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Determination of phytotoxicity of vermicomposts from agricultural waste on seed germination and seedling growth of tomato

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ABSTRACT

An Experiment was conducted in the Laboratory of the Department of Crop Protection, Bayero University Kano (BUK) to evaluate the phytotoxicity effects of vermicomposts on seed germination and seedling growth of tomato. The experiment was laid out in completely randomized design which consisted of three vermicomposts: poultry manure based (POBCO); cow dung based (COBCO) and rice bran based (RIBCO) vermicomposts and loamy soil (control) collected from the Teaching and Research Farms of the Faculty of Agriculture, BUK. The growth media were prepared using 1 kg of top soil and 3 kg of vermicomposts for each treatment. Treatments were replicated five times and data were analysed using analysis of variance with Gensat 17th Edition. Treatment means were separated using LSD. The results of the experiment showed zero phytotoxicity of the vermicomposts with mean values greater than 100% for all the germination indices. Percent relative seed germination of POBCO was 193.3% which differed significantly ($P \leq 0.05$) with COBCO (136.3%) and RIBCO (127.9%), respectively. Percent relative root growth (RRG) and germination index (GI) for the vermicomposts was significantly higher than the control. Poultry manure based vermicompost had 205% RRG and 394.8% GI compared to COBCO (136.3%; 207.4%) and RIBCO which recorded 107.3% RRG and 137.2% GI. Though all vermicomposts showed stimulating effect on tomato growth, POBCO exhibited highest germination indices than COBCO and RIBCO. Physical and chemical properties of the vermicomposts were all within the optimum requirements for plant growth. It is concluded that the vermicomposts especially POBCO are not phytotoxic and could be usedas bio-fertilizer to enhance tomato seed germination and growth.

Keywords: Percent relative seed germination, phytotoxicity, relative root growth, tomato seeds, vermicomposts

Introduction

Reliance and inappropriate application of synthetic chemical fertilizers and pesticides in managing cropped plants is now an issue among scientists as they affect soil fertility, soil beneficial organisms, human health and other environmental issues (Sundarasu, 2019). The use

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of organic sourcesof agricultural inputs such as composts and vermicomposts for managing soil fertility and pestsis now gaining global attention because they are cheap and eco-friendly.Despite the importance of organic amendment such as composts on crops the use of immature compost brings the issue of phytotoxicity on seed germination and seedling growth (Gopinathan and Thirumurthy 2012). Phyto toxicity of composts or vermicomposts is associated with the presence of phenolic compounds, heavy metals, ethylene, and ammonia which led to excess accumulation of salts and organic acids that consequently delayed seed germination and plant growth (Selim *et al.* 2012). Amending soil with mature composts is therefore essential for proper seed germination and seedling growth. Compost maturity can be assessed using Phytotoxicity test to evaluate the suitability of compost or vermicompost as bio-fertilizer or bio-pesticide on crops. Phytotoxicity is usually determined by a seed germination index assay or by plant growth tests (Helfrich *et al.*. 1998). The germination index has been identified as the most sensitive parameter for determining compost phytotoxicity. This test has been used as an integrated test for detecting high levels of toxicity which affect germination and low levels of organic toxic compounds which affect root growth (Zucconi *et al.*. 1981). The relative seed germination, percent relative root growth and germination index were used as indices for determining the Phytotoxicity of the organic amendments. The objective of this study was to determine some of the physico-chemical properties of vermin-composted agricultural wastes and evaluate their phytotoxicity on seed germination and seedling growth of tomato.

Materials and Methods

Sample Collection

Vermicomposts were obtained from the Department of Crop Protection, Bayero University Kano. The vermicomposts were prepared following the procedures of Mahimairaja *et al.* (2008)

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as bio-pesticide to manage Fusarium wilt of tomato. The three vermicomposts used in the experiments are poultry manure based vermicompost (50% poultry manure, 35% cow dung and 15% rice bran); cow dung based vermicompost(50% cow dung, 35% poultry manure and 15% rice bran) and rice bran based vermicompost(50% rice bran, 25% cow dung and 25% poultry manure).These were separately subjected to primary decomposition for three weeks with occasional turning to improve aeration and decomposition.After three weeks 100 earthworms picked from fertile soil were introduced on top of the plastics containing 100 kg organic materials. Moisture was maintained at 60 % throughout the composting period which lasted for 60 days. The castings that formed on the top layer of the plastic containers were collected using photosensitivity method 40 days after onset of vermicomposting and later at weekly intervals. This periodic harvesting was done to ensure free flow of air and retention of the compost quality so that the finished compost will not be compacted due to watering (Mahimairaja *et al.*. 2008).

Phytotoxicity assessment of the vermicomposts

Phytotoxicity test was conducted in the Laboratory of the Department of Crop Protection, Bayero University (BUL) to evaluate the phytotoxicity effects of vermicomposts on tomato seeds. The experiment was laid out in completely randomized design which consisted of three vermicomposts: poultry manure based (POBCO); cow dung based (COBCO) and rice bran based (RIBCO) vermicomposts and loamy soil (control) collected from the Teaching and Research Farms of the Faculty of Agriculture, BUK.Each treatment in the experimental unit contained 20 tomato seeds sown in a plastic container (30cm wide by 12cm depth) containing soil amended separately with RIBCO, COBCO and POBCO (1 kg top soil/ 3 kg bio-enriched vermicompost), while soil not amended (UNASO) served as controlfollowing the procedures used by Kouki *et al.* (2012)..

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Emerged seedlings in each experimental unit were counted at 21 days after sowing. Five seedlings from each of the containers were carefully removed and washed in clean water to remove soil attached to the roots. The seedlings were then blotted dry and roots length were measured and recorded.

Relative seed germination (RSG %) was calculated as (NSV/NSC) * 100. Where NSV and NSC expressed the number of tomato seeds geminated in vermicompost amended soil and in the control treatment, respectively. Relative root growth (RRG %) was computed as (Mean root length in vermicompost amended soil) / Mean root length in control treatment) * 100.

Germination index (Gl) was computed using the following formula used by Fuentes *et al.* (2004) as {Relative seed germination (%)} x Relative root length (%)} / 100.

Data collected were analysed using Analysis of variance with GenStat Release 17.1 (PC/Windows 8), Treatment means were separated using LSD at 5% level of significance.

Determination of physical and chemical properties of thevermicomposts

Two hundred and fifty grams from each of the three bio-enriched vermicomposts were collected and air-dried. Sampled soil (250 g) was obtained from the field as control. The pH of the vermicompost samples were determined using the procedures described by Chandrabose *et al.* (1988). Sample of air-dried bio-enriched vermicompost (30 g) was passed through a 2mm sieve and was transferred to a clean 100ml beaker to which 60 ml of distilled water was added. The content was vigorously stirred and kept for one minutes. The electrode was immersed into the beaker containing the suspension and meter readings were recorded. Electrical conductivity (EC) of the test samples was determined according to the procedures outlined by Chandrabose *et al.* (1988). Fifty millilitres of distilled water was added to 5g of vermicomposts and stirred for 30 minutes. After stirring, the suspension was kept for eight hours. Measurement of EC was done by

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immersion of the electrode into the vermicompost extracts.Organic carbon (OC), total nitrogen (TN), total P, total K, Ca and Mg content were also evaluated. Total N was determined using Kjeldahl method (Bremnerand Mulvaney, 1982), while organic matter was estimated by Walkley and Black method (Nelsonand Sommers, 1982). Exchangeable cations (Ca, Mg, and K) were measured with the atomic absorption spectrophotometer (Wright and Stuczynski, 1996). Ammonium nitrogen and nitrate nitrogen was measured by the indol-phenol method as described by Mulvancy(1996).

Results and Discussion

Phytotoxicity assessment of the vermicomposts

Seeds sown on POBCO significantly (P≤0.05) had higher number of germinated seeds (16) than those in COBCO (13), RIBCO (11) and control treatment (8), respectively (Fig.lA). Mean root length of germinated seeds (Figure IB) was 5.7 cm on POBCO which differed significantly (P≤0.05) with those on COBCO (3.8 cm) and RIBCO 03 cm), respectively (Fig. IB).

Percent relative seed germination was higher on POBCO (193.3%) than those tomatoes on COBCO (151.9%) and RIBCO (107.3%), respectively, compared to the control which recorded 100% relative seed germination (Fig. 2). Similarly, percent relative root growth and germination index were also significantly higher on POBCO (205%; 394.8) compared to COBCO (136.3%; 207.4) and RIBCO (107.3%; 137.2), respectively. Control treatment significantly had the least percent relative root growth and germination index (100%; 100%).

No phytotoxicity of the vermicomposts was recorded in this study. This led to high seed germination and seedling growth. This could be further substantiated by the fact that stability and maturity of the composts as evidenced by low phytotoxicity on the seedlingsprovide ideal environment for the germination of tomato seeds and seedling (Delgado *et al.,* 2010).There is

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considerable evidence that bio-enriched vermicomposts greatly increased microbial populations capable of producing plant hormones and plant-growth regulating substances (PGRs) such as auxins, gibberellins, cytokinins, ethylene and abscisic acid and also humic acids, which enhanced plant growth, thus improving plant health (Edwards *et al.,* 2004). Microbially-produced plant hormones by *Arthrobacter* and *Bacillus* spp. in soils amended with vermicomposts had been reported to increase seedlings vigour and plant growth and development (Inbal and Feldman 1982; Mahmud *et al.,* 1984).

Physical and chemical properties of the vermicomposts

There was significant ($P \leq 0.05$) difference in pH values between the three vermicomposts and the control (Fig. 3). Poultry manure vermicompost (POBCO), COBCO and RIBCO exhibited higher pH values of 8.0, 8.5 and 8.3, respectively indicating slightly alkaline than the control treatment (UNASO) which showed pH of 7.3 (Neutral). Higher electrical conductivity (25.6 ds m^{-1}) was recorded on the soil not amended (UNASO) relative to the vermicomposts. The EC values of the bio-enriched vermicomposts ranged from 4.60 to 5.54 dS m^{1}. The highest value of EC (5.54 dS m^{1}) was found on POBCO and the lowest value of EC (4.60 dS m^{-1}) was recorded on RIBCO (Fig. 3). This EC range is also within the optimum range for growing media as reported by Hanlon (2012).

Vermicompost being a microbiologically-active and nutrient-rich organic material (peat-like material) directly or indirectly influenced plant growth which when added to plant growing media enhance chemical, physical and biological mechanisms (Lazcano and Dominguez, 2010).

The three vermicompost reduced the soil acidity which could be attributed to the release of $NH4^{+}$and the activity of calciferous glands in earthworms that contained carbonic anhydrase which catalyzes the fixation of CO2 as CaCCh, thereby preventing the drop in p^{H} as explained by

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Kale *et al.* (1982) and all these greatly influenced nutrient availability and microbial activity as well as tomato growth.

Control treatment (Table 1) exhibited high value for Ca^+ and Mg^+ (85.3 meq l'^{1}; 55.7 meq l'^{1}). This was followed by POBCO (17.9 meq l"^{1}; 14.4 meq l^1), COBCO (17.4 meq l^1; 13.5 meq l^1) and RIBCO (16.5 meq 1"^{1};12.5 meq I"^{1}, respectively. There was significant (P≤0.01) difference among the vermicompost in terms of sodium content (Table 1). Rice bran based vermicompost (RIBCO) had higher Na^+ values (23.5 meq I'^{1}) than COBCO (22.5 meq I^1) and POBCO (20.3 meq l'^{1}), respectively. Potassium content differed significantly between vermicomposts (BIVCOs) and UNASO. Highest K^+ content was recorded on POBCO (3.8 meq I"^{1}), followed by COBCO (3.7 meq l^1) and RIBCO (3.6 meq l^1). These were significantly different with the control treatment (UNASO) which had low K^+ content (1.7 meq l^1).

Organic carbon (OC) was comparatively higher on POBCO (59.8 g kg^4) than COBCO (57.6 g kg^{-1}) and RIBCO (44.6 g kg"^{1}), respectively. Lowest OC (P≤0.01) was recorded on UNASO (28.6 g kg"^{1}). Total nitrogen (TN) among POBCO (3.3 g kg"^{1}), COBCO (3.3 g kg"^{1}) and RIBCO (3.2 g kg"^{1}) is higher than TN values obtained from the control (UNASO) which had TN value as low as 2.3 g kg"^{1}. Similar pattern was observed on phosphorus content, where POBCO (1.3%), COBCO (1.3%) and RIBCO (1.2%), exhibited statistically same values but higher than value obtained from UNASO (0.4%).

Ammonium (NH4) content of vermicomposts and UNASO were significantly different at P≤0.01. Higher values were obtained from POBCO (34.3 mg kg"^{1}), COBCO (30.4 mg kg"^{1}) and RIBCO (26.7 mg kg"^{1}) than UNASO (0.95 mg kg"^{1}). Similar observation was made on NO3, where POBCO (154.9 mg kg"^{1}) significantly had higher value, followed by COBCO (140.5 mg kg"^{1}) and RIBCO (120.3 mg kg"^{1}). Soils from the control treatment recorded low NO3 content

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(70.4 mg kg^{-1}). All three vermicomposts had appreciable amount of Ca^{+} with highest value recorded on POBCO (Table 1). Calcium being a structural component of cell walls and other plant membranes plays a significant role in the integrity and function of these structures.

Shortages of Ca^{+} in plants increase plant susceptibility to fungi which preferentially invade the xylem and dissolve the cell walls of the conducting tissues leading to wilting (Dorcas, 2008). Higher content of Ca enhanced the suppressive ability of POBCO to confer resistance to plant pathogens.

Conclusions

The three vermicomposts from agricultural wastes evaluated for phytotoxicity using tomato seeds revealed high relative seed germination, relative root growth and germination index. The mean values of relative root growth and germination index were greater than 100% for all the three vermicomposts indicating that poultry manure based vermicompost, cow dung based vermicompost and rice bran based vermicompost have stimulating effect on tomato growth.

Based on this it is concluded that the three vermicomposts are not phytotoxic and could be usedas bio-fertilizer to enhance tomato seed germination and seedling growth.

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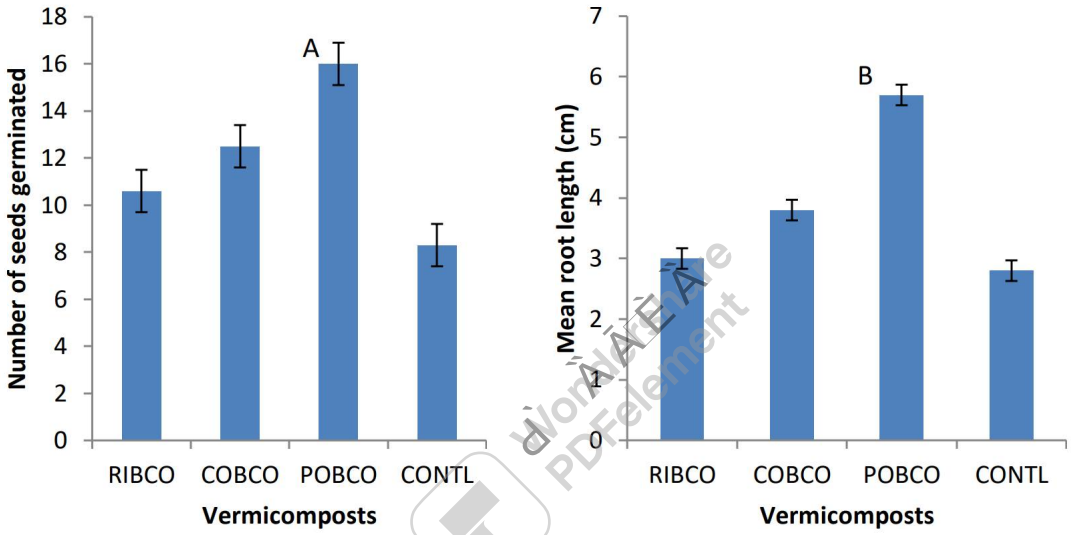


Figure 1: Number of tomato seeds germinated (A) and mean root length (B) of tomato seedlings. RIBCO (rice bran based vermicompost), COBCO (cow dung based vermicompost), POBCO (poultry manure based vermicompost) and CONTL (distilled water). Error bars indicate LSD.

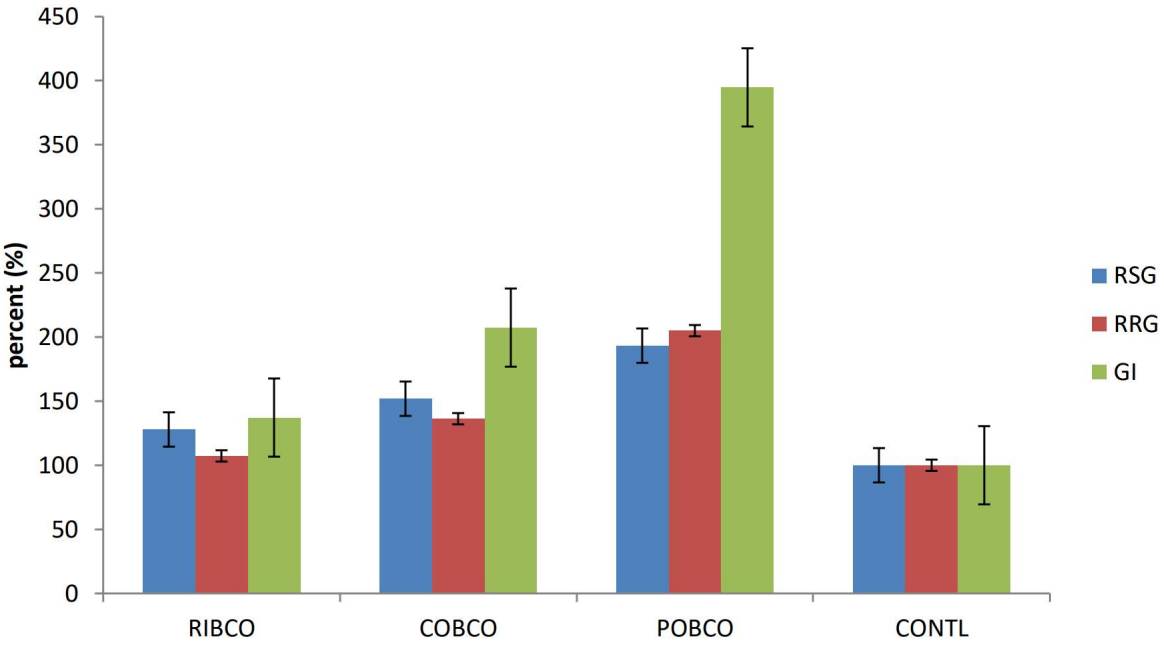


Figure 2: Percent relative seed germination (RSG), percent relative root growth (RRG) and germination index (GI) of tomato seedlings. RIBCO (rice bran based vermicompost), COBCO (cow dung based vermicompost), POBCO (poultry manure based vermicompost) and CONTL (distilled water). Error bars indicate LSD.

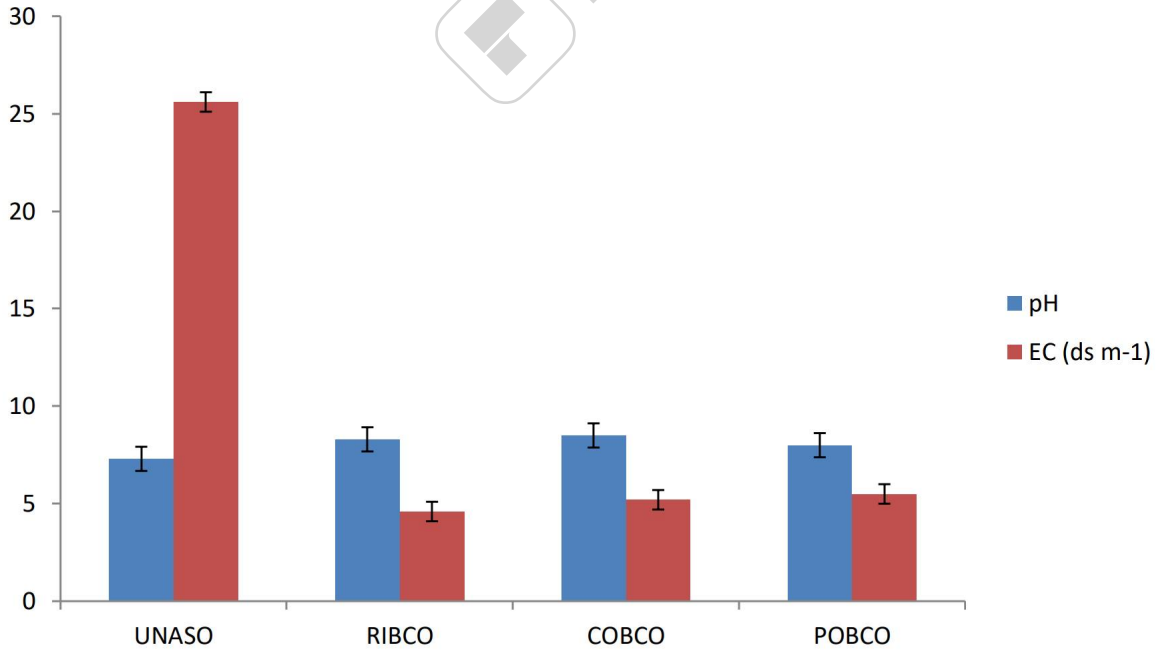


Figure 3: Electrical conductivity and pH of the three vermicompost

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Table 1: Chemical properties of the vermicomposts from agricultural waste

Parameters	Bio- enriched vermicomposts				
	UNASO	RIBCO	COBCO	POBCO	LSD(P<0.01)
Ca^{+}(meq l"^{1})	85.3*	16.5	17.4	17.9	1.03
Mg^{+}(meq l"^{1})	55.7	12.5	13.5	14.4	0.83
Na^{+}(meq l"^{1})	98.5	23.5	22.5	20.3	1.05
K^{+}(meq l"^{1})	1.7	3.6	3.7	3.8	0.07
OC (gkg^{l})	28.6	44.6	57.6	59.8	0.71
TNCgkg^{l})	2.3	3.2	3.3	3.3	0.22
P(%)	0.4	1.2	1.3	1.3	0.12
NH_4(mg kg'^{1})	0.95	26.7	30.4	34.3	0.54
NO3 $^{(}$mg kg^{-1})	70.4	120.3	140.5	154.9	1.15
C/N	12.4	13.9	17.5	18.1	0.63

RIBCO = Rice bran based bio-enriched vermicompost; COBCO = Cow dung based bio-enriched vermicompost; POBCO = Poultry manure based bio-enriched vermicompost; UNASO = Sampled soil obtained from Teaching and Research Farms of Faculty of Agriculture, BUK.*Means of three samples

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