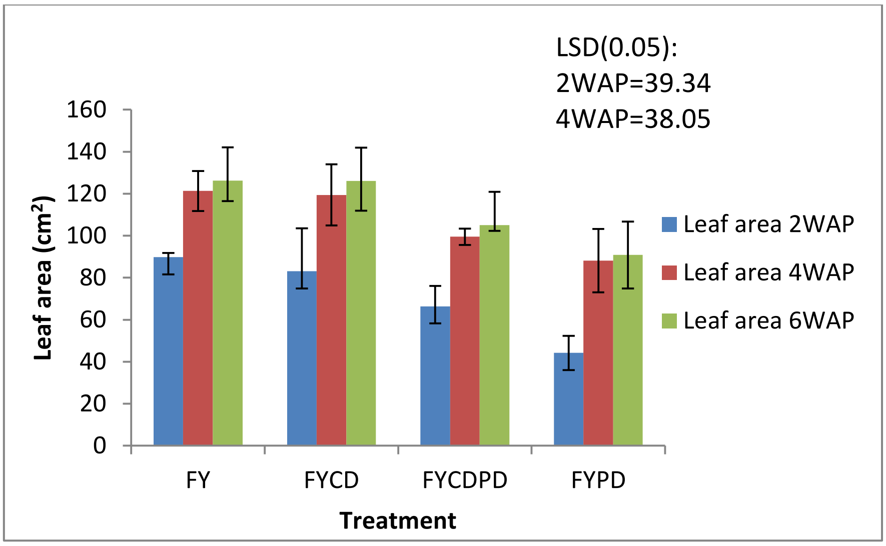

Figure 4: Shows leaf area index of test crop (Set-up 1)

These indications may be associated with the physical conditions such as porosity of the media being similar. Similarly, authors in [27] verified that the leaves of cucumber grown in hydroponic sand culture were larger in total area and had different geometry in relation to plants grown in soil, thus changing the relationship between its length and width, and hence showing that environmental conditions change leaf geometry of plants of the Cucurbitaceae family.

Excessive moisture resulting from poor drainage results in a reduced availability of oxygen which affects plant growth and eventually affects leaf development [28].

Authors in [29] agreed that water tension decreases the leaf area index (LAI) in greenhouse cucumber supporting the suggestion that, such difference could have resulted from poor water holding capacity which resulted in water stress.

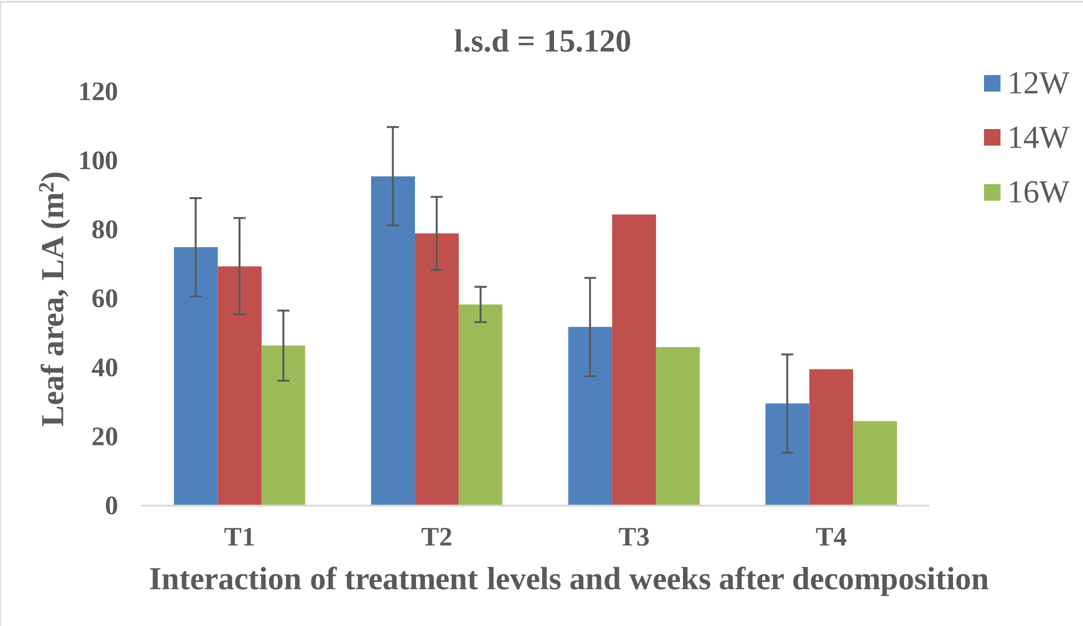

Figure 5: Leaf Area of the test crop (Set-up 2)

The result of figure 5 indicated significant differences among the individual treatments. As reported by authors in [30] organic manure had a profound effect on the vegetative growth of the cucumber plant. The study revealed that 16W of media decomposition recorded the least performance in terms of leaf area for all treatments. This may be ascribed to the fact that the nutrient in the media started increasing to the peak and then started to diminish as the weeks of decomposition increased. This confirms the finding of the author in [31], who reported that the duration of decomposition influenced the nutrient released from the composting material. However, 12W recorded the highest performance at T2. This indicated that treatments with the least amount of decomposed false yam had better performance in terms of leaves than those with high levels of decomposed false yam. This may explain the fact that decomposed false yam provided nutrients for plant growth when added to certain levels. Thus, decreasing the quantity of decomposed false yam, increased performance. The authors in [30] also made a similar observation in the weight of fruit yield of cucumber increased significantly with the application of treatments of poultry manure.

3.4. Number of Leaves Per Plant

Figure 6 shows no significant difference (P>0.05) in the number of leaves measured in all the treatments at two (P=0.055) and four (P=0.097) weeks after planting. However, there is a significant difference at six weeks after planting (P=0.010). Significant differences exist between FYCD and FYCDPD; FYCD and FYPD; FY and FYCDPD.

Table 4 illustrates no significant differences in the number of leaves per plant at two and four after planting but however, at 6WAP significant differences exist between treatments. This may be attributed to the supply of similar amounts of elemental nitrogen as plant nutrients by treatments required for leaf development during the early stages of the experiment. In accordance with this, it has been reported by literature that plants on varied substrates exhibit similarities in organ and general development of plants when nutrients are similar and functions in a sterile condition.

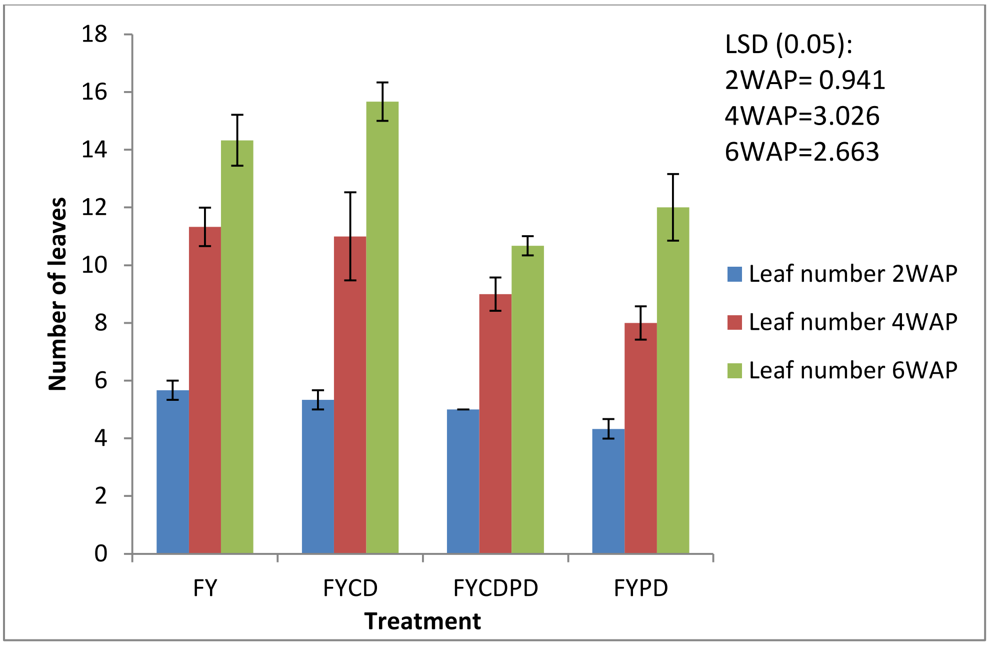

Figure 6: Number of leaves per plant for test crop (Set-up 1)

The difference may be associated with the presence of large amounts of nitrogen in FYCD as well as a resulting availability and supply of the nitrogen to the test crop. A report by the authors in [32] indicated that as the nutrient particularly nitrogen increases, leaf number per plant also tends to increase. The authors in [33] also stated that cattle manure when mixed with another nitrogen source increased the leaf number per plant in maize.

In set-up 2, there was a significant difference (P<0.05) between the treatments applied and the control. Table 4 indicated that T1, T2, and T3 were not significantly different but were different from T4. This may be associated with the fact that decomposed false yam added nutrients to the soil since all the treatments with decomposed false yam mixed with topsoil performed better than the control T4. This agrees with the finding of the author in [34] who report that the incorporation of manure into soil stimulated transformation and mineralization and increase Phosphorus uptake by the plant. However, T1, T2, and T3 were not significantly different from each other.

Table 4: Number of leaves per plant (Set-up 2)

TREATMENT LEVELS		**WAD**	
T1	7.111	12W	6.152
T2	7.091	14W	6.943
T3	6.814	16W	6.569
T4	5.202		
P-Value	<.001		<.001
L.S.D.	0.3208		0.2778

The indication revealed that the treatment levels applied had no effect on the number of leaves a plant produced for all the weeks after decomposition. This may be that decomposed false yam in the various media supplied a similar amount of nutrients to the crop. This agrees with the finding of the authors in [12] who reported that plants on diverse media parade resemblances in growth and development when nutrients available to them are the same. Also, 12W, 14W, and 16W of decomposition differed significantly from each other with 14W recording the highest performance in terms of leaves. This may be attributed to the fact that enough nutrients required for leaves to develop were released from decomposed false yam into the media at 14W.

3.5. Plant Height

There are significant differences ($P<0.05$) in plant height for all the treatments at two ($P=0.015$), four ($P=0.014$) and six ($P=0.010$) weeks after planting, which exist between FYCD and FYCDPD; FY and FYPD at two weeks after planting, FYCD and FYPD; FYCD and FYCDPD; FY and FYPD at four weeks after planting and FYCD and FYPD; FYCD and FYCDPD; FY and FYPD at six weeks after planting (Figure 7).

Figure 8 depicts significant differences in plant height measurements at the different weeks after planting between treatments. These differences in plant height may be associated with the difference in nutrient supply by manure inclusions specifically phosphorus and nitrogen which stimulate vegetative growth in plants or the enrichment of growth media to different degrees. Organic manure is a reservoir of nutrients, and these nutrients are released during humification, thus supplying the necessary elements for plant growth. The differences may be attributed to the differences in the water holding capacity exhibited by the treatment and this resulting in differences in the availability of nutrients.

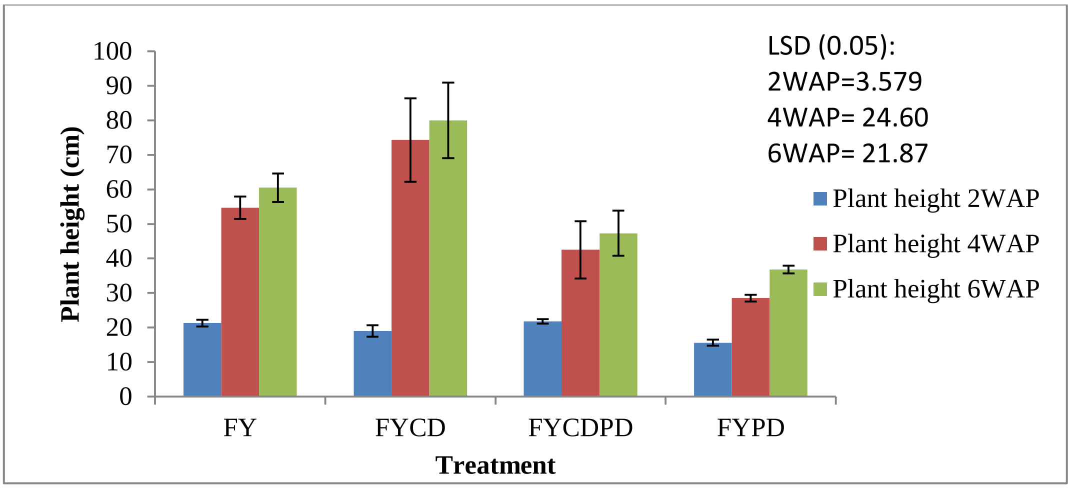

Figure 7: Shows plant height of test crop (Set-up 1)

It was observed that the inclusion of manure increased the soil water holding capacity and this meant that nutrients would be made more available to crops. The cucumber plant, therefore, had enough nutrients for rapid growth and development considering the composition of the farmyard manure which was incorporated into the soil during land preparation [35, 36]. It was further observed that the higher the nutrients available, the higher the values of the vine length and number of leaves produced per plant [37].

Poor water holding capacity resulting in water stress may be a reason for the differences in plant height, which is in line with [38], stating that cucumber (*Cucumis sativus* L.) is extremely sensitive to adverse conditions particularly water stress.

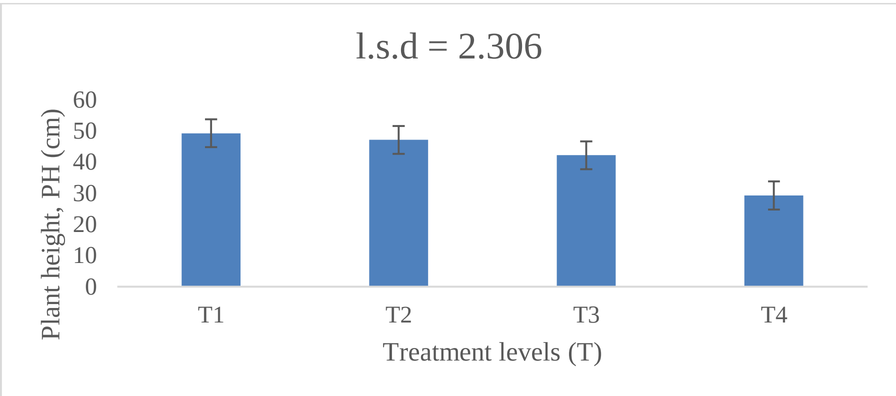

Figure 8: Plant height of test crop (Set-up 2)

In set-up 2, there were significant differences (P<0.05) between all treatments. Generally, T1, T2, and T3 were not significantly different from each other but were different from T4. This may be attributed to the fact that decomposed false yam added nutrients to the soil since all the treatments with decomposed false yam mixed with topsoil performed better than the control. The authors in [39] reported that manure is a source of nutrients, which are released through mineralization, thus supplying the necessary elements for plant growth. However, T1, T2, and T3 were not significantly different from each other. This may be that the nutrients released from decomposed false yam into the media were perhaps enough for growth at the treatment levels as indicated in height.

4. Conclusion

The study revealed that growth performance increased when decomposed false yam was added to topsoil indicating that decomposed false yam added nutrients to the media. FYCD and FY performed better than FYCDPD and FYPD after animal manure was added to twelve weeks old compost in a 1:2 ratio with topsoil. It was noticed that false yam compost integrated with cow dung offered positive support to crop performance with better physical medium characteristics as well as pH. In summary, the study showed that 12W old false yam compost may be preferred at 1:2 ratio with topsoil, integrated with cow dung will positively support crops with better physical medium characteristics that may maximize performance and thus serving as a good source of soil amendment which is cost-effective.

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5. Competing interests

The authors have no competing interests.

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