Original Research Article

ORGANIC AND INORGANIC FERTILIZER EFFECTS ON INCIDENCE OF WEEVIL (*Cylas spp.*), OF SWEET POTATO IN THE FOREST - SAVANNAH TRANSITIONAL ZONE OF GHANA

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ABSTRACT

Two field experiments were conducted at the Multipurpose Crop Nursery of the University of Education Winneba, Mampong Ashanti campus during from September, 2017 to December, 2018. The study was aimed at determining the organic and inorganic fertilizer effects on incidence of weevil *(Cylas spp.),* on the sequential harvesting and vertical distribution of tubers, growth and yield of sweet potato in the forest-savannah transitional zone of Ghana. Severe weevil infestation was produced on *Ogyatanaa* than *Ogyefo* at the minor season, there was severe weevil infestation at the second harvest than the first harvest at the minor season. In the major season there was severe weevil infestation on tubers at the first harvest than the second harvest, Ogyatanaa grown with 5 t/haCM produced the highest number of weevil *(Cylas spp.),* infested tubers at the first harvest. *Ogyatanaa* grown with 300kg/ha N.P.K produced the lowest number of weevil *(Cylas spp.)*, infestation at the first and the second harvests. *Ogyatanaa* grown with300 kg/ha N.P.K at a depth of 5cm recorded the highest number (8) weevils infested tubers at the minor season. At a depth of 10cm, six (6) tubers were found to be infested, while at depth of 15cm and 20cm the number of infested tubers were found to be four (4) and two (2) respectively at the minor and major seasons. *Ogyefo* grown with 150 kg/ha N.P.K + 2.5 t/ha CM produced the lowest level of weevil infestation at a depth of 5cm only two weevils and at 10cm depth, only one weevil was found at the minor and major seasons. At 15cm and 20cm depths no weevils were found.

Key words: sweetpotato,Weevil, *CylasSpp, Ogyefo, Ogyatanaa,* Physiological maturity.

1.0 INTRODUCTION

Scientists believe the sweet potato crop was domesticated more than 5000 years ago [20]. Globally, for every year more than 133 million tonnes are produced. In Africa, Ghana ranks fourth in sweet potato production [4]. One of the most significant crops for carbohydrates in emerging nations is the sweet potato. About 100,000 acres are used to grow sweet potatoes in the United States, with Louisiana, Mississippi, and North Carolina producing the majority of the crop. The majority of Ghana's sweet potatoes are produced in three northern regions: the Northern and Upper East regions yield between three and six tonnes per acre, while the Upper West region yields less, between one and two tonnes per acre. Approximately 73,400 hectares of sweet potato land are harvested in Ghana, with important root crops like cassava and yam following sweet potatoes [7].

Bio fertilizers are one of the most important organic sources because they contain beneficial viable organisms that have the potential to deploy nutritionally important elements from non-usable to usable forms through biological processes [16]. Azospirillum is known to be a very active nitrogen fixer under laboratory as well as in soil conditions, providing fast growth, better health of the plant, and higher yield [12]. The response of organic sources with or without chemical fertilizers on a large number of crops has been reported by several workers [15, 17, 13]. According to Cherryl and Matt, there are numerous types of sweet potatoes. In terms of horticultural traits, these types can be distinguished by their fresh color (orange, deep orange, or cream), skin color (copper, rose, red, white, or purple), and root shape (oval, rectangular, or dumbbell). Along with freshness, flavor (sweetness) might change. Due to their varying growing seasons, some cultivars have different insect resistances [3].

The crop research institute of CSIR (Council for Scientific and Industrial Research) of Ghana has released several varieties of sweet potato. However, although there is an abundance of

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hybrid varieties, there is a problem of serious pest infestation in several of these released varieties, thereby posing food insecurity threats. The major serious pest of sweet potato is the sweet potato weevil (Cylas spp.). The pest was first reported in the state of Louisiana in the U.S.A in 1875 and it causes damage in the field and in storage. In Ghana, the pest is found in all the major production areas of sweet potato, particularly the Northern, Upper East, Upper West, and some parts of the Brong Ahafo Region [2]. The Sweet potato weevil feeds on plants in the Convolvulaceae family. A complete life cycle takes about one to two months, thereby posing serious problems to field and harvested crops if not well catered for. Three species have been identified in Africa. Their dissemination in Africa is being surveyed and it appears that all three species have a similar life history, making all of them difficult targets for conventional pest control measures. Among these three are Cylas formicarius, which is an important pest in India, South East Asia, Oceania, the United States, and the Caribbean. Sweet potato weevil (Cylas spp.) has three different species: Cylas coleoptera, Cylas brennlidue, and Cylas fornicarius. They are the major problem for sweet potato production and utilization worldwide. Cylas brunneus Fabricius and Cylas panticolis Boheman are the most prevalent species in East Africa.

The major constraint of sweet potato production in Cuba is caused by Cylas formicarius. The insect limits the potential increase of sweet potato production in all provinces of Cuba, causing up to 45% damage in the absence of adequate control measures. Selection of sweet potato varieties is important for the control of sweet potato weevils. Deep-rooting and early maturing varieties (90 to 120 days) are about four times less susceptible to infestation than shallow-rooting and late maturing varieties (180 days or more). As a result, both deep storage roots and early maturing varieties tend to reduce the severity of weevil damage. Management of weevils was the highest-ranked need in relation to improved sweet potato crop management in Ghana with regards to the right variety and the desirable soil amendment that has weevil (Cylas spp) resistance. There is therefore a need for research to combine released varieties of sweet potato

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in the same growing conditions, evaluate weevil (Cylas spp) incidence, and yield potentials of these released varieties. There is also the need to assess the response of sweet potato to both organic and inorganic fertilizers, as well as in an integrated management system, and how these affect quality factors of the roots. This will provide farmers with alternative ways of fertilization and also provide consumers with the nutritional values of sweet potato, and also provide farmers and consumers with the potential values of the crop in southern regions of Ghana. Considering the nutritional values of sweet potato will ensure high patronage of the crop and this will provide a market for sweet potato farmers.

MATERIALS AND METHODS

2.1 Experimental Site Two field experiments were conducted on different plots at the Multipurpose crop nursery Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development, Asante Mampong from September to December 2017 minor rainy season and April to August 2018 major rainy season. Mampong-Ashanti (7 8N, 124W) is 457.5m above sea level and is located in the forest-savannah transitional agro-ecological zone. The soil type in Asante Mampong is classified as savannah ochrosol formed from voltaian sandstone of the Afram plains. The soil is friable with a thin layer of organic matter and is a deep brown sandy loam and well-drained with a good water-holding capacity. The soil has been classified by FAO/UNESCO legend as chronic Luvisol and locally as the Bediesi series with a pH of 4.0-6.5 and is good soil for the production of crops such as vegetables, cereals, tubers, and all types of leguminous crops [6, 8]. Mampong-Ashanti receives a bimodal rainfall pattern. The experimental site experiences two seasons of rains within a single year, with the major rainy season observed from March to July and the minor rainy season from September to November and a one-month dry spell in August [8, 9]. Annual rainfall ranges between 1270 mm and 1534 mm, monthly being 91.2 mm. The mean monthly temperature is between 25ºC and 32ºC [8].

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2.2 Experimental Design and Treatment The experimental design used was a 2 x 4 factorial experiment arranged in a randomized complete block design (RCBD) and replicated three times. The treatment was made up of three organic manure and fertilizer rates and the control (without amendment), and two sweet potato varieties (Ogyefo and Ogyatanaa) used as planting materials for the experiment were assigned to each block. Ogyefo was developed and released by CSIR of the Crop Research Institute of Ghana in Fumesua near Kumasi in the Ashanti Region. The Ogyefo variety of sweet potato is a 120-day (4 months) maturing improved variety, the root yield capacity is 20t/ha, the root flesh color is white, the dry matter content is 40%, and the skin color is light reddish. The Ogyatanaa variety of sweet potato is also a 120-day maturing improved variety with root flesh color being light yellow and has a yield capacity of over 22t/ha and a dry matter content of 36%.

2.3 Climatic Conditions During the Experimental Periods Rainfall, temperature, and relative humidity were the climatic factors observed for the two cropping seasons. The total monthly rainfall during the minor rainy season was 335.8 mm and it occurred from September to December 2017 with the peak in September and October. The minor season experienced a minimum monthly temperature of 20.3ºC to 21.7ºC and a maximum temperature of 29.4ºC to 32.0ºC, with the highest daily at 32ºC observed in November and December 2017. The relative humidity at 06.00 hours for the minor rainy season ranged from 83% to 91%, and that of 15.00 hours ranged from 52% to 73%, with the peak observed in September. During the major rainy season, 824.6 mm of rainfall was recorded from April to August 2018 with the peak observed in August. Maximum temperature ranged from 28.3 to 31.9ºC with the highest at 31.9ºC, and minimum temperature ranged from 20.9ºC to 22.8ºC with the peak occurring in April. Relative humidity at 06.00 hours ranged from 88% to 92% with its peak in June, and relative humidity at 15.00 hours ranged from 63% to 75% with the peak recorded in July [9, 10].

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Table 1: Climatic data for 2017 minor rainy season for experiment one

Month	Total Rainfall (mm)	Mean Relative Humidity (%) 06.00h	15.00	Mean Temperature (ºC) Min.	Max.
September, 2017	136.7	91	73	21.1	29.4
October	114.4	83	65	21.3	31.1
November	75.2	87	61	21.7	32.0
December	9.5	84	52	20.3	32.0
Total	335.8				

Source: Ghana meteorological agency-Mampong Ashanti, 2017.

Table 2: Climatic data for 2018 major rainy season for experiment two

Month	Total Rainfall (mm)	Mean Relative Humidity (%) 06.00h	15.00 h	Mean Temperature (ºC) Min.	Max
April ,2018	109.6	88	63	22.8	31.9
May	185.5	90	65	22.2	31.1
June	184.6	92	69	21.8	29.6
July	157.2	88	75	21.2	28.3
August	187.7	91	74	20.9	28.6
Total	824.6				

Source: Ghana Meteorological Agency–MampongAshanti,2018.

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2.4 Organic Manure Preparation The chicken manure used for the experiment was obtained from the deep litter system of a poultry farm from the college. The manure was heaped under shade covered with plantain leaves, supported with wooden sticks for four weeks to decompose and to dry before application was done. The chicken manure was applied and worked into the soil two weeks before planting.

2.4 Soil and Manure Sampling After lining and pegging the experimental area and demarcating it into plots, samples of the soil were taken at a depth of 0-15 cm from each replicate at different spots. The soil plus chicken manure were mixed together and no manure soil (control) samples were taken from the experimental site at a depth of 0-15 cm.

2.5 Soil and Chicken Manure Chemical Analyses The soil and chicken manure samples were sent for analysis at the Soil Research Institute of CSIR at Kwadaso in Kumasi. The soil samples were air-dried and sieved through a 2 mm mesh. Soil pH, total nitrogen, exchangeable potassium, organic carbon, and available phosphorus were the chemical properties determined.

2.6 Land Preparation, Fertilizer Application, and Planting The land measuring 13.0 m × 32.0 m was lined and pegged and cleared with cutlass to remove all vegetation on the soil and debris collected from the land. The cleared land was followed by ridge preparation with a hoe. The ridges were laid 3.0 m long x 4.0 m wide, with four ridges per plot. To ensure complete decomposition, the decomposed and dried chicken manure was worked into the soil according to treatment two weeks before planting. Inorganic fertilizer (N.P.K 15:15:15) at a rate of 300 kg/ha was also applied to respective treatment two weeks after planting of vines. Vine cuttings having at least 4-5 nodes from the apical and semi-woody vigorously growing sections were cut and used for planting. The vines that were about 30 cm in length were planted at a spacing of 1.0 m x 0.3 m per each hill with 2-3 nodes buried inside the soil at an angle leaving two nodes

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above the soil at one vine per stand. There were four ridges in each experimental plot and each had ten plants per row or ridge and a total of forty plants per plot. There were sixteen (16) plants within the harvest area (two central rows per plot). The vine cuttings were planted on a field size which measured 32.0 m x 13.0 m (416 m2). Each experimental plot measured 4.0 m x 3.0 m (12 m2) with 2.0 m left between blocks for each cropping season.

2.7 Agronomic Practices Weeds were controlled using a hoe and hand-picking and sometimes with cutlass in both minor and major seasons at 3 to 4 weeks after planting to reduce weed-crop competition. Subsequently, weeding was done at 7 to 8 WAP after the closure of the canopy. During the minor growing season (September to December) irrigation was carried out once every two days to promote crop growth, each plant received the same amount of water during supplementary irrigation. A hoe was used to carry out reshaping of the ridges from time to time. The N.P.K (15:15:15) was applied two weeks after planting at a rate of 300 kg/ha to respective treatments.

2.8 Data Collection and Statistical Analysis Vegetation growth data collected were percentage crop establishment, number of branches, and vine girth. Percentage plant establishment was estimated by counting the number of vines sprouted from the two central rows per plot at 4 weeks after planting and their percentages were estimated and mean recorded. The number of branches was counted from each of the three tagged plants per plot from the two central rows, 4 weeks after planting and at two weeks' interval up to 12 weeks after planting and the mean estimated. The vine girth was measured on each of the three tagged plants from the two central rows of each plot using vernier calipers from a few centimeters from the base of the plant at 4 WAP to 12 WAP and at 2 weeks' interval and the mean estimated. The parameters measured under yield and yield components were the number of tubers per plot, number of tubers per plant, tuber weight per plot (kg), number of marketable tubers per plot, number of unmarketable tubers per plot, and number of forked tubers per plot. The total number of tubers from each of

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the three plants randomly selected from the two middle rows was counted after harvest and mean estimated. The total number of tubers from the two middle rows was counted after harvest and mean estimated. The total number of tubers from the two middle rows was counted after harvest and mean estimated. The total number of tubers after harvest from the two middle rows was weighed using an electronic weighing scale and mean estimated. The diameter of tubers which were greater than 3 cm was classified as marketable and was measured from the middle portion of each root tuber using vernier caliper and the mean estimated. Root tubers which were less than 3 cm in diameter were classified as unmarketable and were measured from the middle portion using a rope and a meter rule of each root tuber and mean estimated. The total number of forked root tubers from the two middle rows was counted after harvest and mean recorded. The data collected was analyzed using standard ANOVA procedure with the aid of GenStat Statistical Package Discovery Edition 3 (Version 11.0 DE). The means that were statistically different were separated using the Least Significant difference (LSD) at 5% probability level.

3.0 RESULTS

3.1 Chemical Properties of Soil Table 3 shows the chemical properties of the soil for both minor and major rainy seasons. The pH of the soil during the major rainy season was pH 5.55 which was acidic, % organic carbon and total nitrogen were relatively low, and % organic matter was moderate. Exchangeable cations for calcium, magnesium, and sodium were relatively low and that of potassium was high. The Effective Cation Exchange Capacity (E.C.E.C) was relatively low. A pH of 6.03 was recorded for the minor rainy season which was neutral. The organic carbon, total nitrogen, and organic matter were relatively low. The exchangeable cations Ca^{2+}, K^+, and Na were low for the minor rainy season and that of Mg^{2+} was high.

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***Table 3:* Chemical properties of the soil for both Minor and Major Rainy Seasons**

Property	Minor Season	Major Season
pH (1:2.5)	6.03	5.55
Organic carbon (%)	0.91	0.80
Total nitrogen (%)	0.09	0.08
Organic matter (%)	1.57	1.38
Exchangeable cations (Cmol/kg)		
Ca^{2+} (mg/100g)	3.47	4.54
Mg^{2+}(mg/100g)	0.54	3.47
K^{+} (mg/100g)	0.62	0.17
Na^{+} (mg/100)	0.10	0.08
Total exchangeable bases (Cmol/kg)	4.73	8.27
Exchangeable Acidity (Cmol/kg)	0.15	0.60
Effective Cation exchange capacity (Cmol/kg)	4.88	8.87
Base saturated (%)	96.92	93.23

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Table 4 shows nutrient contents of 4-month-old chicken manure which was used for both the minor and major rainy seasons. The minor rainy season manure had a pH of 5.98 which was moderately acidic. Total nitrogen was moderately high, available potassium and available phosphorus were low, and organic carbon and organic matter were relatively high. Total exchangeable bases (TEB), exchangeable aluminum (Al+H), and effective cation exchange capacity (E.C.E.C) were high. The major season manure had a pH of 5.72 which was also moderately acidic. Total nitrogen and organic carbon were high. Available potassium and available phosphorus were low, and organic carbon and organic matter were high.

Table 4. Chemical Properties of Chicken Manure used for both Minor and Major Rainy Seasons 2017 and 2018

Property	**Minor Season**	**Major Season**
pH (1:5)	5.98	5.72
Total nitrogen (%)	3.45	3.86
Available Potassium (%)	2.65	3.38
Available Phosphorus (%)	0.34	0.56
Organic Carbon (%)	3.96	4.36
Organic Matter (%)	7.32	8.24
Total Exchangeable basses (T.E.B)	33.41	24.31
Exchangeable Aluminum ($Al^{+}H$)	0.06	18.93
Effective Cation Exchange Capacity (Me/100g)	34.57	22.43
Bases saturation	99.70	98.45
Exchangeable cat ions		
Ca^{2+}(mg/100g)	23.14	20.34
$Mg^{2+($mg /100g)	12.75	6.31
K^{+}(mg /100g)	0.43	0.63

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3.2 Vegetative growth

3.2.1 Vine length

The results on vine length produced from the two varieties as influenced by chicken manure and inorganic fertilizers for the major and minor cropping seasons are presented in (Figure 1). During the minor season, there was a significant difference between the two varieties in vine length. The vine length was greater ($P<0.05$) in the *ogyatanaa* variety than in *Ogyefo*, there was a significant difference between the fertilizer types. For fertilizer type, the 300 kg/ha N.P.K recorded the longest vine length at 72 DAP and 86 DAP. The control plot produced the lowest vine length at 30 DAP. During the major cropping season, there was a significant difference between the two varieties in vine length, there was a significant difference between the fertilizer types, for fertilizer type, the 5t/ha CM had the second higher vine length and differed significantly from other treatments from 72 DAP to 86 DAP. The control produced the longest vine length followed by 300 kg/ha N.P.K for the entire growing period. The shortest vine length was produced by 150kg/ha N.P.K.+2.5t/ha CM at 86 DAP.

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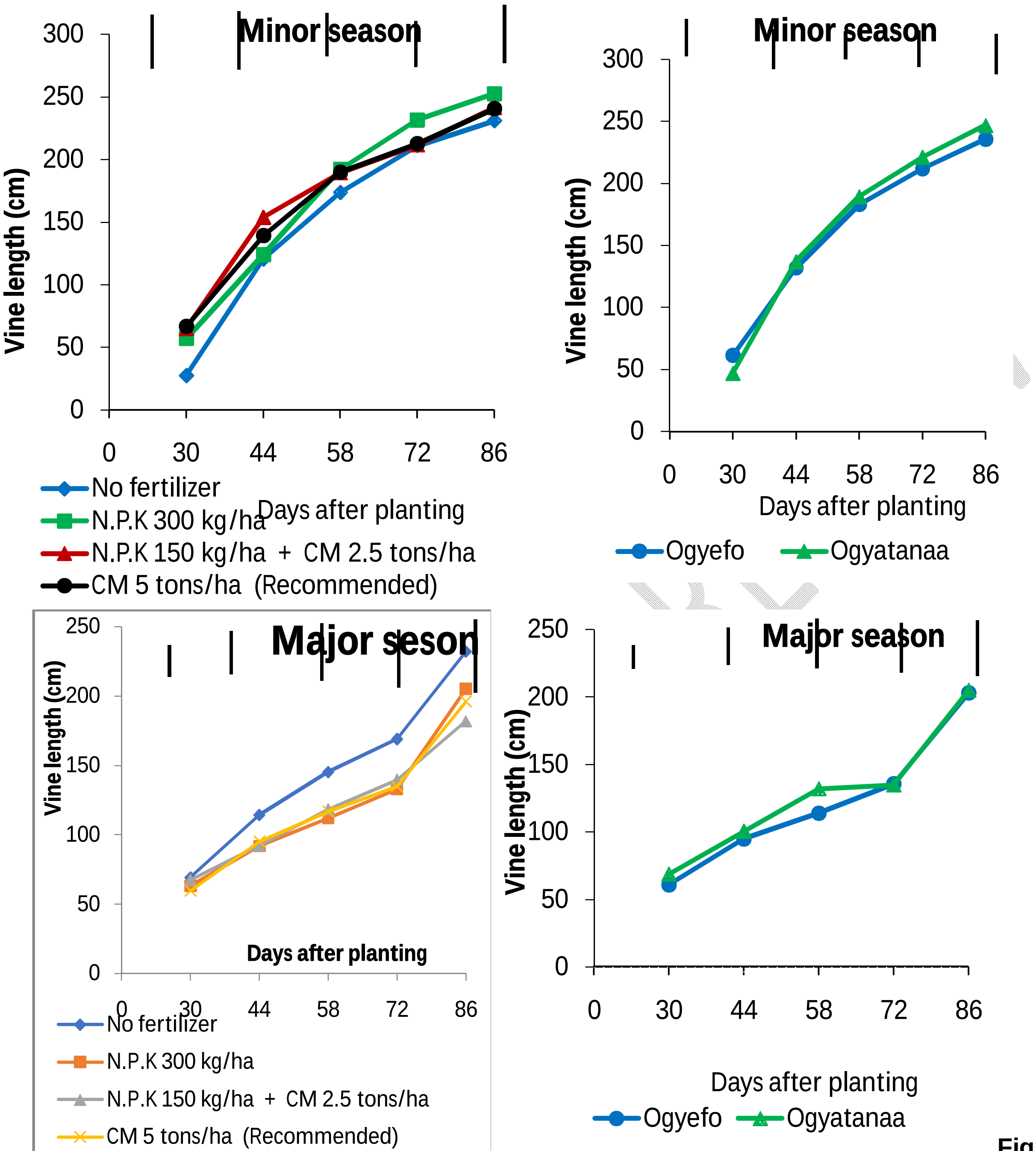

Figure 1: Vine length as influenced by organic manure and inorganic fertilizer

3.2.2 Whiteflies Incidence

The influence of chicken manure and inorganic fertilizer on incidence of whiteflies of two varieties of sweet potato is presented in During the minor season, there was a significant difference between varieties in whiteflies incidence. The whiteflies incidence was significantly greater ($P < 0.05$) in *ogyatanaa* variety than in *Ogyefo* at 86 DAP, there was a significant difference between the fertilizer types. The amended and unamended plots produced high levels of whiteflies incidence were recorded at 86DAP. The300 kg/ha N.P.K and the control produced the same level of whiteflies incidence at 72 DAP. The 150kg/ha N.P.K + 2.5 t/ha CM produced the highest level of whiteflies incidence for the entire minor growing season. During the major cropping season, there was no significant difference between varieties in whiteflies incidence. However, there was a significant difference between fertilizer types. The 150kg/ha N.P. K + 2.5 t/ha CM produced the lowest whiteflies incidence at 30 DAPS.The5t/ha CM produced the highest whiteflies incidence at 44, 72 and 86 DAP. The 150kg/ha N.P.K + 2.5t/ha CM produced the same level of whiteflies incidence at 72 DAP.

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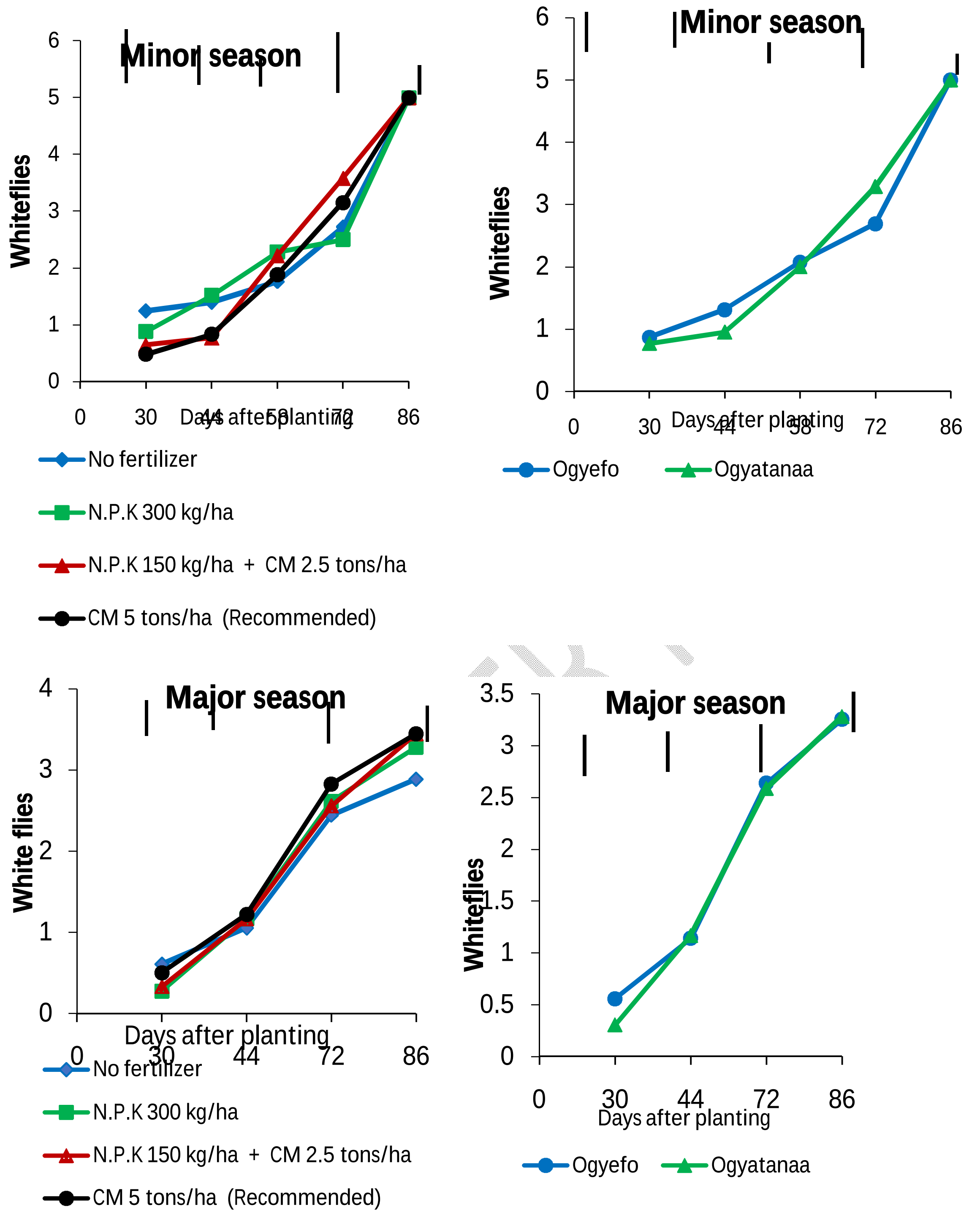

Figure 2: Whiteflies count as influenced by organic manure and inorganic fertilizer

3.3 Yield and yield components of sweet potato

3.3.1Table 5: Effect of variety and fertilizer type on tuber length per plot and number of deformed tubers per plot

	Tuber length per plot		***Number of deformed tubers per plot***	
Treatment	**Minor season, 2017**	**Major season,2018**	**Minor season,2017**	**Major season,2018**
Variety				
Ogyefo	**16.11**	**16.90**	**1.75**	**2.92**
Ogyatanaa	**14.02**	**14.69**	**1.50**	**3.58**
LSD (P ≤ 0.05)	**0.422**	**1.048**	**NS**	**0.528**
Fertilizer rate				
300 kg/ha N.P.K	**15.32**	**17.01**	**1.50**	**4.00**
150 kg/ha N.P.K + 2.5 t /ha CM	**14.44**	**14.45**	**2.33**	**3.67**
5t/ha CM	**14.42**	**15.48**	**1.33**	**2.83**
No fertilizer (control)	**16.14**	**16.23**	**1.33**	**2.50**
LSD (P ≤ 0.05)	**NS**	**NS**	**NS**	**0.747**
CV (%)	**16.60**	**14.87**	**76.60**	**53.76**

Table 5 shows the average tuber length per plot as influenced by chicken manure and inorganic fertilizers. During the minor season (2017), there was a significant difference between varieties in tuber length per plot. *Ogyefo* produced significantly (P< 0.05) longer tuber length per plot than *ogyatanaa*, fertilizer treatments did not significantly (P > 0.05) affect tuber length per plot during the minor season. In major season (2018), *Ogyefo* differed significantly (P<0.05) from *Ogyatanaa* in tuber length per plot. However, there was no significant difference between the fertilizer typesalthough300 kg/ha N.P.K produced longer tuber length per plot than other

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amended treatment and control. Averagely the tuber lengths produced in the major season were longer than those produced in the minor season.

3.3.4 Number of deformed tubers per plot

Table 3 shows the number of deformed tubers per plot as influenced by chicken manure and inorganic fertilizers. During the minor season (2017), there was no significant difference between varieties and fertilizer types in number of deformed tubers per plot although the 150 kg/ha N.P.K + 2.5 t /ha CM had the highest. The 5t/ha CM and the control were at par in number of deformed tubers per plot. During the major season (2018), there was a significant ($P < 0.05$) difference between *Ogyatanaa* and *Ogyefo* in number of deformed tubers per plot. There was a significant ($P < 0.05$) difference between 300 kg/ha N.P.K and 5 t/ha CM and the control in number of deformed tubers per plot.

3.3.5 *Table 6: Effect of variety and fertilizer type on the number of Weevil (Cylas* spp.*), infested tubers per plot and total tuber weight per plot*

	Number of Weevil (*Cylas* spp.*),* infested tubers per plot		***Number of plants harvested***	
Treatment	**Minor season,2017**	**Major season,2018**	**Minor season,2017**	**Major season,2018**
<u>Variety</u>				
Ogyefo	**2.92**	**6.7**	**14.83**	**13.75**
Ogyatanaa	**2.50**	**9.2**	**15.75**	**12.83**
LSD ($P \leq 0.05$)	**NS**	**1.44**	**0.325**	**0.575**
<u>Fertilizer rate</u>				
300 kg/ha N.P.K	**9.00**	**2.00**	**15.00**	**13.17**
150 kg/ha N.P.K + 2.5 t /ha CM	**5.3**	**3.50**	**15.00**	**13.00**
5t/ha CM	**9.8**	**2.33**	**15.67**	**13.33**
No fertilizer (control)	**7.7**	**3.00**	**15.50**	**13.67**

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LSD (P ≤ 0.05)	**2.04**	**0.80**	**NS**	**NS**
CV (%)	**58.20**	**34.09**	**25.64**	**27.5**

3.3.6 Number of Weevil (Cylas spp.) infested tubers per plot

The result on number of weevil infected tubers as influenced by chicken manure and N.P.K fertilizers is presented in Table 6. During the minor season (2017), there was no significant difference between varieties in number of weevil infested tubers per plot, there was a significant difference between5 t/ha CM from 150 kg/ha N.P.K + 2.5 t/ha CM and the control in number of weevil infested tubers per plot. During the major season (2018), there was a significant difference between Ogyatanaa from *Ogyefo* in number of weevil infested tubers per plot, there was a significant ($P < 0.05$) difference between 150 kg/ha N.P.K +2.5 t/ha CM from other amended plots in number of weevil infested tubers per plot with 5 t/ha CM producing the lowest in number of weevil infested tubers per plot.

3.3.6 Number of plants harvested

The results on number of plants harvested from plants amended with chicken manure and inorganic fertilizer is presented in Table 6. During the minor season (2017), there was a significant difference between varieties in number of plants harvested. For fertilizer type,150 kg/ha N.P.K + 2.5 t/ha CM and 300 kg/ha N.P.K were at par and produced the same number of plants harvested. There was no significant ($P < 0.05$) difference between fertilizer types during the minor season although the 5t/ha CM recorded the highest number of plants harvested. During the major season (2018), there was a significant difference between varieties in number of plants harvested. However, there was no significant difference between the fertilizer types. Generally, the minor season produced higher number of plants harvested than in the major season (Table 6.).

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3.3. 7 Effect of organic and inorganic fertilizers on vertical distribution of weevil infested sweet potato tubers at different soil depth

The result shows that during the minor season (2017), there was a significant ($P<0.05$) difference between *Ogyefo* and *Ogyatanaa* planted on chicken manure and N.P.K (Fig. 3), *Ogyatanaa*grown on 300 kg/ha N.P.K at a depth of 5cm produced the highest number of eight weevils infested tubers. At a depth of10 cm six tubers were found to be infested, while at depth of 15cm and 20 cm the number of infested tubers was found to be four and two respectively. *Ogyefo* grown on 150 kg/ha N.P.K + 2.5t/ha recorded the lowest level of weevil infestation at a depth of 5cm with two weevil infested tubers and at 10 cm depth, only one weevil infested tuber was obtained. However, at 15cm and 20 cm depths there were no weevils infested tubers. During the major season (2018), there was no significant difference between *Ogyatanaa* and *Ogyefo* in vertical distribution of tubers per plot. There was no significant difference between the fertilizertypes, although differences exist between treatments.

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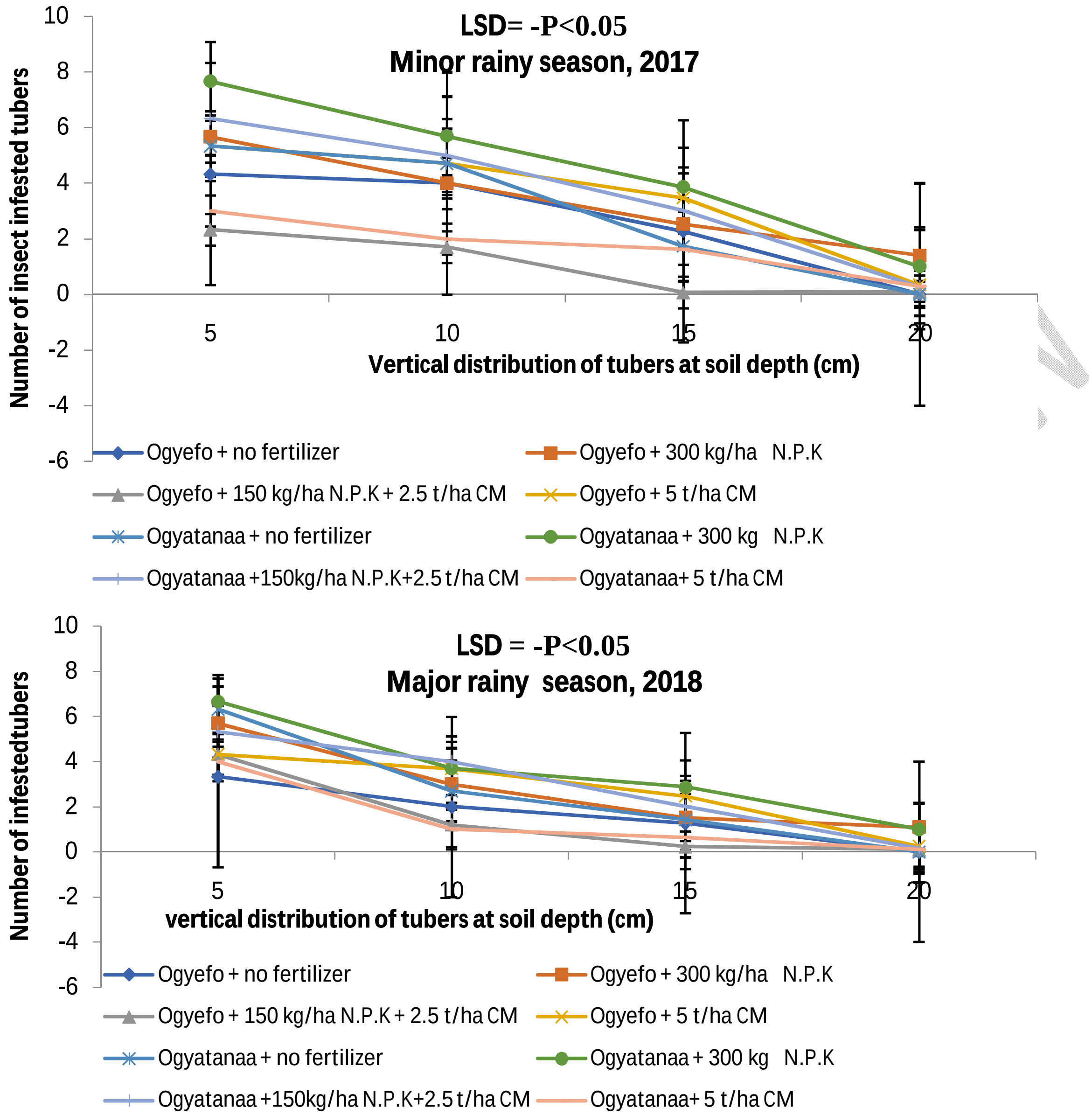

Figure 3: Vertical distributions of infested tubers as influenced by organic manure and inorganic fertilizer.

3.3.8 Effect of organic and inorganic fertilizers and sequential harvesting on incidence of sweet potato weevil

3.3.9 Sequential harvesting of tubers per plot

The result of sequential harvesting of tubers on number of weevil infested tubers per plot as influenced by chicken manure and inorganic fertilizer are presented in Figure 4. During the minor season (2017), *Ogyefo* grown on300 kg/ha N.P.K recorded the highest number of weevil infested tubers at the first harvest. *Ogyatanaa* grown on the control produced the lowest number of weevil infested tubers at the first harvest, *Ogyatanaa* grown on300 kg/ha N.P.K and on the control produced the same weevil infested tubers at the first harvest. In the second harvest *Ogyatanaa* grown on 5 t/ha CM produced the highest level of weevil infested tubers. However, *Ogyefo* grown on 5 t/ha CM produced the lowest level weevil infested tubers at the second harvest. There was severe weevil infestation of tubers in the second harvest than in the first harvest. In the major season (2018), there was severe weevil infestation of tubers in the first harvest than in the second harvest. *Ogyatanaa* grown on 5t/ha CM produced the highest number (12) weevil infested tubers in the first harvest. *Ogyefo* grown on5t/ha CM recorded the lowest number (4) of weevil infested tubers in the first harvest. In the second harvest, *Ogyef*o grown on 5 t/ha CM had the highest level of weevil infested tubers. *Ogyantanaa* grown on 300 kg/ha N.P.K produced the lowest number of weevil infested tubers in the second harvest.

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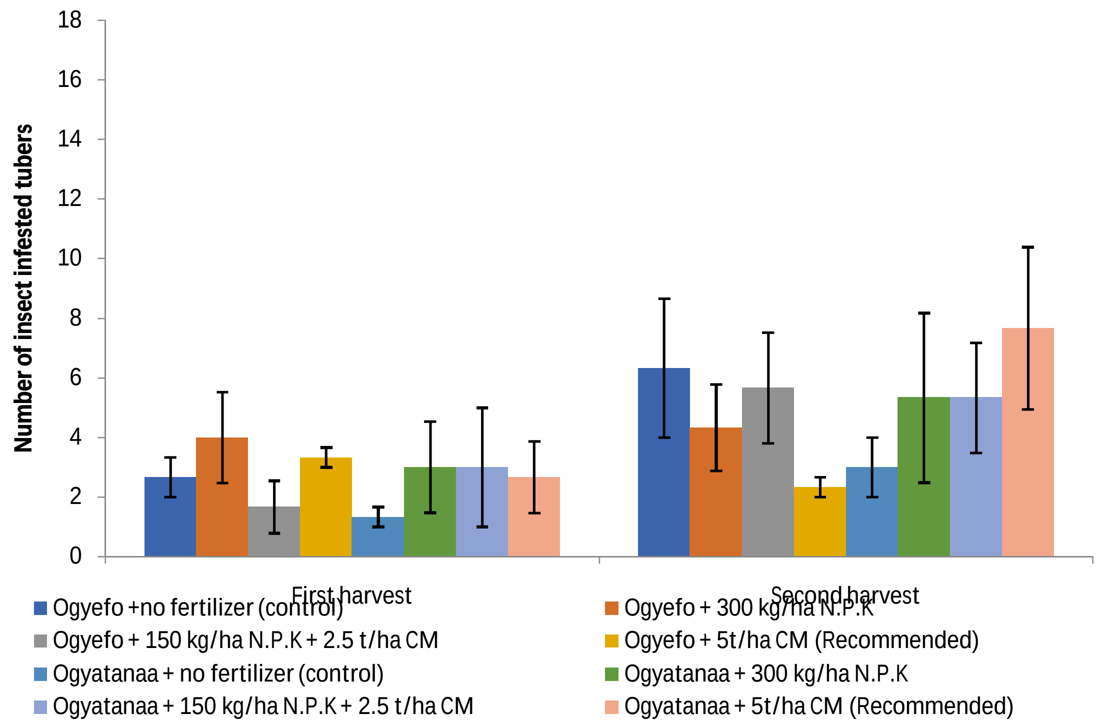

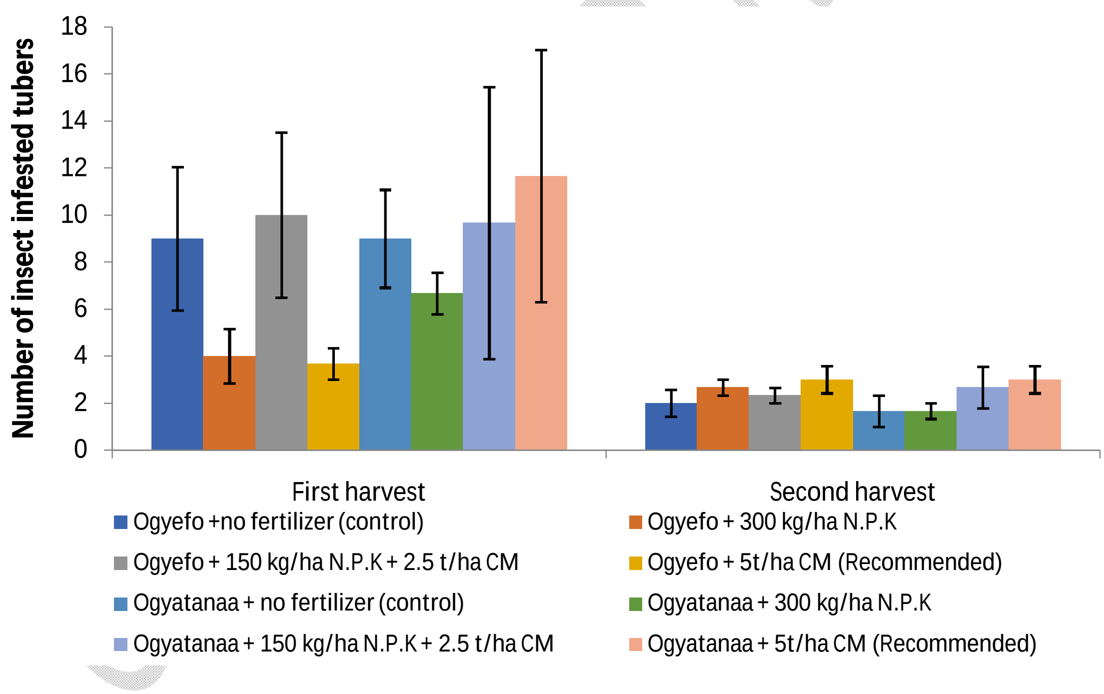

Figure 4: Number Infested tubers during sequential harvesting as influenced by organic manure and inorganic fertilizer.

4.0 DISCUSSION

4.1 Chemical Properties of Soil and Chicken Manure

The chemical properties of the soil for both minor and major rainy seasons experimental sites showed that for the major season site the pH of 5.55 was moderately acidic and pH of 6.03 was recorded for the minor rainy season site which was neutral. The differences in pH could be attributed to soil leaching due to the intensive rainfall during the major season, soil texture, and the amendment that was applied to the soil. % organic carbon and total nitrogen were relatively low; this could be because soil organic carbon and total nitrogen decrease with increasing soil depth. Exchangeable cations for calcium, potassium, and effective cation exchange capacity (E.C.E.C) were low; this could be due to low soil pH, cation exchange capacity (C.E.C), presence of other competing ions in the soil, and soil oxygen content which affects potassium and sodium contents in the soil. The nutrient contents of 4-month-old chicken manure used for both the minor and major rainy seasons showed that the minor rainy season had a pH of 5.98 which was moderately acidic and the major season had a pH of 5.72 which was also moderately acidic. The slight difference in pH that existed between the chicken manure used for the two experiments could be attributed to differences in climatic conditions such as rainfall and temperature during litter production, storage after production, and the time of use of the organic manure. Total nitrogen was moderately high and this could be due to high uric acid and undigested proteins. Organic carbon and organic matter were relatively high, which could be due to the solid and liquid excreta which are excreted together resulting in no urine loss.

4.2 Vegetative Growth of Sweet Potato

4.2.1 Vine Length During the minor season

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Vine length differed significantly between varieties. The significant difference could be due to the amendment's effect on the variety. The 300 kg/ha N.P.K had the longest vine length from 72 DAP to 86 DAP. This might be due to differences in soil fertility status through increased availability of nitrogen in inorganic fertilizer applied to the organic manured plots. Ogyefo and Ogyatanaa grown with either inorganic fertilizer or chicken manure performed better than the control. This is in line with Nedunchezhiyan et al., who reported positive responses of organic manure and chemical fertilizers on sweet potato growth [15]. Ogyefo had the longest vine length across all the treatments. This could be due to differences in varietal characteristics. There was a significant difference between Ogyefo and Ogyatanaa in vine length during the major season. This could be attributed to the amendment's effect on the variety. The 300 kg/ha N.P.K had a steady increase in vine growth at 58 DAP, 72 DAP, and 86 DAP, whilst the 5 t/ha CM had the highest vine length for the entire growing period in the major rainy season. This might be due to the chicken manure applied as it provides both micro and macronutrients coupled with the initial high rainfall experienced during the growing period which enhanced the continuous supply of nutrients to the different vine lengths. Generally, the major season experienced longer vine lengths than in the minor season. This could be attributed to the initial higher rainfall experienced during the major growing period than in the plant. Mukthar et al. attest to the fact that nitrogen could result in excessive vine growth and that application of organic and inorganic fertilizer to two cultivars of sweet potato produced significant differences in vine length [14].

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4.2.2 Whiteflies Incidence

During the minor season, there was a significant difference between varieties in whiteflies incidence. The whiteflies incidence was significantly greater ($P < 0.05$) in the Ogyatanaa variety than in Ogyefo at 86 DAP. This could be due to varietal characteristics. There was a significant difference between the fertilizer types. The amended and unamended plots produced high levels of whiteflies incidence at 86 DAP; this could be due to environmental characteristics. The

300 kg/ha N.P.K and the control produced the same level of whiteflies incidence at 72 DAP. The 150 kg/ha N.P.K + 2.5 t/ha CM produced the highest level of whiteflies incidence for the entire minor growing season; this could be due to the high foliage exhibited. During the major cropping season, there was no significant difference between varieties in whiteflies incidence. However, there was a significant difference between fertilizer types. The 150 kg/ha N.P.K + 2.5 t/ha CM produced the lowest whiteflies incidence at 30 DAP. The 5 t/ha CM produced the highest whiteflies incidence at 44, 72, and 86 DAP. The 150 kg/ha N.P.K + 2.5 t/ha CM produced the same level of whiteflies incidence at 72 DAP.

4.3 Yield and Yield Components of Sweet Potato

4.3.1 Effect of Variety and Fertilizer Type on Tuber Length Per Plot and Number of Deformed Tubers Per Plot

There was a significant difference between Ogyefo and Ogyatanaa in tuber length per plot in both cropping seasons. This could be due to differences in genetic characteristics. The control produced the longest tuber length in the minor rainy season. The increase in tuber length in the control could be due to the amendment having no effect on tuber length. The 300 kg/ha N.P.K recorded the longest tuber length in the major season. This might be due to differences in crop response to soil nutrients coupled with high rainfall experienced during the major rainy season. This is in line with Teshome et al., who attested that sustaining soil fertility in intensive cropping systems for higher crop yields and better quality can be achieved through inorganic nutrient management [19]. There was no significant difference between Ogyefo and Ogyatanaa in the number of deformed tubers per plot in the minor season. The non-significant difference could be due to the amendment having no effect on the variety. However, in the major season, the number of deformed tubers was higher in the minor season. This could be due to differences in

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plant response to amendments applied and climatic conditions in terms of high rainfall experienced during the major season.

4.3.2 Effect of Variety and Fertilizer Type on the Number of Weevil (Cylas spp.) Infested Tubers Per Plot and Number of Plants Harvested

The level of weevil incidence was higher in Ogyatanaa than in Ogyefo. The difference in incidence could be due to varietal characteristics and environmental factors. This confirms with Stathers et al., who attested that deep-rooted varieties seem to be less attacked than shallow-rooted varieties, as the weevils cannot reach the storage roots so easily when deep in the soil. Early maturing varieties can also escape attack because they are harvested early before the soil dries out, cracks, and provides easy access to the roots [18]. The 5 t/ha CM had the highest number of weevil-infested tubers in the minor season. This could be due to cracks on the soil surface due to the longer period of dryness as a result of less rainfall experienced during the latter growth stage of the crop. This is in line with Kabi et al., who attested that weevil (Cylas spp.) populations build up during dry seasons [11]. This also agrees with Ebregt et al., who reported that delay in harvesting, especially at drier periods, increases infestation and damage to sweet potato roots [5]. In the major season, Ogyatanaa had the highest number of weevil-infested tubers compared to Ogyefo. The level of weevil infestation was higher in the minor season than in the major season. This could be due to cracks in the soil and the longer period of dryness. This confirms with Sowley et al., who reported that weevil infestation is most serious when drought persists for a long time and that warm conditions increase the likelihood of serious pest infestation [17]. The 150 kg/ha N.P.K + 2.5 t/ha CM, 300 kg/ha N.P.K, and the control were not significantly different in the number of plants harvested in the minor season. This indicates that the amendment had no effect on the number of plants harvested and they were similar. The major season produced a higher number of plants at harvest than in the minor

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season. This could be due to the high rainfall experienced during the major season since sweet potato requires adequate moisture supply to encourage early vegetative growth.

4.3.3 Effect of Organic and Inorganic Fertilizers on Vertical Distribution of Weevil Infested Sweet Potato Tubers at Different Soil Depths

The results indicated that Ogyefo and Ogyatanaa grown with amended and unamended plots recorded the highest level of weevil (Cylas spp.) infestations at the top 5 cm depth vertical distribution of tubers at the minor and major rainy seasons. Generally, the level of infestations decreases gradually up to 20 cm deep because varieties with deep or higher depth of tubers tend to escape weevil damage. This confirms with Sowley et al., who attested that deep-rooted sweet potato varieties escape weevil damage because their roots are less accessible for females to lay eggs. Such varieties of sweet potato used in India have thin tubers scattered within the ground and well below the surface and are less severely damaged than those with large tubers near the surface of the soil [17].

4.3.4 Effect of Organic and Inorganic Fertilizers and Sequential Harvesting on Incidence of Sweet Potato Weevil

The effect of organic and inorganic fertilizers and sequential harvesting on the incidence of sweet potato weevil showed that Ogyefo produced the highest number of weevil incidence at the first harvest compared to Ogyatanaa. This could be due to differences in varietal characteristics and environmental factors. In the minor rainy season, there was severe weevil infestation of tubers at the second harvest compared to the first harvest. This could be due to varietal characteristics and environmental factors. This confirms with Kabi et al., who attested that weevil populations build up when harvesting is delayed because it allows continuous reproduction on available food. Delay in harvesting increases infestation and damage to sweet

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potato roots [11]. In the major rainy season (2018), there was severe weevil (Cylas spp.) infestation at the first harvest compared to the second harvest. This could be due to high rainfall experienced during the rainy season coupled with environmental factors.

5.0 CONCLUSION

The application of chicken manure and inorganic fertilizer as mineral supplements either singly or in combination influenced the incidence of weevil (Cylas spp.), the vegetative growth, and yield of sweet potato across both seasons.

- Ogyefo grown with 300 kg/ha N.P.K produced the highest number of weevil (Cylas spp.) infestation on tubers at the first harvest in the minor season.
- Ogyefo grown on 300 kg/ha N.P.K produced the highest vine length at 86 DAP in the minor season.
- Ogyatanaa grown with 5 t/ha CM produced the highest number of weevil (Cylas spp.) infestation on tubers at the second harvest in the minor season.
- Ogyefo grown with 5 t/ha CM produced the lowest level of weevil (Cylas spp.) infestation on tubers at the second harvest in the minor season.
- Severe weevil infestation was produced on Ogyatanaa compared to Ogyefo in the minor season, with severe weevil infestation at the second harvest compared to the first harvest in the minor season.
- In the major season, there was severe weevil infestation on tubers at the first harvest compared to the second harvest. Ogyatanaa grown with 5 t/ha CM produced the highest number of weevil (Cylas spp.) infested tubers at the first harvest.
- Ogyatanaa grown with 300 kg/ha N.P.K produced the lowest number of weevil (Cylas spp.) infestation at the first and second harvests.

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- Ogyatanaa grown with 300 kg/ha N.P.K at a depth of 5 cm recorded the highest number (8) of weevil-infested tubers in the minor season.
- At a depth of 10 cm, six tubers were found to be infested, while at depths of 15 cm and 20 cm the number of infested tubers were four and two, respectively, in the minor and major seasons.
- Ogyefo grown with 150 kg/ha N.P.K + 2.5 t/ha CM produced the lowest level of weevil infestation at a depth of 5 cm with only two weevils, and at a depth of 10 cm, only one weevil was found in the minor and major seasons.

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