





EFFECTS OF MORINGA LEAF EXTRACT AND POULTRY MANURE ON THE GROWTH PARAMETERS OF SWEET MAIZE

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ABSTRACT

This study examined the effects of moringa leaf extract (MLE) and poultry manure (PM) on the growth parameters of sweet maize. The experiment was a Randomized Complete Block Design involving nine treatments: control (no extract), 3% MLE, 6% MLE, 9% MLE, 3% MLE + 15 t/ha⁻¹ PM, 6% MLE + 15 t/ha⁻¹ PM, 9% MLE + 15 t/ha⁻¹ PM, 15 t/ha⁻¹ PM, and 30 t/ha⁻¹ PM. Data on growth parameters including plant height, number of leaves per plant, stem girth, and leaf area were collected and analyzed. The results of the study show that there were significant differences ($P = 0.05$) among the treatments because plots that received 30 t/ha⁻¹ PM performed best on plant height (193.6 and 152.8 cm) number of leaves (13.1 and 10.2), stem girth (3.75 and 3.22 cm), and leaf area (584.9 and 402.9 cm²) in both early and late season. This was followed by plots that received 9% MLE and 15 t/ha⁻¹ PM, with values of 189.0 and 152.2 cm; 12.5 and 10.0; 3.58 and 3.15 cm; and 546.2 and 392.2 cm² respectively. The study concluded that 30 t/ha⁻¹ PM can be used to yield effective growth parameters in sweet maize and is hereby recommended to extension workers for dissemination to farmers

Contribution/Originality: This study is one of very few studies to have investigated the effects of *Moringa oleifera* extract on field crops in Delta state, Nigeria. In combination with poultry manure, moringa extract shows great promise in improving the growth characteristics of sweet maize, a major vegetable crop.

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1. INTRODUCTION

Sweetcorn (*Zea mays* var. *saccharata*) is a maize variety with tender, delicious sugar kernels eaten as a vegetable. In contrast to traditional field corn, sweetcorn varieties are harvested when the kernels have just reached the milk stage and are used earlier. Sweetcorn has achieved major commercial success in many tropical and subtropical countries (Okonmah & Eruotor, 2012). The commercial success of maize crops notwithstanding, production in Nigeria has been bedevilled by low yields due to factors such as low soil fertility and negligence regarding soil amendment materials (DIPA, 2006; Enujeke, 2013). While manures and fertilizers are indispensable for increased crop productivity, Phiri (2010) noted that dependence on the use of inorganic fertilizers is associated with land and soil degradation, as well as environmental pollution (Anyaeibu, 2015).

In recent years, there is increasing awareness among maize farmers of the benefits of organic fertilizer application. This is because organic fertilizers not only increase physical soil properties such as porosity, structure,

water-holding capacity, and chemical balance, but also increase mineral deposition, which is essential for the proper development of plants (Amujoyegbe, Opabode, & Olayinka, 2007; Mishra, Singh, Singh, Das, & Prasad, 2013).

Makkar, Francis, and Becker (2007) found that moringa leaf extract (MLE) contains significant quantities of calcium, potassium, and cytokinin in the form of zeatin, antioxidants, proteins, ascorbates, and phenols. Fresh moringa leaves sampled from various parts of the world were found to have high leaf zeatin concentrations of between 5 and 200 mcg/g.

Phiri (2010) and Yasmeen, Basra, Ahmad, and Wahid (2012) have reported that MLE is an excellent seed-priming agent for stress-grown wheat and that it enhanced the germination of sorghum, the length of maize radicles, and the hypocotyls of wheat, thereby affecting cereal germination and establishment. Phiri and Mbewe (2010) have also observed that MLE increased the duration of the first germination of beans and increased the germination percentage of cowpea, but caused reduced germination percentage in groundnut and overall lower seedling survival in all three legumes, thereby leading to the postulation that MLE should not be used as a priming agent for legumes due to the presence of inhibitory substances absorbed through the various seed coats.

Besides the contribution of MLE and poultry manure (PM) to vegetative growth phase, there is a need to guide farmers in regard to the useful and appropriate quantities of MLE and PM to apply from one farm location to another. Hence, this study is a useful guide to determining the effectiveness and application rates of MLE and PM in the study area. The specific aim of the study was to examine the effects of moringa (*Moringa oleifera* Lam.) leaf extract and PM on the growth parameters of sweetcorn.

2. MATERIALS AND METHODS

A field study was carried out from August to November 2018 and April to July 2019 at the Research and Teaching Farms, Department of Agronomy, Delta State University, Asaba Campus, while the analysis was done at the Animal and Environmental Biology Laboratory of Delta State University, Abraka. The experimental site is located at latitude 06°14'N and longitude 06°49'E. Seeds of sweetcorn TZ varieties were procured from the International Institute of Tropical Agriculture (IITA), Ibadan, Oyo State, while moringa was locally sourced from the study area. Moringa leaves were oven dried and analyzed for their nutrient contents, including total nitrogen (Ryan, Estefan, & Rashid, 2001), phosphorus, potassium, calcium, magnesium, copper, iron, manganese, and zinc (Bingham, 1982; Ryan et al., 2001). MLE was prepared using the method of Price (2007) by grinding young shoots (leaves and tender branches) with water (1 l/10 kg fresh material) in a blender for 15 min and then filtering the homogenized solution through no. 2 Whatman filter paper. This was then proportionally diluted with water to obtain 3, 6, and 9% concentration levels for the various treatments.

Preplanting soil analysis: soil samples were randomly collected from the 0–15-cm layer of the experimental plot using a soil auger. The samples were sieved of stones, roots, and leaves before being air-dried at room temperature for three days and pulverized using a porcelain mortar and pestle. The crushed samples were then sieved using a 2-mm-aperture sieve and analyzed. Particle size distribution was determined by the hydrometer method (Gee & Baudex, 1986) after destroying the organic matter with hydrogen peroxide and dispersing the soil with 0.5 N sodium hexameta phosphates, while soil pH was measured using a Pyeunican model MK2 pH meter in a 1:2.5 soil:water suspension ratio. Organic carbon was determined by the Walkley–Black wet oxidation method (Nelson & Sommers, 1982). Total nitrogen was evaluated by the micro-Kjeldahl distillation technique as described by Bremner and Mulvaney (1982). Available phosphorus was measured by the Bray No. 1 method (IITA International Institute of Tropical Agriculture, 1979), while exchangeable potassium (K), calcium (Ca), magnesium (Mg), and sodium (Na) were determined by flame photometry (Chapman, 1965). Cation exchange capacity (CEC) was evaluated by the ammonium acetate saturation method (Roades, 1982). The chemical components of PM used for the experiment were also analyzed in order to ascertain their nutrient composition. *Field procedure:* The study was carried out as a split plot in a randomized complete block design (RCBD), with three replicates. Plots measuring 3.0 x 1.5 m² were prepared on a land area measuring 663.0 m² selected for the study and prepared manually by clearing with hoe and machete, then marked out using a basin formation according to the experimental layout. Improved sweetcorn seeds of the TZ variety obtained from IITA were sown on the plots at the rate of three seeds per hole at a depth of 2–3 cm, with 75 x 25 cm² spacing. At 3 weeks after planting (WAP), the maize crop was thinned to one plant per stand leaving the most vigorous seedlings, to give a plant population density of 53,333/ha. Weeding was done manually three times using a hoe at the 3rd, 6th, and 9th weeks after sowing.

2.1. Treatment Protocol

Nine treatments were involved: T₁, T₂ ... T₉

where

T ₁	=	Control (no extract or PM)
T ₂	=	3% MLE
T ₃	=	6% MLE
T ₄	=	9% MLE
T ₅	=	3% MLE + 15 t/ha ⁻¹ PM
T ₆	=	6% MLE + 15 t/ha ⁻¹ PM
T ₇	=	9% MLE + 15 t/ha ⁻¹ PM
T ₈	=	15 t/ha ⁻¹ PM
T ₉	=	30 t/ha ⁻¹ PM

MLE was applied at 2, 4, 6, and 8 WAP by foliar application, spraying the entire plants in the designated study plots using a knapsack sprayer. The parameters listed henceforth were obtained from the innermost ten plants of each study plot.

The growth parameters measured were plant height, number of leaves, stem girth, and leaf area. Plant height was measured to the nearest centimeter using a measuring tape, from the base to the highest growing point, i.e., the leaf sheath of the last fully opened leaf. The number of leaves was determined by counting the number of fully opened leaves, starting from the base of the plant upwards. Stem girth was measured at the base of the plant with the aid of Vernier calipers, to the nearest millimeter. Leaf area was measured by tape using the non-destructive analysis method: length x width x 0.75, according to Duke and Dulelar as reported by Enujeke (2013), i.e., LA (cm²) = 0.75 x L x W

2.2. Statistical Analysis

Data collected were subjected to analysis of variance (ANOVA) and means were separated using the Duncan multiple range test (DMRT) at the 5% level of significance.

3. RESULTS AND DISCUSSION

3.1. Chemical Composition of Leaves.

The results of the proximate analysis of *M. oleifera* leaves used in the study are shown in Table 1. These show that, per 100 g, moringa leaves contained 10.51 g moisture, 86.2 calories, 21.95 g protein, 2.64 g fat, 49.31 g carbohydrate, 9.83 g fibre, 5.76 g ash, 4.0 g calcium, 0.08 mg copper, 18.7 mg iron, 22.25 mg potassium, 5.0 mg phosphorus, and 0.02 mg sulphur.

Table 1. Chemical composition of *M. oleifera* leaves/100 g.

Component	Value
Moisture (g)	10.51
Calories (n)	86.2
Protein (g)	21.95
Fat (g)	2.64
Carbohydrate (g)	49.31
Fibre (g)	9.83
Ash (g)	5.76
Calcium (mg)	4.0
Copper (mg)	0.08
Iron (mg)	18.7
Potassium (mg)	22.25
Magnesium (mg)	45.0
Phosphorus (mg)	5.0
Sulphur (mg)	0.02

3.2. Chemical Composition of PM

The chemical composition of PM used in the study is shown in Table 2. Analysis shows that it contained 0.61 ppm magnesium, 1.48 ppm calcium, 0.29 ppm sodium, 1.18 ppm phosphorus, 2.67% nitrogen, 0.74 ppm potassium, 1.20% organic carbon, 2.57% organic matter, and the C:N ratio was 0.45.

Table 2. Chemical composition of PM.

Element	Value
Magnesium (ppm)	0.61
Calcium (ppm)	1.48
Sodium (ppm)	0.29
Phosphorus (ppm)	1.18
Nitrogen (%)	2.67
Potassium (ppm)	0.74
Organic carbon (%)	1.20
Organic matter (%)	2.57
C:N ratio	0.45

3.3. Effects of MLE and PM on Plants

3.3.1. Height

The response of plant height to MLE and PM is shown in Table 3. Plant height increased from 2 to 8 WAP and treatment application resulted in significant differences. At 2 WAP, sweetcorn plants in plots that had received PM at an application rate of 30 t/ha⁻¹ were significantly taller in both the early (39.5 cm) and late season (42.3 cm), while plants that did not receive PM or MLE (control plot) had the lowest height (27.9 and 30.7 cm in the early and late

season, respectively). During early season planting there was no significant difference in plant height among plants that received 3% MLE + 15 t/ha⁻¹ PM, 6% MLE + 15 t/ha⁻¹ PM, 9% MLE + 15 t/ha⁻¹ PM, and 15 t/ha⁻¹ PM. Likewise, the control plot was statistically similar for plants that received 3, 6, and 9% MLE. During the late season, there were no significant differences in plant height in plots that received 9% MLE + 15 t/ha⁻¹ PM, 15 t/ha⁻¹ PM, and 30 t/ha⁻¹ PM.

At 4 WAP, plants that had received 30 t/ha⁻¹ PM in the early season were significantly taller (65.8 cm) than those that received 3% MLE + 15 t/ha⁻¹ PM, 6% MLE + 15 t/ha⁻¹ PM, 9% MLE + 15 t/ha⁻¹ PM, and 15 t/ha⁻¹ PM and were statistically similar, with heights of 33.9, 35.2, 35.1, and 35.5 cm, respectively. However in the late season, there was no significant difference between plants that received 9% MLE + 15 t/ha⁻¹ pm, 15 t/ha⁻¹ PM, and 30 t/ha⁻¹ PM. Plants that received no additional materials had heights of 44.1 and 34.2 cm in the early and late season, respectively.

At 6 WAP, plants in plots that received 30 t/ha⁻¹ PM were significantly taller (152.6 cm) in the early season, but were statistically similar to plants that received 9% MLE + 15 t/ha⁻¹ PM (142.2 cm) and 15 t/ha⁻¹ PM (138.1 cm) in the late season. Sweetcorn plants in plots that received neither MLE nor PM had the lowest plant height, of 81.6 and 76.7 cm during the early and late season, respectively. This trend did not change at 8 WAP: sweetcorn plants in plots that received 30 t/ha⁻¹ PM were significantly taller (193.6cm) in the early season but in the late season were not significantly taller than those that received 6% MLE + 15 t/ha⁻¹ PM, 9% MLE + 15 t/ha⁻¹ PM, and 15 t/ha⁻¹ PM, while crops that received neither MLE nor PM had the lowest height (139 and 92.8 cm) for the early and late season, respectively.

The PM application rate of 30 t/ha⁻¹ had a more significant effect on growth parameters than other rates of MLE and PM applied. This could be attributed to its special characteristics of faster mineralization than other organic manures, and rapid release of nutrients for plant uptake and utilization. This is similar to the findings of [Izunobi \(2002\)](#), who identified PM as the richest animal manure with the ability to enhance growth with respect to plant height, leaf area, and total chlorophyll content. It is also in agreement with the findings of [Brady and Wells \(2008\)](#), who reported that PM mineralizes faster and releases its nutrients more rapidly for growth enhancement. This is in agreement with the findings of [Akanni and Ojeniyi \(2008\)](#). [Ayoola and Makinde \(2009\)](#) and [Uwah, Eneji, and Eshiet \(2011\)](#) also observed that increased rates of PM application – 20–30 t/ha⁻¹ – resulted in increased plant height, number of leaves, and leaf area in *Amaranthus* and maize crops. It is also consistent with the findings of [Adeleye, Ayeni, and Ojeniyi \(2010\)](#), who reported that PM application at 30 t/ha⁻¹ increased the growth parameters of tomato including plant height, leaf area, and stem girth, which eventually influenced fruit yield positively.

Table 3. Effects of MLE and PM on plant height of sweetcorn (cm).

Treatment	Weeks after sowing (WAS)							
	2		4		6		8	
	Early season	Late season	Early season	Late season	Early season	Late season	Early season	Late season
Control (0%)	27.9 ^c	30.7 ^b	44.1 ^c	34.2 ^b	81.6 ^d	76.7 ^c	139.0 ^c	92.8 ^b
3% MLE	28.6 ^c	32.6 ^b	45.3 ^c	33.7 ^b	84.4 ^d	84.4 ^c	146.2 ^c	106.1 ^b
6% MLE	28.7 ^c	33.2 ^b	47.9 ^c	35.7 ^b	95.6 ^d	94.2 ^b	153.6 ^c	109.7 ^b
9% MLE	29.2 ^c	31.8 ^b	52.1 ^b	39.1 ^b	98.6 ^d	96.1 ^b	162.6 ^c	118.6 ^b
3% MLE + 15 t/ha ⁻¹ PM	33.9 ^b	33.1 ^b	55.9 ^b	39.8 ^b	111.7 ^c	107.2 ^b	166.3 ^c	132.8 ^b
6% MLE + 15 t/ha ⁻¹ PM	35.2 ^b	33.2 ^b	58.6 ^b	38.3 ^b	121.1 ^c	111.4 ^b	176.3 ^c	148.7 ^a
9% MLE + 15 t/ha ⁻¹ PM	35.1 ^b	39.0 ^a	62.2 ^b	53.1 ^a	148.3 ^b	142.2 ^a	189.0 ^b	152.2 ^a
15 t/ha ⁻¹ PM	35.5 ^b	41.7 ^a	61.5 ^b	52.1 ^a	146.3 ^b	138.1 ^a	188.0 ^b	151.4 ^a
30 t/ha ⁻¹ PM	39.5 ^a	42.3 ^a	65.8 ^a	53.4 ^a	152.6 ^a	144.2 ^a	193.6 ^a	152.8 ^a

Note: Means followed by the same letter(s) in the same column are not significantly different.

3.4. Effects of MLE and PM on Leaf Number

Table 4 shows the effects of treatments on leaf number at different WAP. In all treatments, the number of leaves consistently and significantly increased between 2 and 8 WAP.

At 2 WAP, sweetcorn plants that received PM at 30 t/ha⁻¹ during the early season had significantly more leaves (4.6 per plant) than under all other treatments, while plants that received 3% MLE had the lowest number of leaves (3.8 per plant). Similar results were obtained during the late season: plants that received 30 t/ha⁻¹ PM had significantly more leaves (4.6 per plant) while the remaining treatments were statistically similar except for those in the control plot.

At 4 WAP, sweetcorn that received PM at 30 t/ha⁻¹ had significantly more leaves (8.1 per plant) in the early season while for all remaining treatments there were significantly more leaves than in the control plots (6.8 per plant). In the late season there was no significant difference in the number of leaves among sweetcorn plants in plots

that received 9% MLE, 3% MLE + 15 t/ha⁻¹ PM, 6% MLE + 15 t/ha⁻¹ PM, 9% MLE + 15 t/ha⁻¹ PM, 15 t/ha⁻¹ PM, and 30 t/ha⁻¹ PM. Plants that received neither MLE nor PM in both planting seasons had the lowest number of leaves (5.7 and 6.8 per plant, respectively).

At 6 WAP, there were significant differences in the number of leaves among early-planted, but not among late-planted, plots. Early-planted sweetcorn that received 30 t/ha⁻¹ PM had the highest number of leaves (10.8 per plant), which was statistically similar to that in plots that received 9% MLE + 15 t/ha⁻¹ PM and 15 t/ha⁻¹ PM, while the control plots had the lowest number of leaves (8.8 per plant). At 8 WAP, plants with 30 t/ha⁻¹ PM had the highest number of leaves in both experiments (10.1 and 13.1 per plant) while those in the control plot had the lowest number (9.5 and 10.2 per plant). In the early season, there were no significant differences among sweetcorn that received 9% MLE + 15 t/ha⁻¹ PM, 15 t/ha⁻¹ PM, and 30 t/ha⁻¹ PM.

Poultry manure application at 30 t/ha⁻¹ was significantly better than other rates of MLE and PM. This was probably because that rate satisfied crop requirements in the agro-ecological environment where the experiment was conducted, coupled with the peculiar characteristics of PM such as increased carbon content, water-holding capacity, aggregation of soils, and availability of water-soluble exchangeable potassium and magnesium, while also reducing soil bulk density. This result is in tandem with the findings of Akanni and Ojeniyi (2008); Ayoola and Makinde (2009) and Akram, Athar, and Ashraf (2007), who attributed increases in number of leaves, plant height, stem diameter, and leaf area index of maize to the possibility that the rate satisfied the agro-ecological requirement of the experimental site, and that the essential nutrients supplied by PM are associated with increased photosynthetic activity. This is also consistent with the findings of Zaki and Rady (2015), who observed that MLE application increased the number of leaves, shoot length, leaf area per plant, and old dry leaf weight of *Phaseolus vulgaris* (common bean). It is also in agreement with the findings of Anyaegbu (2015), who reported that plant height in okra following application of N/P/K fertilizer was not significantly different from that in plants that received MLE, thus confirming the assertion of Foidle, Makkar, and Beckee (2001) that *M. oleifera* is a fertility-enhancing plant. It is also similar to the findings of Prabhu, Kumar, and Rajamani (2009), who reported that plant height and number of leaves per plant in kalmegh (*Andrographis paniculata*) were highest with 2% MLE compared to other sources of plant growth regulatory substances, which they attributed to the enhanced cell division and elongation of crops in response to the role of MLE as a plant growth-promoting substance – hence the positively higher fruit yield.

Table 4. Effects of MLE and PM on number of leaves per plant.

Treatment	Weeks after sowing (WAS)							
	2		4		6		8	
	Early season	Late season	Early season	Late season	Early season	Late season	Early season	Late season
Control (0%)	4.0 ^b	3.8 ^c	6.8 ^c	5.7 ^b	8.8 ^b	8.0 ^a	10.2 ^b	9.5 ^b
3% MLE	4.1 ^b	4.0 ^b	7.0 ^b	5.7 ^b	9.0 ^b	8.0 ^a	10.5 ^b	10.0 ^a
6% MLE	4.1 ^b	4.0 ^b	7.3 ^b	6.1 ^b	9.2 ^b	7.9 ^a	11.1 ^b	10.0 ^a
9% MLE	4.1 ^b	4.0 ^b	7.5 ^b	7.3 ^a	9.3 ^b	8.0 ^a	11.4 ^b	10.0 ^a
3% MLE + 15 t/ha ⁻¹ PM	4.2 ^b	4.1 ^b	7.7 ^b	7.3 ^a	9.4 ^b	8.1 ^a	11.6 ^b	10.0 ^a
6% MLE + 15 t/ha ⁻¹ PM	4.3 ^b	4.2 ^b	7.7 ^b	7.2 ^a	9.7 ^b	8.0 ^a	11.7 ^b	10.0 ^a
9% MLE + 15 t/ha ⁻¹ PM	4.3 ^b	4.2 ^b	7.8 ^b	7.3 ^a	10.5 ^a	8.0 ^a	12.5 ^a	10.0 ^a
15 t/ha ⁻¹ PM	4.3 ^b	4.2 ^b	7.8 ^b	7.2 ^a	10.5 ^a	8.0 ^a	12.4 ^a	10.0 ^a
30 t/ha ⁻¹ PM	4.6 ^a	4.6 ^a	8.1 ^a	7.3 ^a	10.8 ^a	8.1 ^a	13.1 ^a	10.2 ^a

Note: Means followed by the same letter(s) in the same column are not significantly different.

3.5. Effects of MLE and PM on Stem Girth

The response of stem girth to MLE and PM is shown in Table 5. Stem girth consistently increased from 2 to 8 WAP in both planting seasons. MLE and PM application caused significant differences in stem girth at 2 WAP. In the early season, sweetcorn plants that received 30 t/ha⁻¹ PM had the highest stem girth (1.33 cm) followed by crops with 15 t/ha⁻¹ PM (1.08 cm). However, these were not significantly different from the other treatments except for the control plot, which showed significantly lower stem girth of 0.75 cm. In the late season cropping, the application of 30 t/ha⁻¹ PM yielded the highest stem girth (1.20 cm) followed by sweetcorn that received 15 t/ha⁻¹ PM (1.14 cm), while the control plot recorded the lowest stem girth of 0.71 cm – not significantly different from plants that received 3 and 6% MLE.

At 4 WAP, results of all other treatments were significantly superior to those in the control plot, which had the lowest stem girth of 1.33 cm during the early season, while sweetcorn that received 30 t/ha⁻¹ PM had the highest stem girth (2.50 cm). A slight difference was observed during late season planting: plants with 30 t/ha⁻¹ PM yielded the highest stem girth (2.02 cm) but were statistically similar to plants that were administered 9% MLE, 3% MLE + 15 t/ha⁻¹ PM, 6% MLE + 15 t/ha⁻¹ PM, 9% MLE + 15 t/ha⁻¹ PM, and 15 t/ha⁻¹ PM. Plants in control plots had the lowest stem girth, 0.85 cm.

At 6 WAP, all treatments resulted in significantly higher stem girth than in the control plot. Plants administered 30 t/ha⁻¹ PM had the highest stem girth (3.08 cm) followed by those given 9% MLE + 15 t/ha⁻¹ PM (2.58 cm) during the early season. However, plants in the control plots had the lowest stem girth (1.67cm). This pattern was repeated in the late season planting, where the highest stem girth of 2.68 cm was recorded in plants administered 30 t/ha⁻¹ PM – statistically similar to the other treatments except for the control plot. Crops in the control plot had the lowest stem girth, 1.56 cm. At 8 WAP there were no significant differences among the various treatments in the early season. Sweetcorn plants administered 30 t/ha⁻¹ PM had the highest stem girth (3.75 cm) while those in the control plots had the lowest (2.17cm). Similarly, there were no significant differences among the various treatments during late season planting, except for plants in the control plots that had the lowest stem girth (2.12 cm).

Sweetcorn crops treated with 30 t/ha⁻¹ PM had the highest stem girth at 8 WAP, statistically similar to plants that received 9% MLE + 15 t/ha⁻¹ PM. This could be attributed to the presence of macro- and micronutrients in MLE and PM, fast mineralization, and ease of absorption, all of which promote the establishment, growth, and maturation of crops at all stages of their life cycle. This is similar to the findings of Foidle et al. (2001), who reported that an aqueous extract of *M. oleifera* influenced apical growth in both tomato and sorghum. The report further argued that MLE also gave significantly higher (100%), vigorous, and good-quality tomato seedlings with respect to plant height, number of leaves, and time of flowering. This is in agreement with the findings of Anyaegbu, Iwuanyanwu, and Omaliko (2013), who observed that the application of various forms of MLE positively influenced the growth and development of fluted pumpkin (*Telfaria occidentalis*).

Table 5. Effect of MLE and PM on stem girth (cm).

Treatment	← Weeks after sowing (WAS) →							
	2		4		6		8	
	Early season	Late season	Early season	Late season	Early season	Late season	Early season	Late season
Control (0%)	0.75 ^b	0.71 ^b	1.33 ^b	0.85 ^c	1.67 ^b	1.56 ^b	2.17 ^a	2.12 ^b
3% MLE	0.92 ^a	0.85 ^b	1.50 ^a	1.24 ^b	1.92 ^a	1.88 ^a	2.58 ^a	2.30 ^a
6% MLE	0.83 ^a	0.85 ^b	1.58 ^a	1.42 ^b	2.17 ^a	2.16 ^a	2.88 ^a	2.55 ^a
9% MLE	0.83 ^a	1.03 ^a	2.00 ^a	1.80 ^a	2.42 ^a	2.33 ^a	3.17 ^a	3.08 ^a
3% MLE + 15 t/ha ⁻¹ PM	1.08 ^a	1.03 ^a	2.08 ^a	1.78 ^a	2.50 ^a	2.41 ^a	3.25 ^a	3.11 ^a
6% MLE + 15 t/ha ⁻¹ PM	1.08 ^a	1.07 ^a	2.17 ^a	1.78 ^a	2.58 ^a	2.55 ^a	3.33 ^a	3.04 ^a
9% MLE + 15 t/ha ⁻¹ PM	1.08 ^a	1.10 ^a	2.33 ^a	1.88 ^a	2.91 ^a	2.58 ^a	3.58 ^a	3.15 ^a
15 t/ha ⁻¹ PM	1.08 ^a	1.14 ^a	2.17 ^a	1.84 ^a	2.83 ^a	2.56 ^a	3.58 ^a	3.15 ^a
30 t/ha ⁻¹ PM	1.33 ^a	1.20 ^a	2.50 ^a	2.02 ^a	3.08 ^a	2.68 ^a	3.75 ^a	3.22 ^a

Note: Means followed by the same letter(s) in the same column are not significantly different.

3.6. Effects of MLE and PM on Leaf Area

The response in regard to leaf area of MLE and PM is shown in Table 6. Leaf area gradually increased from 2 to 8 WAP in both planting seasons.

Significant differences were observed in leaf area of sweetcorn at 2 WAP in both early and late season plantings. For early season planting, plots that received 30 t/ha⁻¹ PM recorded the highest leaf area (115.1 cm²) but this was not significantly different from plants that received 15 t/ha⁻¹ PM, 9% MLE + 15 t/ha⁻¹ PM, 6% MLE + 15 t/ha⁻¹ PM, or 3% MLE + 15 t/ha⁻¹ PM. Sweetcorn plants that received neither MLE nor PM had the lowest leaf area, 68.5 cm². In late season, sweetcorn plants that received 30 t/ha⁻¹ PM had the highest leaf area (88.3 cm²), statistically similar to those that received 9% MLE, 3% MLE + 15 t/ha⁻¹ PM, 6% MLE + 15 t/ha⁻¹ PM, 9% MLE + 15 t/ha⁻¹ PM, and 15 t/ha⁻¹ PM. The control plot, which received neither MLE nor PM, had the lowest leaf area (65.3 cm²) but this was not significantly different from plants that received 3% MLE (65.8 cm²) and 6% MLE (68.9 cm²).

At 4 WAP, sweetcorn plants that received 30 t/ha⁻¹ PM had the highest leaf area (215.7 and 185.1 cm²), followed by those that received 9% MLE + 15 t/ha⁻¹ PM (198.0 cm² and 179.1 cm²). Plants that received neither MLE nor PM had the lowest leaf area (117.4 and 110.1 cm² during early and late season plantings, respectively). At 6 WAP, sweetcorn plants that received 30 t/ha⁻¹ PM had the highest leaf area (451.3 and 259.6 cm²), followed closely by those that received 9% MLE + 15 t/ha⁻¹ (434.8 and 255.1 cm²), while the control plot had the lowest leaf area (235.9 and 202.8 cm² for the late and early season plantings, respectively). In the late season, however, there was no significant difference between the various treatments while in the early season, plants in the control plot and 3, 6, and 9% MLE were statistically similar, as were plants that received 3% MLE + 15 t/ha⁻¹ PM, 6% MLE + 15 t/ha⁻¹ PM, 9% MLE + 15 t/ha⁻¹ PM, 15 t/ha⁻¹ PM and 30 t/ha⁻¹ PM.

At 8 WAP, sweetcorn that received 30 t/ha⁻¹ PM had the highest leaf area (584.9 and 402.9 cm²) followed closely by plants that received 9% MLE + 15 t/ha⁻¹ PM (546.2 and 392.2 cm²), though there was no significant difference. Sweetcorn plants in the control plot had the lowest leaf area, 308.4 and 247 cm². In the early season, there was no significant difference between plants treated with 3, 6, and 9% MLE, or between those grown with 3% MLE + 15 t/ha⁻¹ PM, 6% MLE + 15 t/ha⁻¹ PM, 9% MLE + 15 t/ha⁻¹ PM, 15 t/ha⁻¹ PM, and 30 t/ha⁻¹ PM.

3.7. Effects of MLE and PM on Leaf Area

The results of the effects of MLE and PM on leaf area (cm^2) of sweetcorn are presented in Table 6. These indicate that at 2 WAP, MLE 3, 6, and 9% were significantly different ($P \leq 0.05$) from control in both early and late season croppings. At 4 WAP, control showed 117.4 and 110.0 cm^2 , significantly lower than PM at 15 and 30 t/ha^{-1} with leaf area of 178.3, 215.7, 171.8, and 185.1 cm^2 for both early and late season croppings. At 6 WAP there were no statistical differences in leaf area values in late cropping, though 30 t/ha^{-1} PM yielded 259.6 cm^2 compared to 202.8 cm^2 for control. Similarly, PM15 and 30 t/ha^{-1} yielded 429.5 cm^2 and 457.3 cm^2 , significantly higher than control and MLE applied at different concentrations.

It was observed that there was a steady increase in leaf area as the weeks progressed. PM yielded the highest leaf area of 584.9 cm^2 at 30 t/ha^{-1} followed by 528.6 cm^2 at 15 t/ha^{-1} , while in the control it was 308.4 cm^2 in the early cropping. For late cropping, 247.0 cm^2 was recorded for the control, which was significantly lower than for all other treatments.

The application rate of 30 t/ha^{-1} PM yielded better performance than other treatments at 8 WAP. This could be attributed to the increased quantity and availability of macro- and micronutrients in PM, its rapid mineralization, and ease of absorption, which enhanced crop growth and development. This is similar to the findings of Muhamman and Kwada (2015), who reported that aqueous foliar application of MLE had a higher (and significant) effect on all growth parameters of pawpaw seedlings than the application of coconut milk. It is also in agreement with the findings of Muhamman and Mohammed (2014), Chattha et al. (2015), Anyaegbu (2014), and Anyaegbu (2015), who reported growth and yield increases in various crops, including maize, okra, and garden egg, as a result of foliar application of MLE.

Table 6. Effects of MLE and PM on Leaf Area (cm^2).

Treatment	← Weeks after sowing (WAS) →							
	2		4		6		8	
	Early season	Late season	Early season	Late season	Early season	Late season	Early season	Late season
Control (0%)	68.5 ^b	65.3 ^b	117.4 ^c	110.1 ^b	235.9 ^b	202.8 ^a	308.4 ^c	247.0 ^b
3% MLE	70.1 ^b	65.8 ^b	137.7 ^b	120.8 ^b	268.1 ^b	203.3 ^a	355.9 ^b	307.8 ^a
6% MLE	70.9 ^b	68.9 ^b	148.0 ^b	130.2 ^b	280.0 ^b	214.2 ^a	378.0 ^b	322.2 ^a
9% MLE	70.0 ^b	79.6 ^a	163.5 ^b	170.3 ^a	305.8 ^b	216.0 ^a	395.5 ^b	323.3 ^a
3% MLE + 15 t/ha^{-1} PM	106.7 ^a	77.8 ^a	173.9 ^b	165.6 ^a	386.2 ^a	226.7 ^a	440.2 ^a	312.2 ^a
6% MLE + 15 t/ha^{-1} PM	107.0 ^a	74.9 ^a	190.3 ^a	169.2 ^a	399.9 ^a	228.0 ^a	484.4 ^a	315.6 ^a
9% MLE + 15 t/ha^{-1} PM	107.0 ^a	81.8 ^a	198.0 ^a	179.1 ^a	434.8 ^a	255.1 ^a	546.2 ^a	392.2 ^a
15 t/ha^{-1} PM	107.0 ^a	82.4 ^a	198.3 ^a	171.8 ^a	429.5 ^a	245.3 ^a	528.6 ^a	347.8 ^a
30 t/ha^{-1} PM	115.1 ^a	88.3 ^a	215.7 ^a	185.1 ^a	451.3 ^a	259.6 ^a	584.9 ^a	402.9 ^a

Note: Means followed by the same letter(s) in the same column are not significantly different.

3.8. Agronomic and Agricultural Extension Implications of the Study

The findings listed below from the study are most valuable when the information contained is simplified and disseminated to farmers as new innovations by extension workers. The study provides the extension worker with the following:

- Knowledge of improved sources of seed inputs.
- Awareness of best type of soil for cultivation of sweetcorn for optimal growth performance.
- Chemical composition of MLE and PM.
- Information on accurate quantities for MLE and PM usage.
- Facts on time of application for MLE and PM.

4. CONCLUSION AND RECOMMENDATIONS

The results of this study indicate that the use of PM and MLE, either singly or in combination, is capable of positively influencing the growth of sweetcorn in the study area. Although variations were observed in the effectiveness of various concentrations of MLE, the results reveal the effectiveness of the application of moringa in boosting the growth of sweetcorn. The recommended application rates for optimum vegetative growth are:

- Use of 30 t/ha^{-1} PM, which resulted in significantly better growth of sweetcorn compared to the other treatment applications evaluated.
- Use of a combination of 9% MLE + 15 t/ha^{-1} PM as an alternative treatment.
- Use of 9% MLE as a sole application, which performed significantly better than both control and the other rates of MLE application.

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