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Research Article

Effect of Foliar Application of Moringa Leaf Extract on Biomass Production and Nutrient Content of Maize

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ABSTRACT

The spray of moringa (*Moringa oleifera)* leaf extract is crucial for the biomass output and nutrient content of maize. The current study was conducted in 2021–2022 in green house Department of Soil Science, Sindh Agriculture University Tandojam. The objective of the experiment was to evaluate the impact of foliar application of moringa leaf extract on maize nutritional content and biomass production. Five distinct treatments, each with three repeats, were placed in 15 pots, each pot was filled with 5 kgs of soil, and an experimental trial was conducted using a Complete Randomized Design (CRD). Moringa Leaf Extract was applied as foliar spray after 2, 4, and 6 weeks of plant emergence. The results reveal that the plant growth parameters i.e., shoot length (19.55cm), shoot fresh weight (13.22g plant^{-1}), shoot dry weight (7.00 g plant^{-1}), leaf fresh weight (3.6 g) and No. of leaves plant^{-1} (7.33), tap root length (54.00 cm) and tap root fresh weight (2.89 g plant-1), tap root dry weight (1.73 g) significantly increased in all treated pots. The leaf tissues of maize plant were also assessed for their nutrient content i.e., Nitrogen, Phosphorus and Potassium. The results indicate that the maize plant was affected by three different treatments of moringa leaf extract applied at various crop growth stages. Maximum nitrogen content was found in maize leaf (4.79%) where the crop was sprayed thrice, whereas maximum phosphorus and potassium content was observed (0.72%) and (3.44%) respectively. It is concluded from the study that the biomass production and nutrient content of maize crop were significantly affected by treatment five where foliar spray of moringa leaf extract was applied after 2, 4 and 6 weeks of plant emergence, this indicates that moringa leaf extract spray performed better for most of the investigated traits. We recommend further research to confirm these outcomes.

Keywords: Moringa, Maize, Foliar spray, Biomass production, Nutrient content

Introduction

Moringa (*Moringa oleifera* L.) is an important crop of high medicinal value as its leaves contain appreciable amount of cytokinin, zeatin and other plant hormones (Safinaz & Mostafa, 2015). Various antioxidants, nutrients, and plant hormones i.e. indole acetic acid, gibberellic acid, cytokinin etc. can be sourced from natural growth enhancers (Elzaawely et al., 2017). It has been reported that the moringa leaf extract improved plant growth and increases plant stress tolerance (Rady et al., 2015).

Moringa leaf extract mixed with salicylic acid, hydrogen peroxide and ascorbic acid raise germination and seedling in maize (Imran et al., 2013). Wheat crop responses positively to the application of moringa leaf extract, particularly along with other chemicals, including

hydrogen peroxide at various growth phases of wheat (Yasmeen et al., 2012).

The efficacy of moringa leaf extract as bio stimulant is relatively higher compared to chemical growth regulator sources. Moreover, moringa leaf extract serves as an environmentally friendly and cost-effective source over synthetic growth enhancers (Shahzad et al., 2013).

Liquid spray of moringa leaf extract plays a pivotal role in increasing the enzymatic activities, rate of photosynthesis, protein synthesis, and balanced nutrient supply (Aftab et al., 2010). The appreciable amount of zeatin in moringa leaf extract is responsible for absorption and translocation photo assimilates to fruit (Abdel-Rahman & Abdel-Kader, 2020).

The introduction of alternate organic plant nutrition sources has been advocated to decrease the input cost of fertilizers and hazards to environments (Abdalla, 2015). Moringa contains a number of mineral nutrients, ascorbic acid, and phenols which are capable of enhancing plant growth and produce quality. Furthermore, it is often supplied to plants as foliar spray as natural bio-stimulant (Taha et al., 2015).

Since, moringa leaves contain cytokinin, antioxidants, and both macro and micronutrients, it has attracted a lot of researcher interest (Abdalla, 2015). By maintaining more osmo- protectants and less electrolyte leakage, with the help of 3% moringa liquid reduced the adverse effect of dry stress in squash plants (Abd El-Mageed et al., 2017). Applying moringa leaf extract to plants has been successful in reducing the effects of various abiotic environments, for example, low temperature (Batool et al., 2020).

Moringa leaf extract improves maize seedling performance and germination characteristics are also combined with other synthetic and bio organic growth stimulants. Moringa leaf extract is also more effective than artificial crop growth promoters, and on the other hand, it is economically and environmentally friendly (Shahzad et al., 2013).

In Pakistan, the white-seeded moringa variety from Faisalabad has a distinctive type of seed cover and has been considered the best source of bio stimulant in moringa leaf extract (Shahzad et al., 2013). Moreover, combining moringa leaf extract with other plant growth promoters, including chemical growth enhancers improve growth of maize seedling (Imran et al., 2013).

The germination and seedling growth enhancement of maize, wheat, rice and sorghum crops have been reported by the foliar application of moringa leaf extract (Khan et al., 2020). Under extreme salinity and drought stressors, varying concentrations of moringa leaf water extract significantly enhanced leaf area, plant height, and chlorophyll b content of maize (Ali et al., 2011). Moreover, along with eco-friendly natural source of plant nutrition, moringa leaves are a rich source of macro and micronutrients and other bioactive compounds (Hekmat et al., 2015). Hence, it improves fruiting, post-harvesting, floral characteristics, flowering, and fruit quality while minimizing senescence (Arif et al., 2022). Moringa leaf extract is crucial for enzyme activation, reduction of key plants enzymes which eventually contribute to various physiological functions (Aftab et al., 2010). We conducted this study to evaluate the effect of foliar application of moringa leaf extract on the biomass production of maize and determine nutrient content of maize as affected by the foliar application of moringa leaf extract.

Materials and Methods

Experimental design and treatment details: The pot experiment was carried out in the green house, Department of Soil Science, Sindh Agriculture University, Tandojam. A completely randomized design with three repeats was followed to administer five treatments, viz. T_1: Control or no foliar spray, T_2: Foliar spray of water after 2 weeks of emergence (1 spray), T_3: Foliar spray of moringa leaf extract after 2 weeks of emergence (1 spray), T_4: Foliar spray of moringa leaf extract after 2 and 4 weeks of emergence (2 sprays), and T_5: Foliar spray of moringa leaf extract after 2, 4 and 6 weeks of emergence (3 sprays). A blanket dose of 200-100-100 kg of N-P_2O5-K_2O ha^1 was applied to all treatments.

Soil properties: The soil used in this study was analyzed for selected properties (Ryan et al., 2001). It was silty loam in texture, free from salinity hazards, medium alkaline in nature, strongly calcareous in reaction, deficient in organic matter, low in ABDTPA-P and medium in ABDTPA-K.

Pots filling with processed soil for experiment: The soil was filled in pots, with a capacity to accommodate 5.0 kg soil, after passing through a 4-mm sieve to administer various treatments and sowing of maize seeds.

Preparation of moringa leaf extract: The moringa leaves were collected and washed through distilled water, air dried at room temperature in the laboratory and crushed into a pestle and mortar to collect their extract. This extract was diluted (1:40) by adding distilled water and foliar sprayed to maize as per treatment plan.

Plant Analysis: The NPK content of maize plant samples were analyzed generally as suggested by Ryan et al., (2001). The nitrogen concentration in maize plants was determined by the Kjeldhal methods (Bremner & Mulvaney, 1983). Maize plant tissues were digested to determine P and K content using wet digestion method (Ryan et al., 2001).

Sowing: The sowing of maize seeds (*cv.* Akbar) was done by marking 2-cm deep holes in each pots using a pencil.

Harvesting: Harvesting was done after eight weeks of plant emergence; three plants were selected for observing various agronomical data and plant analysis in every replication of treatments.

Agronomical and other practices: Irrigation, weeding, pest control, and other necessary crop requirements were adopted as per standard protocols. The representative repeats among the pots were randomized twice a week to provide balanced environmental exposure.

Recording of growth parameters: Plants were harvested at eight weeks after sowing to record various agronomic

plant traits, i.e. shoot length, shoot fresh and dry weight, leaf fresh and dry weight, number of leaves per plant, tap root length, tap root fresh and dry weight.

Statistical analysis: The collected data ware subjected to statistical analysis using computer software Statistix-8.1 Analytical software (2023). The LSD test was applied to compare treatment means at alpha 0.05.

Table 1. Selected properties of soil under study

Soil Property	Unit	Value
Texture class	…	Silty Loam
Electrical conductivity (1:2)	(dS m^{-1})	0.48
pH (1:2)	…	7.9
Calcium carbonate	(%)	20
Organic matter	(%)	0.64
ABDTPA-P	(mg kg^{-1})	3.5
ABDTPA-K	(mg kg^{-1})	95

Results

Shoot length (cm): Maximum shoot length of maize crop was observed when the crop was sprayed every two weeks after emergence of plants, followed by moringa leaf sprayed at two weeks of after emergence four weeks of after emergence, and six weeks of after emergence. Minimum shoot length was noted under control treatment. This indicates that the three times sprayed with leaf extract after every 2 weeks is highly beneficial for obtaining maximum shoot length (Table 2).

Shoot fresh weight (g plant $^{-1}$): The plants which were sprayed three times every second week two or three times after emergence produce significantly so the maximum shoot fresh weight of maize crop was observed. While the minimum shoot fresh weight was observed where plant has no sprayed control.

Shoot dry weight (g plant^{-1}): Maximum shoot dry weight of maize crop was observed when the crop sprayed two or three times every second week after plant emergence followed by sprayed after two weeks and four weeks and sprayed after six weeks of emergence. The minimum shoot dry weight was observed in control Table 2).

Leaf fresh weight (g plant^{-1}): Maximum weight of leaf was observed where moringa extract was applied every 2 weeks after plant emergence, two or three times. While the minimum leaf fresh weight was noted under control treatment. This indicates that spraying three times at every two weeks is highly beneficial for obtaining maximum leaf fresh weight (Table 2).

Leaf dry weight (g plant^{-1}): Maximum leaf dry weight of maize crop was recorded where the crop was sprayed two to three times every two weeks after emergences; however, the minimum leaf dry weight was noted under control treatment. This indicates that the three times sprayed after every two weeks is highly beneficial for obtaining maximum leaf dry weight (Table 2).

Number of leaves (per plant): Number of leaves of maize crop was significantly influenced by different moringa leaf extract. The maximum number of leaves was recorded with application of moringa leaf extract sprayed at two to three times every two weeks of after plant emergence, followed by three times sprayed at every fifteen days of after emergence, whereas the minimum number of leaves was found in treatment one where no moringa leaf extract (control) was sprayed (Table 3).

Tap root length (cm): The root length of maize was maximum when the crop was sprayed two to three times after every two weeks after plant emergence, followed by subsequent applications at four and six weeks after emergence. In contrast, the control treatment resulted in the shortest plant height. These findings strongly suggest that applying the spray three times at two-week intervals gives a positive response for obtaining maximum root length of maize crop (Table 3).

Tap root biomass (g plant $^{-1}$): The tap root fresh or biomass was not affected by various treatments, and hence, these data are not presented here.

Nutrient content of maize (%): The nitrogen and potassium content of maize plants was not significantly affected by various treatments. However, a significant effect of different treatments was noted on phosphorus content of maize plants (Table 3). Maximum phosphorus content in maize plant was observed where the crop sprayed 3 times every second week after emergence followed by sprayed after 2 weeks + sprayed after 4 weeks + sprayed after 6 weeks of emergence. Minimum

Table 2. Growth of maize as affected by foliar application of moringa leaf extract

Treatment	Foliar Spray	Number of Spray	Time of Spray (Weeks after emergence)	Shoot length (cm)	Shoot fresh weight (g $plant^{-1}$)	Shoot dry weight (g $plant^{-1}$)	Leaf fresh weight (g $plant^{-1}$)	Leaf dry weight (g $plant^{-1}$)
T1	…	…	…	17.0B	7.33C	4.86C	2.00C	0.36C
T2	Water	1	2	17.3B	7.77C	5.06C	2.00C	0.36C
T3	MLE	1	2	18.3AB	10.44B	7.06B	2.96B	0.60B
T4	MLE	2	2 & 4	19.3A	12.33A	8.50A	3.56A	0.70A
T5	MLE	3	2, 4 & 6	19.5A	13.88A	8.76A	3.66A	0.73A
			LSD0.05	1.4432	1.1195	1.0742	0.6147	0.0987

MLE: Moringa Leaf Extract

phosphorus content was observed in the plant where plants did not receive any treatment (Table 3).

Discussion

Table 3. Number of leaves, tap root length, and N content of maize as affected by foliar application of moringa leaf extract

Treatment	Foliar Spray	Number of Spray	Time of Spray (Weeks after emergence)	Number of Leaves (g plant^{-1})	Tap Root Length (cm)	N content (%)
T1	…	…	…	5.99C	46.17C	0.50E
T2	Water	1	2	6.25BC	47.77C	0.55D
T3	MLE	1	2	6.66AB	49.99B	0.60C
T4	MLE	2	2 & 4	6.99A	53.55A	0.68B
T5	MLE	3	2, 4 & 6	7.11A	53.99A	0.71A
		LSD0.05		0.4540	1.8163	0.225

MLE: Moringa Leaf Extract

According to a study conducted by Yaseen and Hájos (2020), moringa leaf extract can increase yields of various crops up to 50% as it is a rich source of key phytohormones. However, the results show that various moringa leaf extract application timing intervals significantly enhanced maize shoot length. Maximum shoot length was observed with 3 times sprayed every two weeks after emergence of plants; this trend indicates that regular moringa leaf extract application has positive response to shoot growth. Moringa leaf extract also had a significant impact on shoot fresh weight and the highest shoot fresh weight was obtained with three times applications moringa leaf extract every 2 weeks at early growth. This indicates that consistent moringa leaf extract leads to increased fresh weight of maize plants.

Moringa leaf extract containing different phytohormones significantly alters yield and quality of crops though applied at any stage of plant growth (Maishanu et al., 2017). According to the findings of the experiment, shoot dry weight was significantly influenced by the application of moringa leaf extract. It shows that every 2 weeks after emergence resulted in the highest shoot dry wight. The results suggest that regular application of moringa leaf extract promotes greater biomass production. The results of another study conducted by Culver et al. (2012) reported that the application presented that moringa leaf extract increased yield attributes of tomato.

The study revealed the results which show positive influence on leaf growth and increased biomass production, where the crop has been sprayed with moringa leaf extract. The use of moringa leaf extract as a natural growth enhancer has been further proven significantly increase in both fresh and dry weight of maize plants. However, it also shows a positive influence on leaf growth and biomass production. As a potential substitute for chemical fertilizers, the extract of moringa leaves is capable of enhancing seed germination, early seedling growth, and the rate of maturity of plants (Phiri, 2010). The data revealed that the moringa application significantly affected the number of leaves and the highest number of leaves per plant was recorded with treatment 3 where moringa leaf extract applied every 2 weeks after the emergence of plants.

Root fresh/dry weight was also increased significantly by the application of leaves extracted during maize growth and development. It also shows the beneficial impact of moringa leaf extract on plant development and increased root biomass accumulation. The findings of our research are in accordance with few previous studies (Ali et al., 2011; Chattha et al., 2015; Biswas et al., 2016), where they suggested that application of moringa leaf extract as growth enhancer; increased all parameters of plant growth. The results indicated that the growth and yield parameters significantly increased in overall crop growth stages.

The results indicate the positive effect of foliar sprayed 3times moringa leaf extract at every 2 weeks after plant emergence. Maize crop increased nutrient content in leaf tissue by application of moringa leaf extract with various intervals during the growth and development of plants Previously, Foidl (2001) foliar applied moringa leaf extract to various crops and found beneficial impacts.

Conclusion

Our findings conclude that at T5 three spays of moringa leaf extract after two, four, and six weeks of plant emergence with the suggested doses of N, P, and K, the highest growth and nutrient uptake maximum occurred in maize crop.

Due to its variety of benefits, i.e., high nutrient value, low cost, easy to grow and extract preparation, and environmentally friendly production, farmers are highly recommended to grow and use as a bio-organic fertilizer for their crops to get significant increases in plant biomass as well as high yields. Further research is recommended to validate these findings.

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Conflict of Interest

No competing interests are disclosed by the authors.

Author Contribution

WAR: Conducted pot study, collected data, analyzed soil, plant and moringa leaf extract samples, wrote initial draft of MS; NAT: Conceived idea, executed pot study, analyzed data, edited all drafts of MS; IPB & AAK: Validated data analyses, helped in results interpretation; KJ: Data presentation, format and style; NM: Assisted in pot experiment and literature review; IHK: Assisted chemical analyses, format and style.

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