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Effect of *Moringa oleifera* Seed Cake as an Eco-friendly Fertilization Source on the Performance of Snapdragon (*Antirrhinum majus* L.) Plant Grown in Sandy Soil

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ANTIRRHINUM majus is a winter annual plant, it can grow in new areas with sandy soil, which contains low levels of nutrients. A pot experiment was conducted during the two successive seasons of 2020/2021 and 2021/2022 in the greenhouse of the Hort. Res. Inst., ARC, Giza, Egypt, to explore the effect of Moringa Seed Cake (MSC) as natural fertilization source individual or combined with Microbien (M). It was observed that the plants treated with MSC at a rate of 30g/ pot+ 5 ml/ pot M gave the highest values for all vegetative and spikes traits except for the root length which increased with the treatment of MSC at 15 g/ pot + M at 10 ml/ pot. Also, MSC at 15 g/ pot+ M at 5 ml/ pot treatment recorded the highest increment in root, shoot in both seasons. Regarding to the chemical estimations [photosynthetic pigments, crude protein, nutrient elements (N, P, K, Mg and Fe) and total sugars] data revealed that the highest values in shoot with the treatment of MSC at 30 g + M at 5 ml/ pot. The crude protein and nutrient elements including (N, P, K and Fe) in the roots showed the highest values when the treatment was MSC at 45 g/ pot + M at 5ml/ pot, In contrast, for Mg, the highest value appeared in the roots in plants treated with MSC at 30g + M at 5 ml/ pot.

Keywords: Snapdragon, Eco-friendly fertilizer, Moringa seed cake, Sandy soil, Microbien.

Introduction

Snapdragon (*Antirrhinum majus* L.) plant is a member of the Scrophulariaceae family which described by its beauty and different heights according to their cultivars, where the tall cultivars are used as cut flowers, while the short can used as pot plants (Tolety and Sane, 2011). It is considered a perennial plant in warm areas but mostly is cultivated as a winter annual, the short cultivars are used in flowering beds (Mjeed and Ali, 2017). Fertilizers supply the plants with important nutrient elements which gave healthy growth and increase flower yield with high quality (Malik et al., 2019 and Verma et al., 2019).

A. majus plant needs light and well-drained soil, so it is a suitable plant for growing in new residential areas with sandy soil. However, this soil is poor in its nutrients (Liu et al., 2012), so adding an organic matter preferred that helps plants grow in the soil and improve soil properties.

Seed cake is considered an organic matter and its application improves the different properties of the soil and biological functions (Diacono and Montemoro, 2015 and Massoud et al., 2017). Hemdan et al. (2021) elucidated that incorporating organic matter in the sandy soil improves soil hydrophysical properties. Consequently, the plant growth and health show a positive response,

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which has been asserted through many studies (Eifediyi et al., 2015, Massoud et al., 2017 and Gavilanes et al., 2020)

Moringa oleifera is known as a safe, natural source, being investigated to ascertain its effect on the growth and yield of crops (Phiri, 2010). All the parts of the plant contain an important minerals, proteins, vitamins, β carotene, amino acids and phenolic compounds (Anwar and Bhanger, 2003). Moringa seed cake is obtained after the cold-pressing of the seeds to extract moringa oil. *Moringa oleifera* cake is rich in protein content, and as a powder contains all the essential amino acids, phenylalanine, valine, threonine, tryptophan, isoleucine, methionine, leucine, and lysine. Additionally, cysteine (or sulphur-containing amino acid), tyrosine (or aromatic amino acid), histidine and arginine (Jahn, 1988). Seed cakes *Moringa oleifera* have been shown to increase the mineral content of soil (Emmanuel et al., 2011).

Microorganisms are playing a prominent role in our life (Dai and Choi, 2013). They are existing in air we breathe, water we drink, and the food we eat (Zhang et al., 1995). The microorganisms live in close contact with the plant root zone which is defined as the rhizosphere at which the roots are thought to be a major source of nutrients for them (De la Fuente Cantó et al., 2020). Microorganisms have long been used in the cultivation of crops due to their various be beneficial effects to provide nutrients and induce resistance in adverse conditions (Salah et al., 2020). Bio-fertilizers are microbial inoculates used for application to either seeds or soil increase its fertility with the objective of increasing the number of such microorganisms and accelerating certain microbial processes that can change unavailable forms of nutrients into available ones that can be easily assimilated by plants (Dai and Choi, 2013). Microbien is a bio fertilizer that contains nitrogen-fixing bacteria "*Azotobacter sp*., *Azospirillum sp*. and *Pseudomonas sp"* as well as phosphate-dissolving bacteria (*Bacillus megaterium*). The application of bio-fertilizer is an important economically to reduce the cost of fertilizers and ecologically to reduce pollution of the environment (Verma et al., 2019).

This study focuses mainly on the test study of moringa seed cake as a natural environmentally friendly fertilizer source individual or in combination with some bacteria species to support *Antirrhinum majus* growth in sandy soil.

Materials and Methods

The experiment was carried out during the seasons of 2020/2021 and 2021/2022 in the greenhouse of the Horticulture Research Institute (HRI), Agricultural Research Center (ARC).

The seeds of *Antirrhinum majus* were obtained from HRI, ARC and sown in plastic trays on the first Sunday of October during the two seasons. The early seedlings were transplanted on the 1st of November when they started having 5 to 7 real leaves in 15 cm pots, and they were repotted again at the end of November after growing to almost 15 cm of the plant height into 30 cm plastic pots filled sand, the physical and chemical analysis of the used media were shown in Table (1) which were determined according to George et al., (2013).

Moringa oleifera seed cake (MSC) was obtained from the Moringa production unit affiliated with the Egyptian Scientific Association of Moringa at the National Research Centre, it was mixed with the sand soil during repotting at weights 15, 30, and 45g. pot^{-1}, respectively, the analysis of MSC was inserted in Table (2). Microbien (M) was applied with 0, 5, and 10 ml. pot^{-1} one week after repotting as a soil drench plus control plants (without MSC or M). All the plants received a balance NPK fertilizer (20,20,20) at a rate 2g/pot every month during the growing season. The experiment was arranged in a completely randomized design (CRD) with three replicates for each treatment during every season. The plants were harvested in the mid of April to measure the growth parameters, spike parameters and chemical estimations .

Measured data

Vegetative growth characters

Plant height (cm), stem diameter (cm), number of leaves/ plant, leaf area (cm^2), number of branches/ plant, root length (cm), shoot and root fresh and dry weights (g/ plant) and dry root, shoot ratio.

Flowering characters

Number of spikes/ plant, number of flowers/ spike, spike length (cm), spikes fresh and dry weights (g/plant).

Chemical estimations

Photosynthetic pigments in leaves (mg. g^{-1} F.W.) were determined according to Saric et al. (1967). Total sugars in shoot (mg. g^{-1} F.W.) were determined according to Dubois et al. (1956) .

TABLE 1. Physical and chemical analysis of the used soil.

Chemical analysis		Physical analysis	
pH	7.98	V.C.S	9.14%
EC (1,1)	2.73 dS.m^{-1}	C.S.	22.50%
CO_3^{2-}	0.00	M.S.	47.85%
HCO_3^-	1.00 meq/ L	F.S.	15.42%
Cl^-	15.00 meq/ L	V.F.S.	1.61%
SO_4^{2-}	71.91 meq/ L	Silt+Clay	1.40%
Ca^{2+}	3.43 meq/ L	Soil texture	
Mg^{2+}	0.17 meq/ L		
K^+	0.66 meq/ L	Sand	
Na^+	83.65 meq/ L		

Where, V.C.S, very coarse sand, C.S., coarse sand, M.S., medium sand, F.S., fine sand and V.F.S., very fine sand

TABLE 2. Physical properties and chemical analysis of moringa seed cake.

Properties		**Macro elements (%)**	
Moisture content	4.9%	Nitrogen	3.80
pH	4.8	Phosphorus	0.61
EC	3.20 dS.m^{-1}	Potassium	0.70
Organic matter	79.8%	Magnesium	0.31
Carbohydrate	16%	Micro elements (ppm)	
Protein	24%	Zinc	18.80
C/N ratio	12.14	Iron	12.50
		Manganese	40

Crude protein (%) in both shoots and roots were determined as nitrogen content and converted it to protein % by multiplying N % by 6.25 according to Mariotti et al. (2008).

Nutrient elements in shoot and root

The shoot and root samples for each treatment were dried in the oven at 60 °C for 3 days. 0.5g of the dried leaves was crushed and digested using H_2SO_4 and H_2O_2 according to Black et al. (1965). The digested solution was used to determine the following mineral contents, Nitrogen (N%) was assessed by the Kjeldahl method as determined by Cottenie et al. (1982), Phosphorus (P%) was determined according to Snell and Snell (1949), Potassium (K%) was determined in the digested solution described by Chapman and Pratt (1961)**,** Magnesium (Mg%) was determined according to Miyazawa *et* al. (1984) and iron (Fe) content (ppm) was determined according to Mayer and Gorham (1951).

The data were analyzed through analysis of variance ANOVA and the treatments' means were compared for significance by Duncan's new multiple range test (DMRT) at 0.05 level of probability (Duncan, 1955). All the statistical analyses were performed by using CoStat (CoHort software, Monterey, CA, USA) V6.4 (2005). Standard division (±SD) was calculated

Results and Discussion

Vegetative growth characters

The vegetative growth parameters as affected by moringa seed cake (MSC) and microbien (M) treatments are showed in Tables (3&4). The highest significant values of plant height, stem diameter, number of branches, number of leaves, leaf area and fresh and dry weights of shoot and root were obtained by the treatment of 30g MSC+ 5ml M which gave 38.67±0.95, 0.72±0.05, 23.67±1.53, 183.33±3.05, 4.86±0.05, 17.55±1.11, 3.52±0.33, 5.24±0.17 and 1.33±0.06, respectively, followed by the treatment of 15MSC + 10ml M compared with the other treatments and control in the first season. The same trends were recorded in the second season. The previous characters gave the highest significant values by treating plants with 30g MSC+5ml M which showed 41.33±1.78, 0.74±0.03, 25.00±2.65, 198.67±4.04, 5.27±0.05, 21.35±1.24, 4.23±0.17, 6.41±0.17 and 1.59±0.03 followed by the treatment of 15 MSC +10ml which. In this respect, plants treated with 15g MSC+10ml M showed the longest roots giving 31.33±2.57 and 35.67±2.52cm, respectively, in the two seasons, followed with 30g MSC+5ml M which recorded 28.80± 1.44 and 30.93±2.39cm, respectively, in both seasons. The shortest roots were recorded in untreated plants which gave 11.00±0.53 and 9.67±1.53cm, respectively, in the first and second seasons followed by plants treated with 45g MSC+10ml M which gave 13.60±1.47 and 12.67±1.00cm, respectively, in the two seasons.

The negative effect of 45g MSC+10ml M can be attributed to cultivation of plants in MSC (45g/pot) amended soil containing a large amount of nutrients in the soil causing toxicity in plants' roots. This has inhibited the root's ability to uptake and transport the nutrients to the rest of the plant organs reducing plant growth (Elamin & Wilcox, 1986 and Santos et al., 2017).

Additionally, the highest ratio of root, shoot was obtained by 15g MSC+5ml M which showed 0.30±0.04 and 0.28±0.01, respectively, in both seasons, but the lowest ratio 0.16± 0.03 and 0.14 was recorded by control and 30 g MSC treatments in the first and second season, respectively. The positive effect of moringa seed cake (MSC) might be attributed to its formation from cellulose, hemicellulose and lignin. These functional groups consist of macromolecules that have the ability to absorb metal ions through complexation reaction or ion exchange (Pagnanelli et al., 2003) or to their richness in vitamins, minerals and proteins, where seed-cake used as amendment (Meneghel et al., 2013). These results were in line with those obtained by Emmanuel et al. (2011), Salah et al. (2020) and Shaimaa et al. (2021). Moreover, the bio-fertilizers help in synthesis of beneficial hormones, cell division and multiplication of cell also increase the assimilation and accumulation of food materials (Raman, 2012). Bio-fertilization via microbein could be attributed to its bacteria which play profound role in improving soil fertility and plant growth development via N_2 fixation and releasing such certain nutritive element such Fe, Zn and Mn and some phytohormones such as gibberellins, auxins and cytokinins like-substances which may encourage up taking and sufficient nutrients, subsequently plant growth (Sarhaan et al., 2015). These results were confirmed by Hameda et al. (2015), Omar et al. (2018), Rana et al. (2020) and Geethanjali et al. (2021).

Flowering characters

The flowering parameters as affected by moringa seed cake with or without with microbien treatments are showed in Table (5). All flowering characters (No. of spikes/ plant, No. of flowers/ spike, spike length (cm), fresh and dry spikes weights (g/ plant)) were improved by treating plants with the different levels of moringa seed cake and/ or microbien as compared with the control plants. The highest values were obtained in plants treated with 30g MSC+ 5 ml M which gave (13.67±1.53 and 15.00±1.73) number of spikes/ plant, (23.67±1.53 and 27.33±2.52) No. of flowers/ spike, (6.87±0.81 and 7.67±0.81) spike length, (12.57±0.78 and 14.24±0.77) fresh spikes weight and (2.42±0.06 and 2.75±0.04) dry spikes weight in both season, respectively, in comparison with the control and other treatments. Moringa seed cake analysis showed that it is rich in nutrients which are important for plant growth and flowering, where Pandey et al. (2020) mentioned the importance of availability of nutrients in appropriate quantities on flowering and its quality it is substantial in the plants being constituents of proteins, nucleic acids, chlorophyll. A suitable supply of nitrogen results in strong growth of the plant hence yield of flowers with best quality Nain et al. (2016).

The recorded increase in flowering data might be due to the fact that at the onset of the reproductive phase, the vegetative growth seized and thereafter the manufactured food material was utilized in increased flower diameter and stalk length. Similar results were recorded by Sharma et al. (2010) and Pushkar & Rathor (2011) in African marigold.

Chemical estimations

Photosynthetic pigments (mg. g^{-1} F.W.)

From the given data in Table (6) it can be concluded that, using moringa seed cake individual or plus microbien at the different levels increased the content of photosynthetic pigments (chlorophyll a, b and carotenoids) in both seasons. Accordingly, it can be stated that the treatment of 30g MSC+ 5ml M was the most effective one for promoting the synthesis and accumulation of the three photosynthetic pigments, which recorded 5.96±0.04, 2.31±0.04 and 3.84±0.04, respectively, in the first season and 5.81+0.04, 2.43±0.05 and 3.91±0.03, respectively, in the second season, in comparison with the untreated plants and the other treatments. The lowest values of photosynthetic pigments content were obtained in the untreated plants follows by plants treated with 45g MSC+ 10ml M in the first and second seasons.

TABLE 3. Effect of Moringa seed cake (MSC) and Microbein (M) on the some growth traits of *Antirrhinum majus* during 2020/21 and 2021/22 seasons.

Treatment	Plant height (cm)	Stem diameter (cm)	No. of branches	No. of leaves	Leaf area (cm^2)	Root length (cm)
			2020/21 season			
Control	17.20 ± 0.96^{gh}	0.54 ± 0.03^{ef}	8.67 ± 0.58^{g}	97.00 ± 2.65^{h}	1.83 ± 0.05^{j}	11.00 ± 0.53^{f}
15g MSC	22.67 ± 0.64^{ef}	0.60 ± 0.04^{cde}	15.67 ± 1.53^{de}	120.33 ± 3.78^{f}	2.80 ± 0.04^{f}	23.93 ± 1.65^{bc}
15g MSC+5ml M	24.00 ± 0.50^{e}	0.62 ± 0.05^{bcd}	17.00 ± 1.73^{cd}	128.00 ± 2.65^{e}	3.16 ± 0.04^{e}	24.77 ± 1.39^{b}
15g MSC +10ml M	34.37 ± 0.55^{b}	0.68 ± 0.04^{ab}	21.67 ± 1.53^{ab}	161.00 ± 2.65^{b}	4.32 ± 0.04^{b}	31.33 ± 2.57^{a}
30g MSC	31.00 ± 0.82^{c}	0.66 ± 0.03^{abc}	20.00 ± 1.73^{bc}	149.67 ± 1.52^{c}	3.97 ± 0.04^{c}	17.00 ± 2.00^{d}
30g MSC +5ml M	38.67 ± 0.95^{a}	0.72 ± 0.05^{a}	23.67 ± 1.53^{a}	183.33 ± 3.05^{a}	4.86 ± 0.05^{a}	28.80 ± 1.44^{a}
30g MSC +10ml M	28.87 ± 0.59^{d}	0.65 ± 0.03^{bc}	19.33 ± 2.08^{bc}	142.67 ± 3.22^{d}	3.52 ± 0.03^{d}	21.33 ± 1.99^{c}
45g MSC	18.33 ± 0.64^{g}	0.54 ± 0.03^{ef}	11.67 ± 1.53^{fg}	104.00 ± 2.65^{g}	2.33 ± 0.05^{h}	14.10 ± 1.95^{def}
45g MSC +5ml M	21.33 ± 0.55^{f}	0.57 ± 0.03^{def}	13.67 ± 1.53^{ef}	117.67 ± 1.53^{f}	2.65 ± 0.04^{g}	16.67 ± 1.77^{de}
45g MSC +10ml M	16.67 ± 0.55^{h}	0.52 ± 0.03^{f}	9.67 ± 1.15^{g}	91.00 ± 2.65^{i}	2.17 ± 0.04^{i}	13.60 ± 1.47^{ef}
			2021/22 season			
Control	16.67 ± 1.42^{f}	0.49 ± 0.03^{h}	7.67 ± 0.58^{h}	84.33 ± 3.51^{i}	2.00 ± 0.08^{j}	9.67 ± 1.53^{g}
15g MSC	24.64 ± 1.76 ^{d}	0.58 ± 0.03^{ef}	15.00 ± 1.73^{ef}	129.67 ± 2.52^{e}	3.44 ± 0.04^{f}	24.00 ± 2.65^{c}
15g MSC+5ml M	26.67 ± 1.83^{d}	0.61 ± 0.04^{de}	16.33 ± 2.08^{de}	135.00 ± 3.60^{e}	3.73 ± 0.05^{e}	27.80 ± 2.43^{b}
15g MSC +10ml M	37.00 ± 1.91^{b}	0.69 ± 0.03^{b}	22.67 ± 1.53^{ab}	185.33 ±3.78^{b}	4.83 ± 0.04^{b}	35.67 ± 2.52^{a}
30g MSC	32.20 ± 1.40 ^{c}	0.66 ± 0.03^{bc}	20.67 ± 1.53^{bc}	163.67 ± 3.51^{c}	4.35 ± 0.04^{c}	22.67 ± 1.86^{c}
30g MSC +5ml M	41.33 ± 1.78^{a}	0.74 ± 0.03^{a}	25.00 ± 2.65^{a}	198.67 ± 4.04^{a}	5.27 ± 0.05^{a}	30.93 ±2.39^{b}
30g MSC +10ml M	30.87 ± 1.76^{c}	0.63 ± 0.03^{cd}	18.33 ± 2.08^{cd}	146.00 ± 4.58^{d}	4.06 ± 0.05^{d}	20.61 ± 1.75^{cd}
45g MSC	19.00 ± 1.78^{ef}	0.53 ± 0.03^{gh}	10.00 ± 1.73^{gh}	111.00 ± 4.36^{g}	2.58 ± 0.04^{h}	15.77 ± 2.34^{ef}
45g MSC +5ml M	20.77 ± 1.45^{e}	0.55 ± 0.03^{fg}	12.67 ± 1.53^{fg}	120.67 ± 2.52^{f}	3.18 ± 0.04^{g}	18.00 ± 2.27^{de}
45g MSC +10ml M	18.93 ± 1.67^{ef}	0.52 ± 0.03^{gh}	9.00 ± 1.00^{h}	95.33 ± 3.05^{h}	2.21 ± 0.06^{j}	12.67 ± 1.00^{fg}

Table 4. Effect of Moringa seed cake (MSC) and Microbein (M) on the some growth traits of *Antirrhinum majus* during 2020/21 and 2021/22 seasons.

Treatment	Shoot F.W. (g)	Root F.W. (g)	Shoot D.W. (g)	Root D.W. (g)	Root, Shoot (dry)
2020/21 season					
Control	11.74 ± 0.65^{fg}	1.42 ± 0.45^{e}	3.03 ± 0.18^{fg}	0.47 ± 0.06^{g}	0.16 ± 0.03^{e}
15g MSC	13.18 ± 0.96^{def}	2.96 ± 0.46^{ab}	3.64 ± 0.28^{cd}	1.06 ± 0.08^{bc}	0.29 ± 0.04^{ab}
15g MSC+5ml M	13.56 ± 1.05^{cde}	3.11 ± 0.28^{ab}	3.81 ± 0.25^{c}	1.13 ± 0.07^{b}	0.30 ± 0.04^{a}
15g MSC +10ml M	15.84 ± 1.08^{ab}	3.47 ± 0.38^{a}	4.63 ± 0.18^{b}	1.29 ± 0.06^{a}	0.28 ± 0.02^{ab}
30g MSC	15.23 ± 1.20^{bc}	2.28 ± 0.16^{cd}	4.38 ± 0.19^{b}	0.80 ± 0.06^{d}	0.18 ± 0.01^{de}
30g MSC +5ml M	17.55 ± 1.11^{a}	3.52 ± 0.33^{a}	5.24 ± 0.17^{a}	1.33 ± 0.06^{a}	0.25 ± 0.00^{abc}
30g MSC +10ml M	13.83 ± 0.91^{cd}	2.64 ± 0.35^{bc}	3.92 ± 0.17^{c}	0.94 ± 0.08^{c}	0.24 ± 0.01^{bcd}
45g MSC	11.96 ± 1.02^{efg}	1.85 ± 0.25^{de}	3.15 ± 0.26^{ef}	0.63 ± 0.06^{ef}	0.20 ± 0.00^{cde}
45g MSC +5ml M	12.74 ± 1.11^{defg}	2.09 ± 0.19^{cd}	3.40 ± 0.29^{de}	0.73 ± 0.07^{de}	0.22 ± 0.04^{cd}
45g MSC +10ml M	11.35 ± 1.32^{g}	1.72 ± 0.24^{de}	2.78 ± 0.14^{g}	0.58 ± 0.07^{fg}	0.21 ± 0.03^{cde}
2021/22 season					
Control	10.86 ± 0.83^{f}	1.38 ± 0.11^{h}	2.66 ± 0.29^{h}	0.46 ± 0.04^{i}	0.17 ± 0.01^{d}
15g MSC	14.74 ± 1.98^{de}	3.16 ± 0.11^{c}	4.07 ± 0.20^{e}	1.14 ± 0.04^{d}	0.28 ± 0.01^{a}
15g MSC+5ml M	15.58 ± 1.52^{cd}	3.34 ± 0.13^{c}	4.41 ± 0.15^{d}	1.22 ± 0.04^{c}	0.28 ± 0.01^{a}
15g MSC +10ml M	20.49 ± 1.84^{ab}	3.85 ± 0.16^{b}	6.09 ± 0.14^{b}	1.43 ± 0.04^{b}	0.23 ± 0.00^{b}
30g MSC	18.06 ± 1.43^{bc}	2.11 ± 0.14^{e}	5.26 ± 0.13^{c}	0.74 ± 0.03^{f}	0.14 ± 0.00^{e}
30g MSC +5ml M	21.35 ± 1.24^{a}	4.23 ± 0.17^{a}	6.41 ± 0.17^{a}	1.59 ± 0.03^{a}	0.25 ± 0.01^{b}
30g MSC +10ml M	16.65 ± 1.62^{cd}	2.50 ± 0.16^{d}	4.71 ± 0.15^{d}	0.89 ± 0.04^{e}	0.19 ± 0.01^{c}
45g MSC	12.04 ± 1.49^{f}	1.76 ± 0.14^{fg}	3.17 ± 0.17^{fg}	0.60 ± 0.04^{h}	0.19 ± 0.02^{c}
45g MSC +5ml M	12.66 ± 1.50^{ef}	1.93 ± 0.15^{ef}	3.37 ± 0.14^{f}	0.67 ± 0.04^{g}	0.20 ± 0.00^{c}
45g MSC +10ml M	11.73 ± 1.91^{f}	1.53 ± 0.14^{gh}	2.99 ± 0.18^{g}	0.51 ± 0.04^{i}	0.17 ± 0.01^{d}

TABLE 5. Effect of Moringa seed cake (MSC) and microbein (M) on the flowering traits of *Antirrhinum majus* during 2020/ 21 and 2021/ 22 seasons.

Treatment	No. of spikes/ plant	No. of flowers/ spike	Spike length (cm)	Spikes F.W. (g/plant)	Spikes D.W. (g/ plant)
2020/ 21 season					
Control	4.67±1.15^{f}	7.00±2.00^{f}	2.67±0.47^{g}	4.11±0.43^{g}	0.63±0.05^{i}
15g MSC	8.67±1.53^{cd}	19.00±2.65^{b}	5.57±0.35^{bc}	10.24±0.35^{b}	1.75±0.07^{d}
15g MSC+5ml M	10.33±1.15^{bc}	19.67±1.53^{b}	5.73±0.31^{bc}	10.75±0.44^{b}	1.91±0.07^{c}
15g MSC +10ml M	7.67±1.53^{de}	15.33±2.08^{c}	5.33±0.35^{cd}	8.30±0.82^{c}	1.40±0.06^{e}
30g MSC	11.00±1.73^{b}	20.33±2.31^{b}	6.17±0.35^{ab}	11.13±0.77^{b}	2.06±0.07^{b}
30g MSC +5ml M	13.67±1.53^{a}	23.67±1.53^{a}	6.87±0.81^{a}	12.57±0.78^{a}	2.42±0.06^{a}
30g MSC +10ml M	7.67±1.15^{de}	12.33±1.15^{cd}	5.03±0.49^{cde}	7.57±0.78^{cd}	1.24±0.05^{f}
45g MSC	6.00±1.00^{ef}	9.00±1.73^{ef}	4.33±0.45^{ef}	6.09±0.47^{ef}	0.96±0.05^{h}
45g MSC +5ml M	6.33±0.58^{ef}	10.67±1.53^{de}	4.67±0.55^{de}	6.94±0.64^{de}	1.12±0.06^{g}
45g MSC +10ml M	5.67±0.58^{ef}	7.67±1.53^{ef}	3.67±0.15^{f}	5.73±0.4^{6f}	0.89±0.05^{h}
2021/ 22season					
Control	4.00±1.00^{h}	7.33±1.52^{h}	2.87±0.81^{g}	5.13±0.38^{f}	0.76±0.07^{i}
15g MSC	8.33±1.15^{de}	17.67±1.53^{de}	5.84±0.90^{cde}	10.70±1.28^{cd}	1.81±0.05^{e}
15g MSC+5ml M	9.67±0.58^{cd}	19.33±3.05^{cd}	6.11±0.90^{bcd}	11.11±0.79^{c}	1.92±0.04^{d}
15g MSC +10ml M	11.33±1.15^{bc}	21.67±1.53^{bc}	6.51±0.88^{abc}	12.46±0.66^{b}	2.24±0.04^{c}
30g MSC	12.67±1.53^{b}	23.33±2.08^{b}	7.28±0.65^{ab}	12.85±1.00^{b}	2.38±0.06^{b}
30g MSC +5ml M	15.00±1.73^{a}	27.33±2.52^{a}	7.67±0.81^{a}	14.24±0.77^{a}	2.75±0.04^{a}
30g MSC +10ml M	7.67±1.53^{def}	14.67±2.52^{ef}	5.49±0.52^{cde}	9.52±0.42^{d}	1.63±0.05^{f}
45g MSC	5.67±1.15^{fgh}	10.33±1.53^{gh}	4.68±0.70^{ef}	6.18±0.45^{f}	1.00±0.10^{h}
45g MSC +5ml M	7.00±1.00^{efg}	12.33±1.53^{fg}	5.13±0.61^{de}	7.64±0.65^{e}	1.23±0.05^{g}
45g MSC +10ml M	5.00±0.00^{gh}	8.00±2.00^{h}	3.77±0.75^{fg}	6.00±0.62^{f}	0.93±0.05^{h}

TABLE 6. Effect of moringa seed cake (MSC) and microbein (M) on photosynthetic pigments, total sugars content in leaves and crude protein in shoot and root of *Antirrhinum majus* during 2020/21 and 2021/22 seasons.

Treatment	Chl. a (mg.g^{-1} F.W.)	Chl. b (mg.g^{-1} F.W.)	Carotenoids (mg.g^{-1} F.W.)	Total sugars content (mg.g^{-1} F.W.)	Crude protein in shoot (%)	Crude protein in root (%)
2020/ 21 season						
Control	$2.46{\pm}0.04^{j}$	$1.05{\pm}0.04^{h}$	$1.85{\pm}0.05^{i}$	$3.11{\pm}0.05^{j}$	$6.94{\pm}0.24^{h}$	$3.19{\pm}0.47^{g}$
15g MSC	$3.68{\pm}0.05^{f}$	$1.54{\pm}0.05^{e}$	$2.72{\pm}0.06^{f}$	$4.72{\pm}0.05^{f}$	$7.88{\pm}0.29e^{f}$	$3.44{\pm}0.17^{fg}$
15g MSC+5ml M	$4.11{\pm}0.03^{e}$	$1.68{\pm}0.04^{d}$	$2.87{\pm}0.04^{e}$	$4.94{\pm}0.03^{e}$	$8.19{\pm}0.23^{de}$	$3.75{\pm}0.23^{ef}$
15g MSC +10ml M	$5.24{\pm}0.05^{b}$	$2.06{\pm}0.06^{b}$	$3.67{\pm}0.06^{b}$	$6.16{\pm}0.04^{a}$	$10.25{\pm}0.27^{b}$	$3.88{\pm}0.27^{de}$
30g MSC	$4.83{\pm}0.05^{c}$	$1.91{\pm}0.04^{c}$	$3.13{\pm}0.04^{c}$	$5.62{\pm}0.05^{c}$	$8.94{\pm}0.23^{c}$	$4.00{\pm}0.23^{cde}$
30g MSC +5ml M	$5.96{\pm}0.04^{a}$	$2.31{\pm}0.04^{a}$	$3.84{\pm}0.04^{a}$	$5.95{\pm}0.05^{b}$	$10.69{\pm}0.23^{a}$	$4.25{\pm}0.17^{bcd}$
30g MSC +10ml M	$4.51{\pm}0.05^{d}$	$1.84{\pm}0.04^{c}$	$2.95{\pm}0.04^{d}$	$5.34{\pm}0.06^{d}$	$8.44{\pm}0.27^{d}$	$4.38{\pm}0.17^{bc}$
45g MSC	$3.09{\pm}0.06^{h}$	$1.26{\pm}0.05^{f}$	$2.30{\pm}0.04^{g}$	$4.04{\pm}0.05^{h}$	$7.25{\pm}0.17^{gh}$	$4.63{\pm}0.17^{ab}$
45g MSC +5ml M	$3.27{\pm}0.06^{g}$	$1.48{\pm}0.05^{e}$	$2.67{\pm}0.04^{f}$	$4.22{\pm}0.06^{g}$	$7.63{\pm}0.23^{fg}$	$4.81{\pm}0.23^{a}$
45g MSC +10ml M	$2.84{\pm}0.04^{i}$	$1.17{\pm}0.05^{g}$	$2.14{\pm}0.04^{h}$	$3.74{\pm}0.07^{i}$	$7.25{\pm}0.17^{gh}$	$4.56{\pm}0.17^{ab}$
2021/ 22 season						
Control	$2.52{\pm}0.04^{j}$	$1.12{\pm}0.04^{j}$	$1.78{\pm}0.05^{j}$	$2.98{\pm}0.05^{j}$	$6.88{\pm}0.29^{g}$	$3.13{\pm}0.17^{g}$
15g MSC	$4.16{\pm}0.04^{f}$	$1.69{\pm}0.04^{f}$	$2.48{\pm}0.04^{f}$	$4.25{\pm}0.04^{f}$	$9.00{\pm}0.29^{d}$	$3.38{\pm}0.27^{fg}$
15g MSC+5ml M	$4.50{\pm}0.06^{e}$	$1.82{\pm}0.05^{e}$	$2.66{\pm}0.05^{e}$	$4.65{\pm}0.05^{e}$	$9.44{\pm}0.23^{d}$	$3.69{\pm}0.54^{ef}$
15g MSC +10ml M	$5.37{\pm}0.04^{b}$	$2.25{\pm}0.04^{b}$	$3.70{\pm}0.05^{b}$	$5.83{\pm}0.04^{b}$	$10.94{\pm}0.27^{b}$	$3.94{\pm}0.23^{de}$
30g MSC	$5.14{\pm}0.05^{c}$	$2.10{\pm}0.04^{c}$	$3.34{\pm}0.04^{c}$	$5.47{\pm}0.04^{c}$	$10.63{\pm}0.25^{bc}$	$4.13{\pm}0.29^{cde}$
30g MSC +5ml M	$5.81{\pm}0.04^{a}$	$2.43{\pm}0.05^{a}$	$3.91{\pm}0.03^{a}$	$5.97{\pm}0.04^{a}$	$11.44{\pm}0.23^{a}$	$4.31{\pm}0.27^{bcd}$
30g MSC +10ml M	$4.79{\pm}0.04^{d}$	$1.97{\pm}0.05^{d}$	$2.85{\pm}0.04^{d}$	$4.91{\pm}0.04^{d}$	$10.38{\pm}0.29^{c}$	$4.50{\pm}0.25^{bc}$
45g MSC	$3.51{\pm}0.05^{h}$	$1.33{\pm}0.04^{h}$	$1.97{\pm}0.04^{h}$	$3.42{\pm}0.06^{h}$	$7.50{\pm}0.23^{ef}$	$4.75{\pm}0.23^{ab}$
45g MSC +5ml M	$3.82{\pm}0.04^{g}$	$1.51{\pm}0.04^{g}$	$2.14{\pm}0.03^{g}$	$3.86{\pm}0.05^{g}$	$7.94{\pm}0.27^{e}$	$5.00{\pm}0.23^{a}$
45g MSC +10ml M	$2.94{\pm}0.04^{i}$	$1.20{\pm}0.05^{i}$	$1.86{\pm}0.03^{i}$	$3.16{\pm}0.05^{i}$	$7.13{\pm}0.23^{fg}$	$4.56{\pm}0.23^{abc}$

The increment in chlorophylls and carotenoids contents resulted from moringa seed cake plus microbien may be due to providing nitrogen, Amalitois et al., (2004) illustrated that there is a very strong relationship between chlorophyll and nitrogen content. Owing to considering nitrogen as a structural element of the chlorophyll and protein molecules, thereby affects the formation of chloroplasts and accumulation within or inside them (Tucker, 2004). The positive effects of these treatments are in similarity with Omar et al., (2018) and Siswanti and Umah (2021)

Total sugars content (mg. g^{-1} F.W.)

Data recorded in Table (6) indicated that the total sugars content as affected by the different levels of moringa seed cake (MSC) and microbien (M) treatments, followed the same manner obtained previously on photosynthetic pigments, that increased by MSC and M treatments. The highest values of total sugars content were recorded in plants treated with 15g MSC + 10ml M followed by 30g MSC + 5 ml M, then 30g MSC in the season one, respectively, but in the season two, the highest values were obtained by plants treated by 30g MSC + 5 ml M followed by 15g MSC+ 10 ml M, then 30g MSC, respectively, in comparison with the control and other treatments. The provision and availability of phosphorus is supporting carbohydrates metabolism and different researchers have reported that increasing phosphorus level results in variable effects on sugars content related to a source/sink balance between roots and shoots (Garcia-Caparros et al., 2021). The similar results were told by Mohamed et al. (2021) & Hemdan et al. (2021).

Crude protein (%) in shoot and root

The results of crude protein percentage in shoot and root presented in Table (6) showed that growing seedlings with MSC alone or combined with M treatments led to an increase in crude protein% in shoot and root compared to control at the two seasons. The highest values of crude protein in shoot was plants treated with 30g MSC+ 5ml M followed by 15g MSC+ 10ml M, then 30 g MSC which gave 10.69±0.23, 10.25±0.27 and 8.94±0.23%, respectively, in the first season. In the second season, results were recorded, and the corresponding values were (11.44±0.23, 10.94±0.27 and 10.63±0.25%). While, the highest values of crude protein% in root (4.81±0.23, 4.63±0.17 and 4.56±0.17) in the first season and (5.00±0.23, 4.75±0.23 and 4.56±0.23) in the second one were recorded with the treatment of 45g MSC+ 5ml M followed by 45g MSC then 45g MSC+ 10 ml M, respectively. Application of organic and biofertilizers could effectively increase the availability of soil nitrogen, and essential nutrients, which could boost plant growth. Such nutrients from organic sources are more efficient in the different plant functions, such as protein synthesis (Maqshoof et al., 2014).

Nutrient elements

Data of nutrient elements N, P, K, Mg and Fe in shoots as affected by different moringa seed cake (MSC) and microbein (M) levels are presented in Table (7). Application treatments in both seasons throughout experimental periods. It showed clearly that MSC individual or with M at different levels had a positive effect on the content of N, P, K, Mg% and Fe (ppm) of *Antirrhinum majus* in the two seasons. Plants treated with 30g MSC+5ml M contained the highest values of N, P, K, Mg and Fe (1.71±0.04, 0.18±0.04, 0.44±0.05, 11.87±0.53 and 2.33±0.05), respectively in the first season and (1.83±0.03, 0.20±0.03, 0.49±0.03, 13.67±0.43 and 2.41±0.05), respectively, in the second one. Whereas, the lowest values of N, P, K, Mg and Fe were recorded by untreated plants which gave 1.11±0.04, 0.05±0.02, 0.20±0.03, 8.42±0.7 and 0.06±0.01, respectively, in the first season, and 1.11±0.05, 0.04±0.01, 0.17±0.03, 6.93±0.17 and 0.09±0.01, respectively, in the second one. In close agreement with these results were the findings reported by Sarhan et al. (2015) on *Swiestenia mahogani*, Salah et al. (2020) on *Moringa oleifera* and Taher and Ethbeab (2021) on *Ficus carica* plants.

The Obtained data in Table (8) detected that the effect of MSC and microbein (M) on the nutrient elements content N, P, K, Mg and Fe in root of *Antrrihinum majus* in both season. Data showed that all mineral concentrations were increased when the plants were treated with MSC individual or in combination with M in comparison with the untreated one. The maximum values of nutrient elements (N, P, K (%) and Fe (ppm)) were recorded in plants treated with 45 MSC+ 5ml M which resulted in 0.77±0.04, 0.18±0.03 and 0.37±0.04 and 1.63±0.04, respectively, in the first season and 0.80±0.80% N, 0.22±0.04% P and 0.38±0.04% K. While, the treatment 30 MSC+ 5ml gave highest value of Mg % giving 5.56±0.21 and 5.88±0.42 in both seasons, respectively, and Fe in the second season giving 2.33±0.04 ppm.

TABLE 7. Effect of Moringa seed cake (MSC) and microbein (M) on nutrient elements content (N, P, K, Mg% and Fe (ppm)) in shoot of *Antirrhinum majus* during 2020/21 and 2021/22 seasons.

Treatment	N% in shoot	P% in shoot	K% in shoot	Mg% in shoot	Fe (ppm) in shoot
			2020/ 21 season		
Control	1.11±0.04^{h}	0.05±0.02^{e}	0.2±0.03^{f}	8.42±0.70^{f}	0.06±0.01^{i}
15g MSC	1.26±0.05^{ef}	0.09±0.02^{cde}	0.26±0.04^{cdef}	9.73±0.54^{de}	1.54±0.04^{e}
15g MSC+5ml M	1.31±0.04^{de}	0.10±0.03^{cd}	0.27±0.04^{cde}	10.12±0.65^{cd}	1.68±0.04^{d}
15g MSC +10ml M	1.64±0.04^{b}	0.16±0.04^{ab}	0.35±0.04^{b}	11.80±0.62^{ab}	2.06±0.04^{b}
30g MSC	1.43±0.04^{c}	0.13±0.03^{bc}	0.31±0.04^{bc}	10.82±0.51^{bc}	2.01±0.04^{b}
30g MSC +5ml M	1.71±0.04^{a}	0.18±0.04^{a}	0.44±0.05^{a}	11.87±0.53^{a}	2.33±0.05^{a}
30g MSC +10ml M	1.35±0.05^{d}	0.13±0.04^{bc}	0.30±0.04^{bcd}	10.34±0.87^{cd}	1.81±0.03^{c}
45g MSC	1.16±0.03^{gh}	0.07±0.01^{de}	0.22±0.04^{ef}	8.96±0.63^{ef}	1.06±0.05^{h}
45g MSC +5ml M	1.22±0.04^{fg}	0.08±0.03^{de}	0.24±0.04^{def}	9.41±0.41^{def}	1.45±0.04^{f}
45g MSC +10ml M	1.16±0.03^{gh}	0.07±0.02^{de}	0.21±0.04^{ef}	8.77±0.32^{ef}	1.35±0.04^{g}
			2021/ 22 season		
Control	1.11±0.05^{h}	0.04±0.01^{f}	0.17±0.03^{g}	6.93±0.17^{g}	0.09±0.01^{i}
15g MSC	1.44±0.05^{e}	0.11±0.03^{cd}	0.28±0.03^{de}	9.21±0.34^{d}	1.62±0.04^{e}
15g MSC+5ml M	1.51±0.04^{d}	0.11±0.03^{cd}	0.31±0.03^{cd}	9.88±0.23^{cd}	1.74±0.04^{d}
15g MSC +10ml M	1.75±0.04^{b}	0.17±0.03^{ab}	0.42±0.03^{b}	12.15±0.24^{b}	2.17±0.05^{b}
30g MSC	1.70±0.04^{bc}	0.16±0.03^{b}	0.36±0.04^{c}	11.49±0.50^{b}	2.11±0.04^{b}
30g MSC +5ml M	1.83±0.03^{a}	0.2±0.03^{a}	0.49±0.03^{a}	13.67±0.43^{a}	2.41±0.05^{a}
30g MSC +10ml M	1.66±0.05^{c}	0.14±0.03^{bc}	0.33±0.04^{cd}	10.52±0.47^{c}	2.02±0.05^{c}
45g MSC	1.20±0.04^{g}	0.08±0.02^{de}	0.21±0.03^{fg}	8.21±0.49^{ef}	1.18±0.04^{h}
45g MSC +5ml M	1.27±0.04^{f}	0.10±0.03^{de}	0.25±0.04^{ef}	8.44±0.45^{e}	1.50±0.05^{f}
45g MSC +10ml M	1.14±0.04^{gh}	0.07±0.01^{ef}	0.18±0.03^{g}	7.56±0.50^{fg}	1.39±0.03^{g}

TABLE 8. Effect of Moringa seed cake (MSC) and microbein (M) on nutrient elements content (N, P, K, Mg% and Fe (ppm)) in root of *Antirrhinum majus* during 2020/21 and 2021/22 seasons.

Treatment	N% in root	P% in root	K% in root	Mg% in root	Fe (ppm) in root
	2020/ 2021 season				
Control	0.51 ± 0.08^{g}	0.09 ± 0.02^{d}	0.18 ± 0.02^{g}	3.08 ± 0.20^{e}	0.04 ± 0.02^{h}
15g MSC	0.55 ± 0.03^{fg}	0.10 ± 0.03^{d}	0.21 ± 0.03^{fg}	4.27 ± 0.44^{d}	1.23 ± 0.04^{de}
15g MSC+5ml M	0.60 ± 0.04^{ef}	0.12 ± 0.03^{cd}	0.24 ± 0.03^{ef}	4.74 ± 0.35^{c}	1.17 ± 0.04^{e}
15g MSC +10ml M	0.62 ± 0.04^{de}	0.12 ± 0.02^{cd}	0.28 ± 0.03^{cde}	5.24 ± 0.13^{ab}	1.09 ± 0.06^{f}
30g MSC	0.64 ± 0.04^{cde}	0.13 ± 0.02^{bcd}	0.25 ± 0.03^{def}	4.53 ± 0.22^{cd}	1.29 ± 0.04^{cd}
30g MSC +5ml M	0.68 ± 0.03^{bcd}	0.15 ± 0.03^{abc}	0.30 ± 0.03^{bcd}	5.56 ± 0.21^{a}	1.02 ± 0.04^{g}
30g MSC +10ml M	0.70 ± 0.03^{bc}	0.15 ± 0.03^{abc}	0.34 ± 0.02^{ab}	4.87 ± 0.12^{bc}	1.20 ± 0.04^{e}
45g MSC	0.74 ± 0.03^{ab}	0.17 ± 0.03^{ab}	0.33 ± 0.04^{abc}	4.15 ± 0.16^{d}	1.35 ± 0.04^{c}
45g MSC +5ml M	0.77 ± 0.04^{a}	0.18 ± 0.03^{a}	0.37 ± 0.04^{a}	4.26 ± 0.33^{d}	1.63 ± 0.04^{a}
45g MSC +10ml M	0.73 ± 0.03^{ab}	0.16 ± 0.03^{abc}	0.36 ± 0.04^{a}	4.22 ± 0.38^{d}	1.52 ± 0.06^{b}
	2021/ 2022 season				
Control	0.50 ± 0.03^{g}	0.08 ± 0.03^{f}	0.16 ± 0.04^{e}	3.15 ± 0.13^{f}	0.06 ± 0.01^{h}
15g MSC	0.54 ± 0.04^{fg}	0.10 ± 0.03^{ef}	0.19 ± 0.04^{de}	4.30 ± 0.09^{de}	1.31 ± 0.05^{d}
15g MSC+5ml M	0.59 ± 0.09^{ef}	0.11 ± 0.03^{def}	0.21 ± 0.03^{de}	4.55 ± 0.50^{de}	1.17 ± 0.03^{f}
15g MSC +10ml M	0.63 ± 0.04^{de}	0.14 ± 0.04^{cde}	0.22 ± 0.04^{de}	5.49 ± 0.48^{ab}	1.11 ± 0.03^{f}
30g MSC	0.66 ± 0.05^{cde}	0.14 ± 0.03^{cde}	0.24 ± 0.04^{cd}	5.14 ± 0.18^{bc}	1.37 ± 0.04^{d}
30g MSC +5ml M	0.69 ± 0.04^{bcd}	0.15 ± 0.04^{bcde}	0.29 ± 0.03^{bc}	5.88 ± 0.42^{a}	1.00 ± 0.05^{g}
30g MSC +10ml M	0.72 ± 0.04^{bc}	0.16 ± 0.04^{bcd}	0.32 ± 0.04^{ab}	4.73 ± 0.20^{cd}	1.24 ± 0.04^{e}
45g MSC	0.76 ± 0.04^{ab}	0.20 ± 0.03^{ab}	0.34 ± 0.04^{ab}	3.64 ± 0.34^{f}	1.53 ± 0.03^{c}
45g MSC +5ml M	0.80 ± 0.04^{a}	0.22 ± 0.04^{a}	0.38 ± 0.04^{a}	4.37 ± 0.14^{de}	1.68 ± 0.05^{a}
45g MSC +10ml M	0.73 ± 0.04^{abc}	0.19 ± 0.03^{abc}	0.35 ± 0.04^{ab}	4.20 ± 0.21^{e}	1.60 ± 0.03^{b}

The application of MSC enhanced the chemical properties of the soil and hydrophysical characters because the cake is considered an organic matter contains high different nutrients (Hemdan et al., 2021). On the other hand, MSC dissolves rapidly in the same applied period (Emmanuel and Emmanuel, 2011). The low C/N ratio of moringa seed cake may be an effective source of nutrients. MSC contains a high protein up to 68.6 % (Martín et al., 2010). There were also substantial increases in nutrient elements content in plant shoot as well as total carbohydrates, which could result in enhanced root development and formation, nutrient uptake, as well as in increased vegetative growth parameters, photosynthesis, and carbon assimilation (Mohamed et al., 2021). The obtained results are in similar trend with Omar et al. (2018) and Hemdan et al. (2021).

Conclusions

The study showed that Moringa oleifera seed cake has a clear fertilizing importance, either alone or in combination with the microbein, because it contains many important nutrients that the plant needs for growth. Where the results mentioned in the study disclosed that the use of moringa seed cake at rate 30 g + 5 ml microbein / pot gave the preferable results for most of the traits of Antirrhinum majus plants that were grown in sandy soil. We can conclude that it is possible to reduce the waste resulting from squeezing moringa seeds by using it as a natural, safe and non-polluting source of fertilization for the environment, and also many studies have mentioned the ability of Moringa seed to improve the properties of sandy soil.

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Conflict of interests

The authors declare no conflict of interest in the publication of this work.

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تأثير كسب بذرة المورينجا كمصدر تسميد صديق للبيئة على آداء نبات حنك السبع النامي في التربة الرملية

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يعتبر *Antirrhinum maju*s نباتًا معمرًا في المناطق الدافئة ولكنه يزرع في الغالب كنبات حولي شتوي يستخدم في تنسيق الأحواض المزهرة ، ويحتاج إلى تربة جيدة التصريف ، لذلك فهو نبات مناسب للزراعة في المجمعات السكنية الجديدة ذات التربة الرملية ، ولكن هذا النوع من التربة تحتوي على مستوى منخفض من العناصر الغذائية. لذلك كان الهدف من الدراسة إلى استخدام كسب بذور المورينجا (MSC) كمصدر طبيعي للتسميد بمفرده أو مع الميكروبين (M) للوسط. لوحظ أن نباتات *A. maju*s التي نمت في التربة المحتوية على MSC بمعدل 35 جم / أصيص مع إضافة ميكروبين بمعدل 5 مل / أصيص أعطت أعلى القيم لجميع الصفات الخضرية والنورات باستثناء طول الجذر. والتي زادت مع معاملة MSC عند 15 جم +M بمعدل 10 مل / أصيص. أيضا ، سجلت MSC عند الجرعة 15 جم + Mعند معاملة 5 مل /إصيص أعلى زيادة في المجموع الجذري, المجموع الخضري في كلا الموسمين. فيما يتعلق بالتقديرات الكيميائية ، وجد أن صبغات التمثيل الضوئي (الكلوروفيل أ ، الكلوروفيل ب والكاروتينات) والبروتين الخام (٪) ومحتوى العناصر الغذائية متضمنة (N ، P ، K ، Mg٪ و Fe (جزء في المليون)) ومحتوى السكريات الكلية في المجموع الخضري حيث ظهرت أعلى قيم تم الحصول عليها من النباتات التي عوملت بـ MSC عند 30 جم + Mعند 5 مل / إصيص ، أما بالنسبة للبروتين الخام (٪) والعناصر المغذية بما في ذلك (N، P، K٪و Fe (جزء في المليون) في الجذور فقد ظهرت أعلى القيم عندما كانت المعاملة MSC عند 45 جم +M عند 5 مل / أصيص، و بالنسبة لـ Mg (٪) ، ظهر أعلى محتوى في الجذور عند إضافة MSC بمعدل 30 جم + M عند 5 مل / أصيص خلال الموسمين.