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EFFECTS OF LIME AND POULTRY MANURE ON SOIL PROPERTIES AND CUCUMBER (CUCUMIS SATIVUM L) PERFORMANCE IN THE HUMID TROPICS OF SOUTHERN NIGERIA

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ABSTRACT

Purpose: To investigate the effect of lime and organic fertilizer on soil properties and the performance of cucumber in Calabar.
Method: Factorial combination of three levels of lime (0, 4 and 8 t/ha) and three levels of poultry manure (0, 3 and 6 t/ha), laid out in randomized complete block design (RCBD) with three replications. Data were collected on crop growth and yield indices, and soil properties (physical, chemical and biological) each year, then combined and analyzed. Fisher's least significant difference (FLSD) at 5 % probability was used to compare the means.
Results: There was increase in soil pH, total nitrogen, organic carbon, phosphorus, potassium, calcium and magnesium as well as the population of beneficial soil microorganisms. Lime, poultry manure (PM) and their interactions significantly (p <.0. 05) influenced the vegetative growth and fruit yield of cucumber. Cucumber treated with 8 t/ha lime had the highest vegetative growth and fruit yield (22.64 t/ha) values. Cucumber treated with 6 t/ha PM had superior growth and fruit yield (17.89 t/ha) than the control (14.27 t/ha). The interaction of 8 t/ha lime and 6 t/ha PM produced the highest values of vegetative growth and fruit yield of 25.66 t/ha and is therefore recommended for effective soil enhancement and optimum cucumber production in Calabar.

KEYWORDS: cucumber, lime, poultry manure, soil properties, fruit yield.

INTRODUCTION

The productivity of humid tropical soils is constrained mostly by high soil acidity and nutrient fixation due to torrential rainfall and continuous use of inorganic fertilizers in the region (Umunnakwe et al., 2023). Effective soil management approach can integrate lime and organic manure to achieve a low-cost sustainable agricultural system (Akpan et al., 2017; Umunnakwe et al., 2022). Poultry manure (PM) is very rich in organic carbon which has been reported to improve soil bio-physical properties and support optimum crop performance (Ezeibekwe et al., 2009; Idem et al., 2012; Akpan et al., 2019). It also contains high amounts of major soil nutrients such as nitrogen, calcium, magnesium, potassium and phosphorus (Shiyam and Binang, 2013).

Generally, the incorporation of PM to the soil increases its organic matter content, reduces erosion, enhances infiltration and retention of soil moisture, promotes the biological activities on the rhizosphere, improves the structure, neutralizes soil pH and makes more nutrients available to the soil and could benefit cucumber crop (Umunnakwe et al., 2022).
Cucumber (Cucumis sativus L.) is an important dicotyledonous vegetable crop of Cucurbitaceae family that bears cylindrical fruits. The nutrient components of cucumber are vital for body development (Abbey et al., 2017; Raza et al., 2020). Sanni et al. (2015) averred that cucumber has great nutritional and health benefits which include treatment of dyspepsia in children and in skin care, cancer prevention and rehydrating of body, aids in

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weight loss and digestion, cures diabetes, reduces cholesterol, helps in elimination of toxins from the human body and controls blood pressure (Agu et al., 2015). According to Opara et al. (2012) and Umeh and Ojiako (2018), cucumber is a very good source of phytonutrients like dietary fibers, vitamins A, C, K and B6, beta-carotene, flavonoid, lycopene, potassium, phosphorus, manganese, magnesium, copper and equally rich in pantothemic acid. There is dearth of information on the impact of lime and PM on cucumber production in Calabar, thus warranting this present study.

MATERIALS AND METHODS

A field experiment was conducted during the early planting season of 2021 and 2022 at the University of Calabar Teaching and Research Farm, Calabar, Nigeria. Calabar is located at the southeastern rainforest agro-ecological zone of southern Nigeria (4.5^0N - 5.2^0N, 8.3^0E; about 39 m above sea level), and has a bimodal annual rainfall distribution that ranges from 3,000 to 3,500 mm with mean annual temperature range of 27 - 35 ^{0} C and relative humidity of 75 % to 88 % (Efiong, 2011). The experiment was a 3 x 3 factorial laid out in Randomized Complete Block Design (RCBD) with three replications. Each replication comprised nine treatment combinations of three lime ($CaCO_3$) levels (0, 4 and 8 t/ha) and three levels of PM (0, 3 and 6 t/ha). The lime and cured PM were thoroughly worked into the soils during seedbed preparation according to treatment and design specifications, before sowing of cucumber seeds three days later. Seeds of marketer cucumber variety obtained from Cross River Agricultural Development Project (CRADP) were sown at the rate of two per hole at 30 cm × 100 cm spacing and later thinned to one, giving a population of 30,000 plants per hectare. Composite soil samples were taken randomly 5 meters apart at a depth of 0 – 30 cm for pre- and post-cropping in each of the study years using soil auger. Sub-sample was removed from the composite sample obtained, for microbiological analysis and the remaining was air-dried, ground and sieved through a 2 mm sieve and closed in plastic bags for physico-chemical analyses following the procedures described by Udo et al. (2009). Plant growth and fruit yield data were collected from six middle plants per plot and subjected to analysis of variance (ANOVA) procedures for factorial experiments in randomized complete block design (RCBD) using the GenStat Package Version 8.1 of 2015. Means were compared using Fisher's least significant difference (FLSD) method at 5% level of probability as described by Wahua (2010).

RESULTS AND DISCUSSION

Properties of PM and soil of the experimental site

The chemical properties of the PM used for the experiment as well as the physico-chemical and biological properties of the pre- and post-cropping soils of the experimental site are presented in Table 1. Analysis of the PM showed that it had a high pH of 6.41 and had very high contents of total nitrogen, magnesium, calcium, phosphorous and organic carbon, but low contents of potassium and sodium. The textural class was sandy loam in pre- and post-cropping soils. The soil pH, total nitrogen, organic carbon, organic matter, potassium, magnesium, sodium, effective cation exchange capacity (ECEC) and base saturation all increased in post cropping soils relative to pre-cropping. The value of exchangeable acidity (H^+) slightly decreased in post cropping soils. The bacterial population, fungal population, microbial biomass and potentially mineralizable carbon increased in post cropping soils.

The increase in the pH, total nitrogen, organic carbon, organic matter, potassium, magnesium, sodium, effective cation exchange capacity, base saturation and the population of beneficial microorganisms in the soil post cropping suggests that the incorporated lime and PM had improved the soil microclimate by providing sufficient substrates. It also suggests that the soil amendments used could reduce the acidity of the soil and enhance the availability of essential soil nutrients. This observation is at par with the findings of Joshua et al. (2002), Yamada, (2002), Suresh et al. (2004) and Dauda et al. (2008),

Effects of lime and organic soil amendment on the growth parameters of cucumber

The effects of lime, PM and their interactions on the growth parameters of cucumber are presented in Table 2. Results indicated significant effects of lime on all the growth parameters of cucumber measured across the sampling periods. The longest vines were obtained from the plots treated with 8 t/ha lime rate across the sampling periods while the shortest vines were obtained from the plot without lime application (control). However, at 3 WAP, the length of vines obtained from the control and the plot treated with 4 t/ha lime rate were statistically similar ($P > 0.05$). Significantly more vines were obtained from the plots treated with 8 t/ha lime rate across the sampling periods while the lowest values were obtained from the plots not treated with lime.

The effects of PM on the growth parameters of cucumber measured across the sampling periods were significant ($P \leq 0.05$) except on number of leaves at 3 WAP where the total leaf production per plant was statistically similar across the PM rates.

Longer vines were obtained from the plots treated with 6 t/ha PM rate compared with 4 t/ha PM rate and those not treated with PM across the sampling periods. More leaves were produced in the plot treated with higher PM rate of 6 t/ha at 7 WAP compared with 3 t/ha and the control. The control had the lowest values of total leaves produced per plant. The interaction of lime and PM on the growth parameters of cucumber measured was significant ($P \leq 0.05$) across the sampling periods. The longest vines with more leaves were obtained with the combination of 8 t/ha lime and 6 t/ha PM, while the lowest values were obtained from the control plots.

The superior performance of cucumber treated with PM relative to those without suggests that PM contains essential nutrient elements needed for the growth of cucumber and availability of these nutrients varies with the quantity of PM applied. This observation corroborates with earlier reports by Li et al. (1998), Ewulo (2005), Hegazi et al. (2007), Moyin-Jesu (2008), Rasool et al. (2008), Fayed (2010), AL-Kahtani and Ahmed (2012), and Kissetu and Assenga (2013).

Effect of lime and poultry manure on cucumber fruit yield indices

The effects of lime,PM and their interactions on cucumber fruit yield indices are presented in Table 3. Results indicated significant effect of lime on the fruit yield indices measured. Higher number of fruits per plant (7.14) and fruit yield per hectare (22.64 t/ha) were obtained from the plots treated with 8 t/ha lime rate while the lowest values were obtained from the control plot. The effect of PM on the fruit yield indices measured were also significant ($P \leq 0.05$). Higher number of fruits per plant (5.81) and fruit yield per hectare (17.89 t/ha) were obtained from the plots treated with 6 t/ha PM rate compared with 3 t/ha and the control. The control had the lowest fruit yield turnover per hectare.

The interaction effects of lime and PM on the fruit yield indices measured were significant ($P \leq 0.05$). The highest values for number of fruits per plant and fruit yield per hectare were obtained from the combination of 8 t/ha lime rate and 6 t/ha PM, which however, were similar with those obtained from the combination of 8 t/ha lime rate and 3 t/ha PM, while the lowest values were obtained from the control plots.

The higher fruit yield obtained from cucumber plants treated with lime relative to those not treated with lime suggests that the enhancement of vegetative growth of cucumber by lime was translated into higher yield. Also, the incorporation of lime must have released the bound soil nutrients that benefited the cucumber plant from the seedling stage through the reproductive phase. This report conforms with earlier reports of Joshua et al. (2002), Arun and Kurmar (2014), Baghel et al. (2017) and Singh et al. (2020).

The higher fruit yield of cucumber plants treated with PM as compared with those without PM may be as a result of increase in the availability of essential plant nutrients in the soil rhizosphere and effective absorption of those elements by the cucumber plant. Similar findings have also been reported by Ojeniyi et al. (2007), Moyin-Jesu, (2008), andKissetu and Asenga (2013). Poultry manure amendment has also been shown to increase soil organic carbon, total nitrogen and available phosphorus which consequently increased rice yield (Lv et al., 2011).

Table 1: Properties of PM and soils of the experimental site

	Poultry manure	Preplanting soil	Soil after harvest
Biological properties			
BAC_POP($x10^6$ $cfug^{-1}$)	-	20.32	87.88
FUN_POP($x10^{-3}$ $cfug^{-1}$)	-	7.09	24.59
MB($MgCO_2^{-1}$)	-	1.01	2.33
PMC($MgCO_2$-C)		1.32	16.96
Physical properties			
Sand (%)	-	86.47	80.07
Silt (%)	-	8.50	13.93
Clay (%)	-	5.03	6.00
Texture	-	Loamy sand	Loamy sand
Chemical properties			
pH (H_2O)	6.41	5.61	6.24
Organic carbon (%)	28.63	1.21	23.47
Total nitrogen (%)	2.01	0.19	0.92
Available phosphorus (mg/kg)	94.00	63.81	87.66
Exchangeable potassium (cmol/kg)	1.19	0.15	1.02
Exchangeable calcium (cmol/kg)	15.34	6.06	12.35
Exchangeable magnesium (cmol/kg)	7.29	1.80	16.32
Exchangeable sodium (cmol/kg)	0.54	0.07	0.19
Exchange acidity (H^+)(meq/100g)	-	1.35	0.53
Effective cation exchange capacity(cmol/kg)	-	9.43	30.41
Base saturation (%)	-	85.68	98.25

Key:
BAC_POP = Bacterial population, FUN_POP = Fungal population, MB = Microbial biomass, PMC = potentially mineralizable carbon

Table 2: Vine length and number of cucumber leaves as influenced by lime and poultry manure

Treatments	Vine length (cm)			Number of leaves		
Lime	3 WAP	5 WAP	7 WAP	3 WAP	5 WAP	7 WAP
0 t/ha (L0)	16.74	71.60	114.10	5.97	22.36	42.08
4 t/ha (L4)	19.64	84.30	157.00	6.92	30.03	52.67
8 t/ha (L8)	27.18	109.50	170.70	7.64	34.67	59.97
LSD (0.05)	3.03	11.51	11.42	0.54	4.25	4.80
Poultry manure						
0 t/ha (PM0)	20.13	81.00	135.60	6.39	25.50	46.67
3 t/ha (PM3)	19.30	86.70	143.20	6.89	30.17	51.86
6 t/ha (PM6)	24.13	97.60	163.00	7.25	31.39	56.19
LSD (0.05)	3.03	11.51	11.42	NS	4.25	4.80
Interactions						
L0M0	16.96	66.10	88.20	6.08	18.25	36.67
L0M3	15.32	72.20	111.00	6.00	23.75	43.33
L0M6	17.95	76.60	143.00	5.83	25.08	46.25
L4M0	20.03	81.70	154.10	6.58	27.25	51.00
L4M3	18.24	81.00	150.20	6.58	30.75	52.67
L4M6	20.64	90.20	166.80	7.58	32.08	54.33
L8M0	23.41	95.40	164.50	6.50	31.00	52.33
L8M3	24.35	107.00	168.50	8.08	36.00	59.58
L8M6	33.79	126.11	179.30	8.33	37.00	68.00
LSD (0.05)	5.24	19.93	19.78	0.94	7.36	8.31

Key:
WAP: weeks after planting
NS: not significant

Table 3: Effect of lime and poultry manure on number of cucumber fruits per plant and fruit yield per hectare

Treatments	Fruits per plant	Yield per hectare (t/ha)
Lime		
0 t/ha (L0)	2.92	10.53
4 t/ha (L4)	4.75	15.27
8 t/ha (L8)	7.14	22.64
LSD (0.05)	0.59	1.90
Poultry manure		
0 t/ha (PM0)	4.33	14.27
3 t/ha (PM3)	4.67	16.29
6 t/ha (PM6)	5.81	17.89
LSD (0.05)	0.59	1.90
Interactions		
L0M0	2.42	9.63
L0M3	3.00	10.37
L0M6	3.33	11.60
L4M0	4.25	13.37
L4M3	3.92	16.03
L4M6	6.08	16.40
L8M0	6.33	19.80
L8M3	7.08	22.47
L8M6	8.00	25.66
LSD (0.05)	1.02	3.30

CONCLUSION:

The findings of this research have shown that soil amendment with lime and PM can increase soil pH, enhance the activities of beneficial soil microbes and provides essential soil nutrients such as nitrogen, phosphorus, potassium and magnesium for plant usage. The application of lime and PM significantly enhanced the vegetative growth and fruit yield of cucumber. The interaction of lime and PM resulted in synergistic effect that enhanced the vegetative growth and fruit yield of cucumber. Lime at 8 t/ha in combination with 6 t/ha PM had the best positive effects on cucumber growth and yield indices and is recommended for optimum cucumber production in Calabar, Nigeria.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest associated with the study.

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