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Agronomic attributes of cucumber (*Cucumis sativus* L.) as influenced by time of poultry manure application in Abia State, South East, Nigeria

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ABSTRACT

An experiment on agronomic attributes of cucumber (*Cucumis sativus* L.) as influenced by time of poultry manure application in Abia State, South East Nigeria, occurred at the research farm of Michael Okpara University of Agriculture, Umudike, during 2019 and 2020 cropping seasons. It was a 2 x 5 factorial laid in a randomized complete block design, replicated thrice. The treatments comprised two cucumber varieties of POINSETT and THAI 999 as well as time of poultry manure application levels of: 0 application (control); one week after planting (1WAP), one week before planting (1WBP); two weeks after planting (2WAP) and two weeks before planting (2WBP). Results showed that leaf area index, number of vines per plant and total dry weight per plant (leaves, stems and roots) increased at 4 and 8 weeks after planting (WAP) and decreased at 12WAP. Vine length per plant increased at 4, 8 and 12WAP, while crop growth rate was active at 4WAP to 8WAP and negative at 8 to 12WAP. THAI 999 variety yielded longer fruits per plant of 68.1 cm (2019) and 125.43 cm (2020); harvest index of 56.5% (2019) and 68.49% (2020); fruit number per hectare of 7,396 kgha^{-1} (2019) and 8,167 kgha^{-1} (2020) over POINSETT variety. Poultry manure at two weeks before planting (2WBP) yielded longer fruits per plant of 82.0 cm (2019) and 139.12 cm (2020); harvest index of 67.0% (2019) and 80.95% (2020); fruit number per hectare of 10,674 kgha^{-1} (2019) and 13,958 kgha^{-1} (2020) over control. Time of poultry manure application at 2WBP and THAI 999 variety responded better and are recommended for cultivation in southeastern Nigeria.

Keywords: Agronomic attributes; poultry manure; time of application; cucumber; varieties
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Introduction

Cucumber (*Cucumis sativus* L.), is a creeping vine that roots deep in the ground and grows on other supporting frames, wrapping round with thin, spiraling tendrils (Hemphil, 2014). It is an annual vegetable belonging to the family Cucurbitaceae (Eifediyi & Remison, 2010). Cucumber is a monoecious annual crop that has been cultivated for over 3,000 years (Adetula & Denton, 2003; Okonmah, 2011). USDA (2007), reported that China, Turkey, Iran, Russia and the USA are world leading cucumber producers, while Eifediyi & Remison (2010), reported that in world vegetable market, cucumber is ranked fourth most important vegetable crop in Asia.

Production of cucumber in Nigeria has increased probably due to awareness being created by its market demand and economic return, short growth duration and nutritional values (Okoli & Nweke, 2015). Cucumber could be eaten fresh or cooked and it supplies vitamins, minerals and anti-oxidants to the body (Jitendra et al., 2013). Cucumber also supplies thiamine, niacin, iron, calcium to the human body (Gopalan et al., 2015). Due to high content of potassium, cucumber can be used to control both high and low blood pressure (Khanet et al., 2015).

In terms of ecological requirements and adaptations, cucumber performs optimally under the condition of moderate temperature, rainfall and relative humidity conditions. Cucumber equally does well on fertile sandy loamy soils, while infertile and poorly drained soils as well as locations with very high rainfall intensity must be avoided. Remison (2012) earlier reported that very high rainfall will likely result in attendant high humidity which may cause leaf diseases and flower abscission.

Dantata & Babatunde (2013) in their research on cucumber also reported that cucumber is a warm-weather vegetable crop which prefers moderate temperature adding that high temperatures cause cucumber fruit bitterness. The authors opined that cucumbers tend to do well during the dry season, because high humidity in wet season promotes leafy diseases. Hector et al. (1993) reported that the optimum temperature for cucumber growth is 20°C to 25°C, adding that slightly below or above these ranges cucumber can grow and yield severally.

In relations to cucumber yield, cultivation of low yielding variety is the main reason for low yield of cucumber. Simon (1992), reported that varieties of cucumber exist in lengths, shapes and nutrient contents, while Axelson (1980), attributed high yielding traits in some cucumber varieties to genetic make-up and environmental situation. The fertility status of any given soil is vital to the growth and yield of cucumber. The remediation of infertile soils lies on the application of either organic or inorganic fertilizers. Poultry manure which is a major organic fertilizer is often preferred to inorganic fertilizers due its high nutrient composition, slow release of nutrients to crops as well as its environmental-friendly potentials, which therefore informed the adoption of poultry manure for the research.

Application of either organic or mineral fertilizer has been found to be one of the quickest and easiest strategies for increasing the yield of cucumber per unit area (Nweke *et al*., 2014). This was why Eifediyi & Remison (2010), submitted that fertile soils significantly affect the quality and yield of crops as compared to infertile soils. Poultry manure is an excellent organic manure which contains about 3% – 5% nitrogen, 1.5% – 3.5% phosphorus, 1.5% – 3.5% potassium, and many micro nutrients (Mohammed *et al*., 2010). Unlike mineral fertilizer, it adds organic matter to the soil, which improves soil structure, nutrient retention, aeration, soil moisture holding capacity and water infiltration (Ali *et al*., 2011). Rai & Yadav (2004), acknowledged that growing of crops with organic manures result in produce with non-toxic chemicals and improved food tastes.

Since nutrients in poultry manure are released slowly to the soil, it therefore means that time is required for the mineralization of poultry manure by soil microbes before

the eventual release of nutrients to the soil for crop uptake. In some cropping systems, poultry manure is applied shortly after crops had been planted, while in others it is added to the soil shortly before planting. The conflicting time of application therefore justifies this research aimed at establishing the appropriate time of adding poultry manure to the soil to ensure maximum benefits to the crops.

Concerning time of application of poultry manure, Boateng *et al*. (2006) reported that there is a need for an incubation period after manure application before a crop is planted, because of rapid chemical changes in soil, following incorporation of manures. Ekeoma & Adedoji (2018) reported that the significant performance and influence by time of poultry manure application could be attributed to time of decomposition and consequent mineralization of the added poultry manure. Consequently, the research is aimed at evaluating the agronomic attributes of cucumber (*Cucumis sativus* L.) as influenced by time of poultry manure application in Abia State, South East, Nigeria.

Materials and Methods

Study area

The research was conducted at the Teaching and Research Farm of Michael Okpara University of Agriculture, Umudike. The site is located on latitude 05°29`N and longitude 07°33`E on the elevation of 122.0 m above sea level. It has a maximum and minimum temperature of 33°C and 24°C; annual rainfall of 2,690.8 mm and a relative humidity of 50% – 95% respectively. Rainfall pattern is bimodal, with rainfall starting from March – October, with a short spell in August (NRCRI, 2017).

Experimental design and treatments

The design of the experiment was 2 x 5 factorial laid out in a randomized complete block design (RCBD) with three replicates. Factor A comprised the two cucumber varieties (THAI 999 and POINSETT), while factor B comprised the time of poultry manure application including: O application (control), one week after planting (1WAP), one week before planting (1WBP), two weeks after planting (2WAP) and two weeks before planting (2WBP). The adopted varieties which had about three months' growth duration, were sourced from a seed company in Jos and Agro-farm Company in Imo State, Nigeria.

The field layout was 26.5 m × 8.6 m (227.9 m^2), while each plot measured 2.2 m × 2.2 m, 0.5 m spacing between plots, and 1 m spacing between replicates. This research maintained a uniform population density was 37,037 plants ha^{-1} at a spacing of 90 cm x 30 cm. Before cultivation, the site was mechanically ploughed and harrowed, and planting was done on 15th April, 2019 and 2020 cropping seasons, on beds. Two or three seeds were planted per hole and later thinned to one plant per stand at about 10 – 11 days after planting (DAP).

Poultry manure was applied at a rate of 20 tha^{-1} by ring placement method and subsequently incorporated manually into the soil in line with the treatment regime, after curing for one month. Weeding was carried out two times at one monthly interval (Olasantan & Aina, 1987), while pests were controlled with cypermetrin pesticide at the rate of 80 g per 15 litres of water, after the formation of flower buds to control some leaves and flower insects (Omotunde, 1996). Supplying of dead and weak cucumber

seedlings was done at 9 DAP, while mosquito nets were used to protect the research plants against rodents, squirrels and other destructive pests (Akpan, 2014).

Data collection

Data collection on leaf area index (LAI), number of vines per plant, total dry weight per plant, vine length per plant, and crop growth rate were conducted at 4, 8 and 12WAP, while fresh fruits collection for yield attributes such as length of fresh fruits per plant, harvest index and number of fresh fruits per hectare was conducted between 4 – 6 days, depending on the frequency of flowering and fruit formation (Akpan & Ojimadu, 2018). LAI was calculated with this formula:

$$\frac{LA}{P} \text{ (Watson, 1947)}$$

Where:

LA = Leaf area

P = Land area occupied by the plant

Number of vines per plant was determined by counting the vines of three stands of cucumber and the total divided by three. Total dry weight per plant (leaves, stems and roots) was determined by drying three cucumber stands between 3 – 5 days depending on the duration of solar radiation and the weight divided by three (Akpan & Mbah, 2016). Vine length per plant was by measuring the vines of three cucumber stands with the help of a measuring tape and the total subsequently divided by three while crop growth rate (CGR) was obtained by the formula below:

$$CGR = \frac{W_2\text{-}W_1}{(SA)\ T_2\text{-}T_1} \ (gm^2day^{-1}) \text{ (Brown, 1984)}$$

Where:

W_1 and W_2 = Crop dry weights

T_1 and T_2 = Corresponding days

SA = Soil area occupied by the plant

Number of fresh fruits per plant was obtained by counting the total fruits from three cucumber stands, and the total divided by three. Harvest index (HI) was obtained from the formula:

$$HI = \frac{\text{Economic yield}}{\text{Biological yield}} = \frac{\text{Weight fresh fruit per plant}}{\text{Total dry weight per plant}}$$

Number of fresh fruits per hectare ($kgha^{-1}$) was determined by the formula

$$\frac{\text{Fresh fruit per plot}}{\text{Plot size area}} \times 10{,}000m^2$$

Before the commencement of the research, composite soil samples were collected at the depth of 0 – 20 cm from the research site for physicochemical analyses with the help of an auger. The particle size distribution was determined by the Boyoucous hydrometer method (1962) as modified by Ge and Or (2002). Soil pH determination in H_2O and HCl was by a pH meter 1:2:5 ratio (Thomas, 1996). Organic matter was determined using Walkey-Black (1934) method, as outlined by Nelson & Sommer (1982). Total nitrogen was by Kjeldahl method as modified by Bremmer (1996). Available phosphorus was by Bray & Kurtz (1945) method, as modified by (Udo *et al*., 2009). Exchangeable acidity was extracted with 1 N KCl solution and titrated by NaoH (Udo *et al*., 2009). Ca and Mg were determined by atomic absorption spectrometry, while P and S were by flame photometry (Jackson, 1964).

Data analysis

Both vegetative and reproductive data were subjected to analysis of variance (ANOVA) method (Gomez & Gomez, 1984) using Genstat Discovery Edition Statistical Software (VSN International, 2009), while

Fisher's least significant difference (F – LSD) was used to compare significant means at 5% probability level.

Results and Discussion

Soil physicochemical and climatic information of the experimental site

The physicochemical characteristics of the research site (Table 1), shows that the soil textural class was sandy loam. Soil pH was 5.13 and 5.08; available *p* of 13.78 $mgkg^{-1}$ and 11.45 $mgkg^{-1}$; organic carbon of 1.13% and 1.09%; and organic matter of 1.95% and 1.86%; were all moderate in the research site for both cropping seasons. The textural status of the research site as well as pH status corroborates earlier recommendations by Remison (2012), and Chude *et al.* (2014) for the cultivation of cucumber.

Poultry manure (Table 1) was high in organic carbon (25.63 %), organic matter (44.99%), total nitrogen (2.1%), calcium (18.03 $cmolkg^{-1}$), magnesium (6.13 $cmolkg^{-1}$) as well as potassium (1.61 $cmolkg^{-1}$). The experiment was repeated in a separate plot during 2020 cropping season.

TABLE 1
Soil physicochemical properties of the research site during 2019 and 2020 cropping seasons and poultry manure analysis

Soil characteristics	**Values**		**Poultry manure analysis**
Physical properties	**2019**	**2020**	
Sand (%)	79.20	81.50	-
Silt (%)	9.17	8.67	-
Clay (%)	11.61	9.64	-
Textural class	Sandy-loam	Sandy-loam	
Chemical properties			
pH	5.3	5.8	-
Available P ($mg\,Kg^{-1}$)	13.78	11.45	4.90
Total nitrogen (%)	0.10	0.08	2.1
Organic carbon (%)	1.13	1.09	25.63
Organic matter (%)	1.95	1.86	44.99
Exchangeable Base (Cmol kg^{-1})			
Ca	1.82	1.80	18.03
Mg	1.08	1.03	6.13
K	0.24	0.16	1.61
Sodium	0.12	0.13	0.93
Exchange acidity	1.49	1.68	
Base saturation	18.63	5.68	
ECEC (Cmol kg^{-1})	4.75	3.69	

The climatic information of the research area in 2019 and 2020 cropping seasons (Table 2) showed that rainfall status was low from January and March. Rainfall situation however rose from April and dropped in October, preparatory for the commencement of dry seasons in November (Table 2). The amount of rainfall in a given month, seems to vary with rainfall intensity of that month and not the number of days that the rainfall occurred. Maximum and minimum temperatures also fluctuated in tandem with the wet and the dry periods of the research durations (Table 2). The total rainfall situation of the site and the temperatures conformed to the earlier reports by Ibia & Udo (2009), and Remison (2012).

TABLE 2
Climatic information of the research site during 2019 and 2020 cropping seasons

Months	2019				2020			
	Rainfall amount (mm)	Days	Tempt (°C) Max.	Min	Rainfall amount (mm)	Days	Tempt (°C) Max.	Min
January	51.0	3.0	33	23.4	33.0	2.0	34	22
February	0.0	0.0	35	24.6	80.1	6	35	24
March	76.7	10.0	35	24.6	96.0	9	34	24
April	188.3	8.0	33	24.2	337.5	15	33	23
May	134.2	16.0	32	23.7	246.6	18	33	23
June	298.1	16.0	32	23.5	326.6	22	33	21
July	493.9	15.0	30	23.3	237.0	15	30	20
August	222.4	22.0	31	23.1	173.3	11	30	22
September	400	15.0	30	29.7	334.7	12	30	23
October	184.2	7.0	30	23.6	238.9	18	31	23
November	31.0	2.0	32	23.6	44.3	3	31	24
December	0.0	0.0	34	23.5	0		33	21
Total	2,079.7				2,148.0			

Source: Meteorological unit, National Root Crops Research Institute, Umudike, Abia State, Nigeria

Vegetative attributes of cucumber as affected by time of poultry manure application

Leaf area index (LAI) for both variety and time of poultry manure application (Table 3) increased at 4 and 8WAP with a depreciation at 12WAP due to senescence. Higher LAI for both variety and time of application was recorded at 8WAP in both 2019 and 2020 cropping seasons. Variety THAI 999 recorded higher LAI of 0.119 and 0.117 (4WAP); 1.97 and 0.729 (8WAP) and 0.825 and 0.625 (12WAP) over POINSETT variety with lesser LAI values.

Poultry manure application at 2WBP recorded the biggest LAI of 0.233 and 0.122 (4WAP), 1.66 and 0.901 (8WAP), and 0.985 and 0.829 (12WAP), compared with the control with lesser LAI values in both cropping seasons (Table 3). LAI did not significantly ($p > 0.05$) affect variety at 4WAP in 2019. LAI was significantly ($p < 0.05$) affected by time of poultry manure application in 2019 and 2020 cropping seasons, except at 8WAP in 2019 cropping season when the parameter was non-significantly ($p > 0.05$) affected by time of poultry manure application. The parameter varied non-significantly ($p > 0.05$) with variety × time of application (interaction) at 4, 8 and 12WAP in 2019 cropping season. It however varied significantly ($p < 0.05$) with variety × time of poultry manure application at 4, 8 and 12WAP, in both cropping seasons. This result suggests that variety planted and time of poultry manure application have significant influences on LAI of cucumber. This result corroborates the findings by Adesina *et al*. (2014), Aliyu (2002) and Alabi (2006), that poultry manure improved the vegetative growth of cucumber.

TABLE 3
Effect of time of poultry manure application on leaf area index of cucumber varieties at 4, 8 and 12WAP during 2019 and 2020 cropping seasons

	Leaf area index (LAI)					
	4WAP		8WAP		12WAP	
Cucumber varieties	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
POINSETT	0.110	0.057	0.84	0.638	0.568	0.585
THAII 999	0.119	0.117	1.97	0.725	0.825	0.652
Mean	0.115	0.087	1.41	0.681	0.697	0.618
LSD ($p < 0.05$)	ns	0.002*	1.215	0.030*	0.188	0.087
Time of Application						
0 (Control)	0.083	0.048	0.21	0.218	0.131	0.175
1WAP	0.117	0.067	1.12	.717	0.841	0.639
1WAP	0.114	0.088	2.77	0.832	0.883	0.736
2WAP	0.076	0.111	1.27	0.738	0.642	0.714
2WBP	0.233	0.122	1.66	0.901	0.985	0.829
Mean						
LSD ($p < 0.05$)	0.077	0.002*	ns	0.048*	0.299	0.014*
Variety x time of application	ns	0.003*	ns	0.068	ns	0.019*

Number of vines per plant (Table 4) for variety and time of application increased at 4WAP and 8WAP and decreased at 12WAP with improved number of vines recorded at 8WAP in both cropping seasons. Variety THAI 999 produced higher 226 number of vines of 0.460 and 1.213 (4WAP), 4.15 and 3.140 (8WAP), 2.23 and 1.967 (12WAP), compared with POINSETT variety with fewer number of vines in both cropping seasons. Poultry manure application time at 2WBP produced higher number of vines of 0.767 and 1.617 (4WAP), 4.88 and 3.850 (8WAP), 3.32 and 2.433 (12WAP), compared with control with fewer number of vines (Table 4) in 2019 and 2020 cropping season.

Number of vines per plant was significantly ($p < 0.05$) by variety in both cropping seasons apart from at 12WAP in 2019 cropping season. Time of poultry manure application significantly ($p < 0.05$), influenced number of vines per plant, apart from the application at 8WAP in 2019 cropping season. Variety × time of application (interaction), significantly affected ($p < 0.05$) number of vines at 4 and 8WAP during 2020 cropping. The research has proven that variety planted and time of poultry manure application has greater influences on vine numbers of cucumber. This result confirms the earlier report by Khanet *et al.* (2017) that increased poultry manure level increased the vegetative performances of cucumber, due to high concentration of nutrients present in poultry manure. The result further showed that number of vines per plant varies with variety planted and time of poultry manure application. Also, THAI 999 has the genetic potential of producing more vines over that of POINSETT.

TABLE 4
Effect of time of poultry manure application on number of vines per plant of cucumbervarieties at 4, 8 and 2WAP during 2019 and 2020 cropping seasons

Cucumber varieties	Number of vines per plant					
	4WAP		8WAP		12WAP	
	2019	2020	2019	2020	2019	2020
POINSETT	0.180	0.273	2.35	1.713	1.52	1.433
THAI 999	0.460	1.213	4.15	3.140	2.23	1.967
Mean	0.320	0.743	3.25	2.427	1.88	1.700
LSD ($p < 0.05$)	0.2468	0.0880*	1.562	0.1086*	ns	0.2010*
Time of Application						
0 (Control)	0.00	0.00	1.47	1.350	0.45	1.000
1WAP	0.117	0.667	3.00	2.017	1.07	1.617
1WBP	0.550	0.283	3.25	2.667	1.92	1.733
2WAP	0.167	1.150	3.67	2.250	2.00	1.717
2WBP	0.767	1.617	4.88	3.850	3.32	2.433
Mean						
LSD ($p < 0.05$)	0.3902	0.1391*	ns	1.1717*	1.768	0.3179*
Variety × time of application	ns	0.1967	ns	0.2429*	ns	ns

Total dry weight per plant (Table 5) for variety and time of poultry manure application increased at 4 and 8WAP and depreciated at 12WAP, while higher total dry weight per variety and time of poultry manure application plant was recorded at 8WAP in both 2019 and 2020 cropping seasons. Variety THAI 999 recorded higher total dry weight of 0.628 g and 1.560 g (4WAP), 5.41 g and 41.10 g (8WAP), 2.40 g and 33.27 g (12WAP), compared with POINSETT with lower total dry weight per plant (Table 5) in year 2019 and 2020. Poultry manure application time at 2WBP gave highest total dry weight per plant of 0.732 g and 1.983 g (4WAP), 9.25 g and 56.22 g (8WAP), 4.22 g and 44.90 g (12WAP), over the control with lesser total dry weight per plant values in 2019 and 2020 respectively.

Total dry weight per plant varied non-significantly ($p > 0.05$) with variety in 2019 cropping seasons at 4, 8 and 12WAP. Total dry weight varied significantly ($p < 0.05$) with time of poultry manure application in both cropping seasons, while variety × time of application (interaction) significantly ($p < 0.05$) affected total dry weight only at 4WAP in 2020 cropping season. This therefore suggests that total dry weights will vary with variety and time of poultry manure application.

TABLE 5
Effect of time of poultry manure application on total dry weight per plant of cucumber varieties at 4, 8 and 12WAP during 2019 and 2020 cropping seasons

	Total dry weight per plant (g)					
	4WAP		8WAP		12WAP	
Cucumber varieties	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
POINSETT	0.459	1.240	4.76	37.48	2.37	29.36
THAI 999	0.628	1.560	5.41	41.10	2.40	33.27
Mean	0.544	1.400	5.09	39.29	2.40	31.32
LSD ($p < 0.05$)	ns	0.073*	ns	0.953*	Ns	1.333*
Time of Application						
0 (Control)	0.110	0.417	1.44	20.20	0.36	12.68
1WAP	0.515	1.233	4.97	33.93	2.41	31.47
1WBP	0.852	1.733	5.27	47.83	2.67	38.58
2WAP	0.510	1.633	4.49	38.27	2.13	28.95
2WBP	0.732	1.983	9.25	56.22	4.42	44.90
Mean						
LSD ($p < 0.05$)	0.454	0.114*	3.250	1.507*	1.386*	2.18
Variety × time of application	ns	0.162	ns	ns	Ns	ns

Vine length per plant (Table 6), for variety and time of poultry manure application increased at 4, 8 and 12WAP with the longest vines recorded at 12WAP in both cropping seasons. Variety THAI 999 produced longer vines of 15.871WBP cm and 24.631WBP cm (4WAP); 44.8 cm and 61.991WBP cm (8WAP); 59.8 cm and 71.51 cm (12WAP), compared with POINSETT variety which gave cucumber with shorter vines in 2019 and 2020 respectively. Time of poultry manure application at 2WBP gave longest vines of 23.78 cm and 30.52 cm (4WAP); 63.5 cm and 62.25 cm (8WAP), 71.5 cm and 75.73 cm (12WAP) compared with the control with shortest vines during both cropping seasons. Vine length per plant varied significantly ($p < 0.05$) with variety in 2020 cropping season at 4 and 8WAP, and at 12WAP in 2019 and 2020 cropping seasons. The parameter varied non-significantly ($p > 0.05$) with variety at 4 and 8WAP in 2019 cropping season. It also varied significantly ($p < 0.05$) with variety × time of application (interaction) at 4, 8 and 12WAP during 2020 cropping season.

Time of application at 2WBP produced cucumbers with the longest vine over other time of application. This suggests that the proper mineralization of poultry manure for nutrient release was optimized at 2WBP over other time of application. This result suggests that vine length per plant of cucumber will vary with variety and time of poultry manure application. This result is in conformity with Adekiya & Ojeniyi (2002) and Ewulu *et al.* (2008), who reported that poultry manure was a rich source of nutrient which also makes available essential nutrients elements to the crops. Ekeoma & Adedoji (2018) noted that poultry manure requires time for proper decomposition and subsequent mineralization for the eventual release of plant nutrients. The research suggested that THAI 999 variety possess higher genetic potentials of producing longer vines over POINSETT variety.

TABLE 6
Effect of time poultry manure application on vine length per plant of cucumber varieties at 4, 8 and 12WAP during 2019 and 2020 cropping seasons

	Vines length per plant(cm)					
	4WAP		8WAP		12WAP	
	2019	2020	2019	2020	2019	2020
POINSETT	14.96	17.55	37.7	39.75	44.0	51.54
THAI 999	15.87	24.63	44.8	61.99	59.8	71.51
Mean	15.42	21.09	41.2	50.86	51.9	61.53
LSD ($p < 0.05$)	ns	0.536*	ns	0.859*	10.80	0.606*
Time of Application						
0 (Control)	5.95	10.48	15.1	35.02	20.8	40.00
1WAP	16.45	20.30	41.1	47.08	50.4	56.53
1WBP	14.20	20.95	41.3	57.43	57.0	71.72
2WAP	16.70	23.22	45.2	52.53	60.1	63.65
2WBP	23.78	30.52	63.5	62.25	71.5	75.33
LSD ($p < 0.05$)	4.209*	0.848*	21.51	1.359	17.07	0.958*
Variety × time of application	ns	0.199*	ns	1.922*	ns	1.355*

Crop growth rate (Table 7), for variety and time of poultry manure application was active at 4 to 8WAP and negative at 8 to 12WAP during 2019 and 2020 cropping seasons. Variety THAI 999 gave active growth rate of 0.590 gm^{-2} week and 4.881 gm^{-2} $week^{-1}$ at 4 to 8WAP, as well -0.318 gm^{-2} $week^{-1}$ and -1.002 gm^{-2} $week^{-1}$ at 8 to 12WAP, compared with POINSETT variety. Time of application of 2WBP gave positive growth of 1.052 gm^{-2} $week^{-1}$ and 6.695 gm^{-1} $week^{-1}$ at 4 to 8WAP, as well -0.596 and -1.397 gm^{-2} $week^{-1}$ at 8 to 12WAP, compared with the control during 2019 and 2020 cropping seasons (Table 7).

Crop growth rate varied significantly ($p < 0.05$) with variety at 8WAP in 2020 cropping seasons. It however varied significantly ($p < 0.05$) with time of application at 4, 8, and 12WAP and non-significantly ($p > 0.05$) with variety × time (interaction) in both cropping seasons. This has shown that cucumber growth rate is active between 4 to 8WAP and also depreciated between 8 to 12WAP, which signals the terminal growth phase of cucumber and zero dry matter partitioning. This finding conforms with Akpan *et al.* (2021) who reported active and negative growth phases for turmeric. The authors identified the negative growth period as a terminal growth phase which according to the authors is worsened by the process of senescence.

TABLE 7
Effect of time poultry manure application on crop growth rate of cucumber varieties at 4WAP – 8WAP, and 8WAP – 12WAP during 2019 and 2020 cropping seasons

Cucumber varieties	Crop growth rate (gm^{-2} day^{-1})			
	4WAP – 8WAP		8WAP – 12WAP	
	2019	2020	2019	2020
POINSETT	0.531	4.474	-0.295	-0.916
THAI 999	0.590	4.881	-0.318	-1.002
Mean	0.561	4.674	-0.332	-0.984
LSD ($p < 0.05$)	ns	0.115	ns	ns
Time of Application				
0 (Control)	0.531	2.442	-0.133	-0.928
1WAP	0.550	4.037	-0.316	-0.305
1WBP	0.545	5.691	-0.321	-1.142
2WAP	0.492	4.523	-0.292	-1.150
2WBP	1.052	6.695	-0.596	-1.397
Mean				
LSD ($p < 0.05$)	0.3834	0.2560	0.3863	0.3763
Variety x time of application	ns	ns	ns	ns

Reproductive growth of cucumber as affected by time of poultry manure application

The values of the evaluated reproductive parameters, including length of fresh fruits per plants, harvest index and number of fresh fruits per hectare (Table 8), varied with variety planted and time of poultry manure application. Longer fruits per plant (Table 8) of 68.1 cm (2019) and 125.43 cm (2020) were recorded for THAI 999 over POINSETT variety with shorter fresh fruits per plant. Poultry manure application time at 2WBP yielded longer fruits per plant of 82.0 cm (2019) and 139.12 cm (2020), compared with the control. The length of fresh fruits per plant varied significantly ($p < 0.05$) with variety in 2020 and non-significantly ($p > 0.05$) in 2019. It also varied significantly ($p < 0.05$) with time of application in both cropping seasons. The parameter varied significantly ($p < 0.05$) with variety x time of application (interaction) in 2020 cropping season. The increased yield performance of THAI 999 and application time at 2WBP over POINSETT variety and other times of application respectively showed that variety planted and time of poultry manure application have tremendous influences on the yield performance of cucumber. This result corroborates earlier report by Adediran *et al.* (2003), who reported that poultry manure is a rich source of nutrients which significantly increased fruit length.

Higher harvest index (Table 8) of 56.5% (2019) and 68.49% (2020) was recorded by THAI 999 compared with POINSETT variety with lesser values (Table 8). Poultry manure application time at 2WBP gave the highest harvest index of 67.0% and 80.99% in both cropping seasons compared with the control. Harvest index varied significantly ($p < 0.05$) with variety in 2020 cropping season, and non-significantly ($p > 0.05$) in 2019 cropping season. It varied significantly ($p < 0.05$) with time of application during both cropping seasons. Variety × time of poultry manure application (interaction) significantly ($p < 0.05$) affected harvest index in 2020 cropping season.

Higher number of fresh fruits per hectare ($kgha^{-1}$) of 7,396 and 8,167 ($kgha^{-1}$) was obtained from THAI 999 over POINSETT variety. Poultry manure

application time at 2WBP produced higher number of fresh fruits per hectare of 10,674 (kgha^{-1}) (2019) and 13.958 kgha^{-1} (2020) compared to the control in both cropping seasons. Number of fresh fruits per hectare varied significantly ($p < 0.05$) with variety, and time of poultry manure application in both cropping seasons. It varied significantly with variety x time of application (interaction) in 2019 cropping seasons.

The result clearly explained that variety and time of poultry manure application impacted positively on reproductive indices of cucumber. This result was earlier reported by Ekeoma & Adesoji (2018), that significant increases on number of fruits per hectare as influenced by time of poultry manure application could be attributed to the fact that time is needed for the decomposition and consequent mineralization of the applied poultry manure. The higher reproductive performance by THAI 999 could be attributed to the possession of some improved growth attributes such as higher LAI, dry weight, possession of higher number of vines as well as longer vines.

TABLE 8
Effect of time of poultry manure application on some reproductive attributes of cucumber varieties during 2019 and 2020 cropping seasons

Cucumber variety	Length of fresh fruits per plant (cm)		Harvest index (%)		Number of fresh fruits per hectare (Kgha^{-1})	
	2019	2020	2019	2020	2019	2020
POINSETT	55.8	54.34	53.3	60.27	6144	1024
THAI 999	68.1	125.43	56.5	68.49	7396	8167
Mean	61.9	89.88	54.9	64.38	6770	9201
LSD ($p < 0.05$)	ns	1.596*	ns	0.191*	6855	1028.0*
Time of Application						
0 (Control)	29.7	27.62	22.2	11.94	2424	3750
1WAP	59.0	86.90	57.6	77.93	6625	8611
1WBP	69.5	86.92	66.8	74.0	8403	9896
2WAP	69.4	108.87	61.1	77.08	5726	9792
2WBP	82.0	139.12	67.0	80.99	10674	13958
Mean						
LSD ($p < 0.05$)	26.44	2.521*	26.03	0.301*	1083.3*	16258.0*
Variety x time of application	ns	3.565*	ns	0.426*	1532.8	ns

Conclusion and Recommendation

This study has shown that although poultry manure is necessary for optimum plant growth and yield irrespective of the time of application, it is equally important to allow the organic manure to properly decompose and mineralize before crops are planted. Variety THAI 999 and time of application of 2WBP performed better than other varieties and time of application. This therefore suggests that the growth and yield attributes of cucumber will vary with the variety and time of poultry manure application. Variety THAI 999 was more adaptive to the agro-ecosystem compared with POINSETT variety, while 2WBP offered ample time for the decomposition and mineralization of the manure for the release of the needed nutrients. For a positive result, the site requires a higher rate of poultry manure application.

Consequently, for optimum production of cucumber in South Eastern, Nigeria THAI 999 and poultry manure application time at 2WBP are recommended.

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