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REGULAR ARTICLE

Comparison of the effects of *Craseonycteris thonglongyai* (bumblebee bat) droppings and synthetic fertilizer on some phytotoxins in the leaf of *Amaranthus cruentus*

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Abstract

Leafy vegetables such as *Amaranthus cruentus* form important part of diet because they provide valuable nutrients for maintenance of good health and prevention of some diseases. Despite these enormous nutritional benefits, they may accumulate toxic substances that could have negative effects on health at high concentrations. The concentrations of these plant toxins could be influenced by the soil nutrient compositions. It is against this background that pot experiment was conducted to investigate the effects of *Craseonycteris thonglongyai* droppings and chemical fertilizer on the concentrations of some phytotoxins (phytate, oxalate, cyanide and nitrate) in *A. cruentus*. The leaves of *A. cruentus* were harvested at maturity and were subjected to standard chemical analysis. The oxalate and phytate contents were determined by titrimetric method while cyanide and nitrate were evaluated by colourimetric method. The results showed that the application of both *C. thonlongyai* droppings and synthetic fertilizer significantly ($p < 0.05$) increased the nitrate content in the vegetable, however, the nitrate content in the vegetable treated with *C. thonlongyai* droppings was significantly lower when compared with the one fertilized with synthetic fertilizer. Similarly, application of *C. thonlongyai* droppings and chemical fertilizer has no significant effect on oxalate and phytate contents in *A. cruentus* except that the concentration of oxalate decreased significantly ($p<0.05$) with the application of *C. thonglongyai* droppings. Whereas chemical fertilizer has no significantly effect on the concentration of cyanide in the leaves of *A. cruentus,* its concentration decreased significantly with application of *C. thonglongyai* droppings. The study concludes that application of *C. thonglongyai* droppings decreased the bioaccumulation of some phytotoxins in the leaf of A. *cruentus* and improves its nutritional quality compared with the synthetic fertilizer

Key words: *Amaranthus cruentus*, *Craseonycteris thonglongyai*, nitrate, oxalate, phytate, cyanide

Introduction

The tropical and sub-tropical nations of the world are honored with lots of vegetables some of which are cultivated, while others develop wild and their costs are generally moderate when contrasted and other food prodcuts in the regions (Beis et al., 2007). They contain

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important nourishments which can be effectively used to develop and repair human body (Rickman et al., 2007; Musa, 2010).

Amaranthus cruentus is an annual leafy vegetable cultivated all year round and is produced fresh for market within 4 to 6 weeks after planting. In Nigeria, *A. cruentus* in combination with other condiments are used for sauce preparation (Musa, 2010). This preparation contains vitamins like β-carotene (precursor of vitamin A), vitamin B_6, vitamin C, riboflavin and folate, minerals such as calcium, iron, magnesium, phosphorus, potassium, zinc, copper and manganese as well as essential amino acids and hence incorporated in cereals and tubers based diets (Musa, 2010; Musa and Ogbadoyi, 2014). The leaves of *A. cruentus* are however, reported to contain cyanogenic glycoside which is a respiratory poison, a moderately high content of oxalic acid which inhibits the absorption of calcium and other mineral elements hence leads to the formation of kidney stone, oxalaneamia and electrolyte imbalance (Chen et al., 2004; Musa, 2010).

Manures are the major sources of plant nutrients (Abdel-Aziz, 2007; Musa et al., 2016) and are the most important and controllable factor affecting the nutritional value of vegetables (Heaton, 2001). The type and value of fertilizer as well as the level of application directly influence the concentrations of nutrients available to plants required for the biosynthesis of secondary metabolites or phytonutrients mainly required for plant growth and development (Heaton, 2001). John et al. (2004) observed that synthetic fertilizers are important and quick source of elemental nutrients, however, constant use is known to contribute to environmental pollution problems with potential hazards to flora and fauna and also on human beings. Organic matter on the other hand has been reported to acts as a reservoir of plant nutrients especially N, P, K and micronutrients and also some microorganisms that reconditioned the soil and prevents leaching of the nutrient contents of the soil (Karim et al., 1994; Musa et al., 2016).

Due to constant used of land for cultivation of crops, most soils are impoverished of essential nutrients required for plant growth and development and therefore application of fertilizers to enrich the soil become necessary. The soil can be enriched either with application organic fertilizer or synthetic fertilizer. It is against this background the present study was designed to evaluate the effects of *Craseonycteris thonglongyai* droppings and synthetic fertilizer on the concentrations of some phytotoxins in *A. cruentus*.

Materials and methods

Sources of seeds and fertilizers

The seeds of *A. cruentus* were obtained from the Department of crop Production, Ibrahim Badamasi Babangida University, Lapai, Niger State. The *C. thonglongyai* droppings and the synthetic fertilizer were obtained from Cave in Faso Village, Edati Local Government Area and Department of Agriculture, Lapai Local Government Area of Niger State, Nigeria, respectively.

Experimental site

The pot experiment employed in this research was conducted in the green house of Department of Crop Production, Faculty of Agriculture, Ibrahim Badamasi Babangida University, Lapai, Niger State Nigeria.

Soil sampling and analysis

Soil samples from three different sites were obtained from the upper soil surface layer (0-20 cm) using a 5 cm diameter soil auger. The samples were then bulked, air dried ground and sieved through a 2 mm sieve to give a uniform sample and to remove rubble. The Physical and chemical properties of the soil samples and *C. thonglongyai* droppings were analyzed according to the method described by Jou (1979).

Experimental design and treatments

Ten seeds of *A. cruentus* were sown in a polythene bag filled with 10.00 kg of top soil but after germination, two plants were maintained per pot after thinning. Complete randomized design (CRD) was adopted using two treatments of 10 pots each with each treatment having three levels of soil fertility. Treatments were added to the soil in each pot. Pots were irrigated twice daily (morning and evening). The experimental area and the surroundings were kept clean to prevent harboring of pest. The pots were lifted from time to time to prevent the roots of the plants from growing out of the container. Exactly 50 g of the processed *C. thonglongyai* droppings were used to grow *A. cruentus* per pot. The synthetic fertilizer was applied at recommend dose of 30 mg K_2O/kg soil, 30 mg N/kg soil, 30 mg P_2O_2/kg soil for the vegetable (NIHORT, 1983).

Analytical Method

The nitrate content in the fresh leaves of *A. cruentus* was determined by the colorimetric method of Sjoberg and Alanko (1994). The alkaline picrate method of Ikediobi et al. (1980) was used to evaluate the cyanide concentration in the samples. Titrimetric methods as described by AOAC (1984) and Maga (1983) were used to estimate the oxalate and phytate contents in the fresh leaves of the vegetable, respectively.

Statistical analysis

Statistical analyses of data obtained for determination of the concentrations of phytotoxins in *A. cruentus* leaves were done by one – way analysis of variance (ANOVA) using the statistical package, SPSS 17.3. Mean values of triplicate determinations were compared using the 5% level of significance. Mean values were separated using Duncan's Multiple Range Test (DMRT). The data is given as mean ± SEM (Armitage and Berry, 1985).

Results and discussion

Physicochemical properties of soil

Result of analysis of the soil used for pot experiments is presented in Table 1. The results obtained showed that the soil is sandy loam which means that the soil has high water holding capacity. The soil pH showed that the soil is acidic in water and moderately basic in calcium chloride ($Cacl_2$). The concentration of organic carbon, magnesium and calcium present in the soil are moderate while the total nitrogen, available phosphorus, sodium and potassium contents are very low. The low concentrations of these essential plant nutrients necessitated the application of fertilizers to improve the nutrient contents of the soil for optimal growth and development (Musa, 2016).

Chemical analysis of *Craseonycteris thonglongyai* droppings

Result of chemical properties of the *C. thonglongyai* droppings used for the pot experiment is presented in Table 2. It showed a high total nitrogen, potassium, magnesium and sodium and available phosphorus content with moderate concentration of calcium. The result also showed that the droppings are slightly basic in water with very high organic carbon content. The high contents of these plant nutrients justify the used of the droppings as organic manure for cultivation of crops by local farmers and serves as good nutrients source for plant growth and development (Musa et al., 2016; Musa, 2016).

Table 1. Physico-chemical properties of the soil (0 – 20 cm) used for pot experiment.

Parameters	Values
Sandy (g kg^{-1})	93.27
Silt (g kg^{-1})	5.95
Clay (g kg^{-1})	0.39
Textural class	Sandy loam
pH (H_2O)	5.98
pH ($CaCl_2$)	7.41
Organic carbon (g kg^{-1})	4.60
Total nitrogen (g kg^{-1})	0.17
Available phosphorus (mg kg^{-1})	51.85
Na^+ (cmol kg^{-1})	0.21
K^+ (cmol kg^{-1})	1.15
Mg^{2+} (cmol kg^{-1})	0.08
Ca^{2+} (cmol kg^{-1})	1.40
Acidity (cmol kg^{-1})	0.15
CEC (cmol kg^{-1})	2.99
EC (cmol kg^{-1})	1.31

CEC = Cation Exchange Capacity, EC = Exchangeable Cations. Values represent means of triplicate determinations

Table 2. Chemical properties of the *Craseonycteris thonglongyai* droppings.

Parameters	Values
pH (H_2O)	7.67
Organic carbon (g kg^{-1})	32.00
Total nitrogen (g kg^{-1})	7.00
Available phosphorus (mg kg^{-1})	8745.39
Na^+ (cmol kg^{-1})	3.16
K^+ (cmol kg^{-1})	11.92
Mg^{2+} (cmol kg^{-1})	3.66
Ca^{2+} (cmol kg^{-1})	2.80
Acidity (cmol kg^{-1})	1.30
CEC (cmol kg^{-1})	22.84
EC (cmol kg^{-1})	3688.00

CEC = Cation Exchange Capacity, EC = Exchangeable Cations. Values represent means of triplicate determinations.

Effects of *C. thonglongyai* droppings and chemical fertilizer on the concentrations of some phytotoxins in *A. cruentus* leaves

The results presented in Table 3 showed the effects of the application of *C. thonlongyai* droppings and synthetic fertilizer as compared against the control of the concentrations of the phytotoxins studied. It showed both synthetic fertilizer and *C. thonlongyai* droppings significantly increased the nitrate content in the vegetable with values of 1600.20 ± 153.97, 2778.12 ± 111.12, and 2089.25 ± 117.60 for the control, synthetic fertilizer and *C. thonglongyai* droppings, respectively. However, the nitrate content in the leaves of performed these functions it is *A. cruentus* treated with synthetic fertilizer was significantly higher compared to the one treated with *C. thonlongyai* droppings. This high concentration of nitrate in the vegetable treated with both fertilizers could be attributed to high nitrogen content in both manures. This observation corroborates with finding of Musa and Ogbadoyi (2012), Musa and Ogbadoyi (2014) and Musa et al. (2016) who reported that when plants are presented with high nitrogen, a nutrient required for growth and protein formation, if nitrogen is in excess of what the plant require to performed these functions it is then converted to nitrate and stored predominantly in the leaves. The lower concentration of nitrate in *A. cruentus* cultivated with *C. thonlongyai* droppings when compared to synthetic fertilizer justify the preference of organic fertilizers over synthetic fertilizers.

The result for oxalate content showed no significant effect when *C. thonlongyai* droppings were applied but considerably increases upon chemical fertilizer application. The mean values of oxalate in the vegetable were 5.75 ± 0.00, 11.50 ± 0.66 and 7.28 ± 0.77 mg/g for the control, chemical fertilizer and *C. thonglongyai* droppings, respectively. The higher concentration of this antinutrient responsible for electrolytes imbalance and kidney stone in the vegetable treated with synthetic fertilizer compared to *C. thonlongyai* droppings confers the safety of organic food than the conventional food (Musa et al., 2016).

Whereas the concentrations of phytate and cyanide were not significantly affected upon the chemical fertilizer application, their values decrease significantly when *C. thonglongyai* droppings were applied.

The mean values for the phytate concentration in the vegetable were 5.51 ± 0.22, 5.74 ± 0.27 and 5.20 ± 0.15 g/100 g while that for cyanide were 157.69 ± 53.83, 140.51 ± 27.97 and 118.99 ± 6.42 for the control, chemical fertilizer and *C. thonglongyai* droppings, respectively. The decrease in the cyanide content upon the application of *C. thonglongyai* droppings suggests that the droppings have potentials to reduce the plant toxin in vegetables which is in agreement with the report of Nur Faezah et al. (2013) and Musa et al. (2016) who observed that crops grown with organic manure have low concentration of cyanide in their leaves. Musa et al. (2016) put forward that since organic manures are known to recondition the soil with adequate nutrients and promote plant health, application of the *C. thongongyai* droppings is likely to reduce the enzymatic conversion of tyrosine to p-hydroxymandelonitrile, an intermediate compound for production of cyanide and thereby reduce the concentration of this respiratory poison.

The lower concentrations of the phytotoxins (nitrate, oxalate, phytate and cyanide) in the leaves of *A. cruentus* treated with *C. thonglongyai* droppings when compared to synthetic fertilizer justify the preference of foods grown with organic fertilizer over synthetic fertilizer. Since the associated health problems of high intake of the plant toxins will be significantly reduced in organic foods compared with conventional food.

Table 3. Effects of *C. thonglongyai* droppings and synthetic fertilizer on concentrations of some phytotoxins in *A. cruentus*.

Phytotoxins	Control (no application)	Synthetic fertilizer	*C. thonglongyai* droppings
Nitrate (mg/kg)	1600.20 ± 153.97[a]	2778.12 ± 111.12[c]	2089.25 ± 117.60[b]
Oxalate (mg/g)	5.75 ± 0.00[a]	11.50 ± 0.66[b]	7.28 ± 0.77[a]
Phytate (g/100 g)	5.51 ± 0.22[a]	5.74 ± 0.27[a]	5.20 ± 0.15[a]
Cyanide (mg/kg)	157.69 ± 53.83[b]	140.51 ± 27.97[b]	118.99 ± 6.42[a]

Mean values along the same row with different superscript are significantly different ($p < 0.05$).

Conclusion

The research concludes that the application of *C. thonglongyai* droppings decrease the bioaccumulation of the phytotoxins in *A. cruentus* than synthetic fertilizer and hence help to improve the nutritional quality of the vegetable when compared to synthetic fertilizer.

Author contributions

The contributions of authors to the study and preparation of the manuscript are equal. All the authors read and approved the manuscript before final submission.

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