Growth and yield response of Sweet pepper (*Capsicum annuum* L.) to Moringa (*Moringa oleifera* Lam.) leaf extract and NPK 15:15:15 fertilizer application

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Abstract

In a nursery experiment, the growth and yield response of sweet pepper to Moringa leaf extracts and NPK 15:15:15 fertilizer application were investigated. Sweet pepper seeds were drilled on 1 m x 5 m nursery beds, allowed to germinate and develop into seedlings for four weeks before transplanting into twenty pots, each containing 8 kg of soil. Fresh Moringa leaves were collected, air dried at room temperature, and the active ingredients extracted using ethanol and water, following standard procedures. The experiment was arranged in completely randomized design and pepper seedlings were treated with 20 ml foliar application of Moringa leaf extracts (ethanol and water extractions); NPK 15:15:15 (at 280 kg/ha) using the side dressing method, while control seedlings were untreated. The treatments were replicated five times and foliar application was done at 2, 4 and 6 weeks after transplanting. The growth and yield parameters were measured weekly, from the second to tenth week after transplanting. Data were analysed using ANOVA at $p \leq 0.05$ level of significance. There were significant differences in the growth and yield parameters. The NPK 15:15:15 treatment had the highest plant height (28.20 cm), collar diameter (4.07 mm), number of leaves (113.60), leaf area (38.20 cm^2) and yield (8.43 t/ha). Ethanol extracts of Moringa leaves had a better growth performance (plant height: 23.00 cm, number of leaves: 87.60, collar diameter: 3.46 mm and yield: 5.24 t/ha), while the control treatment had the least. The NPK 15:15:15 and Moringa leaf extracts enhanced growth and yield of sweet pepper. Therefore, they can be used to boost sweet pepper production in the study area.

Keywords: Moringa leaf extract, *Capsicum annuum*, NPK, Growth, Yield

Introduction

Sweet Pepper (*Capsicum annuum* L.) is an important fruit vegetable of global importance (Perry *et al*., 2017). The fruit is in high demand, and consumed mainly as a spice in various cuisines. It has many nutritional benefits because of its richness in vitamins, proteins and minerals (Temu and Temu, 2005; Olaniyi and Ojetayo, 2010).

Farmers continue to make efforts to increase the yield of the crop using biofertilizers, organic and inorganic fertilizers. Thus, various researchers have recommended different amounts of fertilizer inputs for optimum growth and yield of the crop. For example 80 kg N/ha by Muhammed and Rilwan (2018); 60 kg P_2O_5/ha by Emmanuel *et al.* (2019) and 90 kg K_2O/ha by Emmanuel *et al*. (2021).

However, inorganic fertilizers such as NPK 15:15:15 are scarce and sometimes expensive. In addition, the prolonged use of inorganic fertilizers increase soil acidity and damage soil structure. It is therefore necessary to identify other organic sources of nutrients that are readily available and environmentally friendly. The use of extracts from plants could be an alternative that would increase crop yield and maintain the health of the soil.

Moringa oleifera is a common multipurpose tropical tree, highly valued for its medicinal, nutritional and agricultural qualities (Foidle *et al*., 2001; Shahzad *et al*., 2013). It is ranked as one of the most useful trees in the world, because all parts of the tree can be used (Ashfaq *et al*., 2012). The extracts from Moringa have been shown to have plant growth regulatory properties, particularly because of the presence of cytokinin (zeatin), essential amino acids and several mineral elements (Emongor, 2012; Howladar, 2014). The extracts could also accelerate seed germination, vegetative growth and crop yield (Rady *et al*., 2013; Rady *et al*., 2015). The species is a common tree in many home gardens and farms in tropical Africa. Hence, extracts from the leaves could be a readily available input that could improve sweet pepper production.

This study investigated the effect of Moringa leaf extracts and NPK 15:15:15 fertilizer application on the growth and yield of sweet pepper.

Materials and Methods

The experiment was carried out in the screen house of the Crop Production Technology Department, Oyo State College of Agriculture and Technology, Igboora, Nigeria, from August to October, 2020. Igboora is located in Ibarapa Central Local Government Area of Oyo State at 397 m above sea level. The town shares its boundaries with Abeokuta, Ibadan and Oke-Ogun regions. It is in the derived savanna zone and has two distinct seasons. The dry season is from November to March, while the wet season is from April to October. The average monthly high and low temperatures are 33°C and 22°C, respectively.

Composite soil samples were collected at 0 – 20 cm depth using a soil auger. The samples were air dried, sieved with a 2 mm aperture sieve, before determining their physical and chemical properties at the Department of Agronomy, University of Ibadan, Ibadan, Nigeria.

The soil pH in H_2O (1:1) was determined with a pH meter, while available phosphorus was estimated using Bray and Kurtz (1945) method. The soil particle size was determined using the hydrometer method (Bouyoucos, 1962), while the Macro-Kjeldahl method was used to estimate total nitrogen (Jackson, 1958). The exchangeable calcium, magnesium, potassium, sodium and effective

cation exchange capacity were determined using atomic absorption spectrophotometer (Tel and Hargerty, 1984).

Fresh leaves were harvested from a Moringa plantation (Latitude 27.261N and Longitude 13.1716E) in Igboora. The leaves were washed with distilled water and then, air dried. The dried leaves were milled and stored in sample bags. Nutrient extraction from the leaves was done using ethanol and distilled water. For the ethanol extraction, 20 g of Moringa leaf powder was added to 675 ml of ethanol in a 2.5 L Winchester bottle and left for 24 hours (Makkar and Becker, 1996). For the aqueous extraction, 1 kg of fresh Moringa leaf was added to 200 ml of distilled water and left for 24 hours (Bashir *et al*., 2014). The chemical composition of the leaf extracts were determined.

Sweet pepper seeds (*Capsicum annuum*) Habanero were obtained from National Horticultural Research Institute in Ibadan, Nigeria. The seeds were drilled on a nursery bed (1m x 5m), allowed to germinate and develop into seedlings for four weeks before transplanting one seedling into each of twenty pots, containing 8 kg of soil. The pots were arranged in a completely randomized design experiment, containing four treatments: Ethanol Moringa Leaf Extract (EMLE), Aqueous Moringa Leaf Extract (AQMLE), NPK 15:15:15 and control (no treatment). Each treatment was replicated five times. A syringe was used for foliar application of 20 ml of EMLE and AQMLE at 2, 4 and 6 weeks after transplanting. The NPK 15:15:15 was applied using the side-dressing method at the standard rate of 280 kg/ha at 2 weeks after transplanting (Isah *et al.,* 2014). The untreated sweet pepper seedlings (control) had no application of fertilizer or Moringa leaf extract.

Weekly data collection commenced 2 weeks after transplanting. The meter ruler was used to measure plant height from base to the tip of the main shoot, as well as the leaf length (L) and width (W). Leaf area (LA) was estimated using the leaf area model, $LA = a + bLW$ where a = 0.96, b = 0.5 (Karaca *et al*., 2020). Number of leaves were visually counted, while the collar diameter was determined using Vernier minicalliper. Sweet pepper fruits were harvested and weighed, then air dried and weighed at the end of the experiment. Fruit weight was determined using Falcon electronic scale BL 3002. The data were subjected to Analysis of Variance (ANOVA) and significant means separated using Duncan Multiple Range Test at 5% significant level.

Results

The soil was slightly acidic (6.47) and low in essential nutrients such as nitrogen (0.17%), phosphorus (9.97 mg/kg) and potassium (0.36 cmol/kg). The soil textural class was sandy loam, with 89.4% sand, 5.80% silt, and 4.80% clay (Table 1). Similarly, natural growth enhancers (zeatin: 4.94 mg/kg and giberrellin: 2.80 mg/kg) were higher in the ethanol leaf extract than in aqueous leaf extract (2.83 mg/kg and 1.90 mg/kg, respectively). The essential plant nutrients were present in the Moringa leaf extracts. The nitrogen (11.68 mg/kg), phosphorus (5.24 mg/kg) and potassium (4.20 cmol/kg) contents in the ethanol Moringa leaf extract were higher than that of the aqueous Moringa

leaf extract (Table 2). Similarly, natural growth enhancers, zeatin (4.94 mg/kg) and giberrellin (2.80 mg/kg) found in the ethanol Moringa leaf extract were higher than those of aqueous Moringa leaf extract which were 2.83 mg/kg and 1.90 mg/kg, respectively.

Table 1. Soil physical and chemical properties

Element	Values
pH (H_20)	6.47
Exchangeable cations (cmol/kg)	
Ca^{2+}	3.65
Mg^{2+}	0.76
K^{+}	0.36
Na^{+}	0.54
ECEC	5.34
Total N (%)	0.17
Total Org. C (%)	0.87
Av. P	9.97
Particle size analysis	
Sand (%)	89.4
Silt (%)	5.8
Clay (%)	4.8
Textural class	Sand loamy

There were significant differences in the height of *Capsicum annuum* seedlings subjected to different treatments from the fourth to tenth week, after transplanting. At 10 weeks after transplanting, *Capsicum annuum* treated with NPK 15:15:15 had the highest plant height (28.20 cm) while control treatment seedlings had the least (15.40 cm) (Table 3).

Table 2. Chemical composition of leaf extracts of *Moringa oleifera*

Element	Ethanol leaf extract (mg/kg)	Aqueous leaf extract (mg/kg)
Nitrogen	11.68	4.10
Phosphorus	5.24	1.20
Potassium	4.20	1.83
Zeatin	4.94	2.83
Giberellin	2.80	1.90

Also, significant differences were observed for the number of leaves from the fourth to tenth week, after transplanting. Plants treated with NPK 15:15:15 had the highest number of leaves (113.60), while control treatment had least (25.60). There were significant differences in collar diameter of the plants from various treatments. At 10 weeks after transplanting, *Capsicum annuum* treated with NPK 15:15:15 had the highest collar diameter (4.07 mm), while the control treatment had least (2.37 mm).

The leaf area significantly differed among treatments, with those treated with NPK 15:15:15 producing the highest leaf area (38.20 cm^2) at 10 weeks, while control was least (20.70 cm^2). The yield was significantly higher in the treated seedlings when compared with the control. Sweet pepper treated with NPK 15:15:15 had the highest yield (8.43 t/ha), while the control treatment had the least (1.99 t/ha) (Table 4).

Table 3. Growth responses of *Capsicum annuum* to Moringa leaf extracts and NPK 15:15:15 fertilizer application

Plant height (cm)					
Treatment	**2WAT**	**4WAT**	**6WAT**	**8WAT**	**10WAT**
NPK	12.30[a]	22.60[a]	26.00[a]	27.40[a]	28.20[a]
EMLE	12.60[a]	17.50[b]	20.60[b]	22.00[b]	23.00[b]
AQMLE	12.90[a]	16.20[bc]	17.60[c]	19.20[c]	20.80[c]
CONTROL	10.70[a]	13.40[c]	14.40[d]	15.00[d]	15.40[d]
Number of Leaves					
NPK	15.60[a]	36.00[a]	62.20[a]	86.40[a]	113.60[a]
EMLE	12.80[a]	29.60[a]	54.20[a]	65.40[ab]	87.60[a]
AQMLE	12.80[a]	18.40[b]	28.40[b]	46.80[b]	50.60[b]
CONTROL	11.60[a]	16.60[b]	21.20[b]	22.00[c]	25.00[b]
Collar Diameter (mm)					
NPK	2.45[a]	3.31[a]	3.74[a]	4.00[a]	4.07[a]
EMLE	2.36[a]	2.61[b]	3.00[b]	3.29[b]	3.46[b]
AQMLE	1.88[b]	2.23[c]	2.58[c]	2.81[c]	2.87[c]
CONTROL	2.03[b]	2.18[c]	2.23[c]	2.28[d]	2.37[d]
Leaf Area (cm^2)					
NPK	23.54[a]	30.76[a]	33.19[a]	33.68[a]	38.20[a]
EMLE	14.84[b]	19.08[b]	20.01[b]	22.80[b]	25.68[b]
AQMLE	14.18[b]	17.32[b]	17.98[b]	19.02[b]	24.39[b]
CONTROL	12.29[b]	16.44[b]	17.37[b]	17.41[b]	20.70[b]

Means with the same alphabet in column were not significantly different at $p \leq 0.05$

EMLE - Ethanol Moringa leaf extract, AQMLE - Aqueous Moringa leaf extract, NPK - NPK 15:15:15, CONTROL- No application. WAT - Weeks after transplanting.

Table 4. Yield of *Capsicum annuum* treated with Moringa leaf extracts and NPK 15:15:15 fertilizer

Treatment	**Yield (t/ha)**
NPK	8.43[a]
EMLE	5.24[b]
AQMLE	3.11[c]
CONTROL	1.99[d]

Means with the alphabet in column were not significantly different at $p \leq 0.05$

EMLE - Ethanol Moringa leaf extract, AQMLE - Aqueous Moringa leaf extract, NPK - NPK 15:15:15, CONTROL - No application. WAT - Weeks after transplanting.

Discussion

In this study, the essential nutrients in the soil were below critical levels for soils in the derived savanna ecological zone (Adeoye and Agboola, 1985). Therefore, the growth and yield of *Capsicum annuum* was enhanced by the application of Moringa leaf extracts and NPK 15:15:15. The inorganic fertilizer produced the highest values for all variables observed. This is probably due to the high levels of essential nutrients (nitrogen, phosphorus and potassium) in inorganic fertilizer, when compared with the Moringa leaf extracts.

Nevertheless, Moringa leaf extracts increased the growth and yield of sweet pepper. This corroborates the findings of Tetley and Thiamann (1974) and Fuglie (2000), who reported that zeatin in Moringa leaf extracts, increased leaf chlorophyll content, leaf area and photosynthetic activity in plants. The zeatin in the leaf extracts have been shown to induce cytokinin bio-synthesis and increase the number of photosynthetic active leaves on plants, thus increasing yield of plants (Thomas and Howarth, 2000). In addition, Fuglie (2000) mentioned that Moringa extracts increased cell division rates and enlargement, thereby producing higher yield of crops.

Conclusion

Moringa leaf extracts were shown to enhance growth and yield of *Capsicum annuum*. The zeatin and gibberellin in Moringa leaf extracts are natural growth enhancers. However, ethanol leaf extract had a slightly improved performance than aqueous leaf extract. Moringa leaves are easily accessible to farmers in Igboora, and could be an alternative to NPK 15:15:15 fertilizer in pepper production.

References

Adeoye, O. A. and Agboola, A. A. (1985). Critical level of soil plant available P, K, Zn, Mg, Cu and Mn on maize leaf content in sedimentary soils of southwest Nigeria. *Fertility Residual*, 6: 60-71.

Ashfaq, M., Basra, S. M. and Ashfaq, U. (2012). *Moringa oleifera*: A miracle plant for agroforestry. *Journal of Agricultural Social Science,* 8: 115–122.

Bashir, K. A., Bawa J. A. and Mohammed, I. (2014). Efficacy of leaf extract of drumstick tree (*Moringa oleifera* L.) on the growth of local tomato (*Lycopersicon esculentum*). *Journal of Pharmacy and Biological Sciences,* 9(4): 74-79.

Bouyoucos, G. J. (1962). Hydrometer method improved for making particle size analysis of soils. *Soil Science Society of America Proceedings* 26: 464-465.

Bray, R. H. and Kurtz, L. T. (1945). Determination of total organic and available forms of phosphorus in soils. *Soil Science*, 39:39-45.

Emmanuel, O. A., Olufemi, J. A. and Aluko, M. (2021). Growth, yield and proximate composition responses of hot pepper (*Capsicum annuum* L Rodo variety) to potassium fertilizer application at Ado-Ekiti, Nigeria. *Journal of Experimental Agriculture International* 43(11): 136-145; 2021.

Emmanuel, O. A., Olufemi, J. A. and Aluko, M. (2019). Effect of phosphorus fertilizer on

plant growth, fruit yield and proximate composition of hot pepper (*Capsicum annuum* L Rodo variety) *International Journal of Plant and Soil Science* doi: 10.9734/IJPSS/2019/v31i330210

Emongor, V. E. (2012). Guidelines on good agricultural practices in the production of Moringa (*Moringa oleifera* L). *Scripta Horticulturae*, (15): 115-132.

Foidle, N., Makkar, H. P. S. and Becker, K. (2001). The potential of *Moringa oleifera* for agricultural and industrial uses. In: Fuglie L. J, editor. *The Miracle Tree: The Multiple Attribute of Moringa.* Pp.: 45-76.

Fuglie, L. J. (2000). The Miracle Tree: *Moringaoleifera: Natural nutrition for the tropics. The miracle tree: the multiple attributes of Moringa.* pp: 172.

Howladar, S. M. (2014). A novel *Moringa oleifera* leaf extract can mitigate the stress effects of salinity and cadmium in bean (*Phaseolus vulgaris* L.) plants. *Ecotoxicology and Environmental Safety,* 100: 69-75.

Jackson, M. L. (1958). Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd., New Delhi, 498.

Karaca, C., Buyuktas, D. and Sehir, S. (2000). Determination of leaf area of some vegetable plants grown under greenhouse condition by non-destructive methods. *Horticulture* 8(1): 23-28. http://doi.org/10.16882/HortiS.841745

Makkar, H. P. and Becker, K. (1996). Nutritional value and antinutritional components of whole and ethanol extracted *Moringa oleifera* leaves. *Animal Feed Science and Technology,* 63: 211-228.

Muhammed, D. T. and Rilwan Y. (2018). Performance of sweet pepper (*Capsicum annuum*) under five levels of nitrogen fertilizer in Zaria Kaduna State, Nigeria. *Asian Journal of Agriculture in Agricultural Research* 5(4): 1-7.

Olaniyi, J. O. and Ojetayo, A. E. (2010). The effect of organo-mineral and inorganic fertilizer on the growth, fruit yield and quality of pepper (*Capsicum frutescence*). *Journal of Animal and Plant Sciences,* 8(3): 1070-1076.

Perry, L., Dickau, R., Zarrillo, S., Holst, I., Pearsall, D. M. and Pipemo, D. R. (2007). Starch fossils and the domestication and dispersal of chilli peppers *Capsicum spp* in the Americas. *Science*, 315: 986-988.

Rady, M. M., Varma B. C. and Howladar, S. M. (2013). Common bean (*Phaseolus vulgaris* L.) seedlings overcome NaCl stress as a result of presoaking in *Moringa oleifera* leaf extract. *Scientia Horticulturae,* 162: 63-70.

Rady, M. M., Gamal, F., Mohamed, A. M. and Yasmin, H. M. (2015). Integrated application of salicylic acid and *Moringa oleifera* leaf extract alleviates the salt-induced adverse effects in common bean plants. *Journal of Agricultural Technology,* 11(7): 1595-1614.

Shahzad, U., Khan, M. A., Jaskani, M. J., Khan, I. A. and Korban, S. S. (2013). Genetic diversity and population structure of *Moringa oleifera. Conservation Genetics,* (14): 1161-1172.

Tel, D. A. and Hargerty M. (1984). Soil and plant analyses study guide for agricultural laboratory directors and technologies

working in tropical regions IITA and University of Gueloh Pp. 227.

Temu, A. E. and Temu, A. A. (2005). High value agricultural products for small holder market in Sub-saharan Africa: Trends, opportunities and research priorities international. International Center for Tropical Agriculture, Cali, Colombia, pp: 37.

Tetley, R. M. and Thimann, K. V. (1974). The metabolism of oat leaves during senescence. Respiration, carbohydrate metabolism, and the action of cytokinins," *Plant Physiology,* 54: 294-303.

Thomas, H. and Howarth, C. J. (2000). Five ways to stay green. *Journal of Experimental Botany,* 51: 329-337.