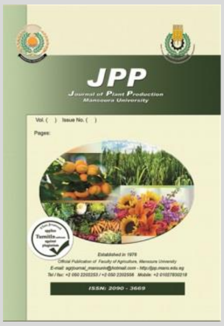
Journal of Plant Production

Journal homepage & Available online at: www.jpp.journals.ekb.eg

Studies on Improving the Properties of Moringa Plants under the Conditions of Reclaimed Soils

Sharaf El-Din, M. N.[1]; Hebatalla A. M. El-syed[2]; A. A. E. Helaly[1]; M. M. N. Shalan[3] and H. M. H. Awad[1*]

[1]Veg. and Flori. Dept., Fac. Agric., Mansoura Univ., Egypt.
[2]Agric. Econ. Dept., Fac. Agric., Mansoura Univ., Egypt.
[3]Hort. Res. Inst., Agric. Res. Center, Cairo., Egypt.



ABSTRACT

A field experiment was conducted at Geneffa Village (third field army), El-Ganaien District, Suez Governorate, Egypt over the periods of 2021 and 2022 to investigate different treatments for improving the development and production of *Moringa oleifera* Lam. plants in reclaimed soil conditions. The goal of this study was to assess the effects of various organic sources (including control, farmyard manure, poultry manure, plant compost, animal compost, and plant animal compost), various planting spaces (15, 30, and 45 cm between hills), and their combinations on the growth, yield, and chemical composition of moringa plants. The results obtained indicated that based on the number of branches per plant and the fresh and dry weights of the herb per feddan, the best treatment was a combination of plant animal compost with a 15 cm distance between plant hills. Both in the first and second cuts of the two seasons, this mix did better than the other treatments that were studied. When 20 m^3/ feddan of plant animal compost and 15 cm between plants were used, the overall chlorophyll content of moringa plants rose significantly compared to the other treatments. With 45 cm between plants and compost from plants and animals, the biggest amounts of N, P, K, and Mg were found as well as the highest contents of Fe, Mn and total phenols. The highest return on the invested pound for fresh and dry herb yield per feddan was obtained with poultry manure as well as animal/ plant compost.

Keywords: Moringa, organic fertilization, plant space, growth, yield, chlorophyll

INTRODUCTION

The plant often known as horseradish or the miracle tree (*Moringa oleifera*, Lam.) is a member of the *Moringaceae* family, which encompasses a single genus called *Moringa*. This genus is comprised of approximately 10-14 species. The moringa plants are extensively cultivated in several regions, including the Thailand, Philippines, Pakistan and Malaysia as well as other tropical and subtropical places found in Africa, America and Central Asia (Morton, 1991; Ramachandran *et al.*, 1980). In order to enhance animal welfare and improve feed availability, it is proposed to offer *Moringa* fodder cultivation methods to farmers. By familiarizing farmers with this extremely nutritious and cost-effective fodder, it has the potential to bring about a revolutionary impact (Fuglie, 2001 a & b). The moringa serves as a significant provider of fat (2-10% of dry matter), protein (9-35% of dry matter), starch, and fiber (9-28% of dry matter) as indicated by Makkar and Becker (1997) and Foidl *et al.* (2001). Additionally, it is worth noting that this substance comprises minerals ranging from 0.6% to 11% of its dry matter composition. Moreover, it contains vitamins A, B, C, and E, antibiotics and alkaloids. Furthermore, it is important to highlight that this substance also contains cytokinin phytohormones, which have the ability to stimulate plant growth (Fuglie, 2001b).

Sandy soil of Geneffa Village (third field army), El-Ganaien District, Suez Governorate, Egypt is poor soil with limit organic matter, inferior nutrient elements and does not hold water, which is reflected in low growth and yield. Organic matter is the essence of the soil. Moreover, the benefits of organic fertilization are enhancing the soil's physical, biological and chemical properties. Cook and Ellis (1987) pointed out that the presence of clay soils can be beneficial as it enhances porosity, mitigates waterlogged situations through improved drainage, and enhances soil texture. According to Jamal and Ozra (2014), the presence of plant hormones, as well as micro- and macronutrients in compost, has been found to result in enhanced seed germination, growth, and yield. In addition, it has been shown that compost has the potential to mitigate the appearance of plant diseases and also boost the physiological state of plants, leading to improvements in both the amount and quality of crop output (Loredana *et al.*, 2015).

Furthermore, the aerial parts of *Tropaeolum majus* plants yielded the ﺵgreat fresh mass when treated with the highest rate (19000 kg/ hectare) of chicken manure (Carbonari *et al*., 2006). The study conducted by Samanhudi *et al*. (2014) shown a notable enhancement in the growth and yield of the temulawak (*Curcuma xanthorrhiza* Roxb.) plant with the application of organic manure. The positive growth observed in the fenugreek plant while just utilizing farm yard manure (FYM) substantiates its capacity to effectively utilize the nutrients included in manure (Bhagubha, 2021). The utilization of compost manure as a soil supplement demonstrated notable superiority over individual resources in enhancing the growth and yield attributes of marjoram plants (Attia *et al*., 2022).

*** Corresponding author.**
E-mail address: hanyawad6666@gmail.com
DOI: 10.21608/jpp.2023.241397.1272

Additionally, the arrangement of plants at specific distances from each other is a crucial factor that contributes to the enhancement of agricultural productivity. The population of plants in a specific area is influenced by the design of plant spacing (Amara and Mourad, 2013). An optimal layout can effectively mitigate competition for essential resources such as water, light, and nutrients. Also, Mehriya *et al*. (2022) found that a row spacing of 40 cm has been found to facilitate the optimal production of chamomile flowers, as it allows for improved crop canopy development and provides better crop canopy for effective crop management.

Hence, the present investigation was conducted to evaluate the suitability of *Moringa oleifera* for commercial cultivation in newly recovered soil conditions. This involved assessing the efficacy of organic fertilizers as a source of nutrition and determining the optimal spacing between moringa plants to enhance growth, herb output, and chemical composition of moringa plants.

MATERIALS AND METHODS

A field experiment was carried out in Geneffa Village (third field army), El-Ganaien District, Suez Governorate, Egypt during the two consecutive seasons of 2021 and 2022. The objective of the experiment was to examine the impacts of various organic fertilization sources on the growth and production of *Moringa oleifera* Lam. plants in reclaimed soil conditions. The organic fertilization sources included a control as well as farmyard manure, poultry manure, plant compost, animal compost, and plant animal compost, each applied at a rate of 20 m^3/ feddan. Additionally, the experiment investigated the impact of different plant spacing, specifically 15 cm, 30 cm and 45 cm. The moringa seeds source was Hort. Res. Inst., Agric. Res. Center, Mansoura, Egypt. The seeds were sown (about 2- 3 seeds/hill) at different spacing under study with 70 cm distance between ridges and irrigated by drip irrigation system. The sowing date was 20th March for both seasons. The seedlings were thinned to be one plant / hill after 15 days from sowing date. In order to assess the physical and chemical properties of the soil, a series of soil samples were collected from the field using a randomized sampling approach. The methodology employed for this analysis followed the standardized procedure outlined by Chapman and Pratt (1978). Table 1 displays various soil properties.

Table 1. Physical and chemical properties of experimental soil (average of the two seasons)

Physical analysis											Soil texture
Clay (%)	Silt (%)	Sand (%)			$CaCO_3$ (%)						Sandy
13.97	16.89	65.68			3.46						
Chemical analysis											
pH	E.C. m.mohs/cm	N (%)	Available nutrients								
			As mg /100 g soil					As ppm			
			P	K	Ca	Mg	Fe	Mn	Zn	Cu	
8.69	0.77	10	2.1	27	160	31	12	10	2.1	0.9	

The plot area was 2.80 × 5 m (14 m^2) included four rows; each row was 70 cm apart and 5 meters in length. All plots were treated with chemical NPK fertilizers, which comprised a combination of ammonium sulphate (20.5%), phosphoric acid (85%), and potassium sulphate (48.5%) at the Agriculture Ministry of Egypt's recommended rate (300 – 150 – 75) for both seasons. The NPK rates were divided into three equal dosages and applied three times throughout each growing season via drip irrigation water. The initial dose was taken two weeks following the sowing date, followed by a subsequent measurement one and a half months after the first measurement. The third dose was conducted one month after the second measurement. The aforementioned applications were repeated for each cut in both seasons. Various sources of organic fertilization, including farmyard manure (FYM), poultry manure, plant compost and animal compost, were applied to the experimental field at a rate of 20 m3 per feddan during soil preparation for seed sowing. The various sources of organic fertilization were examined at the water and soil laboratory during seasons, as documented in Table 2.

Experimental Design:

The running experiments were set up in a split-plot design with three replicates. The main plots were occupied by six organic fertilization sources. Moreover, the sub plots were entitled to three plant spacing. The combination treatments between main factor and sub factor were 18 treatments.

Sampling and recording Data:

Plant growth traits:

The moringa plants were subjected to biannual harvesting, occurring in both seasons, where the aerial parts of the plant were removed 10 cm above the soil surface. The initial harvest of aerial components occurred in 30th June, followed by a further harvest in 20th October. Three plants were selected at random from each cut within each treatment for two seasons, then, the growth traits were recorded as follow: plant height (cm), number of branches /plant and total fresh and dry weight/plant (g).

Table 2. Analysis of organic manure sources used in the current study (average of the two seasons)

Analysis	Organic manure				
	FYM	Poultry manure	Plant compost	Animal compost	Plant/ animal compost
Weight of m^3 (kg)	754	614	517	804	760
Wetness (%)	38	21	27	37	28
pH (in 1: 10)	8.12	8.01	7.77	8.17	8.35
E.C. (ds/m)	5.87	2.54	4.96	6.56	7.27
Total nitrogen (%)	0.41	0.39	1.23	1.54	0.80
Total P_2O_5 (%)	0.18	0.58	0.63	1.01	0.29
Total K_2O (%)	0.14	0.43	0.80	0.72	0.47
Organic matter (%)	24.67	21.28	37.04	19.26	24.25

Yield and its components:

After each cut during both seasons, herb fresh and dry yield per feddan were recorded. Multiplying the herb fresh and dry weights output per moringa plant by the number of plants per feddan (ton) gave us the amount of herb yield per feddan produced in each treatment.

Chemical constituents:

Total chlorophyll (a+ b) content (mg/ 100g as fresh weight) was determined in in the upper 4 or 5 moringa leaves (after 90 days from sowing date and the first cut) during 1st and 2nd seasons according to the method reported by Cherry (1973). In addition, mineral elements was carried out in the Laboratory of Chemical Dept., Fac. Agric., Mansoura Univ. Plant samples were dried in an electric oven at 70˚ C for 48 hour then finely ground for chemical determination according to A.O.A.C. (1970). Total nitrogen, total phosphorus, potassium, magnesium percentages were determined in the second cut only during both seasons according to method of

Kjeldahl as described by Chapman and Pratt (1978). Also, iron and manganese contents (mg/kg as dry weight) were determined in the second cut only during both seasons according to Kumpulainen *et al*. (1983).

The Folin–Ciocalteu method, as described by Waterhouse (2002) and Vaher *et al*. (2014), was employed to quantify the concentration of total phenolic components in methanol extracts derived from moringa leaf powder. The extracts were subjected to incubation with Folin–Ciocalteu reagent (Sigma-Aldrich, St. Louis, MO, USA) for duration of 5 minutes, after which they were treated with 10% Na_2CO_3 for a period of 40 minutes. The absorbance was measured at a wavelength of 752 nm using a spectrophotometer (APEL, PD-303S, Japan).

Income analysis:

Economic profit: The economic profit represents the difference between the total incomes and the total costs, and by estimating the economic profit according to each farm capacity.

The return on the invested pound: The return on the invested pound can be calculated by dividing the total revenue by the total costs.

Statistical Analysis:

The data that was gathered was examined in accordance with the methodology outlined by Gomez and Gomez (1984). The Least Significant Difference (L.S.D.) was employed to distinguish between means with a level of significance set at 5%. The means were compared using the Statistix version 9 computer application (Analytical software, 2008).

RESULTS AND DISCUSSION

Results

Plant growth traits

Data from Tables 3 and 4 show that, when compared to other sources in the first and second cuts of the first and second seasons, moringa plants treated with animal/plant compost produced the highest values of plant height (2.39 and 2.39 as well as 2.30 and 2.26 m). When compared to the other plant spacing under examination, 45 cm plant spacing typically generated the tallest plants. The optimum combination of treatments, in terms of moringa height and the number of branches per plant was plant + animal compost in combination with 45 cm plant spacing.

Table 3. Impact of organic fertilization source on plant height (m) of moringa plant under different plant spaces during 2021 and 2022 seasons

Organic fertilization source (A)	Planting space (cm) (B)							
	15	30	45	Mean (A)	15	30	45	Mean (A)
	2021 season							
	First cut				Second cut			
Control	1.84	2.07	2.30	2.07	1.88	2.10	2.27	2.08
Farm yard manure	2.07	2.35	2.32	2.24	2.06	2.34	2.25	2.22
Poultry manure	1.66	2.27	2.38	2.11	1.71	2.26	2.32	2.10
Plant compost (PC)	1.70	1.87	1.98	1.85	1.77	1.87	2.37	2.00
Animal compost (AC)	2.27	2.27	2.22	2.25	2.23	2.27	2.14	2.21
PC + AC	2.39	2.39	2.41	2.39	2.41	2.36	2.38	2.39
Mean (B)	1.99	2.20	2.27		2.01	2.20	2.29	
L.S.D. at 5 %	A= 0.06	B= 0.08		AB= 0.17	A= 0.16	B= 0.10		AB= 0.26
	2022 season							
	First cut				First cut			
Control	1.98	2,28	2.27	2.18	1.96	2.24	2.02	2.07
Farm yard manure	1.97	2.35	2.35	2.22	2.04	2.31	2.24	2.19
Poultry manure	1.78	2.40	2.23	2.14	1.82	2.33	2.23	2.13
Plant compost (PC)	1.82	1.95	2.14	1.97	1.83	1.96	2.08	1.96
Animal compost (AC)	2.30	2.35	2.28	2.31	2.12	2.38	2.24	2.25
PC + AC	2.40	2.17	2.33	2.30	2.39	2.21	2.17	2.26
Mean (B)	2.04	2.25	2.27		2.03	2.24	2.16	
L.S.D. at 5 %	A= 0.11	B= 0.06		AB= 0.15	A= 0.10	B= 0.09		AB= 0.21

Table 4. Impact of organic fertilization source on number of branches / plant of moringa plant under different plant spaces during 2021 and 2022 seasons

Organic fertilization source (A)	Planting space (cm) (B)							
	15	30	45	Mean (A)	15	30	45	Mean (A)
	2021 season							
	First cut				Second cut			
Control	3.00	3.00	2.67	2.89	3.00	2.67	3.33	3.00
Farm yard manure	3.00	2.67	4.67	3.44	2.67	3.00	4.00	3.22
Poultry manure	2.33	3.33	4.00	3.22	2.67	3.33	3.67	3.22
Plant compost (PC)	3.67	2.67	2.33	2.89	3.33	3.00	2.33	2.89
Animal compost (AC)	3.00	3.67	2.67	3.11	3.00	3.67	3.00	3.22
PC + AC	4.67	3.00	3.00	3.56	5.33	3.33	3.00	3.89
Mean (B)	3.28	3.06	3.22		3.33	3.17	3.22	
L.S.D. at 5 %	A= N.S.	B= N.S.		AB= 1.58	A=0.94	B= N.S.		AB= 1.54
	2022 season							
	First cut				First cut			
Control	2.67	3.00	3.00	2.89	3.00	3.33	3.33	3.22
Farm yard manure	3.00	3.33	3.67	3.33	3.33	3.67	4.00	3.67
Poultry manure	3.00	3.00	4.00	3.33	3.00	2.67	3.67	3.11
Plant compost (PC)	3.33	3.33	2.33	3.00	3.33	2.67	2.67	2.89
Animal compost (AC)	2.67	2.67	2.67	2.67	3.00	3.33	2.67	3.00
PC + AC	3.67	3.33	3.33	3.44	4.33	3.33	3.67	3.78
Mean (B)	3.06	3.11	3.17		3.33	3.17	3.33	
L.S.D. at 5 %	A= 0.69	B= N.S.		AB= 1.24	A= N.S.	B= N.S.		AB= 1.25

Yield and its components

Overall, the application of animal + plant compost at a rate of 20 m^3 per feddan resulted in a significant increase in the total fresh and dry yield per feddan for fertilized moringa plants. This was observed in both cuttings and across the two seasons, as indicated in Tables 5 and 6. In general, it was observed that an increase in the planting space between plants led to a steady drop in the overall fresh and dried herb yield per feddan. The highest recorded fresh and dry weights of the herb per unit area were seen when the plants were fertilized with 20 m^3 of animal plant compost per unit area, and when a planting space of 15 cm was maintained for both cuts in both seasons.

Table 5. Impact of organic fertilization source on total herb fresh weight / feddan (ton) of moringa plant under different plant spaces during 2021 and 2022 seasons

Organic fertilization source (A)	Planting space (cm) (B)							
	15	30	45	Mean (A)	15	30	45	Mean (A)
	2021 season							
	First cut				Second cut			
Control	39.00	28.40	14.29	27.30	39.73	25.97	14.08	26.59
Farm yard manure	45.27	33.93	21.15	33.45	42.29	31.67	19.78	31.25
Poultry manure	20.47	28.13	25.73	24.78	20.93	27.53	23.69	24.05
Plant compost (PC)	33.07	20.27	19.33	24.22	35.33	20.53	20.62	25.50
Animal compost (AC)	40.67	36.67	19.18	32.17	42.67	32.33	19.42	31.47
PC + AC	68.00	38.63	31.29	45.98	69.81	35.53	24.89	43.41
Mean (B)	41.08	31.01	21.83		41.80	28.93	20.41	
L.S.D. at 5 %	A=4.49	B=3.68	AB=8.62		A=4.05	B=2.32	AB=6.15	
	2022 season							
	First cut				Second cut			
Control	41.13	34.93	24.36	33.47	37.20	28.60	22.31	29.37
Farm yard manure	52.47	36.13	25.89	38.16	49.75	25.52	25.82	33.70
Poultry manure	37.13	33.93	26.13	32.46	37.81	32.71	25.73	32.08
Plant compost (PC)	39.93	30.03	17.15	29.04	41.85	24.83	17.96	28.21
Animal compost (AC)	48.07	26.97	17.60	30.88	46.33	30.23	18.09	31.55
PC + AC	85.87	35.93	24.94	48.91	81.33	33.00	22.89	45.74
Mean (B)	50.77	32.99	22.71		49.05	29.15	22.13	
L.S.D. at 5 %	A=3.72	B=2.12	AB=5.63		A=4.81	B=3.63	AB=8.70	

Table 6. Impact of organic fertilization source on total herb dry weight/ feddan (ton) of moringa plant under different plant spaces during 2021 and 2022 seasons

Organic fertilization source (A)	Planting space (cm) (B)							
	15	30	45	Mean (A)	15	30	45	Mean (A)
	2021 season							
	First cut				Second cut			
Control	9.80	6.43	4.00	6.75	7.93	6.37	3.72	6.01
Farm yard manure	11.60	9.07	4.89	8.52	12.64	8.37	4.28	8.43
Poultry manure	5.07	6.90	6.67	6.21	5.23	6.93	6.64	6.27
Plant compost (PC)	7.40	4.43	4.51	5.45	8.47	4.03	4.70	5.73
Animal compost (AC)	8.47	7.83	4.75	7.02	7.96	6.70	4.88	6.51
PC + AC	11.87	9.77	7.51	9.72	17.47	9.27	6.53	11.09
Mean (B)	9.03	7.41	5.39		9.95	6.95	5.13	
L.S.D. at 5 %	A=1.67	B=1.22	AB=2.95		A=0.82	B=0.62	AB=1.48	
	2022 season							
	First cut				Second cut			
Control	15.93	8.77	6.51	10.40	15.33	8.95	6.12	10.14
Farm yard manure	14.87	9.93	6.80	10.53	14.87	9.97	6.51	10.45
Poultry manure	7.80	8.03	6.98	7.60	8.00	7.94	6.79	7.58
Plant compost (PC)	8.07	7.53	5.40	7.00	8.27	7.77	5.85	7.29
Animal compost (AC)	12.40	8.30	5.44	8.71	12.20	7.13	5.20	8.18
PC + AC	20.80	9.37	6.84	12.34	22.67	8.63	6.61	12.64
Mean (B)	13.31	8.66	6.33		13.56	8.40	6.18	
L.S.D. at 5 %	A=0.83	B=0.99	AB=2.14		A=0.54	B=0.66	AB=1.43	

Chemical constituents

The data presented in Tables 7, 8, 9, 10 and 11 demonstrate the variations in chemical constituents of the moringa (*Moringa oleifera* Lam.) plant when subjected to different fertilization methods. Specifically, the determinations of total nitrogen, total phosphorus, potassium and magnesium percentages as well as iron, manganese and total phenols content (expressed as mg /kg of dry weight) were examined. The results indicate that the application of organic fertilizers, particularly animal + plant compost and poultry manure, led to an increase in these chemical constituents. Notably, there were no significant differences observed between the two organic fertilizers in most cases, specifically during the second cut and across both seasons. The data indicated that the chemical contents stated above were significantly influenced by the 40 cm planting space treatment in the second cut, observed in both seasons. In addition, while examining the data presented in the Tables, it becomes evident that the interaction between planting space and organic fertilization treatments resulted in a significant rise in all chemical constituents of moringa. The combination treatment with a planting space of 40 cm and an application rate of 20 m^3/ feddan of animal/plant compost yielded the greatest values. Similarly, the combined treatment of planting distances at 40 cm and an application rate of 20 m^3/ feddan of poultry manure resulted in the highest values during the second cut in both seasons, in most cases.

Table 7. Impact of organic fertilization source on total chlorophyll (a+ b) content (mg/100 g as fresh weight) of moringa plant under different plant spaces during 2021 and 2022 seasons

Organic fertilization source (A)	Planting space (cm) (B)							
	15	30	45	Mean (A)	15	30	45	Mean (A)
	2021 season							
	First cut				Second cut			
Control	4.39	4.40	3.19	3.99	4.25	4.36	3.18	3.93
Farm yard manure	4.41	3.42	3.32	3.72	4.39	3.48	3.29	3.72
Poultry manure	4.39	3.26	4.31	3.99	4.36	3.29	3.82	3.82
Plant compost (PC)	4.05	3.05	4.27	3.79	4.06	2.84	4.12	3.67
Animal compost (AC)	4.30	3.19	3.31	3.60	4.22	3.15	3.27	3.55
PC + AC	4.41	3.32	3.24	3.66	4.45	3.33	3.25	3.68
Mean (B)	4.33	3.44	3.61		4.29	3.41	3.49	
L.S.D. at 5 %	A= 0.12	B= 0.09	AB= 0.21		A= 0.25	B= 0.12	AB= 0.35	
	2022 season							
	First cut				Second cut			
Control	3.41	2.05	3.25	2.91	3.31	2.06	3.13	2.84
Farm yard manure	3.31	2.14	3.22	2.89	3.28	2.14	3.19	2.87
Poultry manure	2.69	1.91	3.45	2.68	2.74	2.00	3.45	2.73
Plant compost (PC)	2.29	2.14	3.58	2.67	2.32	2.13	3.55	2.67
Animal compost (AC)	2.20	2.16	3.46	2.60	2.21	2.21	3.47	2.63
PC + AC	4.19	2.52	3.25	3.31	4.59	2.33	3.23	3.38
Mean (B)	3.02	2.15	3.37		3.08	2.14	3.34	
L.S.D. at 5 %	A= 0.24	B= 0.16	AB= 0.40		A= 0.17	B= 0.12	AB= 0.30	

Table 8. Impact of organic fertilization source on total nitrogen and phosphorus percentages of moringa plant under different plant spaces during 2021 and 2022 seasons

Organic fertilization source (A)	Planting space (cm) (B)							
	15	30	45	Mean (A)	15	30	45	Mean (A)
	Total nitrogen (%)							
	2021 season				2022 season			
Control	2.43	2.68	2.74	2.62	2.54	2.85	2.89	2.76
Farm yard manure	2.47	2.93	2.96	2.79	2.57	3.09	3.11	2.92
Poultry manure	2.80	3.22	3.31	3.11	2.94	3.37	3.48	3.26
Plant compost (PC)	2.54	3.01	3.12	2.89	2.68	3.15	3.26	3.03
Animal compost (AC)	2.59	3.04	3.17	2.93	2.72	3.19	3.34	3.08
PC + AC	2.84	3.26	3.34	3.15	2.98	3.44	3.52	3.31
Mean (B)	2.61	3.02	3.11		2.74	3.18	3.27	
L.S.D. at 5 %	A= 0.09	B= 0.06	AB= 0.14		A= 0.15	B= 0.10	AB= 0.26	
	Total phosphorus (%)							
	2021 season				2022 season			
Control	0.225	0.253	0.256	0.244	0.230	0.256	0.261	0.249
Farm yard manure	0.234	0.273	0.277	0.261	0.239	0.278	0.283	0.267
Poultry manure	0.262	0.302	0.315	0.293	0.266	0.308	0.321	0.298
Plant compost (PC)	0.242	0.283	0.293	0.273	0.247	0.288	0.299	0.278
Animal compost (AC)	0.248	0.287	0.297	0.277	0.253	0.293	0.300	0.282
PC + AC	0.266	0.309	0.319	0.298	0.269	0.316	0.325	0.303
Mean (B)	0.246	0.284	0.293		0.251	0.290	0.298	
L.S.D. at 5 %	A=0.002	B=0.003	AB=0.006		A=0.002	B=0.003	AB=0.006	

Table 9. Impact of organic fertilization source on potassium and magnesium percentages of moringa plant under different plant spaces during 2021 and 2022 seasons

Organic fertilization source (A)	Planting space (cm) (B)							
	15	30	45	Mean (A)	15	30	45	Mean (A)
	Potassium (%)							
	2021 season				2022 season			
Control	1.45	1.61	1.61	1.56	1.49	1.66	2.02	1.61
Farm yard manure	1.49	1.76	1.82	1.69	1.52	1.81	1.88	1.74
Poultry manure	1.67	2.06	2.11	1.95	1.72	2.10	2.18	2.00
Plant compost (PC)	1.51	1.85	1.96	1.77	1.55	1.93	2.02	1.83
Animal compost (AC)	1.57	1.92	2.02	1.83	1.62	1.98	2.09	1.90
PC + AC	1.69	2.08	2.14	1.97	1.74	2.14	2.22	2.03
Mean (B)	1.56	1.88	1.94		1.61	1.94	2.01	
L.S.D. at 5 %	A= 0.08	B= 0.07	AB= 0.16		A= 0.11	B= 0.06	AB= 0.17	
	Magnesium (%)							
	2021 season				2022 season			
Control	0.197	0.273	0.303	0.258	0.178	0.227	0.247	0.217
Farm yard manure	0.223	0.353	0.387	0.321	0.180	0.347	0.377	0.301
Poultry manure	0.323	0.523	0.563	0.470	0.283	0.527	0.587	0.566
Plant compost (PC)	0.243	0.410	0.453	0.369	0.203	0.423	0.477	0.368
Animal compost (AC)	0.247	0.427	0.477	0.383	0.210	0.443	0.507	0.387
PC + AC	0.343	0.527	0.577	0.482	0.307	0.573	0.627	0.502
Mean (B)	0.263	0.419	0.460		0.227	0.423	0.470	
L.S.D. at 5 %	A=0.021	B=0.018	AB=0.041		A=0.028	B=0.019	AB=0.048	

Table 10. Impact of organic fertilization source on iron and magnesium percentages (mg/ kg as dry weight) of moringa plant under different plant spaces during 2021 and 2022 seasons

Organic fertilization source (A)	Planting space (cm) (B)							
	15	30	45	Mean (A)	15	30	45	Mean (A)
	Iron (mg/kg as dry weight)							
	2021 season				2022 season			
Control	175.26	179.12	180.02	178.14	179.01	184.06	184.34	182.47
Farm yard manure	176.13	183.17	184.15	181.15	179.73	187.52	188.22	185.16
Poultry manure	180.89	188.53	190.43	186.62	185.49	193.83	194.62	191.31
Plant compost (PC)	177.40	184.81	186.61	182.94	180.56	188.90	190.89	186.78
Animal compost (AC)	178.26	186.00	187.80	184.02	182.57	189.59	191.31	187.83
PC + AC	182.11	189.46	191.35	187.64	185.83	194.14	195.10	191.69
Mean (B)	178.34	185.18	186.73		182.20	189.68	190.75	
L.S.D. at 5 %	A= 2.70	B= 1.56	AB= 4.12		A= 3.16	B= 1.69	AB= 4.63	
	Manganese (mg/kg as dry weight)							
	2021 season				2022 season			
Control	35.48	36.93	37.08	36.50	36.28	37.25	37.60	37.04
Farm yard manure	36.01	37.73	38.22	37.32	36.63	38.39	38.59	37.87
Poultry manure	37.50	39.34	39.74	38.86	37.91	39.93	40.45	39.43
Plant compost (PC)	36.33	38.44	38.86	32.88	36.91	38.92	39.47	38.44
Animal compost (AC)	36.57	38.67	39.26	38.17	37.30	39.17	39.72	38.73
PC + AC	37.85	39.49	40.14	39.16	38.38	40.25	40.71	39.78
Mean (B)	36.62	38.43	38.88		37.23	38.98	39.43	
L.S.D. at 5 %	A= 1.69	B= 1.23	AB= 2.98		A= 0.62	B= 0.29	AB= 0.85	

Table 11. Impact of organic fertilization source on total phenols content (mg/ 100 g as dry weight) of moringa plant under different plant spaces during 2021 and 2022 seasons

Organic fertilization source (A)	Planting space (cm) (B)							
	15	30	45	Mean (A)	15	30	45	Mean (A)
	Total phenol content (mg/ 100 g as dry weight)							
	2021 season				2022 season			
Control	165.99	177.46	180.60	174.69	171.36	183.72	185.84	180.30
Farm yard manure	169.21	188.04	191.06	182.77	174.45	193.75	198.78	189.00
Poultry manure	184.04	203.78	209.22	199.01	189.56	209.49	217.49	205.51
Plant compost (PC)	171.52	194.12	199.06	188.24	176.82	199.92	206.18	194.30
Animal compost (AC)	174.90	195.94	201.86	190.90	179.88	202.58	208.59	197.02
PC + AC	185.98	206.34	211.93	201.42	192.97	213.42	219.90	208.76
Mean (B)	175.27	194.28	198.96		180.84	200.48	206.13	
L.S.D. at 5 %	A= 3.10	B= 1.45	AB= 4.25		A= 3.21	B= 1.45	AB= 4.32	

Economics analysis:

Data presented in Table 12 reveal that the moringa farm capacity regard total herb fresh yield per feddan for the treatment with poultry manure fertilization of is the highest in terms of the value of return and economic profit, with an average value of 125.00 to 152.64 thousand pounds as well as 3.47 to 4.24 pounds, followed by the treatment with animal/ plant compost, with an average value of 123.52 to 128.68 thousand pounds as well as 3.43 to 3.57 pounds. In addition, the moringa farm capacity regard total herb dry yield per feddan for the treatment with poultry manure fertilization of is the highest in terms of the value of return and economic profit, with an average value of 843.00 to 1053.00 thousand pounds as well as 23.42 to 29.25 pounds, followed by the treatment with farmyard manure, with an average value of 601.00 to 1040.00 thousand pounds as well as 16.69 to 28.88 pounds. In general, it is clear from the economic analysis that the dry herb yield gives a higher financial return than the fresh grass herb yield per feddan

Table 12. Indicators of the economic evaluation of herb fresh yield/ feddan under different sources of organic fertilization effect during the first and second cuts during 2021 and 2022 seasons

Organic fertilization source	The return on the invested pound				Economic profit (pound)			
	Fresh yield of herb/ feddan (ton=4,000 pounds)							
	2021 season		2022 season		2021 season		2022 season	
	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut	1st cut	2nd cut
Farm yard manure	109.20	106.36	133.88	117.48	3.03	2.95	3.72	3.26
Poultry manure	133.80	125.00	152.64	134.80	3.72	3.47	4.24	3.74
Plant compost (PC)	99.12	96.20	129.84	128.32	2.75	2.67	3.61	3.56
Animal compost (AC)	96.88	102.00	116.16	112.84	2.69	2.83	3.23	3.13
PC + AC	128.68	125.88	123.52	126.20	3.57	3.49	3.43	3.50
	Dry yield of herb / feddan (ton= 100,000 pounds)							
Farm yard manure	675.00	601.00	1040.00	1014.00	18.75	16.69	28.88	28.16
Poultry manure	852.00	843.00	1053.00	1045.00	23.66	23.42	29.25	29.03
Plant compost (PC)	621.00	627.00	760.00	758.00	17.25	17.42	21.11	21.05
Animal compost (AC)	545.00	573.00	700.00	729.00	15.14	15.92	19.44	20.25
PC + AC	702.00	651.00	871.00	818.00	19.50	18.08	24.19	22.72

Discussion

Effect of organic fertilization

The observed enhancements in plant height and branch count per plant could potentially be attributed to the crucial and indispensable influence of organic fertilizer. The utilization of animal/ plant compost has been found to have a stimulatory impact on soil conditions, including improvements in physical, chemical, biological, textural, and drainage properties. These enhancements subsequently contribute to the good growth of plants (Kocabas *et al.*, 2010).

Similarly, Massoud *et al.* (2016) conducted a study on *Achillea millefolium*, while Sharaf EL-Din *et al.* (2019) focused on *Thymus vulgaris* and Attia *et al.* (2022) examined *Majorana hortensis*, all of which yielded comparable findings. In a study conducted by Kamal *et al*. (2023), it was observed that the application of organic fertilizers had a significant impact on the growth of coriander. Specifically, the use of 20 m^3/ feddan of compost resulted in the highest and most significant improvements in vegetative growth and yield metrics for both seasons.

Effect of planting space

The observed increase in plant height and number of branches per plant resulting from the manipulation of plant distance can likely be attributed to reduced rivalry among plants for light acquisition. This phenomenon leads to a more robust growth pattern, characterized by increased plant height and branching, particularly in instances when wider spacing is used. Furthermore, the study conducted by Murti *et al.* (2021) found that the treatment with a planting spacing of 10 × 20 cm exhibited the most significant development and productivity in shallots. This treatment yielded various lengths of bulbs, as well as higher wet and dry bulb yields per plot. The findings presented here are consistent with the research conducted by Vakili Shahrbabaki (2014) regarding the therapeutic properties of the henna plant, as well as the study conducted by Refaay *et al.* (2023) on *Thymus vulgaris*. In contrast, Massoud *et al*. (2012) found that *Melissa officinalis* plants grown in a restricted space of 40 cm exhibited the greatest height.

Effect of combination between organic fertilization and planting space

As previously stated, the use of both organic fertilization and planting space treatments individually resulted in enhanced plant growth. However, when used in conjunction, these treatments may have a synergistic effect, resulting to the tallest moringa plants, increased branch density, and the highest fresh and dry weight of herbs per unit area. Furthermore, Riyana *et al.* (2018) suggest that the utilization of chicken manure at a rate of 20 ton/ha, in conjunction with a plant spacing of 40 cm × 40 cm, yielded the most significant outcomes in terms of leaf length, fresh weight, and dry weight of *Elephantopus scaber* plants. Additionally, Joshi *et al*. (2020) proposed that in order to achieve increased flower and essential oil production in chamomile, it is advisable to use barnyard millet straw at a rate of 5 tons per hectare, combined with a spacing of 30×10. In the same time, Mirjalili *et al.* (2022) have highlighted that the highest recorded plant weight of *Satureja bachtiarica* was achieved by the application of manure at a high plant density of 80,000 plants per hectare during the second year of cultivation. The layouts that received manure treatment and high plant density had the highest amounts of nitrogen (N) and magnesium (Mg). Furthermore, a study conducted by Mohamed *et al*. (2023) on *Artemisia annua* demonstrated that optimal values for vegetative growth parameters and chemical constituents (including chlorophyll a and b contents, total carbohydrates, and percentages of N, P, and K) were observed in both cutting methods and seasons when using a planting distance of 40 × 40 cm and 100% organic fertilizers.

CONCLUSION

The present study aimed to assess the effects of various organic fertilization sources and different planting space on the growth and development of moringa (*Moringa oleifera* Lam.). The findings of the study indicated that both planting area and organic fertilizer had a statistically significant favorable effect on the growth and productivity of moringa. The significant outcome in this research was achieved when the plant had a treatment of 20 m^3 per feddan of animal+ plant compost, and was afterwards seeded with a spacing of 15 cm. From economic analysis it is clear that, the highest the values of return and economic profit for fresh yield was that animal + plant compost as organic fertilization source.

REFERENCES

A.O.A.C. (1970). "Methods of Analysis of the Association Official Agricultural Chemists" 20th Ed., Washington. D.C. USA.

Amara, D.G. and S.M. Mourad (2013). Influense of organic manure on the vegetative growth and tuber production of potato (solanum tuberosum L varspunta) in a Sahara desert region. J. Agri. Crop Sci., 22 (5): 2724-2731.

Analytical Software (2008). Statistix Version 9, Analytical Software, Tallahassee, Florida, USA.

Attia, E.M.; W.I. Mohamed and E.S. Hamed (2022). Influence of some types of organic fertilizers on marjoram plant under Siwa Oasis conditions. International Journal of Herbal Medicine, 10 (2): 20-25.

Bhagubha, G. Y. (2021). The impact of farm yard manure (FYM) on plant pigment of women friendly medicinal plant fenugreek by paper chromatography. Journal of Emerging Technologies and Innovative Research, 8 (1): 988-993.

Carbonari, V. B.; M. C. Vieira; N. A. Z. Heredia and M. E. Marchetti (2006). Phosphorus and chicken manure on development and yield of *Tropaeolum majus* L. Rev. Bras. Pl. Med., Botucatu, 8 (esp.): 71-77.

Chapman, D.H. and R.F. Pratt (1978). Methods of Analysis for Soils, Plants and Waters. Div. Agric. Sci. Univ. of California USA pp: 16-38.

Cherry, J. H. (1973). Molecular Biology of Plants (A text manual). Columbia Univ. Press, New York.

Cook, R. L. and B.G. Ellis (1987). Soil Management: A Worldview of *Coiisenatioti* and Production. Wiley: New York, pp. 152- 170.

Foidl, N.; H.P.S. Makkar and K. Berker (2001). The potential of *Moringa oleifera* for agricultural and industrial uses. In: Fuglie, L. J. (ed.). The miracle tree: the multiple attributes of Moringa. CTA / CWS. Dakar, Sénégal. Pp. 45–76.

Fuglie, L. J. (2001a). Introduction to the multiple uses of Moringa. In: Fuglie, L. J. (ed.). The miracle tree: the multiple attributes of Moringa. CTA /CWS. Dakar, Sénégal.Pp.7–10.

Fuglie, L. J. (2001b). Natural nutrition for the tropics. In: Fuglie, L. J. (ed.). The miracle tree: the multiple attributes of Moringa. CTA / CWS. Dakar, Sénégal. Pp. 103–115.

Gomez, N.K. and A.A. Gomez (1984). Statical Procedures for Agricultural Research. 2nd Ed., John wiley and sons, New York. USA, 680.

Jamal, J and H. Ozra (2014). Humic acid and manure tea affected reproductive stage and fruit quality factors of pepino in organic production system, proceedings of the 4th ISOF SAR Scientific Conference (Building Organic Bridges), at the Organic World Congress , 13-15 Oct., Istanbul , Turkey (e-print ID 23677).

Joshi, Sh.; S. Melkani and M. Y. Sajwan (2020). Effect of organic mulching and distance on soil properties and yield of chamomile (*Matricaria chamomilla* L.) cv. CIM Sammohak. International Journal of Chemical Studies, 8 (5): 1109-1115.

Kocabas, I.; M. Kaplan; M. Kurkcuoglu and K. H. C. Baser (2010). Effects of different Compost applications on the essential oil components of Turkish sage (*Salvia fruticosa* Mill). Asian J. Chem., 22 (2): 1599-1605.

Kumpulainen, I.; A. M. Raittila; I. Lehto and P. Koiristoinen (1983). Electro thermal atomic absorbtion spectrometric determination of heavy metals in foods and diets. I. Associ. Off. Anal. Chem., 66: 1129-1135.

Loredana, L.; P. Catello; A. Donatella; C. Giuseppe; Z. Massimo and M. Marisa (2015). Compost and compost tea management of mini watermelon cultivations affects the chemical, physical and sensory assessment of the fruits. Agricultural Sciences, 6:117-125

Makkar, H.P.S. and K. Becker (1997). Nutrients and anti- quality factors in different morphological parts of the *Moringa oleifera* tree. J. Agric. Sci., 128:311–32.

Massoud, H.Y.; H.H. Abdel-Kader; F.R. Ibrahim and A.M. Ibrahim (2016). Effect of mineral fertilizer and compost on vegetative growth and essential oil content of yarrow (*Achillea millefolium* l.) plant. J. Plant Production, Mansoura Univ., 7 (6): 559-565.

Massoud, H. Y. ; S.M.A. El-Gamal and R. M. M. Ali (2012). Effect of planting space and some biofertilization on plant growth, yield and chemical composition of lemon balm (*Melissa officinalis* L.) plants. J. Plant Production, Mansoura Univ., 3 (5): 889 – 905.

Mehriya, M.L.; D. Singh; A. Verma; S.N. Saxena; A. Alataway; A.A. Al-Othman; A.Z. Dewidar and M.A. Mattar (2022). Effect of date of sowing and spacing of plants on yield and quality of chamomile (*Matricaria chamomilla* L.) grown in an arid environment. Agronomy, 2912 (12): 1-13.

Mirjalili, A.; M.H. Lebaschi; M.R. Ardakani; H. H. Sharifabad and M. Mirza (2022). Plant density and manure application affected yield and essential oil composition of Bakhtiari savory (Satureja bachtiarica Bunge.). Industrial Crops and Products, 177 (1): 1-14.

Mohamed, S.M.; Y. F. Y. Mohamed; D.M. Saleh and E.M. Abou-El-Ghait (2023). Influence of planting distances in presence of chemical fertilization and compost on growth, essential oil, artemisinin content and chemical constituents of Artemisia annua L. plant. J. of Plant Production, Mansoura Univ., 14 (2):31-43.

Morton, J. F. (1991). The horseradish tree, *Moringa pterygosperma* (Moringaceae) a boon to arid lands. Econ. Bot., 45 (3): 318-333.

Murti, A.C.; W.D.P. Al Machfudz; A. E. Prihatiningrum and S. Arifin (2021). Effect of planting distance and bulb size on growth and production of shallots (*Allium ascalonicum* L.). IOP Conf. Series: Earth and Environmental Science, 1104: 1-8.

Ramachandran, C.; K. V. Peter and P. K. Gopalakrishnan (1980). Drumstick (*Moringa oleifera*): a multipurpose Indian vegetable. Econ. Bot., 34 (3): 276- 283.

Refaay, M.S.; Y. F. Y. Mohamed; A. A. Dewidar and S.M. Mohamed (2023). Impact of planting distances and natural plant extracts on vegetative growth, chemical constituents and oil productivity on thyme plant. J. of Plant Production, Mansoura Univ., 14 (7): 357-365.

Riyana, D.; Y. Widiyastuti; H. Widodo; E. Purwanto and S. Samanhudi (2018). Effect of manure and plants spacing on yield and flavonoid content of *Elephantopus scaber* L. IOP Conf. Series: Earth and Environmental Science, 142: 1-12.

Samanhudi, A. Y.; B. Pujiasmanto and M. Rahayu (2014). Application of organic manure and mycorrhizal for improving plant growth and yield of temulawak (*Curcuma xanthorrhiza* Roxb.). Scientific Research Journal (SCIRJ), 2 (5): 11-16.

Sharaf EL-Din, M. N.; H. A. Ahmed; M. M. Shalan and H. M. Hussien (2019). The effect of organic and bio-fertilization on vegetative growth and yield of thyme (*Thymus vulgaris*, L.). J. of Plant Production, Mansoura Univ., 10 (12): 1175 -1185.

Vaher, M.; M. Borissova; A. Seiman; T. Aid; H. Kolde; J. Kazarjan and M. Kaljurand (2014). Automatic spot preparation and image processing of paper microzone-based assays for analysis of bioactive compounds in plant extracts. Food Chem., 143: 465-471.

Vakili Shahrbabaki, S.M.A. (2014). The effect of plant density and quantity of nitrogen fertilizer on vegetative function of *Lawsonia inermis* L. in Jiroft. Int. J. Adv. Biol. Biom. Res., 2 (1): 51-62.

Waterhouse, A.L. (2002). Determination of total phenolics. Curr. Protoc. Food Anal. Chem., 6: 111–118.

دراسات على تحسين خواص نباتات المورينجا النامية تحت ظروف اراضي الاستصلاح

محمد نزيه شرف الدين[1]، هبه الله على محمود السيد[2]، أحمد عبد المنعم السيد هلالي[1]، محمود محمد ناجي شعلان[3] وهاني محمد حسين عوض[1]

[1] قسم الخضر والزينة- كلية الزراعة - جامعة المنصورة - مصر.
[2] قسم الإقتصاد الزراعي- كلية الزراعة - جامعة المنصورة – مصر.
[3] قسم النباتات الطبية والعطرية – معهد بحوث البساتين – مركز البحوث الزراعية – القاهرة – مصر.

الملخص

أجريت تجربة حقلية (منطقة الجيش الثالث) بقرية جنيفا بمركز الجناين بمحافظة السويس بمصر خلال الموسمين المتتاليين لأعوام 2021 و 2022 لدراسة معاملات مختلفة لتحسين تطور وإنتاج نبات المورينجا أوليفيرا. كانت النباتات نامية تحت ظروف التربة المستصلحة. كان الهدف من هذه الدراسة هو تقييم تأثير مصادر مختلفة من الأسمدة العضوية (الكنترول، سماد المزرعة، سبلة الدواجن، الكمبوست النباتي، الكمبوست الحيواني والكمبوست النباتي الحيواني كل منها بمعدل 20 م3 / فدان)، ومسافات زراعة مختلفة (15 و 30 و 45 سم بين الجور) ومعاملات التداخل بينهما على النمو والإنتاجية والمحتوى الكيميائي لنباتات المورينجا. وتشير النتائج التي تم الحصول عليها إلى أن المعاملة الأكثر فعالية من حيث عدد الأفرع لكل نبات وكذلك الأوزان الطازجة والجافة للعشب للفدان هي معاملة التداخل بين الكمبوست النباتي الحيواني مع زراعة جور النبات على مسافة 15 سم. وقد تفوقت تلك المعاملة على المعاملات الأخرى قيد الدراسة في كلا الحشتين الأولي والثانية من كلا الموسمين. أدت إضافة 20 م3/ فدان من الكمبوست النباتي + الحيواني بمعدل 20 م3/ فدان ومسافة الزراعة على 15 سم إلى زيادة معنوية في المحتوى الكلي من الكلوروفيل لنباتات المورينجا مقارنة بالمعاملات الأخرى. أدى الكمبوست النباتي + الحيواني مع زراعة النباتات على مسافة 45 سم إلى الحصول على أعلى النسب المئوية للنيتروجين والفوسفور والبوتاسيوم والمغنيسيوم، بالإضافة إلى أعلى محتوى من الحديد والمنجنيز والفينولات الكلية. تم الحصول على أعلى عائد على الجنيه المستثمر لإنتاج محصول العشب الطازج والجاف للفدان باستخدام الكمبوست النباتي الحيواني.