Effect of Planting Distances and N.P.K Fertilization on Biomass Production and Chemical Composition of *Moringa oleifera*.

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ABSTRACT

This work was conducted at the experimental farm of El-Gemmezah Research Station, Agricultural Research Center (ARC) during three consecutive seasons 2019, 2020 and 2021. to study the effect of planting distances(0.15 × 0.60, 0.30 × 0.60, and 0.60 × 0.60 m.) and fertilizer doses of NPK (0-0-0, 50-17-17, 100-33-33, and 200-66-66 Kg^{-fed}) on three year transplants of *Moringa oleifera* biomass. The results indicated that, the highest fresh and dry biomasswere produced by planting distancesof 0.15 × 0.60 m. which received 200-66-66 Kg^{-fed} NPK. That treatment produced 45.5 and 14 ton/ Feddan/cuts for fresh and dry biomass, during 2021 season 1st and 2nd cut respectively.

Keywords: Moringa, planting distances, fertilization.

INTRODUCTION

Many researchers have shown an increasing interest for trees and shrubs as alternative fodder to cattle in tropical regions. There are different practices in alley farming, live fences, windbreak, tree browsing and cut and carry fodder banks (CCFB). According to Pezo and Ibrahim (1998).

*Moringaoleifera*is a fast-growing, drought-resistant tree of the family Moringaceae,nativeto the Indian Subcontinent (Vélez-Gavilán, 2017). Moringa leaves are a valuable source of protein for ruminants but they have a moderate palatability (Heuz*éet al.*, 2019).

Mabapa*et al.*, (2017) demonstrated that, the greater the plant density, the higher total aboveground dry biomass production of moringa across harvests times. Adekola and Abdulrahaman (2017) on moringa showed that, the population density of 250,000 plants/ha (250plant/m^2) could be considered the optimum for sustainable growth and high leaf yield in an intensive mono-cropping system.

Sandra and Suárez (2014) reported that, the application of 25 ton ha-1 of bovine manure and EcoMic showed the highest yield of moringa (6.61 ton DM ha-1) and the best contribution to nutrient contents of the soil. Mouchili*et al.*, (2019) found that the biomass of stems, leaves, and whole plants increased with increasing the level of N fertilization. The highest biomass was obtained with cutting at 6 months and a fertilization rate of 200 kg N ha-1 (1.51, 0.90, and 2.41 ton DM/ ha, respectively, for leaves, stems, and whole plants). Huang *et al.*, (2017) showed that, the fertilization with NPK increased yield of *M. oleifera*leaves significantly. The highest yield was 595.67 g /tree when the nitrogen rate was 300 mg kg^{-1} soil, it was good for accumulation the dry matter especially leaves when the nitrogen application rate was 300 mg N/kg soil and increases its absorption of potassium and phosphorus.

MATERIALS AND METHODS

The present study was performed at El-Gemmezah Research Station, Agricultural Research Center (ARC) during 2019, 2020 and 2021 seasons. Moringa seeds were obtained from (HRI). Physical and chemical analysis of the soil was carried out at ARC. Seeds were sown in field in the 1st week of March. Germination was completed after

two weeks. Three cuts/year were taken (the end of May, 10 August and 20October) every 70 days during the growing season.

The experimental design was Randomized Complete Block Design (RCBD) with twelve treatments replicated three times. Significant means were compared by Duncan's Multiple Range test (Duncan, 1955).

A field experiment was performed with four levels of N-P-K fertilizer doses as follows: (control) 0-0-0; (1)50-17-17; (2) 100-33-33; and (3) 200-66-66 kg fed^{-1} $year^{-1}$, and three different planting densities as 11111 (0.6x0.6m); 22222 (0.3x0.6 m) and 444444 (0.15x0.6 m) plants fed^{-1}. The sources of fertilizers were ammonium nitrates (33% N) - mono superphosphate (15.5% P_2O_5) and potassium sulphate (50% K_2O. The phosphorus fertilizers was added once before planting, in the 1st year and in the last week of March in the 2nd and 3rd year while, N and K fertilizer ware divided into 3 batches and added at the end of March and after the 1st and 2nd cuts.

The plot area was 4 × 5 m. The following traits were used for data collection: plant height, leaves fresh and dry weight plant and total fresh and dry weight feddan (ton).

Table 1: Mean of the chemical and physical characteristics of sowing soil.

	Sowing soil
pH (1:2.5 soil extract)	8.2
EC (soil paste extract) ds m-1	3.1
Soluble ions (meq L-1)	
Ca_2^+	6.6
Mg_2^+	7.2
Na^+	7.6
K^+	0.7
Cl^-	6
HCO_3^-	8.5
SO_4^{--}	10.5
Available NPK (mg kg-1)	
N	75.3
P	5.7
K	520
Particle size distribution (%)	
Clay	49.6
Silt	29.3
Sand	21.1

Leaf minerals and carbohydrate contents:

As follows: samples of the mature leaves 7 and 8 from stem top were taken, distilled water washed and oven dried at 70 C^o till constant weight the dried samples were pulverized separately. Samples of 0.2 (g) ware digested with a mixture of sulphuric acid and hydrogen peroxide, to determine the following:

Total nitrogen percentage was measured by the Microkjeldahl methods described by Pregl (1945). Phosphorus percentage was determined colorimetrically according to Murphy and Reily (1962). Potassium was measured according to Jakson (1973) by flame photometer. Carbohydrate concentration (%) was determined according to Dubois *et al.* (1956).

Statistical Analysis:

The collected data were subjected to the statistical analysis of variance (ANOVA) using CO-STAT software program to evaluate the significance difference according to Stern (1991). LSD at 5% probability was used to compare between the differences among treatment means.

RESULTS AND DISCUSSION

Effect of planting distances and fertilizer rates on plant height of *Moringaoleifera*.

Data presented in Table (2) indicated that, all treatments of plant distancesdid not affect significantly the plant height of the three cuttings, with the exception of 3rd cut on the 1st season at the space of 60x60 cm, in the 3rd season, 30x60 and 60x60 cm plant distances in the 3rd season in the 3rd cut which significantly decreased the plant height, as compared to the other treatments.

For effect of fertilizer rates on plant height: Data in (Table 2) showed significantly differences through the three growing seasons of the study in all cuts as compared with the control (zero fertilizer). Where the plant heights increased by increasing fertilizer rates but the differences ware not significant among the three levels of fertilizer in most cuts.

Concerning the interaction between plant distances and fertilizer rates: Generally the highest rate of fertilizer compared with the narrow planting produced the tallest plants than the other treatments, the difference ware significant in most cuts, in the three seasons than the unfertilized treatments in most planting spaces.

Table (2).Effect of planting distances and fertilizer rate on plant height (cm) of *M. oleifera* during 2019, 2020 and 2021 seasons.

Spacing / Ferti.	1st cut			Mean B	2nd cut			Mean B	3rd cut			Mean B
	15x60	30x60	60x60		15x60	30x60	60x60		15x60	30x60	60x60	
	2019 season											
Con	113.3 cd	107.3 dc	101.7 e	**107.4 C**	149.3 ab	149.0ab	141.7 b	**146.7 B**	135.7 bc	139.7 bc	128.7 c	**134.7 C**
1	116.0 cd	116.7b-d	115.7 cd	**116.1 B**	175.7 ab	162.7 ab	154.7ab	**164.4 AB**	159.3 a-c	141.7 a-c	138.7 bc	**146.6 BC**
2	118.3 b-d	120.3 bc	121.7 a-c	**120.1 B**	178.0ab	168.3ab	159.7 ab	**168.7 A**	160.7ab	150.7 a-c	143.0 a-c	**151.5 AB**
3	132.7 a	128.0 ab	128.3 ab	**129.7 A**	185.0 a	176.0 ab	165.0 ab	**175.3 A**	172.3 a	164.7 ab	154.3 a-c	**163.8 A**
Mean A	**120.1 A**	**118.1 A**	**116.8 A**		**172.0 A**	**164.0 A**	**155.3 A**		**157.0 A**	**149.2 AB**	**141.2B**	
	2020 season											
Con	144.3 a	140.0 a	140.7 a	**141.7 B**	140.0 b	144.0 ab	138.7 b	**140.9 B**	137.3 b	141.7 ab	134.0 b	**137.7 B**
1	171.7 a	153.7 a	158.7 a	**161.4 AB**	171.7ab	157.3 ab	152.3 ab	**160.4 AB**	163.3 ab	149.0 ab	146.0 ab	**152.8 AB**
2	177.0 a	161.7 a	160.3 a	**166.3 A**	173.3 ab	161.7 ab	156.3 ab	**163.8 AB**	170.0 ab	156.7 ab	150.7 ab	**159.1 A**
3	178.3 a	171.0 a	162.3 a	**170.5 A**	180.7 a	172.0 ab	159.0 ab	**170.6 A**	176.0 a	168.7 ab	159.0 ab	**167.9 A**
Mean A	**167.8 A**	**156.6 A**	**155.5 A**		**166.4 A**	**158.8 A**	**151.6 A**		**161.7 A**	**154.0 A**	**147.4 A**	
	2021 season											
Con	151.7 bc	151.0 bc	148.0 c	**150.2 C**	148.7 b	149.0 b	144.0 b	**147.2 B**	141.3 b	138.3 b	136.3 b	**138.6 B**
1	171.7 a-c	166.0 a-c	167.3 a-c	**168.3 B**	181.3 ab	162.3 ab	158.0 ab	**167.2 A**	168.7 ab	149.7 ab	149.3 ab	**155.9 A**
2	178.0 a	175.0 ab	177.3 a	**176.8 AB**	183.3 ab	166.0 ab	165.7 ab	**171.7 A**	178.7 a	154.0 ab	155.7 ab	**162.8 A**
3	181.3 a	177.7 a	177.0 a	**178.7 A**	192.3 a	178.3 ab	163.3 ab	**178.0 A**	181.7 a	164.0 ab	170.0 ab	**171.9 A**
Mean A	**170.7 A**	**167.4 A**	**167.4 A**		**176.4 A**	**163.9 AB**	**157.8 B**		**167.6 A**	**151.5 B**	**152.8B**	

(1) NPK 50-17-17; (2) NPK 100-33-33; and (3) NPK 200-66-66 kg fed^{-1} year^{-1}

Effect of planting distances and fertilizer rate on leaves fresh weight /plant (g) of *M. oleifera*

Data presented in Table (3) cleared that, planting distances significantly affect the leaves fresh weight /plant (g) during the three seasons at the three cuts, with exception of 1st cut in 1st season. The medium and wide distances (30x60 and 60x60 cm.) significantly increased the leaves fresh weight at the three cuts in all seasons as compared to the narrow distance 15x60 cm., with the exception of the 1st cut in 1st season.

Concerning the fertilizer rates, data in Table (3) showed that, leaves fresh weight / plant (g) generally was significantly enhanced by increasing fertilization rates. The heaviest leaves fresh weight obtained from 3rd level of fertilizer (200-66-66 kg fed^{-1}) NPK, but the differences between the 3rd level and 2nd one of NPK fertilizer was insignificant in 2nd cut in the 1st season as well as 2nd and 3rd cut in 2nd one.

The interaction effect between distances and fertilizer rates on the leaves fresh weigh / plant (g) as shown in Table (3), cleared that, planting moringa at the widest plant distance (60x60) and fertilizing them with the highest rates of fertilizer (200-66-66 kg fed^{-1}) NPK significantly increased the leaves fresh weight in all seasons(2019,2020 and 2021) as compared to all the other interactions.

Table (3).Effect of planting distances and fertilizer rates on leaves fresh weight /plant (g) of *M. oleifera*during 2019, 2020 and 2021 seasons.

Spacing / Ferti.	1st cut			Mean B	2nd cut			Mean B	3rd cut			Mean B
	15x60	30x60	60x60		15x60	30x60	60x60		15x60	30x60	60x60	
	2019 season											
Con	136 cd	128.8 de	122 e	**128.9 C**	251.7e	314 de	300 de	**288.6 B**	229.3 e	278 de	286 de	**264.4 D**
1	139.2 cd	140 b-d	138.8 cd	**139.3 B**	321de	355b-e	344.7c-e	**340.2 B**	278.3 de	361b-d	331 cd	**323.4 C**
2	142 b-d	144.4 bc	146 a-c	**144.1 B**	359.3b-e	447.3 bc	448 be	**418.2 A**	313.3c-e	444.3 b	396.7 be	**384.8 B**
3	159.2 a	153.6 ab	154 ab	**155.6 A**	367.7b-d	456.7 b	586.3 a	**470.2 A**	333.3 cd	443.3 b	544 a	**440.2 A**
Mean A	**144.1 A**	**141.7 A**	**140.2 A**		**324.9 B**	**393.3 A**	**419.8 A**		**288.6 B**	**381.7 A**	**389.4 A**	
	2020 season											
Con	263.7 e	298 e	298.3 c	**286.7 C**	265.3 d	303.3 cd	303.3 cd	**290.6 B**	256 e	296.7 de	297.3 de	**283.3 C**
1	302.7 e	340.3 bc	366.3 bc	**336.4 C**	300 cd	346.3 b-d	346.3 b-d	**330.9 B**	291.7 de	376bc-e	338.7 c-e	**335.5 BC**
2	344.8 bc	434.7 b	443.7 b	**407.7 B**	346.7 b-d	438.3 bc	438.3 bc	**407.8 A**	336 c-e	461 a-c	406.3 b-d	**401.1 AB**
3	345.7 bc	451.7 b	621.3 a	**472.9 A**	354 b-d	454.7 b	621.3 a	**476.7 A**	339 c-e	483 ab	576.3 a	**466.1 A**
Mean A	**314.2 B**	**381.2 A**	**432.4 A**		**316.5 B**	**385.7 A**	**427.3 A**		**305.7 B**	**404.2 A**	**404.7 A**	
	2021 season											
Con	281.9 d	320.7 cd	337.7 cd	**313.4 D**	268 d	307 d	307.3 d	**294.1 C**	261.3 d	300.3 cd	301.3 cd	**287.6 D**
1	317.7 cd	359.3 b-d	368.3 b-d	**348.4 C**	313 d	353.3 b-d	354 b-d	**340.1 C**	303.3 cd	385.7 bc	346.3 cd	**345.1 C**
2	369.5 b-d	439 b	446 b	**418.2 B**	339 cd	447 bc	445 bc	**410.3 B**	342.7 cd	467.3 b	454 b	**421.3 B**
3	388.2 bc	452.3 b	621.7 a	**487.4 A**	350 b-d	466 b	626.7 a	**480.9 A**	350.3 cd	487 b	617.7 a	**485.0 A**
Mean A	**339.3 C**	**392.8 B**	**443.4 A**		**317.5 B**	**393.3 A**	**433.3 A**		**314.4 B**	**410.1 A**	**429.8 A**	

(1) NPK 50-17-17; (2) NPK 100-33-33; and (3) NPK 200-66-66 kg fed^{-1} $year^{-1}$

Effect of planting distances and fertilizer rates on leaves dry weight /plant (g) of *M. oleifera*

Data presented in Table (4) show theeffect of planting distances and fertilizer rates on leaves dry weight /plant (g) of *M. oleifera*, it take the same trend of leaves fresh weight, as planting distances significantly affected leaves dry weight /plant (g) during the three seasons at the three cuts with the exception of the 1st cut in 1st season. The medium and wide distances significantly increased the leaves dry weight at the three cuts in all seasons as compared to the narrow distance with exception of the 1st cut in 1st season and the differences between the medium and wide distance ware not significant generally, except of the 3rd cut in the 1st season.

Concerning the fertilizer rates, data in Table (4) showed also that, the leaves dry weight /plant (g) generally increased significantly by increasing fertilization rates. The highest leaves dry weight was produced from 3rd level of fertilizer (200-66-66 kg fed^{-1} $year^{-1}$ NPK), but the difference between the 3rd and 2nd level of NPK fertilizer was insignificant in 1st and 2nd cut in the 1st season.

The interaction between distances and fertilizer rates on leaves dry weigh /plant (g) shown in Table (4) cleared that, the widest plant distance (60x60 cm.) and highest rates of fertilizer (200-66-66 kg fed^{-1} $year^{-1}$ NPK) gave the highest leaves dry weight /plant (g) generally with a significant differences than the most of interactions treatments in allconsecutiveseasons.

Effect of planting distances and fertilizer rates on total fresh biomass (ton) /feddan of *M. oleifera.*

Data presented in Table (5) indicated that, during the three seasons at the three cuts the narrow distances (15x60 cm.) significantly increased the total fresh biomass /feddan as compared the other two planting distances.

For the effect of fertilizer rates data in the same table cleared that, total fresh biomass (ton) /feddan of *M. oleifera* was significantly increased by increasing fertilization rates. The highest fresh biomass /feddan (45.5 ton/ feddan) was produced from the 3rd level (200-66-66 kg fed^{-1}) of NPK. But, the difference between the 3rd and 2nd levels of fertilizer was insignificant in 2nd season and 3rd cut in 1st one.

The effect of interaction between planting distances and fertilizer rates on, the total fresh biomass (Table 5) showed that, the highest total fresh biomass /feddan was from the narrow distance (15x60 cm), combined with the three fertilizer rates during the three seasons at the three cuts as compared to all other interactions. With exceptions the highest fresh biomass was 45.5 ton /feddan was recorded with planting moringa at 15x60 cm witch fertilized by 200-66-66 kg fed^{-1} NPK in first cut in 3rd season (Table 5). Meanwhile, the differences between

3rd and 2nd rates of fertilizer in case of the narrow distance (15x60 cm.) was significant in the 1st cut in the 1st and 3rd season only, but it was insignificant for all other cuts during theconsecutive seasons.

Table (4).Effect of planting distances and fertilizer rates on leaves dry weight /plant (g) of *M. oleifera* during 2019, 2020 and 2021 season.

Spacing / Ferti.	1st cut			Mean B	2nd cut			Mean B	3rd cut			Mean B
	15x60	30x60	60x60		15x60	30x60	60x60		15x60	30x60	60x60	
	2019 season											
Con	36.6 c	40.0 bc	38.7 bc	**38.4 C**	82.3 f	91.7 ef	101.2 def	**91.7 C**	73.7 g	73.0 g	91.3 efg	**79.3 D**
1	39.6 bc	43.0 abc	42.0 abc	**41.5 BC**	109.9 def	127.0 cd	128.7 cd	**121.9 B**	86.0 fg	110.7 de	133.0 cd	**109.9 C**
2	41.7 abc	44.2 abc	44.3 abc	**43.4 AB**	120.7 cde	144.7 bc	163.7 ab	**143.0 A**	102.9ef	131.0 cd	143.3 bc	**125.7 B**
3	46.3 ab	49.9 a	45.7 abc	**47.3 A**	125.4 cd	169.3 ab	178.5 a	**157.7 A**	106.7 ef	163.3 ab	175.0 a	**148.3 A**
Mean A	**41.1 A**	**44.3 A**	**42.7 A**		**109.6 B**	**133.2 A**	**143.0 A**		**92.3 C**	**119.5 B**	**135.7 A**	
	2020 season											
Con	77.1 d	80.4 d	90.4 d	**82.6 D**	75.2 f	80.6 ef	78.0 ef	**77.9 C**	73.6 e	72.0 e	95.0 de	**80.2 C**
1	97.0 d	105.3 cd	111.0 cd	**104.4 C**	101.7 def	133.3 cd	127.3 cd	**120.8 B**	95.0 de	118.0 cd	136.6 abc	**116.5 B**
2	109.5 cd	140.5 bc	139.3 bc	**129.8 B**	116.2 cde	143.3 c	150.3 bc	**136.6 B**	109.9 cde	132.3 bcd	144.0 abc	**128.7 B**
3	110.8 cd	149.3 b	199.1 a	**153.1 A**	113.2 c-f	182.2 ab	188.9 a	**161.4 A**	113.4 cd	169.4 ab	172.7 a	**151.8 A**
Mean A	**98.6 B**	**118.9 A**	**135.0 A**		**101.6 B**	**134.9 A**	**136.1 A**		**98.0 B**	**122.9 A**	**137.1 A**	
	2021 season											
Con	98.0 e	106.8 e	105.7 e	**103.5 D**	49.6 d	102.9 cd	172.9 ab	**108.5 D**	79.7 e	80.0 e	92.7 de	**84.1 D**
1	109.9 de	130.2 cd	111.0 de	**117.0 C**	107.4 cd	146.9bcd	108.3 cd	**120.9 C**	90.0 de	122.3 bc	125.0 bc	**112.4 C**
2	110.0 de	153.1 b	140.5 bc	**134.5 B**	125.0bcd	154.3 bc	147.9 bcd	**142.4 B**	115.0 cd	135.7 bc	149.0 ab	**133.2 B**
3	118.6 de	157.7 b	199.2 a	**158.5 A**	138.4bcd	154.3 bc	148.3 bcd	**147.0 A**	126.7 bc	167.3 a	173.4 a	**155.8 A**
Mean A	**109.1 B**	**137.0 A**	**139.1 A**		**105.1 B**	**139.6 A**	**144.4 A**		**102.9 B**	**126.3 A**	**135.0 A**	

(1) NPK 50-17-17; (2) NPK 100-33-33; and (3) NPK 200-66-66 kg fed^{-1} year^{-1}

Table (5).Effect of planting distances and fertilizer rates on total fresh biomass /feddan (ton) of *M. oleifera* during 2019, 2020 and 2021 season.

Spacing / Ferti.	1st cut			Mean B	2nd cut			Mean B	3rd cut			Mean B
	15x60	30x60	60x60		15x60	30x60	60x60		15x60	30x60	60x60	
	2019 season											
Con	12.1 c	6.5 e	3.1 f	**7.2 C**	28.0 cd	14.8 e	14.7 e	**19.2 D**	23.4 de	12.8 g	15.4 fg	**17.2 C**
1	12.7 bc	6.9 de	3.4 f	**7.7 BC**	36.1 ab	21.0 de	22.1 d	**26.4 C**	30.7 abc	19.4 ef	20.4 ef	**23.5 B**
2	13.4 b	7.1 de	3.8 f	**8.1 B**	39.6 a	24.0 d	27.4 cd	**30.3 B**	34.2 ab	23.2 de	24.9 cde	**27.4 A**
3	14.7 a	7.9 d	4.0 f	**8.9 A**	42.4 a	27.6 cd	32.1 bc	**34.0 A**	35.4 a	28.0bcd	28.8bcd	**30.7 A**
Mean A	**13.2 A**	**7.1 B**	**3.6 C**		**36.5 A**	**21.9 B**	**24.1 B**		**30.9 A**	**20.9 B**	**22.4 B**	
	2020 season											
Con	27.0 bc	13.6 f	14.6 ef	**18.4 C**	26.8 cde	13.6 g	14.3 fg	**18.2 C**	25.3 bc	13.4 e	15.9 de	**18.2 C**
1	34.9 a	19.6 def	20.3 de	**24.9 B**	34.7 abc	21.0 efg	22.5 def	**26.1 B**	32.6 ab	20.9 cde	21.4 cde	**25.0 B**
2	38.6 a	23.3 cd	27.0 bc	**29.6 A**	38.7 ab	23.5 de	27.5 cde	**29.9 AB**	36.7 a	23.9 bcd	26.1 bc	**28.9 AB**
3	39.1 a	25.8 cd	32.7 ab	**32.5 A**	40.5 a	30.3 bcd	32.7 abc	**34.5 A**	37.6 a	30.4 ab	30.4 ab	**32.8 A**
Mean A	**34.9 A**	**20.6 C**	**23.7 B**		**35.2 A**	**22.1 B**	**24.3 B**		**33.1 A**	**22.2 B**	**23.5 B**	
	2021 season											
Con	28.3 d	15.2 g	15.8 g	**19.8 D**	28.1 c	15.4 e	15.2 e	**19.6 D**	26.4 bc	13.8 e	16.3 de	**18.8 D**
1	36.0 c	20.1 f	20.6 f	**25.6 C**	34.7 b	21.3 de	23.1 cd	**26.4 C**	31.0 b	21.3 cd	22.3 c	**24.9 C**
2	40.7 b	23.4 ef	24.8 de	**29.6 B**	39.9 ab	24.8 cd	28.3 c	**31.0 B**	37.3 a	24.5 c	27.2 bc	**29.7 B**
3	45.5 a	25.7de	28.7 d	**33.3 A**	42.9 a	28.5 c	34.9 b	**35.4 A**	38.5 a	30.5 b	31.3 b	**33.4 A**
Mean A	**37.6 A**	**21.1 B**	**22.5 B**		**36.4 A**	**22.5 B**	**25.4 B**		**33.3 A**	**22.5 B**	**24.3 B**	

(1) NPK 50-17-17; (2) NPK 100-33-33; and (3) NPK 200-66-66 kg fed^{-1} year^{-1}

Effect of planting distances and fertilizer rates on total dry biomass (ton)/feddan of *M. oleifera*

Data presented in Table (6) cleared that, total dry biomass (ton)feddan of *M. oleifera* take the same trend of total fresh biomass(ton) /feddan. Also during the three seasons at the three cuts the narrow distances (15x60 cm.) significantly increased total dry biomass /feddan as compared to all the other planting distances.

For the fertilizer rates, data in Table (6) showed that, total dry biomass (ton) /feddan of *M. oleifera* significantly increased by increasing fertilization rates. The highest dry biomass /feddan was obtained from 3rd level of fertilizer NPK, at (200:66:66), but the differences between the 3rd and 2nd level of fertilizer ware insignificant only in the 2nd cut for the 1st and 3rd seasons and the 1st cut of the 2nd season.

Also, the effect of interaction between planting distances and fertilizer rates on total

dry biomass, as shown in the same table, showed that, 15x60 cm planting distance combined with the three fertilizer rates significantly increased the dry biomass of *M. olivera* as compared to the other interactions. With the exception of 1st and 2nd fertilizer rates at 1st cut and 1st fertilizer rat at 3rd cut all in the first season. Also the combined treatments of the 1st fertilizer rate at 15x60 cm planting distance at 1st and 3rd cut in the 3rd season, which significantly decreased dry biomass as compared to the above mentioned treatments. The highest dry biomass (14 ton /feddan) was obtained from planting moringa in 15x60 cm which fertilized by 200-66-66 kg fed^{-1} NPK in 2nd cut from 3rd season.

Table (6).Effect of planting distances and fertilizer rates on total dry biomass /feddan (ton) of *M. oleifera* during 2019, 2020 and 2021 season.

Spacing / Fertilizer	1st cut			Mean B	2nd cut			Mean B	3rd cut			Mean B
	15x60	30x60	60x60		15x60	30x60	60x60		15x60	30x60	60x60	
						2019 season						
Con	3.5 c	1.9 e	0.9 f	**2.1 C**	8.2 cd	4.3 e	4.3 e	**5.6 C**	6.8 ef	3.7 h	4.5 h	**5.0 D**
1	3.7 bc	2.0 de	1.0 f	**2.2 BC**	10.5 ab	6.1 de	6.4 de	**7.7 B**	8.9 bc	5.6 g	6.0 fg	**6.8 C**
2	3.9 b	2.1 de	1.1 f	**2.4 B**	11.5 ab	7.0 d	8.0 cd	**8.8 AB**	9.9 ab	6.8 ef	7.2 de	**8.0 B**
3	4.3 a	2.3 d	1.2 f	**2.6 A**	12.3 a	8.0 cd	9.3 bc	**9.9 A**	10.3 a	8.2 cd	8.4 c	**9.0 A**
Mean A	**3.9 A**	**2.1 B**	**1.1 C**		**10.6 A**	**6.4 B**	**7.0 B**		**9.0 A**	**6.1 B**	**6.5 B**	
						2020 season						
Con	7.8 cd	4.0 h	4.2 gh	**5.3 C**	7.8 def	4.0 g	4.2 g	**5.3 D**	7.4 cd	3.9 f	4.6 ef	**5.3 D**
1	10.2ab	5.7 fg	5.9 efg	**7.3 B**	10.1abc	6.1 f	6.5 ef	**7.6 C**	9.5 ab	6.1 de	6.2 de	**7.3 C**
2	11.3ab	6.8 def	7.8 cd	**8.6 A**	11.3 ab	6.9 ef	8.0 de	**8.7 B**	10.7 a	7.0 d	7.6 cd	**8.4 B**
3	11.4 a	7.5 cd	9.5 bc	**9.5 A**	11.8 a	8.8 cd	9.5 bcd	**10.0 A**	11.0 a	8.9 bc	8.8 bc	**9.6 A**
Mean A	**10.2 A**	**6.0 C**	**6.9 B**		**10.3 A**	**6.5 B**	**7.1 B**		**9.7 A**	**6.5 B**	**6.8 B**	
						2021 season						
Con	8.9 c	5.0 f	4.9 f	**6.3 D**	8.9 bcd	4.7 ef	4.2 f	**5.9 C**	7.7 c	4.0 e	4.8 e	**5.5 D**
1	10.7 b	6.4 de	6.0 ef	**7.7 C**	10.5 abc	6.5 def	6.3 def	**7.8 B**	9.0 b	6.2 d	6.5 d	**7.2 C**
2	11.1 ab	7.0 de	7.4 d	**8.5 B**	12.1 ab	7.2 cdef	7.8 cde	**9.0 AB**	10.9 a	7.1 cd	7.9 c	**8.6 B**
3	12.0 a	8.5 c	9.1 c	**9.9 A**	14.0 a	7.9 cde	9.1 bcd	**10.3 A**	11.5 a	8.9 c	9.1 b	**9.8 A**
Mean A	**10.7 A**	**6.7 B**	**6.9 B**		**11.4 A**	**6.6 B**	**6.9 B**		**9.8 A**	**6.6 C**	**7.1 B**	

(1) NPK 50-17-17; (2) NPK 100-33-33; and (3) NPK 200-66-66 kg fed^{-1} year^{-1}

Effect of planting distances and fertilizer rates on Nitrogen and Phosphors content of Moringa leaves at 2019 and 2020 seasons.

The chemical composition content ofNitrogen and Phosphors percentage of Moringa leaves was affected by plant density as shown in (Table 7) in generally wide distances (60x60 cm.) plants contained highly N and P content 4.69 and 0.7, respectively in the 2nd cut seasons 2019 and 2020 for nitrogen and in 3rd cut season 2020 for Phosphors.

Concerning the fertilizer rates the Nitrogen and Phosphors content meanly increased by increasing rates of fertilizers the highest N and P content was 5.0 and 0.82 respectively in 3rd level of fertilizer during 1st cut 2020 season for Nitrogen and 3rd cut 2019 season for Phosphors.

Also the effect of interaction between planting distances and fertilizer rates on Nitrogen and Phosphors content showed that, highly content of N and P was mainly in the 3rd level of fertilizer with narrow or wide distains of plants.

Effect of planting distances and fertilizer rates on potassium and total carbohydrates content of Moringa leaves at 2019 and 2020 seasons.

Data in (Table 8) cleared that, meanly wide distance plants contained highly carbohydrates content in general but potassium not affected clearly with plant distances.

For fertilizer rates potassium and total carbohydrates percentage was increased with increasing fertilizer rates than the control. The highest values ware 12.12 and 36.99 respectively in 1st cut 2020 and 2nd cut 2019 with the 3rd level of fertilizer.

Concerning to the interaction between planting distances and fertilizer rates on potassium and total carbohydrates percentage data in the same table showed that, Potassium and total carbohydrates percentage generally increased with highly fertilizer rates with any spacing distance.

Table (7): Effect of planting distances and fertilizer rates on nitrogen and phosphors contents of Moringa leaves at 2019 and 2020 seasons.

Fertilizer \ Spacing	1st cut								2nd cut								3rd cut							
	2019			Mean B	2020			Mean B	2019			Mean B	2020			Mean B	2019			Mean B	2020			Mean B
	15	30	60		15	30	60		15	30	60		15	30	60		15	30	60		15	30	60	
Nitrogen																								
Con	3.89	4.20	4.39	**4.16**	3.99	3.97	4.46	**4.14**	3.59	3.73	4.39	**3.90**	3.53	3.39	4.48	**3.80**	3.83	3.83	3.83	**3.83**	3.75	3.88	3.83	**3.82**
1	4.24	4.57	4.48	**4.43**	4.24	4.27	4.16	**4.22**	4.05	3.83	4.57	**4.15**	4.05	3.83	4.57	**4.15**	4.20	4.20	4.11	**4.17**	4.20	4.01	4.44	**4.22**
2	4.33	4.67	4.48	**4.49**	4.40	4.83	4.48	**4.57**	4.39	4.57	4.76	**4.57**	4.39	4.18	4.69	**4.42**	4.80	4.20	4.20	**4.40**	4.67	4.37	4.58	**4.54**
3	5.32	4.88	4.76	**4.99**	5.33	4.92	4.76	**5.00**	4.80	4.67	5.04	**4.84**	4.92	4.72	5.01	**4.88**	4.95	4.29	4.67	**4.64**	5.02	4.29	4.67	**4.66**
Mean A	**4.44**	**4.58**	**4.53**		**4.49**	**4.50**	**4.47**		**4.21**	**4.20**	**4.69**		**4.22**	**4.03**	**4.69**		**4.44**	**4.13**	**4.20**		**4.41**	**4.14**	**4.38**	
Phosphors																								
	15	**30**	**60**	**Mean B**	**15**	**30**	**60**	**Mean B**	**15**	**30**	**60**	**Mean B**	**15**	**30**	**60**	**Mean B**	**15**	**30**	**60**	**Mean B**	**15**	**30**	**60**	**Mean B**
Con	0.31	0.33	0.42	**0.35**	0.31	0.36	0.40	**0.36**	0.47	0.48	0.55	**0.50**	0.46	0.50	0.50	**0.49**	0.28	0.57	0.66	**0.50**	0.39	0.54	0.66	**0.53**
1	0.33	0.42	0.50	**0.42**	0.32	0.41	0.52	**0.42**	0.57	0.54	0.56	**0.56**	0.57	0.54	0.63	**0.58**	0.59	0.60	0.65	**0.61**	0.51	0.59	0.68	**0.59**
2	0.33	0.46	0.53	**0.44**	0.36	0.45	0.53	**0.45**	0.60	0.77	0.67	**0.68**	0.62	0.76	0.67	**0.68**	0.61	0.71	0.71	**0.68**	0.78	0.76	0.71	**0.75**
3	0.48	0.53	0.65	**0.55**	0.41	0.52	0.65	**0.53**	0.69	0.77	0.82	**0.76**	0.68	0.81	0.75	**0.75**	1.01	0.72	0.74	**0.82**	0.80	0.72	0.74	**0.75**
Mean A	**0.36**	**0.44**	**0.52**		**0.35**	**0.43**	**0.52**		**0.58**	**0.64**	**0.65**		**0.58**	**0.65**	**0.64**		**0.62**	**0.65**	**0.69**		**0.62**	**0.65**	**0.70**	

(1) NPK 50-17-17; (2) NPK 100-33-33; and (3) NPK 200-66-66 kg fed-1 year-1

Table (8) Effect of planting distances and fertilizer rates on potassium and total carbohydrates contents of Moringa leaves at 2019 and 2020 seasons.

Fertilizer \ Spacing	1st cut								2nd cut								3rd cut							
	2019			Mean B	2020			Mean B	2019			Mean B	2020			Mean B	2019			Mean B	2020			Mean B
	15	30	60		15	30	60		15	30	60		15	30	60		15	30	60		15	30	60	
Potassium																								
Con	1.31	1.75	1.50	**1.52**	1.67	1.80	1.52	**1.66**	1.42	1.34	1.32	**1.36**	1.40	1.35	1.32	**1.36**	1.27	1.36	1.20	**1.28**	1.17	1.43	1.20	**1.27**
1	1.88	1.87	1.55	**1.77**	1.92	1.88	1.55	**1.78**	1.48	1.36	1.33	**1.39**	1.48	1.36	1.40	**1.41**	1.38	1.49	1.29	**1.39**	1.37	1.42	1.36	**1.38**
2	2.01	1.95	1.80	**1.92**	2.01	1.95	1.87	**1.94**	1.53	1.59	1.45	**1.52**	1.64	1.63	1.66	**1.64**	1.40	1.50	1.39	**1.43**	1.45	1.50	1.42	**1.46**
3	2.10	2.08	1.86	**2.01**	2.13	2.33	1.89	**2.12**	1.80	1.62	1.50	**1.64**	1.88	1.72	1.73	**1.78**	1.56	1.63	1.47	**1.55**	1.67	1.63	1.47	**1.59**
Mean A	**1.82**	**1.91**	**1.68**		**1.93**	**1.99**	**1.71**		**1.56**	**1.48**	**1.40**		**1.60**	**1.52**	**1.53**		**1.40**	**1.49**	**1.34**		**1.41**	**1.50**	**1.36**	
Total carbohydrates																								
	15	**30**	**60**	**Mean B**	**15**	**30**	**60**	**Mean B**	**15**	**30**	**60**	**Mean B**	**15**	**30**	**60**	**Mean B**	**15**	**30**	**60**	**Mean B**	**15**	**30**	**60**	**Mean B**
Con	16.00	21.61	29.88	**22.50**	17.00	20.95	29.42	**22.46**	15.10	18.78	28.59	**20.82**	20.07	20.45	28.59	**23.04**	23.25	18.20	30.38	**23.94**	23.58	19.85	30.38	**24.60**
1	20.78	22.81	31.42	**25.00**	21.45	22.46	31.42	**25.11**	25.02	23.64	32.15	**26.94**	24.70	23.64	32.79	**27.04**	25.43	20.20	35.74	**27.12**	25.77	20.54	35.74	**27.35**
2	21.00	23.74	33.51	**26.08**	23.49	25.10	33.51	**27.37**	28.58	26.76	43.70	**33.01**	28.37	27.41	35.02	**30.27**	27.54	28.32	36.72	**30.86**	27.21	27.32	37.05	**30.53**
3	27.49	26.64	33.77	**29.30**	25.16	25.56	34.15	**28.29**	33.08	33.02	44.87	**36.99**	34.08	29.37	40.60	**34.68**	33.50	32.58	38.10	**34.73**	29.83	36.92	38.10	**34.95**
Mean A	**21.32**	**23.70**	**32.15**		**21.78**	**23.52**	**32.13**		**25.44**	**25.55**	**37.33**		**26.81**	**25.22**	**34.25**		**27.43**	**24.82**	**35.23**		**26.60**	**26.16**	**35.31**	

(1) NPK 50-17-17; (2) NPK 100-33-33; and (3) NPK 200-66-66 kg fed^{-1} year^{-1}

DISCUSSION

The observed growth and developmental trends showed an increase in all studed characters. For plant height, the narrow planting distance showed the highest increase than the wider one. Mabapa*et al.,* (2017) and Amaglo*et al.,* (2006) when studying the performance of moringa, found similar results to those referred in this study on plant height, that the closer distances gives the tallest plants than the wider spacing.

According to Amaglo*et al.,* (2006), increasing plant density speeds up the rate of plant growth and thus increases heights at closer spacing. Growth depends on the interaction of external and internal factors, in an organized system. As when the number of plants per unit area increases, plants begin to compete for the essential growth factors likesunlight, nutrients and water. vice versa, The effect of increasing competition is the same to decrees the concentration of growth factors (Norman, 1992). So the wider planting distance (60x60 cm) gave the highest number of leaves per plant while the narrow one (15x15 cm)) gave the tallest plants. Meanwhile, the total aboveground fresh and dry biomass production of moringa was increased by increasing number of plants per unit area at all cuts, the same results also shown byMabapa*et al.,* (2017).

This is in harmony with Igbokwe*et al.,* (2017), Adekola and Abdulrahaman (2017), and Amaglo*et al.,* (2006) observed that the wider distances give more leaves per plant than the medium and closer spacings. The fresh and dry weights of leaves is in harmony with Amaglo*et al.,* (2006). These results agree with Adebayo *et al.,* 2017, and Mouchili*et al.,* (2019) showed that the leaf biomass of the fertilized plots was significantly ($P < 0.05$) higher than that of the unfertilized plots.

Results of the total fresh and dry biomass (ton) /feddan are also agree with Mouchili*et al.,* (2019), Adekola and Abdulrahaman (2017) and Foidl*et al.,* (2001) who indicated that increasing plant density does not affect individual plants if the plant density is below the level at which competition occurs between plants. However, when the plant density is too high and there is competition between plants, yield decreases. Therefore, yield per plant decreases also total biomass production per unit area increases by increasing planting density.

While the main effect of NPK fertilizer on total fresh and dry weights yield/ feddan the obtained data showed that, the total biomass yield per feddan increased significantly with increasing fertilizer treatments. Mouchili*et al.,* (2019), studied the performance of moringa, and found similar results that *M. oleifera*plants fertilized with 5 and 10 kg N ha-1 of poultry manure had higher biomasses than unfertilized plants. In fact, fertilization increased the rate of vegetative growth, thus increasing production for a given growth stage or reducing the time required to reach a defined yield.

The results of chemical composition N, P and K of Moringa leaves revealed that there contents ware affected by plant density and this trend was similar to those reported by S´anchez*et al., (*2006), who reported that the plant density affected the biomass production with no differences in chemical composition even at continuous harvests or in the harvesting of young leaves and tender stems.

The data of the effect of fertilizer rate is agrees with Dania *et al.,* (2014), and Attia*et al.,* (2014) who indicated that increasing of NPK fertilizers rates increased yield components of Moringa. NPK application also improved the nutrient content of

Moringa Dania *et al.*, (2014). Badran*et al.*, (2016) and Ewetola*et al.*, (2019) also, referred that compost and NPK 15: 15: 15 had a significant influence on the uptake of N and K. All compost and NPK treatments significantly increased N and P uptake when compared with the control.

Vegetative growth of *Moringaoleifera*was better enhanced by the application of NPK 200:66:66 kg/feddan as it produced the tallest plants and highest number of leaves which was significantly higher than the other treatments. Application of nitrogen and phosphorus to Moringa trees will encourage root development as well as leaf canopy growth.

The application of NPK fertilizer positively influenced the biomass production of *M. oleifera*by increasing the leaves, total fresh weight/ plant, and accumulation of dry matter. When the application of NPK at 200:66:66 kg/feddan, the yield of leaves and the quantity of fresh and dry matter were better than the other treatments and control at all cuts. Also, the effect of NPK on different parts of Moringa was different, which was shown by the dry matter accumulation of different parts of the plant. In our experiment, the dry matter accumulation of all plants was highest at NPK application level of 200:66:66 kg/feddan at all cuttings. These results are in harmony with Adebayo *et al.*, (2017), Huang *et al.*, (2017) and Mouchili*et al.*, (2019).

CONCLUSION

The highest fresh and dry biomass was produced by planting distances at 0.15 × 0.60 m and fertilization with NPK at 200:66:66 or 100: 33:33 kg/feddan which produced the highest fresh and dry biomass/ feddan of *Moringaoleifera* without significant differences between the two fertilizer rates.

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تأثير مسافة الزراعة والتسميد بالـ N.P.K على الكتلة الحيه والتركيب الكيميائي للمورينجا *Moringa oleifera*.

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قسم بحوث الأشجار الخشبية والغابات – معهد بحوث البساتين – مركز البحوث الزراعية –الجيزة – مصر.

أجريت هذه الدراسة في المزرعة البحثية لمحطة البحوث الزراعية بالجميزة. محافظة الغربية. مصروالتابعة لمركز البحوث الزراعيه خلال ثلاثة مواسم متتالية هى 2019 ,2020 و 2021.وكان الهدف هو دراسة تأثير مسافة الزراعة ومعدلات تسميد بـ النيتروجين ,الفوسفور والبوتاسيوم عند مستويات 0: 0:0 ، 50:17:17 ، 100: 33. : 33و 200: 66: 66 كجم / فدان على التوالي. ومسافات زراعة للنباتات 0.15 × 0.60 م، 0.30 × 0.60 م، و 0.60 × 0.60 م. على الكتلة الحيوية الناتجة من المورينجا أوليفيرا والتركيب الكيماوى للأوراق . وأشارت النتائج إلى أن أعلى كتلة حيوية طازجة وجافةومحتوى كيماوى تم الحصول عليها عند الزراعة على مسافة 0.15 × 0.60 م مع تسميد النباتات بـ 200: 66: 66 كجم / فدانحيث اعطى اعلى وزن طارج وجاف للحشة 45.5 و 14 طن فدان/حشه الكتلة الحيوية الطازجة والجافة على التوالى خلال موسم 2021 فى الحشه الاولى والثانية.