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Effect of planting dates and plant spacing on growth, yield and chemical constituents of *Moringa oleifera* plants

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Abstract

A field experiment was carried out in Sohag governorate, Egypt, during two successive seasons, 2017 and 2018, to evaluate the effect of planting dates and plant spacing on growth, yield and some chemical constituents of moringa plants. The planting dates were (May 1st, May 15th and June 1st), and the plant spacing were (10, 20 and 30 cm). The results showed that, generally, planting dates improved growth characters, yield and chemical constituents. The highest values were observed when planting moringa on May 1st. In regard plant spacing, all of them led an increase the growth characters, yield and chemical constituents. The best results when plant spacing was 30 cm between plants, the combined effect between planting dates and plant spacing on moringa parameters was statistically significant. In most cases, planting moringa on the May 1st with plant spacing of 30 cm was the most effective treatment concerning growth, yield as well as chemical constituents.

Keywords: *Moringa oleifera*, planting dates, plant spacing, yield.

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1. Introduction

Moringa oleifera Lam. (Moringaceae) is a plant of great importance because of its industrial, medicinal and food uses. *Moringa oleifera* leaves and fruits are widely consumed by rural populations of tropical regions of the world (Ramachandran *et al*. 1980; Lockett *et al*., 2000). *Moringa oleifera* originated from the foothills of the Himalayas in North-Western India and is cultivated throughout the tropics (Nagao, 2008). moringa can be cultivated in a wide range of soil types but grow best in well-drained loam to clay loam soil with slightly acidic to neutral pH. However, it cannot withstand prolonged water logging. Moringa is very useful in the following areas; as alley cropping, animal forage, biogas, domestic cleaning agent, green manure, gum, medicine, ornamental plants, and water purification. Moringa leaves, seeds, and roots are also used in treating diseases like lung diseases, hypertension and skin infection (Fuglier, 1999; WHO, 2012). Moringa is nutritional and rich in vitamins and minerals, the most nutritious part of the plant are leaves, being a significant source of vitamin B6 vitamin C, and provitamin A as beta carotene, magnesium, and calcium (Bharali *et al*., 2003). Effective cultivation of any crop is located by several factors; sowing date is one of the earnest aspects of the production system of sundry crops. Optimum sowing or planting date encloses proper development and growth of plant, resulting in maximum growth and yield of the crop and economic utilize of cultivated regions (Islam *et al*., 2010). Planting date has serious influence on plant development and influences on the active substances of aromatic and medicinal crops (Ghani *et al*., 2011). Earlier sowing enhanced the time length that plants can use suitable growing conditions (Soleimani *et al*., 2011). Therefore, this investigation was designed to study the influence of planting dates, plant spacing and their interactions on growth, yield and some chemical constituents of moringa plants.

2. Materials and methods

2.1 Experimental site and treatments

An experiment was carried out on a private farm in Sohag governorate, Egypt, during two successive seasons (2017 and 2018) to study the influence of planting dates and plant spacing on growth, yield parameters and chemical constituents of moringa plants under Upper Egypt conditions. The experimental plot was 2.4 × 3.6 m having 5 rows at 60 cm apart with 10, 20 and 30 cm hills distances in the row (115, 55 and 35 plants/plot), approximate plant population was 53245, 25465 and 16205 plants per acre, respectively. The experiment was a split-plot design with three replicates. moringa plants were sown three time on May 1st, May 15th and June 1st of the two seasons. Chemical and physical analyses of soil were carried out according to Page *et al*. (1982) and Klute (1986). Some physical and chemical properties of the field experiment are presented in Table (1).

Table (1): The physical and chemical properties of the experimental soil.

Characters	Value	
	2017	2018
Clay (%)	48.21	47.81
Silt (%)	35.12	36.20
Sand (%)	13.61	13.12
Organic matter (%)	2.45	2.61
Texture	Clay loam	Clay loam
$CaCo_3$ (%)	2.53	2.41
PH (1:2.5)	7.71	7.82
E.C m/mhos/cm	1.31	1.37
Total N (%)	0.15	0.13
Available P (%)	2.78	3.05
Exchange K (mg/100 g soil)	2.28	2.17
Exchange Ca^{++} (mg/100 g soil)	35.3	33.10
Exchange Na (mg/100 g soil)	2.22	2.31

The following data were recorded for each cut as follows: (plant height, leaves number /plant, leaves fresh weight (g)/ plant, leaves dry weight (g)/plant, leaves fresh yield and leaves dry yield (ton/acre), as well as, Fe, Zn were determined in the acid digested samples according to Cottenie *et al*. (1982), protein and carbohydrates percentage (total Carbohydrates were determined in dry leaves according to Dubois *et al*. 1956). All obtained data were tabulated and statistically analyzed according to Statistix version 8.1 (2003) using the L.S.D. test at 5% to know the differences among all treatments according to Mead *et al*. (1993).

3. Results and discussion

3.1 Plant height

Data listed in Table (2) reveal that the planting dates on May 1st, May 15th and June 1st led to a significant increase in plant height in both seasons. Moreover, it was found that planting the seeds on 1st June led to a significant increase in plant height produced. The highest values were (111.2, 117.1 and 120.4 cm)) at the second season for all cuts respectively compared to the other planting dates. Concerning the influence of plant spacing, data in Table (2) show that all of them significantly led increasing plant height in the two seasons. The tallest plants of moringa were obtained at 30 cm space between plants which recorded (111.6, 124.2 and 127.6) and (113.6, 126.9 and 130.4) in the two growing seasons, at all cuts respectively. With respect to the combined effect between planting dates and plant spacing on plant height, it was significant in both seasons. The most effective treatments concerning plant height were planting on 1st June with space 30 cm which recorded (121.7, 129.3 and 133.7) and (123.0, 133.3 and 136.3) in the three cuts at the two experimental seasons, respectively compared to the other combination treatments, as illustrated in Table (2).

Table (2): The influence of planting dates and plant spacing on plant height (cm) of moringa plants during the seasons of 2017 and 2018.

Planting density (B)	Planting dates (A)											
	First cut			Mean (B)	Second cut			Mean (B)	Third cut			Mean (B)
	May 1st	May15th	June 1st		May 1st	May15th	June 1st		May 1st	May15th	June 1st	
First season												
10 cm	84.0	88.0	98.0	90.0	89.0	91.3	100.3	93.6	92.3	97.7	104.3	98.1
20 cm	90.3	112.3	114.0	105.6	104.7	119.7	121.7	115.3	110.0	114.3	123.3	115.9
30 cm	96.3	116.7	121.7	111.6	120.3	123.0	129.3	124.2	123.7	125.3	133.7	127.6
Mean (A)	90.2	105.7	111.2		104.7	111.3	117.1		108.7	112.4	120.4	
L.S.D. at 5%	A: 1.0	B: 0.9	AB: 1.7		A: 1.1	B: 1.0	AB: 1.8		A: 2.1	B: 2.5	AB: 4.3	
Second season												
10 cm	86.7	90.0	101.0	92.6	92.0	95.3	110.7	99.3	99.7	104.0	111.3	105.0
20 cm	93.3	115.7	117.3	108.8	105.7	121.3	125.7	117.6	112.3	117.3	127.0	118.9
30 cm	99.3	118.3	123.0	113.6	122.7	124.7	133.3	126.9	125.7	129.3	136.3	130.4
Mean (A)	93.1	108.0	113.8		106.8	113.8	123.2		112.6	116.9	124.9	
L.S.D. at 5%	A: 1.5	B: 1.2	AB: 2.1		A: 0.7	B: 1.0	AB: 1.7		A: 2.6	B: 1.6	AB: 2.8	

3.2 Leaves number /plant

Data in Table (3) revealed that the cultivation of moringa plants on 1st May, 15th May and 1st June, in all cuts, during both seasons, significantly increased leaves number/ plant of moringa, the highest values of leaves number/ plant at all cuts, when moringa was sowing on 1st June which reached 14.83, 15.72 and 16.67, 15.59, 16.67 and 17.67 during the two seasons, respectively. Obviously, with plant spacing 10, 20 and 30 cm, at all cuts, in both seasons them significantly increased in this aspect. Moreover, 30 cm space gave the best results which recorded (15.48, 16.22 and 17.22) and (16.26, 17.28 and 18.28) in the two growing seasons, at all cuts respectively. As a result of the interaction treatments between the two examined factors. The highest values of leaves number/ plant were obtained from the third cut, followed by the second cut and then the first one, during the two seasons. Clearly, the most effective treatment on augmenting leaves number/ plant was given by cultivation the plants on 1st June with the space of 30 cm between plants in comparison with those revealed by other combination treatments, during the two consecutive seasons.

Table (3): The influence of planting dates and plant spacing on leaves number /plant of moringa plants during the seasons of 2017 and 2018.

Planting density (B)	Planting dates (A)											
	First cut			Mean (B)	Second cut			Mean (B)	Third cut			Mean (B)
	May 1st	May15th	June 1st		May 1st	May15th	June 1st		May 1st	May15th	June 1st	
First season												
10 cm	9.5	10.5	12.5	10.83	9.83	11.17	13.33	11.44	10.33	12	14.17	12.17
20 cm	11.43	13	15	13.14	11.67	14	16	13.89	12.33	15	17	14.78
30 cm	14.43	15	17	15.48	14.83	16	17.83	16.22	15.83	17	18.83	17.22
Mean (A)	11.79	12.83	14.83		12.11	13.72	15.72		12.83	14.67	16.67	
L.S.D. at 5%	A: 0.3	B: 0.3	AB: 0.5		A: 0.5	B: 0.4	AB: 0.7		A: 0.7	B: 0.3	AB: 0.6	
Second season												
10 cm	10.33	12	13.33	11.89	10.83	13	14.33	12.72	11.67	14	15.33	13.67
20 cm	12.33	14.5	15.83	14.22	13	15.33	17	15.11	13.67	16.33	18	16
30 cm	15	16.17	17.6	16.26	16.17	17	18.67	17.28	17.17	18	19.67	18.28
Mean (A)	12.55	14.22	15.59		13.33	15.11	16.67		14.17	16.11	17.67	
L.S.D. at 5%	A: 0.2	B: 0.4	AB: 0.7		A: 0.3	B: 0.4	AB: 0.8		A: 0.3	B: 0.4	AB: 0.8	

The effectiveness of planting dates and plant spacing in augmenting growth parameters of moringa was revealed by Edward *et al*. (2012), Goss Maria (2012), Douglas (2014), Adegun and Ayodele (2015), Hegazi (2015), Sosa-Rodríguez *et al*. (2017), Mabapa *et al*. (2017), Chau and Sam (2021) and Mahmoud *et al*. (2021).

3.3 Leaves fresh and dry weight (g/plant) and yield (ton/ acre)

The presented data in Tables (4, 5, 6 and 7) shows that planting moringa (*Moringa oleifera*) plants at the following times on 1st May, 15th May and 1st June led to a significant increase in leaves fresh and dry weight g/ plant and leaves fresh and dry yield ton/acre at all times. However, it is obvious that the best production of leaves g/plant were obtained due to planting the plants at the third time (1st June) in all cuts and the total yield of leaves fresh and dry weight during both seasons, the results were as follows (206.56, 220.00 and 228.72) and (215.33, 228.44 and 238.16) g/plant leaves fresh weight and it was (45.98, 69.60 and 78.9) and (57.14,71.89 and 81.33) g/plant leaves dry weight at the three cuts to both seasons respectively. Results represented in Table (6) demonstrated that the highest yield of the fresh leaves were 17.65 and 18.34 ton/acre as a result of the increment in leaves fresh yield on 1st June, the yield of dry leaves were the highest on the same time which the values of 5.60 and 5.77 ton/acre (Table 7).

Table (4): The influence of planting dates and plant spacing on leaves fresh weight (g)/plant of moringa plants during the seasons of 2017 and 2018.

Planting density (B)	Planting dates (A)											
	First cut			Mean (B)	Second cut			Mean (B)	Third cut			Mean (B)
	May 1st	May15th	June 1st		May 1st	May15th	June 1st		May 1st	May15th	June 1st	
First season												
10 cm	108	115.33	125.67	116.33	118.67	126	139.67	128.11	123.83	132.5	152.17	136.17
20 cm	136	172.67	194	167.56	149	181.33	204	178.11	155.5	186.83	209.83	184.05
30 cm	186.67	262.67	300	249.78	199.33	273.33	316.33	263	205.83	280.83	324.17	270.28
Mean (A)	143.56	183.56	206.56		155.67	193.55	220		161.72	200.05	228.72	
L.S.D. at 5%	A: 2.2	B: 2.7	AB: 4.7		A: 2.5	B: 2.3	AB: 4.1		A: 1.6	B: 1.7	AB: 2.9	
Second season												
10 cm	111.67	121.33	130.67	121.22	123.33	130.33	144.33	132.66	127.5	138.17	156.83	140.83
20 cm	146	178.33	202	175.44	157.33	188.33	213.33	186.33	166.83	194.5	218.83	193.39
30 cm	193.67	267.67	313.33	258.22	210.33	279.67	327.67	272.56	215.17	289.17	338.83	281.06
Mean (A)	150.45	189.11	215.33		163.66	199.44	228.44		169.83	207.28	238.16	
L.S.D. at 5%	A: 2.1	B: 3.1	AB: 5.4		A: 2.4	B: 3.9	AB: 6.7		A: 2.7	B: 1.8	AB: 3.1	

Table (5): The influence of planting dates and plant spacing on leaves dry weight (g)/ plant of moringa plants during the seasons of 2017 and 2018.

Planting density (B)	Planting dates (A)											
	First cut			Mean (B)	Second cut			Mean (B)	Third cut			Mean (B)
	May 1st	May15th	June 1st		May 1st	May15th	June 1st		May 1st	May15th	June 1st	
First season												
10 cm	29.53	32.07	33.6	31.73	43.33	45.5	47.8	45.54	51.93	55.2	56.7	54.61
20 cm	39	47.33	51.33	45.89	53	62	66.33	60.44	63	70.83	75.67	69.83
30 cm	44.67	68.33	80	64.33	60	83.67	94.67	79.45	69.67	93.17	104.33	89.06
Mean (A)	37.73	49.24	54.98		52.11	63.72	69.6		61.53	73.07	78.9	
L.S.D. at 5%	A: 0.6	B: 0.8	AB: 1.4		A: 1.2	B: 0.6	AB: 1.1		A: 1.0	B: 1.0	AB: 1.7	
Second season												
10 cm	29.87	33.03	34.43	32.44	44	47.5	48.67	46.72	52.9	56.33	58.33	55.85
20 cm	39	49.67	53.33	47.33	55	64	68	62.33	64.67	72.33	77.33	71.44
30 cm	46.67	71.33	83.67	67.22	62.33	86.33	99	82.55	72.33	96.67	108.33	92.44
Mean (A)	38.51	51.34	57.14		53.78	65.94	71.89		63.3	75.11	81.33	
L.S.D. at 5%	A: 1.7	B: 1.9	AB: 3.4		A: 1.0	B: 1.2	AB: 2.1		A: 1.1	B: 1.0	AB: 1.6	

Table (6): The influence of planting dates and plant spacing on leaves fresh yield (ton/acre) of moringa plants during the seasons of 2017 and 2018.

Planting spacing (B)	Planting dates (A)			
	May 1st	May15th	June 1st	Mean (B)
First season				
10 cm	18.66	19.90	22.23	20.26
20 cm	11.22	13.77	15.48	13.49
30 cm	9.59	13.24	15.24	12.69
Mean (A)	13.16	15.64	17.65	
L.S.D. at 5%	A: 0.27	B: 0.26	AB: 0.45	
Second season				
10 cm	19.3	20.76	22.99	21.02
20 cm	11.97	14.29	16.15	14.14
30 cm	10.03	13.56	15.88	13.16
Mean (A)	13.77	16.2	18.34	
L.S.D. at 5%	A: 0.14	B: 0.16	AB:0.27	

Table (7): The influence of planting dates and plant spacing on leaves dry yield (ton/acre) of moringa plants during the seasons of 2017 and 2018.

Planting spacing (B)	Planting dates (A)			
	May 1st	May15th	June 1st	Mean (B)
First season				
10 cm	6.64	7.07	7.35	7.02
20 cm	3.95	4.59	4.92	4.49
30 cm	2.83	3.97	4.52	3.77
Mean (A)	4.47	5.21	5.6	
L.S.D. at 5%	A: 0.14	B: 0.18	AB: 0.31	
Second season				
10 cm	6.75	7.29	7.53	7.19
20 cm	4.04	4.74	5.06	4.61
30 cm	2.94	4.12	4.72	3.93
Mean (A)	4.58	5.38	5.77	
L.S.D. at 5%	A: 0.07	B: 0.13	AB: 0.21	

Concerning the influence of plant spacing, data in Tables (4, 5, 6 and 7) show that all of them significantly led to an increase leaves fresh and dry weight g/ plant and leaves fresh and dry yield (ton/acre) in the two seasons. It is clear that the best results of moringa fresh and dry leaves were obtained when the space was 30 cm between plants which recorded (249.78, 263.00 and 270.28) and (258.22, 272.56 and 281.06) leaves fresh weight g/plant. Also, the same space was recorded (64.33, 79.45 and 89.06) and (67.22, 82.55 and 92.44) g/plant leaves dry weight at the three cuts in the two growing seasons respectively. While the plant spacing of 10 cm gave the highest production (20.26 and 21.02) ton/acre fresh yield and (7.02 and 7.19) ton/acre dry yield of leaves in two seasons respectively. As for the interaction, it could be noticed that it was statistically significant on leaves fresh and dry weight g/plant and leaves fresh and dry yield (ton/acre) of moringa among all cuts, during the two growing seasons. Clearly, applying all combined treatments, in the three cuts, for both seasons, resulted a significant augment in leaves fresh and dry weight g/plant and leaves fresh and dry yield (ton/acre). In this concern, the use of the planting date

June 1st with the space 30 cm was the highest among all cuts for leaves fresh and dry weight g/ plant. While the same planting date 1st June with 10 cm space between plants gave the best result for leaves fresh and dry yield (ton/acre) in comparison with those revealed by other combination treatments, during the two consecutive seasons, as clearly shown in Tables (4, 5, 6 and 7). The effectiveness of planting dates and plant spacing on augmenting yield parameters on moringa revealed by Edward *et al*. (2012), Goss Maria (2012), Douglas (2014), Adegun and Ayodele (2015), Hegazi (2015), Mabapa *et al*. (2017), Chau and Sam (2021) and Mahmoud *et al*. (2021).

3.4 Chemical constituents

The presented data in Tables (8-11) shows that planting (*Moringa oleifera*) plants at the three times on 1st May, 15th May and 1st June led to a significant increase in Fe, Zn ppm, protein and carbohydrates percentage at all times. It is obvious that the best result was obtained due to sowing the plants at the second time (May 15th) in all cuts during both seasons.

Table (8): The influence of planting dates and plant spacing on protein percentage of moringa plants during the seasons of 2017 and 2018.

Planting spacing (B)	Planting dates (A)			
	May 1st	May15th	June 1st	Mean (B)
First season				
10 cm	20.17	20.88	21.83	20.96
20 cm	22.61	23.54	24.17	23.44
30 cm	23.44	24.06	24.79	24.1
Mean (A)	22.07	22.83	23.6	
L.S.D. at 5%	A: 0.53	B: 0.10	AB: 0.17	
Second season				
10 cm	21.04	21.98	22.4	21.81
20 cm	23.23	24.59	25.52	24.45
30 cm	24.06	25.63	27.4	25.7
Mean (A)	22.78	24.07	25.11	
L.S.D. at 5%	A: 0.18	B: 0.27	AB: 0.47	

Table (9): The influence of planting dates and plant spacing on carbohydrates percentage of moringa plants during the seasons of 2017and 2018.

Planting spacing (B)	Planting dates (A)			
	May 1st	May15th	June 1st	Mean (B)
First season				
10 cm	17.1	18.5	19.67	18.42
20 cm	17.87	19.2	21.27	19.45
30 cm	18.63	19.97	23.1	20.57
Mean (A)	17.87	19.22	21.35	
L.S.D. at 5%	A: 0.3	B: 0.3	AB: 0.5	
Second season				
10 cm	17.3	19.1	20.73	19.04
20 cm	18.4	20.4	22.7	20.5
30 cm	19.3	21.33	24.47	21.7
Mean (A)	18.33	20.28	22.63	
L.S.D. at 5%	A: 0.4	B: 0.2	AB: 0.4	

Table (10): The influence of planting dates and plant spacing on Zn ppm of moringa plants during the seasons of 2017 and 2018.

Planting spacing (B)	Planting dates (A)			
	May 1st	May15th	June 1st	Mean (B)
First season				
10 cm	32.83	36.47	37.13	35.48
20 cm	34.4	37.87	41.4	37.89
30 cm	36.6	38.33	42.8	39.24
Mean (A)	34.61	37.56	40.44	
L.S.D. at 5%	A: 0.45	B: 0.21	AB: 0.36	
Second season				
10 cm	33.5	37.57	38.67	36.58
20 cm	34.9	38.8	42.33	38.68
30 cm	37.83	40.17	45.53	41.18
Mean (A)	35.41	38.85	42.18	
L.S.D. at 5%	A: 0.39	B: 0.46	AB: 0.80	

Table (11): The influence of planting dates and plant spacing on Fe ppm of moringa plants during the seasons of 2017 and 2018.

Planting spacing (B)	Planting dates (A)			
	May 1st	May15th	June 1st	Mean (B)
First season				
10 cm	136.73	142.23	145.3	141.42
20 cm	139.27	144.03	146.23	143.18
30 cm	140.83	146.23	152.57	146.54
Mean (A)	138.94	144.16	148.03	
L.S.D. at 5%	A: 0.87	B: 0.75	AB: 1.3	
Second season				
10 cm	139.43	146.33	149.47	145.08
20 cm	142.67	148.5	150.47	147.21
30 cm	143.4	150.47	155.1	149.66
Mean (A)	141.83	148.43	151.68	
L.S.D. at 5%	A: 2.65	B: 0.54	AB: 0.93	

As for the plant spacing 10, 20 and 30 cm, the obtained results in Table (8-11) pointed out that Fe, Zn ppm, protein and carbohydrates percentage of moringa was significantly augmented as a result of all the plant spacing. According to the interaction between the two studied factors it had a significant effect on Fe, Zn ppm, protein, and carbohydrates percentage of moringa plants, in both seasons under study conditions. The most effective treatments concerning chemical constituents were planting on 1st June with space 30 cm. The effectiveness of planting dates and plant spacing on augmenting some chemical constituents on moringa revealed by Hegazi (2015), Adegun and Ayodele (2015), Mabapa *et al*. (2017) and Alaa (2012) on fennel plant.

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