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Growth, yield and antioxidant profile of pumpkin (*Cucurbita pepo* L.) leafy vegetable as affected by NPK compound fertilizer

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Abstract

Pumpkin young leaf is an underutilized leafy vegetable in the Southwestern Nigeria. The objective of this study is to provide information on the influence of NPK fertilizer on the agronomic performance and antioxidant concentration of pumpkin leafy vegetable for the purpose of enhancing its cultivation and popularizing its utilization. The experiment was conducted in 2007 and 2008, at the Teaching and Research Farm, Obafemi Awolowo University, Ile-Ife, Nigeria. The experiment was a randomized complete block design with 3 replications. Compound fertilizer, NPK /15:15:15/ was used and added as ring dressing in four levels; 0, 90, 180, 270 kg/ha^{-1}. Data were recorded for several growth and leaf yield parameters. At the seventh week after planting, the harvested young leaves extracts were analyzed for antioxidant activities and antioxidant phenolic compounds concentration using different antioxidant assays. The significant highest estimates for vine length, leaves number, stem diameter, number of branches and number of tendrils per plant and total young leaf yield were resulted from plants treated with 180 and 270kg/ha^{-1}. It is concluded that 180 kg/ha^{-1} of NPK fertilizer is required for optimal yield and antioxidant composition of pumpkin leafy vegetable.

Keywords: Pumpkin, leafy vegetable, yield, antioxidant activities, NPK fertilizer.

1. Introduction

Cucurbita pepo Linn commonly known as pumpkin and locally called "Elegede" in the Southwest Nigeria belongs to the Cucurbitaceae Family. The family is one of the largest families in plant kingdom consisting of largest number of edible plant species. Pumpkin young leaf locally called "Gboro" is used as an indigenous leafy vegetable. In this form, processing or pretreatment is not required or done before cooking unlike many leafy vegetables consumed in Nigeria.

Past work on the nutrient composition of *C. pepo* leaves by Duke and Ayensu (1985) reveals that the leaf has 43.8% protein which is comparable with that of soybean. The leafy vegetable produced by *C. pepo* is one of the most palatable leafy vegetables ever known in the South West Nigeria. Vegetable constitutes an important component in man's diet, especially in developing countries. It is needed to complement staples in diet, supplying essential minerals and vitamins that may not be obtained solely from staples. They generally produce more nutrients per unit land area than staples such as rice. There is little chance for malnutrition to occur where enough vegetables are eaten (AVRDC, 1990). Fruits and vegetables are important components of a healthy diet, and their consumption could help prevent wide range of diseases (Rainer 1998; Van't veer *et al*., 1999; Hu 2003; Agudo, 2005).

The positive health effects of fruit and vegetable have been attributed to the relatively high antioxidant concentration in fruits and vegetables (Ames *et al*., 1993; Rice - Evans and Miller, 1995). Antioxidants are naturally present in fruits and vegetables. They are micronutrients that posses ability to neutralize free radicals or their actions (Cadenzas and Packer, 1996; Nicoli *et al.,* 1999). Free radical have been implicated in the etiology of several major humans ailments, including cancer, cardiovascular disease, neural disorders, diabetes and arthritis (Sies, 1996; Yoshikawa *et al*., 2000; Devasagayam *et al*., 2004).

Fertilizer affects the productivity and nutrient quality of crops. Weak vegetative growth, poor fruit setting, undesirable fruit quality and low nutritional quality result from inadequate levels of the primary nutrients namely: Nitrogen, Phosphorus and Potassium (Shukla *et al.*, 1980; Alwan, 1986; Martinetti and Paganini, 2006; Liu *et al*., 2010. Aduayi *et al*., (2002) reported that NPK is the three major fertilizer elements known to be deficient in most Nigerian soils due to intense pressure on land as a result of continuous cropping. Hence, this study aimed at determining the influence of NPK fertilizer on the growth and yield of pumpkin young leaf and to investigate the effect of NPK fertilizer on the antioxidant property and phenolic antioxidant compositions of pumpkin young leaf. There are a few leafy vegetables available in Nigerian markets; pumpkin leafy vegetable is not yet included. Despite its protein composition it is still underutilized. For a successful exploitation of pumpkin leafy vegetable, information on fertilizer requirement and its chemical composition is paramount.

2. Materials and methods

2.1 Field studies

The experiment was conducted in 2007 and 2008, at the Teaching and Research Farm, Obafemi Awolowo University, Ile-Ife, Nigeria. The experiment was a randomized complete block design with 3 replications. Compound fertilizer, NPK /15:15:15/ was added as ring dressing in four levels; 0, 90, 180, 270 kg/ha. Data were collected weekly on the vine length, vine diameter, number of leaves, tendrils number and number of branches per plant. At the seventh week after planting, the vegetable was harvested at different replications to form composite samples for each level of fertilizer application. The harvested young leaves were dried at 40^0C in an oven for 48 hours.

2.2 Laboratory studies

The dried samples of the young leaves at different NPK levels were milled. About 20g each of the powder at different NPK levels were extracted by cold extraction for 24 hours using 70% methanol. The crude extract was obtained by evaporating the methanol soluble extract in a rotary evaporator at 45^0C and then analyzed for: Antioxidant activities, total phenolic concentration, total flavonoid concentration, proanthocyanidin concentration, anthocyanin concentration. The antioxidant activities or hydrogen donating or radical scavenging of the extract was determined using the stable radical DPPH (2, 2-diphenyl-2-picrylhydrazyl hydrate) according to the method described by Brand-Williams (1995). DPPH reacts with an antioxidant compound which can donate hydrogen, it is reduced. The change in colour from deep violet to light yellow was measured spectrophotometrically at 517 nm. Total phenol content was determined by the method of Singleton and Rossi (1965) using the Folin – Ciocalteau reagent in alkaline medium. Total flavonoid content was determined using $AlCl_3$ method as described by Lamaison and Carnet, (1990). The proanthocyanidin content was determined using a modified method of Porter, Hristch and Chan (1986) using the AlCl / Butan – 1-0l assay method. The total anthocyanin content of the test samples was determined using the pH differential method of Fuleki and Francis (1968) as described by Guisti and Wrolstad (2001).

2.3 Statistical Analysis

The data collected, were subjected to analysis of variance. Means, where significantly different, were separated using Duncan Multiple Range Test (DMRT) at 5% level of probability.

3. Results

As presented in Tables 1-5, NPK fertilization significantly influenced the vegetative growth of pumpkin biomass. The number of leaves produced by pumpkin taken at different intervals after emergence was significantly affected by the NPK fertilization. The results showed that plants that received 180 and 270 kg NPK ha^{-1} were more vigorous than under all other NPK levels. There was no significant difference in the number of leaves produced between the plants that received 180 and 270kg NPK ha^{-1}. The plants that received 0 kg NPK ha^{-1} had fewest number of leaves. The vine length of pumpkin plants that received 180 and 270 kg NPK ha^{-1} were significantly longer than plants those that received lower NPK fertilizer application and at control throughout the sampling periods. There was no significant difference in the vine length of the plants that received 180 and 270 kg NPK ha^{-1}. However, the plants that received 90 kg P_2O_5 ha^{-1} were significantly longer than those that received 0 kg NPK ha^{-1}. Similar trends were observed for stem diameter, the stem diameter of pumpkin vine was significantly thicker in the plants that received higher dose of fertilizer. The thickness reduced at 90 kg P_2O_5 ha^{-1} and was lowest at control. There was no significant difference in the stem diameter and number of branches produced between the plants that received 180 and 270 kg NPK ha^{-1}. The number of branches was very few in the control, but not as much in 90 kg P_2O_5 ha^{-1}. Number of tendrils was the same also in plants that received 180 and 270 kg NPK $ha^{-1}$and they were more compared to other NPK level and control. The control had the fewest number.

Table 1. Number of leaves of pumpkin as affected by NPK compound fertilizer

NPK level (kg ha^{-1})	Weeks after sprouting				
	2	3	4	5	6
0 (control)	7c	10c	17	30c	35c
90	9b	11b	20b	35b	45b
180	11a	13a	27a	48a	65a
270	11a	13a	28a	48a	66a

Means with the same letter in each column are not significantly different at 5% level of Probability using Duncan's multiple range test.

Table 2. Vine length per plant (cm) of Pumpkin as affected by NPK compound fertilizer

NPK level (kg ha^{-1})	Weeks after sprouting				
	2	3	4	5	6
0 (control)	10.86c	18.17c	46.03c	83.92c	122.47c
90	12.75b	20.06b	54.56b	98.31b	137.14b
180	14.61a	23.61a	70.89a	133.08a	197.28a
270	14.44a	23.97a	72.64a	133.67a	201.42a

Means with the same letter in each column are not significantly different at 5% level of probability using Duncan's multiple range test.

Table 3. Stem diameter per plant (cm) of pumpkin as affected by NPK compound fertilizer

NPK level (kg ha^{-1})	Weeks after sprouting				
	2	3	4	5	6
0 (control)	0.37c	0.56c	0.76c	0.93c	1.06c
90	0.42b	0.62b	0.94b	1.00b	1.17b
180	0.45a	0.75a	0.99a	1.21a	1.41a
270	0.46a	0.73a	1.02a	1.21a	1.39a

Means with the same letter in each column are not significantly different at 5% level of probability using Duncan's multiple range test.

Table 4. Number of branches per plant of Pumpkin as affected by NPK compound fertilizer

NPK level (kg ha^{-1})	Weeks after sprouting			
	4	5	6	7
0 (control)	1c	3c	4c	4c
90	2b	4b	5b	5b
180	3a	6a	7a	8a
270	3a	6a	7a	8a

Means with the same letter in each column are not significantly different at 5% level of probability using Duncan's multiple range test

Table 5. Number of tendrils per plant of Pumpkin as affected by NPK compound fertilizer

NPK level (kg ha^{-1})	Weeks after sprouting			
	4	5	6	7
0 (control)	6c	14c	27c	30c
90	7b	19b	35b	53b
180	9a	27a	48a	52a
270	9a	28a	48a	52a

Means with the same letter in each column are not significantly different at 5% level of probability using Duncan's multiple range test.

Figure 1 shows the effect of NPK on the yield of pumpkin leafy vegetable. Yield depends on NPK fertilization. The vegetable yield was very low in control (2.8 tons/ha). The highest estimate for total yield resulted from plants fertilized with 180 and 270 kg/ha^{-1} (9.32 and 9.72 tons/ha respectively), followed by the plants fertilized with 90 kg/ha (4.8tons/ha respectively).

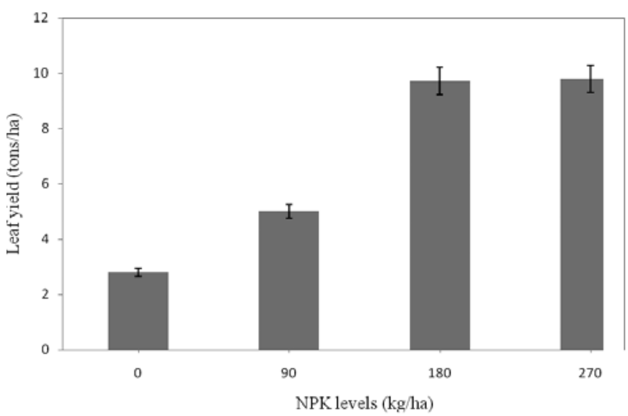

Figure 1. NPK effect on the yield of pumpkin leafy vegetable, means of 2007-2008 (tons/ha) Footnote: (The vegetable yield was gotten from the young shoot being consumed which is about 10 cm to the plant vine tip)

The effect of NPK on the anti-oxidant activities and components of young leaves of two cultivars of pumpkin is presented in (Table 6). The plants under 180 kg NPK ha^{-1} had the highest anti-oxidant activity (72.5%) while there was no significant difference in antioxidant activity of the plants under other levels of NPK including control. The total phenolic contents of plants under 180 kg NPK ha^{-1} were significantly higher than the plants under other NPK levels. Flavonoid content was not significantly affected by NPK fertilizer. The plants under 180 kg NPK ha^{-1} had the highest anthocyanin content (7.4 mg 100^{-1}). There was no significant difference in anthocyanin contents among other levels of NPK. The plants under 180 kg NPK ha^{-1} had the highest proanthocyanidin content compared to the plants under other NPK levels followed by the plants under 90 kg NPK ha^{-1}.

Table 6. Anti-oxidant activities and antioxidant phenolic compounds of pumpkin as affected by NPK compound fertilizer* (Dry weight basis)

NPK Levels	Antioxidant Activity (%)	Total phenolic content	Flavonoid content	Anthocyanin content	Proanthocyanidin content
		mg100 g^{-1}			
0 (control)	47.6b	5684c	195.8a	1.2b	0.07c
90	59.2b	9612b	228.0a	3.2b	0.11b
180	72.5a	16393a	393.5a	7.4a	0.16a
270	47.4b	5625c	218.3a	2.8b	0.08c

Means with the same letter are not significantly different at 5% level of probability according to Duncan's multiple range test.

*Values are means of triplicate analyses expressed on dry matter basis

4. Discussion

In this study, the result of the effect of NPK on growth, leaf yield and antioxidant profile of *C. pepo* was consistent with earlier findings on related crops and on *C. pepo* itself. Application of N, P and K has been reported to increase the growth and productivity of pumpkin and crops generally (Al-Mukhtar *et al.,* 1987; Kumar *et al*., 1995). Mobile phosphorus and potassium have also been reported to be very important for the setting, development and storage of pumpkin (MacCarthy *et al.*, 1990). Adams (1986) reported that when P level is optimum, much of energy required for plant metabolism which is stored chemically in the form of complex organic phosphates adenosine triphosphate (ATP) will be made available and released as required. Therefore, important chemical processes involved in growth will be driven steadily.

The antioxidant activity and phenolic antioxidant contents of pumpkin leaf as observed in this study increased with the NPK fertilization, it peaked at 180 kg ha^{-1}. This corroborates with some recorded findings on fruits and vegetables by Skwarylo-Bednarz and Krzepilko (2008) who reported that the use of mineral fertilizer, particularly Nitrogen increases the Vitamin C content which is a frequently used indicator of the antioxidant properties of fruits and vegetables.

The optimum NPK level in this study was 180 kg ha^{-1} where the growth, fruit yield and its components were higher than all other levels. At 270 Kg ha^{-1}, law of diminishing returns sets in. At this level there was no more significant effect of NPK on yield of *C. pepo*. At 180 kg ha^{-1} levels of NPK also, antioxidant activity and phenolic antioxidant components of *C. pepo* leaf were highest. Further increase in the application of NPK resulted in over fertilization and subsequent effect of decline in the antioxidant activity and phenolic antioxidant constituents. This is in agreement with the study conducted in China by Juan *et al.*, (2008) on effects of N and S on total phenolics and antioxidant activity of leaf Mustard. They reported that increasing N supply considerably decreased total phenolic concentrations. Similar findings were emphasized in addition to the type of soil in accumulation of nutrients by cultivated plants (Lester, 2007; Kadar, 2002; Kadar, 1988).

5. Conclusion

The results provide evidence that NPK fertilizer progressively increased the vegetative growth and the yield of pumpkin leafy vegetable, though beyond 180 kg NPK ha^{-1}, there was no significant yield increase during the two consecutive years of study. Moreover, it is remarkable that pumpkin leafy vegetable requires 180 kg NPK ha^{-1} or less for optimal antioxidant activities and concentration of phenolic antioxidant. It is also noteworthy that at higher levels of NPK fertilizer, antioxidant activities and phenolic antioxidant concentration of *C. pepo* leafy vegetable reduced drastically.

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