International Journal of Plant & Soil Science
5(3): 167-174, 2015; Article no.IJPSS.2015.070
ISSN: 2320-7035

SCIENCEDOMAIN *international*
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Performance of Three Varieties of Cucumber (*Cucumis sativus*) in Composted Rice Husks Plus Poultry Manure Media and the Effects on Soil Nutrient Status

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Authors' contributions

This work was carried out in collaboration between all authors. Authors UMN and CCO designed the experiment. Author UMN did the draft and final write-up. Author EEI assisted in the laboratory and data analyses. The write-up was accepted by all the authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2015/13603
Editor(s):
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Complete Peer review History: http://www.sciencedomain.org/review-history.php?iid=781&id=24&aid=7406

Original Research Article

Received 25th August 2014
Accepted 13th October 2014
Published 18th December 2014

ABSTRACT

A field trial was conducted to evaluate the effects of composted rice husks plus poultry manure rates on the soil chemical properties, morphological growth and yield of three varieties of cucumber (*Cucumis sativus*). The experiment was a 3 × 4 factorial laid out in a randomized complete block design (RCBD) with three replications. Twelve treatment combinations consisting of four rates (0 t ha $^{-1}$, 5 t ha $^{-1}$, 10 t ha $^{-1}$ and 15 t ha^{-1}) of composted rice husks + poultry manure (75%:25%, volume to volume; v/v) and three cucumber varieties (*Poinsett, Marketer* and *Supermarketer*) were laid out in the Teaching and Research Farm of Department of Crop Science, University of Nigeria, Nsukka. The highest application rate of 15 t ha^{-1} gave significantly (P = .05) the highest values of

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total nitrogen (1.36%), available phosphorus (80.36 ppm), organic carbon (4.10%), organic matter content (7.07%), exchangeable potassium (0.38 meq/100 g), exchangeable calcium (5.80 meq/100 g) and exchangeable magnesium (4.30 meq/100 g) compared with the other rates. There was highest correlation coefficient (r = .995**) between soil organic carbon and exchangeable calcium and the least between exchangeable potassium and magnesium (r = .473). The 15 t ha^{-1} of compost manure significantly (P = .05) also gave the highest values of plant height, stem girth, leaf area, number of leaves and yield in the three varieties of cucumber (*Poinsett, Marketer and Supermarketer*).

Keywords: Cucumber; poultry manure; rice husks; soil nutrient.

1. INTRODUCTION

Cucucmber (*Cucumis sativus*) is an important fruit vegetable crop eaten with the other vegetables as salad. The cultivation of cucumber in Nigeria is constrained by low soil fertility. Cucumber requires fertile soil as infertile soil results in bitter taste and misshapen fruits that are rejected by consumers [1]. However, there is increasing concern on the health hazard posed by frequent addition of chemical fertilizers into the soil. Consequently, concerted efforts had been made to review the use of chemical fertilizers and place more emphasis on the use of organic fertilizers such as green manure, compost manure, farm yard manure and crop residues like rice husks and maize stalk [1,2]. One of the roles of organic manure amendment is to improve soil properties and supply nutrients to enrich the soil [18]. Hussien [3] noted that nutrients present in the leaf of cucumber increased gradually with increasing levels of sewage sludge application. This was evident in the plant tissue analysis data which showed that the leaf macronutrients like nitrogen (N), phosphorus (P), and potassium (K), and micronutrient contents increased with increasing levels of sewage sludge application. In the sub-humid zone of Burkina Faso, surface application of compost at 5 t ha^{-1} to *Sorghum bicolor* led to grain and straw yield increases of 46%-49% and 16%-20% respectively above the unamended control [4]. Similarly, Dommergues and Ganry [5] reported yield increases of 13% and 54% above the control in soy bean (*Glycine max*) and maize (*Zea mays*) grain, respectively, when 1.5 - 2 t $ha\text{-}^{1}$ of compost was applied. There is paucity of information on the use of composted rice husks plus poultry manure rates for the production of cucumber crop.

The aim of this study, therefore, was to investigate the effects of different rates of composted rice husks plus poultry manure (75%:25%, volume to volume; v/v) on soil nutrient status, morphological growth and yield of three varieties of cucumber (*Cucumis sativus* L.)

2. MATERIALS AND METHODS

The experiment was carried out at the Teaching and Research Farm of the University of Nigeria, Nsukka. Nsukka is located on latitude 06^0 52'North, longitude 07º 24'East and altitude 447.26 meters above sea level (m.a.s.l). Rainfall distribution pattern in this region is bimodal with peaks in July and September and a short dry spell around mid-August. The soil of the experimental site is a reddish-brown loamy clay Ultisol (Oxic paleustult) belonging to the Nsukka series [6]. Nsukka is located in a derived savanna vegetation zone with mean annual minimum and maximum temperatures of 25ºC and 32ºC respectively [7].

2.1 Composting

Rice husks obtained from Songhai Farm Adani, Nsukka and poultry manure obtained from Telefood Research Project, University of Nigeria, Nsukka (Hujii-UNN) were composted using a mixing ratio of 75%:25% (volume to volume; v/v). Composting was done aerobically in perforated black plastic buckets with lids for three months. Turning and watering were done whenever necessary throughout the period of composting.

2.2 Experimental Design and Field Operations

Field trials were conducted in 2012 and 2013 using twelve treatment combinations i.e. three varieties of cucumber (*Poinsett, Marketer* and *Supermarketer*) and four rates of composted rice husks + poultry manure (0 t ha^{-1}, 5 t ha^{-1}, 10 t ha^{-1} and 15 t ha^{-1}). Cucumber seeds were obtained from Enugu State Agricultural Development Programme. The experiments were 3 × 4 factorial experiments in randomized complete block design (RCBD) with three replications. The land was cleared of existing grasses, ploughed and made into beds of 2 m by 2 m (4 m^2). A total of thirty-six beds were made in each planting season. The beds were separated from one another by a spacing of 1 m. The composted rice husks + poultry manure was properly cured for four weeks (to avoid health hazards) before being incorporated into the soil to a depth of 0-15 cm using a hand hoe. Seeds of three cucumber varieties namely; *Poinsett, Marketer* and *Supermarketer* were planted to a depth of 5 mm in the prepared beds at a spacing of 50 cm by 50 cm thus, giving a total of sixteen plants per plot. Planting was done at the rate of two seeds per hole and thinned down to one plant per hole at two weeks after planting. Three plants from the two centre rows were randomly sampled during data collection. Prophylactic application of 15 mls of Karate in 5 liters of water was done at five days after seedling emergence to avert pest incidence. Weeding was done manually whenever necessary throughout the experimental period.

2.3 Soil Sample Collection and Analysis

Soil samples were collected from the top soil at a depth of 0 -15 cm before and two weeks after the application of the compost manure (rice husks + poultry manure) to determine the effects of the manure rates on the chemical properties of the soil. Representative soil samples were randomly collected and bulked to form a composite sample for the experimental site. The analysis of the soil was done at the Teaching and Research Laboratory of the Department of Soil Science, University of Nigeria, Nsukka. Samples were air-dried, ground and passed through a sieve with 2 mm standard mesh size. Organic carbon was determined using the Walkley and Black wet digestion method [8]. Soil organic matter content was obtained by multiplying the value of organic carbon by 1.724 (Van Bemmeler factor). Total nitrogen was determined by micro-kjeldahl procedure [9]. Available phosphorus was extracted with Bray II extractant as described by Bray and Kurtz [10] and determined colorimeterically using ascorbic acid method [11]. Exchangeable potassium was extracted using 1N ammonium acetate (NH_4OAC) solution and determined by the flame emission spectroscopy as outlined by Anderson and Ingram [12]. Calcium and magnesium were determined by the complexiometeric titration method as described by Chapman [13]. The results of the chemical and physical properties of the soil before the compost manure application are shown on (Table 1).

Table 1. The physical and chemical properties of the soil before the application of composted rice husks + poultry manure

Parameters	Level
Particle size distribution (%)	
Fine sand	36.00
Coarse sand	34.00
Silt	12.00
Clay	18.00
Textural class	Sandy loam
Soil pH (H_20)	5.00
Soil pH (KCL)	4.10
Total nitrogen (%)	0.042
Organic carbon (%)	1.07
Organic matter content (%)	1.85
Exchangeable cations (meq/100 g)	
Sodium	0.252
Potassium	0.242
Calcium	3.60
Magnesium	0.40
Cation exchange capacity (meq/100 g)	6.80
Base saturation (%)	66.08
Exchangeable acidity (meq/100 g)	2.40
Available phosphorus (ppm)	8.39

2.4 Morphological Growth and Yield Data Collection and Analysis

Morphological growth parameters were measured fortnightly for six weeks (peak of vegetative growth) in each season. Plant height was determined by measuring the length of the plant from soil level to the shoot tip using a measuring tape. Leaf area per plant was estimated as leaf length (L) x width (W) x 0.85 as described by Blanco and Folegatti [14]. Number of leaves per plant was determined by counting. Stem diameter of the main vine was measured with vernier calipers and converted to girth using the following formula:

$$SG = SD\pi = SD \times 22/7$$

Where SG is stem girth and SD is the stem diameter.

The yield parameters i.e. number of fruits/plant and total fruit fresh weight/plant for each season were measured at harvest. Data collected were subjected to analysis of variance (ANOVA) as outlined by Obi [4]. Significant means were separated using Fishers least significant difference (F-LSD) at 5% probability level. Statistical analysis was executed using GENSTAT Release 7.2DE Discovery Edition 3 [15]. Correlation coefficients (r) between the soil chemical properties were computed.

3. RESULTS AND DISCUSSION

The highest application rate of 15 t ha^{-1} gave the highest values of total nitrogen (1.36%), available phosphorus (80.36 ppm), organic carbon (4.10%), organic matter content (7.07%), exchangeable potassium (0.38 meq/100 g), exchangeable calcium (5.80 meq/100 g) and exchangeable magnesium (4.30 meq/100 g) respectively after two weeks of compost manure application. The least values of all the elements were obtained in the control treatment (Table 2). There were high significant (P = .01) positive correlations between total nitrogen and available phosphorus, organic carbon, organic matter, exchangeable calcium and magnesium (r = .862**, .933**, .945**, .918** and .880** respectively). There were also high significant (P = .01) positive correlations between the available phosphorus and organic carbon, organic matter, exchangeable calcium and magnesium (r = .981**, .973**, .991** and .990** respectively). The relationship between the soil organic carbon and organic matter, exchangeable calcium and magnesium were also highly significant at 1% probability (r = .994**, .995** and .979**). Organic matter correlated significantly (P = 0.01) with exchangeable calcium and magnesium (r = .992** and .972**) as well as calcium with magnesium (r = .992**). There were no significant correlations between exchangeable potassium and other soil chemical elements. The association between organic carbon and exchangeable calcium gave the highest correlation coefficient value of r = .995** and that between exchangeable magnesium and exchangeable potassium, the least r value of .473 (Table 3).

The 15 t ha^{-1} manure rate significantly (P = .05) gave the highest values of plant height, stem girth, leaf number and leaf area at six weeks of planting while the control gave the least. *Supermarketer* variety performed best of the three cucumber varieties followed by *Marketer* and then *Poinsett*. There were significant (P = .05) treatment, varietal and treatment x variety interaction effects on all the morphological characteristics (Table 4). The 15 t ha^{-1} manure rate significantly (P = .05) also gave the highest values of total fresh fruit weight and number of fruits per plant. There were significant (P = .05) treatment, varietal and treatment x varietal interaction effects on the yield traits (Table 5).

The increase in the chemical properties and consequent improved morphological growth and yield in the cucumber varieties with increasing levels of the compost manure was an indication that composted rice husks + poultry manure (75%:25%, v/v) at the rate of 15 t ha^{-1} could be used effectively in soil and vegetable crop improvement programme. Ayoola and Adediran [2] noted that organic manure such as poultry manure, sewage sludge, composted crop residues etc. improved the chemical properties of the soil due to the addition of organic matter. The significant increase in soil total nitrogen and organic carbon contents observed at highest rate of application (15 t ha^{-1}) could be attributed to the decomposition of the organic matter fraction and the production of organic acids like carbonic and humic acids in the soil. Hussein [3] reported that the use of different rates of sewage sludge as soil amendments in the cultivation of cucumber (*Cucumis sativus* L.) in sandy and calcareous soils increased the soil total nitrogen and organic carbon respectively. Increase in the exchangeable potassium, calcium, magnesium and available phosphorus could be as a result of nutrient release during manure decay by micro-organisms and the high content of such essential elements in the compost materials (rice husks and poultry manure). These results are in agreement with the reports by Abdel-Nasser and Harhash [16] and Mendoza et al. [17]. The significant positive relationships between the different soil chemical elements were good indications of the interactive nature of the elements in the soil and would give a guide on the mode of nutrient application to the soil.

The increase in the vegetative growth and yield of the cucumber varieties especially at the higher rates of the compost manure could be as a result of increased availability of the nutrient elements and the consequent uptake by the plants. This result coincides with those obtained by Barker and Pilbeam [18]. They found that compost manure rates had significant effects on the growth, nutrient uptake and yield of tomato cultivar (HHAe-58).

Table 2. Chemical properties of the soil after two weeks of compost manure application

Rates	TN (%)	Av. P (ppm)	OC (%)	0M (%)	Exch. K (meq/100 g)	Exch. Ca (meq/100 g)	Exch. Mg (meq/100 g)
Before manure application	0.03	7.61	1.07	1.85	0.24	3.60	0.40
Two weeks after application							
0 t ha^{-1}	0.03	7.62	1.05	1.81	0.24	3.30	0.20
5 t ha^{-1}	0.08	46.63	2.20	3.62	0.26	4.40	2.40
10 t ha^{-1}	1.03	60.42	3.23	5.57	0.31	5.20	3.70
15 t ha-^{1}	1.36	80.36	4.10	7.07	0.38	5.80	4.30
F-LSD $_{(.05)}$	.15	.20	.19	.39	.22	.04	.04

TN - total nitrogen, Av. P - available phosphorus, OC - organic carbon, Exch. K - exchangeable potassium, Exch. Ca - exchangeable calcium, Exch. Mg - exchangeable magnesium, 0M- organic matter, F-LSD $_{(.05)}$ = Fishers least significant differences at P = .05

Table 3. Correlation coefficients of the soil chemical properties after two weeks of compost manure application

Variable	TN	Av. P	OC	OM	Exch. K	Exch.Ca	Exch. Mg
TN	1.000						
Av.P	.862**	1.000					
OC	.933**	.981**	1.000				
OM	.945**	.973**	.994**	1.000			
Exch. K	.516	.480	.519	.573	1.000		
Exch.Ca	.918**	.991**	.995**	.992**	.505	1.000	
Exch.Mg	.880**	.990**	.979**	.972**	.473	.992**	1.000

*TN - total nitrogen (%), Av. P - available phosphorus (ppm), OC - organic carbon (%), Exch. K - exchangeable potassium (meq/100 g), Exch. Ca - exchangeable calcium (meq/100 g), Exch. Mg - exchangeable magnesium (meq/100 g) and 0M- organic matter (%); ** Correlation is significant at P = .01*

Table 4. Effects of the compost manure on average stem girth, plant height, number of leaves and leaf area of the cucumber varieties planted for two seasons

	Stem girth (cm)				Plant height (cm)				Number of leaves				Leaf area per plant (cm^2)			
	6WAP				6WAP				6WAP				6WAP			
Rates	**P1**	**P2**	**P3**	**Mean**	**P1**	**P2**	**P3**	**Mean**	**P1**	**P2**	**P3**	**Mean**	**P1**	**P2**	**P3**	**Mean**
0 t ha^{-1}	1.47	1.90	2.30	1.89	5.33	5.67	41.40	34.30	5.33	5.67	6.00	5.67	57.40	68.80	82.00	69.40
5 t ha^{-1}	3.60	3.90	4.00	3.83	9.33	9.33	159.30	144.50	9.33	9.33	10.33	9.67	213.40	412.10	370.00	331.80
10 t ha^{-1}	3.90	4.30	4.60	4.27	10.00	10.67	154.00	150.00	10.00	10.67	12.67	11.11	284.60	329.10	446.70	353.50
15 t ha^{-1}	4.40	4.80	5.10	4.77	10.33	14.00	198.50	185.80	10.33	14.00	16.33	13.56	435.80	494.80	553.30	494.60
Treatment mean (T)	3.34	3.73	4.00	3.69	8.75	9.92	138.30	128.70	8.75	9.92	11.33	10.00	247.80	326.20	363.00	312.30

	Plant girth	Stem height	Number of leaves	Leaf area
	6WAP	**6WAP**	**6WAP**	**6WAP**
F-LSD $_{(.05)}$ for 2 Treatment means (T)	.02	10.18	1.04	28.17
F-LSD $_{(.05)}$ for 2 Variety means (V)	.02	11.75	1.20	32.53
F-LSD $_{(.05)}$ for 2 T × V means	.04	20.35	2.08	56.35

P1 – Poinsett, P2 - Marketer, P3 - Supermarketer and F-LSD $_{.05}$ = Fishers least significant differences at P = .05

Table 5. Effects of the compost manure on average fresh fruit weight (kg/ha) and number of fruits per plant taken for two seasons

	Cucumber variety (P)							
	Fresh fruit weight (kg/ha)				Number of fruits per plant			
Rates	**P1**	**P2**	**P3**	**Mean (V)**	**P1**	**P2**	**P3**	**Mean (V)**
O t ha^{-1}	163.67	217.33	410.67	263.89	2.67	3.67	5.00	3.78
5 t ha^{-1}	183.00	361.00	551.67	365.22	5.00	6.67	8.67	6.78
10 t ha^{-1}	210.00	405.00	762.67	459.22	7.00	8.00	10.00	8.33
15 t ha^{-1}	306.00	672.00	1005.00	661.00	8.00	9.00	11.00	9.33
Treatment mean (T)	215.67	413.83	632.50	437.33	5.67	6.83	8.67	7.06

	Fresh fruit weight	Number of fruits per plant
F-LSD $_{(0.05)}$ for 2 treatment means (T)	4.22	.49
F-LSD $_{(0.05)}$ for 2 variety means (V)	4.87	.56
F-LSD $_{(0.05)}$ for 2 T × V means	8.44	.97

4. CONCLUSION

The highest compost manure application rate of 15 t ha^{-1} gave the highest values of the soil chemical properties, morphological characteristics and yield of the tree varieties of cucumber. Significant positive correlations existed between the various soil chemical elements. *Supermarketer* variety performed best of the three cucumber varieties in terms of the morphological characteristics and yield followed by *Marketer* and then *Poinsett*.

COMPETING INTERESTS

The authors have no competing or conflicting interests.

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http://www.sciencedomain.org/review-history.php?iid=781&id=24&aid=7406