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Effect of irrigation intervals, mineral and organic fertilization on productivity of henna (*Lawsonia alba* Lam) plants

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Abstract

A field experiments were carried out in Aswan governorate, Egypt, during the two successive seasons, 2019 and 2020, to evaluate the effects of irrigation intervals, organic fertilization and NPK at the recommended dose (NPK_R) on growth, yield and some chemical constituents of henna (*Lawsonia alba* Lam) plants. The irrigation intervals were I_1 (every 7 day), I_2 (every 14 day) and I_3 (every 21 day), while fertilizer treatments were control (without), chemical fertilizer (recommend does of NPK_R), two levels of farmyard manure (15 and 25 m^3/ $feddan^{-1}$ (feddan =4200 m^2)) and two levels of compost (10 and 15 m^3 $feddan^{-1}$). The results showed that, generally, by increasing irrigation intervals from one week to 3 weeks interval the growth characteristics, yield and chemical constituents, among all cuts, in both seasons were decreased. The highest values of these traits were observed when irrigating henna plants everyone I1, followed 2 weeks (I_2). Regarding NPK and organic fertilization treatments, all of them led an increase in the growth, yield and chemical constituents mostly. The best results when the addition of NPK_R followed by compost at 15 m^3 $feddan^{-1}$. The combined effect between irrigation intervals, NPK and organic fertilization on henna (*Lawsonia alba* Lam) plants was statistically significant. In most cases, irrigation of henna plants every one week (I) with fertilization of NPK at the recommend dose or with compost at 15 m^3 $feddan^{-1}$ were the most effective treatments, mostly concerning growth, yield, as well as chemical constituents.

Keywords: Henna, irrigation intervals, organic fertilization, NPK_R.

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1. Introduction

Henna (*Lawsonia alba*) belongs to the family Lythraceae. It is one of the most popular sources of natural dyes of the old world. It has been in the Middle East and Egypt at least since 3000 BP (Aronson *et al.*, 2017). Where mummies were found whose hands had been dyed with henna. The flowers of such tree were also used by the ancient Hebrews to make a perfume and later by the Romans and the Greeks. It is still in many places thought to bring 'barakah' or divine blessing and is still used in all major Islamic ceremonies (births, weddings and funerals) in many parts of the Middle East, North Africa and Asia (Aronson *et al.*, 2017). Henna is a medicinal and industrial plant which has been considered as one of the natural dyes. The leaves contain a red-orange color component known as lawsone (2 hydroxy 1, 4 napthoquinone), which is also named as hennotannic acid. Lawsone is the main constituent taking charge of the dying properties of henna plants (Kidanemariam *et al.*, 2013; Semwal *et al.*, 2014). Henna is one of the medicinal plants which tolerant to drought and can grow only if minimum temperatures stay above 11°C (Kidanemariam *et al.*, 2013). Irrigation is the main sector in water consumption at the national level. Water allocated for irrigation is about 85% from the total renewable water resources (Veldwisch *et al.*, 2019). So, effective water management at the irrigation sector is the major way towards the rationalization policy for the country. Water shortage problem in Egypt is continuously increased and it is prospected to reach the threshold level of less than 500 m^3/year/capita which so-called water scarcity limits (Abdelhafez *et al.*, 2020). Moreover, the per capita use of water for different purposes is gradually decreasing to less than the water poverty limit of 1000 m^3 per annum (El-Quosy, 1998). To overcome the water shortage, it is necessary to develop water-saving agriculture countermeasures, thereby producing more crops per drop. Shortage irrigation and alternate partial root-zone irrigation are water-saving irrigation strategies being widely used in arid and semi-arid regions (Jensen *et al.*, 2010). Alternate partial root zone irrigation is a further development of increasing water saving; it includes irrigating only part of the root zone, leaving the other part to dry to a pre-determined level before the next irrigation (Kang and Zhang, 2004). Organic farming is one of the most agricultural practices Thus, organic fertilizers act primarily cast effective and easily available from locality products than those of mineral fertilizers (Solomon *et al.*, 2012). Organic manures are important role in promoting microbial biomass (Suresh *et al.*, 2004). So, the basis of soil fertility was due to the presence of organic matter (Aboudrare, 2009). Therefore, the objective of this investigation was to the impact investigate of irrigation intervals and organic fertilizers rate, as well as their

interactions on growth, yield and chemical composition of henna (*Lawsonia alba* Lam) plants under Upper Egypt conditions.

2. Materials and methods

2.1 Experimental site and treatments description

This experiment was carried out in a private Farm Aswan Governorate, Upper Egypt, during the two growing summer seasons of 2019 and 2020 to study the effect of irrigation intervals and fertilization sources, as well as their interactions on the growth, yield and chemical constituents of henna (*Lawsonia alba* Lam). The soil samples were air-dried, crushed, homogenized and sieved < 2 mm for further analyses. Fundamental physical and chemical properties of the soils and the organic fertilization were determined by standard methods (Blume *et al.*, 2011) and are listed in Tables (1 and 2).

Table (1): Some physical and chemical properties of the experimental site.

Properties	0-30 cm	30-60 cm
Sand (%)	34.02	33.55
Silt (%)	27.98	28.97
Clay (%)	38.00	37.53
Texture	Clay Loam	Clay Loam
Filed capacity (v%)	39.3	38.8
Witling point (v%)	22.3	21.5
Available water (v%)	17.0	17.3
$CaCO_3$ (%)	3.80	4.55
pH (1:2.5 suspension)	7.85	7.98
EC_e (dS m^{-1})	0.38	0.46
Organic matter (g/kg)	24.1	22.5
Available N (mg kg^{-1})	68.2	65.4
Available Olsen P (mg kg^{-1})	12.78	14.32
Available K (mg kg^{-1})	298.1	466.4

Table (2): Some chemical characteristics of the studied organic fertilization.

Property	Unit	Farmyard manure	Compost
pH (1: 2.5)	---	6.92	7.85
EC (1:2.5)	(dS/m)	1.69	2.88
OM	(%)	35.80	37.95
N	(%)	2. 27	2.22
P	(%)	1.29	1.33
K	(%)	0.95	1.83

2.2 Growth and yield characteristics

The plants were harvested two times in both seasons, after three months in June and September by cutting vegetative growth at 10 cm above the soil surface. Then, the leaves of every plant were individually separated from the branches and air dried in shade at room temperature (about 25°C) then, packed in paper bags. Yield characteristics were recorded in the two cuttings: plant height

(cm), number of main branches branches/ plant, leaves fresh and dry weights/plant (g) and dry leaves yield (kg feddan^{-1}).

2.3 Chemical constituents

Chemical measurements were taken in the second cut for both seasons. Lawson and tannins are the main active constituents in henna leaves. Lawsone (2-hydroxy, 1, 4-aphthoquinone) is mainly responsible for the color development in the leaves of henna. Lawson pigment content was determined in the air-dried henna leaves according to Pratibha and Korwar (1999). Lawson yield in kg feddan^{-1} was calculated by multiplying leaves dry weight (kg feddan^{-1}) in Lawson percentage and total carbohydrates percentage in the dry leaves of each treatment were calorimetrically determined by the method of Michel *et al.* (1956). The free amino acid proline (ppm) was determined by the method explained by Bates *et al.* (1973).

2.4 Statistical analysis

All obtained data was tabulated and statistically analyzed. LSD range test and one-ANOVA were proceeded by Costat package at probability level of 5%.

3. Results and discussion

3.1 Plant height

The data listed in Table (3) revealed that the main effect of irrigation intervals on the plant height of henna plants was statistically significant among the two cuts in the two experimental seasons. From the obtained data, it is obvious that plant height was gradually significantly decreased by irrigated the plants from 2–3 week intervals. Whereas the differences between the irrigation every one week (I_1) and every two weeks (I_2) were not significant, mostly, among all cuts, in both seasons. Therefore, plants irrigated everyone week interval gave the highest values of plant height (145.2 and 147.7 cm) in the first season and (175.7and 189.0 cm) in the second one for the two cuts, respectively, as compared to the other irrigation intervals. Concerning organic fertilizer treatments, the data in Table (3) proved that treating henna plants with the two organic fertilizers at all rates and the NPK at the recommended doses, in the two cuts, for the two seasons, led to a significant increase in plant height, mostly, as compared to control, except for FYM in the two cuts, for both seasons. Clearly, the addition of NPK at the recommended doses and compost at 15 m^3 feddan^{-1} proved to be more effective in increasing plant height in two cuts, than those obtained by other treatments and control, in the two seasons. Numerically, these previous superior treatments augmented such an aspect by 36.71, 32.96 and by 51.21, 44.97% in the first cut and by 34.65, 29.56 and by 51.72, 48.06 % in the second cut over control, for both seasons, respectively.

Table (3): Effect of irrigation intervals and fertilization treatments on plant height (cm) of henna plant during the two seasons of 2019 and 2020.

Mineral and organic fertilizers (B)	Irrigation intervals (A)							
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
	First cut							
	First season				Second season			
CO	123.7	122.7	105.7	117.4	139.0	133.7	112.3	128.3
NPK_R	173.0	165.7	142.7	160.5	221.7	214	146.3	194
FYM1	129.0	126.0	113.0	122.7	148	147.3	118	137.8
FYM2	142.0	156.3	131.0	143.1	180	175	139.7	164.9
COM1	135.0	130.7	118.7	128.1	160.3	157	131.3	149.5
COM2	168.3	162.3	137.7	156.1	205	203.3	149.7	186
Mean	145.2	144.0	124.8		175.7	171.7	132.9	
$LSD_{0.05}$	A=8.6 B= 10.1 A*B= NS				A=3.5 B= 4.6 A*B=8.0			
Second cut								
CO	128.3	127.3	109.7	121.8	148	143.3	126.3	139.2
NPK_R	174.7	171.7	145.7	164	241.0	227.7	165.0	211.2
FYM1	132.7	130.7	115	126.1	154.0	156.7	131.3	147.3
FYM2	146	157.3	136.3	146.5	190.0	187.7	158.3	178.7
COM1	137.7	135.7	125.3	132.9	174.7	171.3	151.3	165.8
COM2	166.7	164	142.7	157.8	226.0	217.0	175.3	206.1
Mean	147.7	147.8	129.1		189.0	184.0	151.3	
$LSD_{0.05}$	A=8.6 B= 10.0 A*B= NS				A=6.5 B= 6.1 A*B= 10.3			

The effectiveness of organic manures on augmenting plant height was also revealed by Abdel-Mola and Ayyat (2021) on henna plant, Hassan *et al*. (2015) on rosemary, Shehata (2013) on guar and Abdou *et al*. (2014) on marjoram. In regard to the interaction between the two studied factors, it was statistically significant effect on plant height, in two cuts, during the second season only. Obviously, the most combined treatments, among the two cuts, in second season, resulted a significant augment in plant height, comparing to untreated plants. In most cases, the values of plant height were high in the first cut, followed by the second cut during the second season. Furthermore, the longest plants were detected due to irrigating henna plants every one week or two week intervals plus NPK at the recommended dose followed by the irrigation every one week + compost at 15 m^3/feddan, among the two cuts, in comparison with those given by other combination treatments, during both seasons, as clearly indicated in Table (3).

3.2 Main branches number/plant

Data listed in Table (4) revealed that the main effect of irrigation interval dates on the main branches number of henna plants was statistically significant for the two cuts, in the two experimental seasons, except for the first cut in the first season. From the obtained data, branch number was significantly increased by the irrigation every one week (I_1) over than the irrigation every two or three weeks (I_2 or I_3), among all cuts, mostly, during the two seasons. The highest branch number were obtained by the irrigation every one week interval among all cuts as ranged 2.50, 4.10 and by 2.30, 3.20 in the first cut, by 2.80, 3.90 and by 2.30, 3.40 over than every 2 weeks and over than every three weeks, respectively.

Table (4): Effect of irrigation intervals and fertilization treatments on main branches number/plant of henna plant during the two seasons of 2019 and 2020.

Mineral and organic fertilizers (B)	Irrigation intervals (A)							
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
	First cut							
	First season				Second season			
CO	1.6	1.3	1.6	1.5	2.3	2.0	2.0	2.1
NPK $_R$	3.0	3.3	3.0	3.1	5.7	4.7	4.3	4.9
FYM1	1.7	1.3	1.7	1.6	3.3	2.0	2.0	2.4
FYM2	3.7	2.7	2.0	2.8	4.0	3.3	3.7	3.7
COM1	2.0	2.0	1.3	1.8	4.0	3.0	3.0	3.3
COM2	3.0	3.0	2.3	2.8	5.3	4.3	2.3	4.0
Mean	2.5	2.3	2.0		4.1	3.2	2.9	
$LSD_{0.05}$	A=NS B= 0.7 A*B= NS				A=0.5 B= 0.6 A*B= 0.9			
Second cut								
CO	1.7	1.3	1.3	1.4	2.7	2.7	2.3	2.6
NPK $_R$	4.3	3.7	3.0	3.7	5.2	4.5	3.0	4.2
FYM1	2.0	1.7	2.0	1.9	3.0	2.3	2.0	2.4
FYM2	3.3	3.0	2.0	2.8	4.0	3.7	4.0	3.9
COM1	2.3	2.3	2.3	2.3	3.7	3.3	2.7	3.2
COM2	3.3	3.3	2.3	3.0	4.5	4.0	3.3	3.9
Mean	2.8	2.3	2.2		3.9	3.4	2.9	
$LSD_{0.05}$	A=0.3 B= 0.5 A*B= NS				A=0.5 B= 0.6 A*B=1.1			

Concerning organic fertilizer treatments, the data in Table (4) proved that treating henna plants with the two organic fertilizers at all rates and NPK at the recommended dose, in the two cuts, for the two seasons, led to a significant increase in main branches number, except for FYM in the first cut forboth seasons and, also COM, in the second cut for the first season, as compared to control. Clearly, addition of NPK at the recommended dose and compost at 15 m^3 $feddan^{-1}$ proved to be more effective in increasing main branches number in the two cuts, than those obtained by other treatments and control, in the two seasons. Numerically, these previous superior treatments augmented such aspect by 106.67, 86.67 and by 133.33, 90.48 in the first cut, by 164.29, 151.54 and by 114.29, 50.00 % and in the second cut over control, for both seasons, respectively. Many investigators came to similar results obtained in the present study which indicated that organic fertilization augmented branch number such as, Abdel-Mola and Ayyat (2021) on henna plant, Hassan *et al*. (2015), on rosemary, Shehata (2013) on guar, Abdou *et al*. (2014) on marjoram and Helmy and Zarad (2003) on *Borago officinalis*. In regard to the interaction between the two studied factors, it was statistically significant effect on main branches number per plant, in the two cuts, during the second season only. Obviously, all combined treatments, among the two cuts, in the second season only, resulted a significant augment in main branches number, comparing to untreated plants. In most cases, the values of main branches number were higher in the first cut, followed by the second cut during the second season. Furthermore, the highest main branches number/ plant was detected due to irrigating henna plants every one week interval (I_1) plus NPK at the recommended dose followed by compost at 15 m^3 $feddan^{-1}$, among the two cuts, in

comparison with those given by other combination treatments, during both seasons, as clearly indicated in Table (4).

3.3 Leaves fresh weight (g)/plant

The listed data in Table (5) cleared shows that the main effect of irrigation intervals on the leaves fresh weight (g) /plant of henna plants were statistically significant in the two experimental seasons. From the obtained data, it is obvious that a leaves fresh weight (g) /plant was gradually significantly decreased with increasing the irrigation intervals from the irrigation every one week to every three weeks interval, among all cuts, in both seasons.

Table (5): Effect of Effect of irrigation intervals and fertilization treatments on fresh leaves weight/plant (g) of henna plant during the two seasons of 2019 and 2020.

Mineral and organic fertilizers (B)	Irrigation intervals (A)							
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
	First cut							
	First season				Second season			
CO	98.8	79.5	44.5	74.3	84.5	61.3	35.2	60.3
NPK_R	185.0	161.2	90.0	145.4	186.0	163.3	91.5	146.9
FYM1	112.0	92.2	51.8	85.3	107.5	88.9	55.1	83.8
FYM2	157.5	138.7	68.5	121.6	158.5	140.7	69.0	122.7
COM1	130.8	101.7	58.1	96.9	132.3	98.0	31.5	87.3
COM2	171.5	146.2	81.0	132.9	171.3	147.3	79.5	132.7
Mean	142.6	119.9	65.7		140.0	116.6	60.3	
$LSD_{0.05}$	A=5.8 B=5.8 A*B= 10.0				A=12.6 B= 9.4 A*B= 16.3			
Second cut								
CO	98.3	91.6	35.9	88.6	98.5	75.5	37.3	70.4
NPK_R	190.2	165.3	95.0	150.2	191.7	167.0	94.5	151.1
FYM1	131.6	120.9	54.6	109.0	127.4	92.4	59.3	93.0
FYM2	166.3	141.8	71.5	126.5	167.0	146.7	73.3	129.0
COM1	149.3	103.1	68.6	107.0	147.7	95.9	66.2	103.3
COM2	180.8	148.3	85.0	138.0	183.5	160.0	87.3	143.6
Mean	152.1	128.5	68.4		152.6	122.9	69.7	
$LSD_{0.05}$	A=18.1 B=22.9 A*B=31.3				A=12.3 B= 7.2 A*B= 13.6			

Therefore, irrigating the plants one week (I_1) produced the highest values of fresh leaves weight (g)/plant (142.6 and 152.1 g) in the first season and (140.0 and 152.6 g) in the second season for the two cuts, respectively as compared to other irrigation intervals. Concerning organic and NPK fertilizers treatments, the data in Table (5) proved that treating henna plants with the two organic fertilizers at all rates and NPK, in two cuts, for the two seasons, led to a significant increase in leaves fresh weight/plant (g), mostly, as compared to control. Clearly, the addition of NPK_R and compost at 15 m^3/feddan proved to be more effective in increasing leaves fresh weight (g) /plant in two cuts than those obtained by other treatments and control, in the two seasons. Numerically, the two previous superior treatment augmented such on aspect by 95.69, 69.53 and by 78.87, 55.76 % in the first cut and by 143.62, 114.63 and by 120.07, 103.98 % in the second cut over control, for both seasons, respectively. In regard to the interaction between the two studied factors, it was a statistically significant effect on leaves

fresh weight/plant (g), in the two cuts, during the two seasons. Obviously, several combined treatments, among two cuts, in second seasons, resulted a significant augment in leaves fresh weight (g)/plant comparing to untreated plants. In most cases, the values of leaves fresh weight (g)/plant were higher in the second cut than those noticed by the first cut. Furthermore, the highest values were detected due to irrigating henna plants every one week (I_1) plus NPK_R followed compost at 15 m^3/feddan, among the two cuts, in comparison with those given by other combination treatments, during both seasons Table (5).

3.4 Leaves dry weight (g)/plant

The listed data in Table (6) shows that the main effect of irrigation intervals on the leaves dry weight (g)/plant of henna plants were statistically significant in the two experimental seasons. From the obtained data, it is obvious that leaves dry weight (g)/plant have gradually decreased with increasing the irrigation intervals from the irrigation every one week to every three weeks interval, in the two cuts, for both seasons. Therefore, the irrigation rate one every one week (I_1) produced the highest values of leaves dry weight (g)/plant by (39.7 and 42.8 g) in the first season and (48.10 and 53.0 g) at the second season for the two cuts, respectively compared to the other irrigation intervals. Concerning organic and NPK fertilizers treatments, the data in Table (6) proved that treating henna plants with the two organic fertilizers at all rates and NPK, in the two cuts, for the two seasons, led to a significant increase in leaves dry weight (g)/plant, as compared to control. Clearly, the addition of NPK_R followed by compost at 15 m^3/feddan proved to be more effective in increasing leaves dry weight (g) /plant in two cuts, than those obtained by other treatments and control, in the two seasons. Numerically, these previous superior treatments augmented such aspect by 137.43, 117.11 and by 104.40, 84.00% in the first cut and by 120.67, 102.40 and by 90.66 & 80.97 % in the second cut over control, for both seasons, respectively. The effectiveness of organic manures in augmenting leaf weight was also explained by Abdel-Mola and Ayyat (2021) on henna plant and El-Leithy *et al.* (2006) on *Salvia officinalis*. In regard to the interaction between the two studied factors, it was statistically significant effect of leaves dry weight (g)/plant, in the two cuts, during the two seasons. Obviously, the most combined treatments, among the two cuts, in both seasons, resulted a significant augment in leaves dry weight (g)/plant comparing to untreated plants. In most cases, the values of leaves dry weight (g)/plant were higher in the second cut than those of the first one in the two seasons. Furthermore, the highest values of such trait were detected due to irrigating henna plants every one week (I_1) plus NPK_R followed by compost at15 m^3/feddan, among the two cuts, in comparison with those given by other combination

treatments, during both seasons, as clearly indicated in Table (6).

Table (6): Effect of irrigation intervals and fertilization treatments on dry leaves weight/plant (g) of henna plant during the two seasons of 2019 and 2020.

Mineral and organic fertilizers (B)	Irrigation intervals (A)							
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
	First cut							
	First season				Second season			
CO	22.5	18.5	15.2	18.7	34.3	24.7	15.9	25.0
NPK_R	52.8	50.3	30.0	44.4	61.2	51.7	40.5	51.1
FYM1	32.0	28.9	17.3	26.1	41.3	29.8	18.9	30.0
FYM2	45.0	43.3	22.8	37.0	51.0	47.2	26.2	41.5
COM1	36.6	31.7	19.4	29.2	45.5	38.2	23.5	35.7
COM2	49.0	45.7	27.0	40.6	55.5	49.0	33.5	46.0
Mean	39.7	36.4	22.0		48.1	40.1	26.4	
$LSD_{0.05}$	A=1.8 B= 1.9 A*B=3.1				A=3.0 B= 1.8 A*B=3.2			
Second cut								
CO	23.8	21.1	14.6	20.8	37.8	29.3	19.7	28.9
NPK_R	54.3	51.7	31.7	45.9	64.0	55.3	46.0	55.1
FYM1	37.6	29.4	18.2	28.4	47.6	34.3	23.3	35.1
FYM2	47.5	44.3	23.8	38.5	55.0	52.3	36.5	47.9
COM1	42.0	32.2	22.9	32.4	53.6	42.7	40.3	45.5
COM2	51.7	46.3	28.3	42.1	59.8	58.8	38.3	52.3
Mean	42.8	38.0	23.3		53.0	45.5	34.0	
$LSD_{0.05}$	A=2.6 B= 2.6 A*B=4.6				A=2.1 B= 1.5 A*B=3.1			

3.5 Leaves dry yield (kg)/feddan

The listed data in Table (7) cleared shows that the main effect of irrigation intervals on the leaves dry yield (kg/feddan) of henna plants, among the two cuts were statistically significant in the two experimental seasons. From the obtained data, it is obvious that leaves dry yield (kg/feddan) has gradually significantly has decreased with the first one irrigation to third irrigation time dates among all cuts, in both seasons. Therefore, planting with irrigation rate one (I_1) produced the highest values of yield dry leaves (kg/feddan) (925.8 and 999.8kg) in the first season and (1123.9 and 1236.8 kg) at in the second season to two cuts, respectively, compared to the other irrigation intervals. Concerning organic and NPK fertilizer treatments, the data in Table (7) proved that treating henna plants with the two organic fertilizers at all rates and NPK, in two cuts, for the two seasons, led to a significant increase in leaves dry yield (kg/feddan) mostly, as compared to control. Clearly, the addition of NPK_R followed by compost at 15 m^3 $feddan^{-1}$ proved to be more effective in increasing the leaves dry yield (kg/feddan) in two cuts than those obtained by other treatments and control, in the two seasons. Numerically, these previous superior treatments augmented such an aspect by 110.27, 120.31 and by 92.25, 10.06% in the first cut and by 104.80, 90.43 and by 84.24, 80.76 % in the second cut over control, for both seasons, respectively. In regard to the interaction between the two studied factors, it was statistically significant effect or leaves dry yield (kg/feddan), in the two cuts, during both seasons. Obviously, all

combined treatments, among two cuts, in second seasons, resulted a significant augment in leaves dry yield (kg/feddan) mostly, comparing to untreated plants.

Table (7): Effect of irrigation intervals and fertilization treatments on leaves dry yield (kg/feddan) of henna plant during the two seasons of 2019 and 2020.

Mineral and organic fertilizers (B)	Irrigation intervals (A)							
	I_1	I_2	I_3	Mean	I_1	I_2	I_3	Mean
	First cut							
	First season				Second season			
CO	525.4	597.8	354.9	492.7	800.9	576.7	371.3	583.0
NPK_R	1232.9	1174.5	700.5	1036.0	1429.0	1207.2	945.7	1194.0
FYM1	747.2	674.8	404.0	608.7	964.4	695.8	441.3	700.5
FYM2	1050.8	1011.1	532.4	864.7	1190.9	1102.1	611.8	968.2
COM1	854.6	740.2	453.0	682.6	1062.4	892.0	548.7	834.4
COM2	1144.2	1067.1	630.5	947.2	1295.9	1144.2	782.2	1074.1
Mean	925.8	877.6	512.5		1123.9	936.3	616.8	
$LSD_{0.05}$	A=71.4 B= 51.8 A*B=88.7				A=342.6 B= 447.7 A*B=735.7			
Second cut								
CO	555.7	562.7	340.9	486.5	882.6	684.2	460.0	675.6
NPK_R	1267.9	1207.2	740.2	1071.8	1494.4	1291.3	1074.1	1286.6
FYM1	878.0	686.5	425.0	663.1	1111.5	800.9	544.1	818.8
FYM2	1109.1	1034.4	555.7	899.8	1284.3	1221.2	852.3	1119.2
COM1	980.7	751.9	534.7	755.8	1251.6	997.0	941.0	1063.2
COM2	1207.2	1081.1	660.8	983.0	1396.3	1373.0	894.3	1221.2
Mean	999.8	887.3	542.9		1236.8	1061.3	794.3	
$LSD_{0.05}$	A=88.7.7 B= 102.1 A*B=153.5				A=124.6 B= 124.6 A*B=173.1			

In most cases, the values of leaves dry yield (kg/feddan) were higher in the second cut than those of the first one, in the two seasons. Furthermore, the highest values were detected due to irrigating henna plants every one week plus NPK_R followed by compost at 15 m^3 $feddan^{-1}$, among the two cuts, in comparison with those given by other combination treatments, during both seasons, as clearly indicated in Table (7).

3.6 Chemical constituents

3.6.1 Lawson percentage

The data listed in Table (8) showed that irrigation intervals of henna at three intervals significantly affected the Lawson percentage of the dried leaves of henna plant during the two seasons 2019 and 2020. From the obtained data, it is obvious that Lawson percentage has gradually increased with the first irrigation to third time dates, in both seasons. Therefore, planting with irrigation rate one (I_1) produced the highest values of Lawson percentage (1.795 and 1.560 %) in both seasons, respectively compared to the other irrigation intervals. Concerning organic and NPK fertilizers treatments, the data in Table (8) proved that treating henna plants with the two organic fertilizers at all rates and NPK, in two cuts, for the two seasons, led to a significant increase in Lawson percentage, mostly, as compared to control. Clearly, the addition of NPK_R followed bt FYM_1 at 10 m^3/feddan proved to be more effective in increasing Lawson percentage, than those obtained by other treatments and control, grown in the two seasons. In regard to the interaction between the two studied factors, it was a statistically

significant effect of Lawson percentage, during both seasons. The highest values were detected due to treating henna plants with the higher level of irrigation plus NPK_R followed by FYM_2 at 15 m^3 $feddan^{-1}$, in comparison with those given by other combination treatments, during both seasons (Table 8).

Table (8): Effect of irrigation intervals and fertilization treatments on Lawson percentage of henna plant during the two seasons of 2019 and 2020.

Mineral and organic fertilizers (B)	Irrigation intervals (A)			
	I_1	I_2	I_3	Mean
	First season			
CO	1.214	1.035	1.203	1.151
NPK_R	1.717	1.425	1.567	1.570
FYM1	1.764	1.153	1.571	1.496
FYM2	1.306	1.083	1.629	1.339
COM1	1.667	1.096	1.343	1.369
COM2	1.603	1.168	1.259	1.343
Mean	1.795	1.160	1.429	
$LSD_{0.05}$	A= 0.052 B=0.069 A*B=0.117			
Second season				
CO	1.323	1.02	1.253	1.199
NPK_R	1.565	1.818	1.577	1.653
FYM1	1.865	1.252	1.671	1.596
FYM2	1.316	1.092	1.639	1.349
COM1	1.677	1.089	1.373	1.380
COM2	1.613	1.159	1.319	1.364
Mean	1.560	1.238	1.472	
$LSD_{0.05}$	A= 0.042 B=0.146 A*B=0.217			

3.6.2 Lawson yield (kg)/feddan

The listed data in Table (9) cleared that the main effect of irrigation intervals on the Lawson yield (kg) per feddan of henna plants was statistically significant in the two experimental seasons. From the obtained data, it is obvious that Lawson yield (kg) per feddan were gradually decreased with one irrigation compared to third irrigation, in both seasons. Therefore, the irrigation interval one (I_1) produced the highest values of Lawson yield (kg)/feddan by 25.61 and 31.40 kg), respectively, compared to the other irrigation intervals. Concerning organic and NPK fertilizers treatments, the data in Table (9) proved that treating henna plants with the two organic fertilizers at all rates + NPK at recommended dose, in the two seasons led to a significant increase in Lawson yield per feddan (kg), mostly, as compared to control. Clearly, the addition of NPK_R follow by compost at 15 m^3 $feddan^{-1}$ proved to be more effective in increasing Lawson yield per fed (kg), than those obtained by other treatments and control, in the two seasons. Numerically, this previous superior treatment augmented such aspect 195.79 and 135.90% in the first season and 167.17 and 115.31% in the second season, respectively. It worthy mention that the combined effect between the two studied factors, it was statistically significant effect on Lawson yield per (kg)/feddan, during the both seasons. Obviously, all combined treatments, in second seasons, resulted a

significant augment in Lawson yield per feddan (kg), mostly, comparing to untreated plants. In most cases, the values of Lawson yield/feddan (kg) were higher, Furthermore, the highest values were detected due to irrigating henna plants with three weeks interval of irrigation plus NPK_R followed by compost at 15 m^3 $feddan^{-1}$, among the two cuts, in comparison with those given by other combination treatments, during both seasons (Table 9).

Table (9): Effect of irrigation intervals and fertilization treatments on Lawson yield (kg)/feddan of henna plant during the two seasons of 2019 and 2020.

Mineral and organic fertilizers (B)	Irrigation intervals (A)			
	I_1	I_2	I_3	Mean
	First season			
CO	13.12	12.01	8.37	11.17
NPK_R	35.64	40.89	22.58	33.04
FYM1	28.67	15.70	13.02	19.13
FYM2	28.21	22.15	17.73	22.70
COM1	30.59	16.35	13.26	20.07
COM2	37.69	25.09	16.26	26.35
Mean	25.61	21.34	15.08	
$LSD_{0.05}$	A= 5.2	B=6.9	A*B=11.7	
	Second season			
CO	20.44	13.05	10.00	14.50
NPK_R	41.66	42.90	31.65	38.74
FYM1	36.62	17.26	15.48	23.12
FYM2	32.32	25.16	23.85	27.11
COM1	38.57	20.70	20.01	26.43
COM2	43.16	29.40	21.11	31.22
Mean	31.40	24.15	20.16	
$LSD_{0.05}$	A= 5.2	B=6.9	A*B=11.7	

3.6.3 Total carbohydrates and proline

The listed data in Table (10) cleared shows that the main effect of irrigation intervals on the total carbohydrates (%) and proline (ppm) of henna plants was statistically significant in the two experimental seasons. From the obtained data, it is obvious that total carbohydrates (%) and proline (ppm) were gradually significantly has decreased with the first irrigation to third time dates, in both seasons. Therefore, planting with irrigation rate one(I_1) next to the third rate (I_2) then the second cutes (I_3) of irrigation produced the highest values of total carbohydrates (%), While the best obtained of the proline was estimated at the part of the million at the first rate of irrigation, followed by the second yate and then the third, respectively. Concerning organic and NPK fertilizer treatments, the data in Table (10) proved that treating henna plants with the two organic fertilizers at all rates and NPK_R, in the two seasons led to a significant increase in total carbohydrates (%) and proline (ppm), mostly, as compared to control. Clearly, the addition of FYM_2 proved to be more effective in increasing total carbohydrates (%) and proline (ppm), than those obtained by other treatments and control, in the two seasons. It worthy of mention that the combined effect between the two studied factors was a statistically significant

effect or total carbohydrates (%) and proline (ppm), during both seasons.

Table (10): Effect of irrigation intervals and fertilization treatments on total carbohydrates (%) and proline (ppm) of henna plant during the two seasons of 2019 and 2020.

Mineral and organic fertilizers (B)	Irrigation intervals (A)			
	I_1	I_2	I_3	Mean
	Total carbohydrates (%)			
CO	16.73	19.10	20.93	18.92
NPK_R	20.37	19.40	21.60	20.46
FYM1	24.00	19.67	20.23	21.30
FYM2	27.70	19.63	18.87	22.07
COM1	24.73	19.60	17.50	20.61
COM2	21.77	19.60	20.02	20.46
Mean	22.55	19.50	19.86	
$LSD_{0.05}$	A= 1.08	B=2.07	A*B=2.18	
Proline (ppm)				
CO	605.60	733.30	756.60	698.50
NPK_R	700.50	738.60	769.30	736.10
FYM1	795.40	743.80	709.80	749.70
FYM2	890.30	739.60	650.30	760.10
COM1	836.20	735.30	590.80	720.80
COM2	782.20	731.10	641.10	718.10
Mean	768.40	737.00	686.30	
$LSD_{0.05}$	A= 2.9	B=4.1	A*B=7.22	

Obviously, all combined treatments, in second seasons, resulted a significant augment in total carbohydrates (%) and proline (ppm) mostly, comparing to untreated plants. In most cases, the values of total carbohydrates (%) and proline (ppm) were high, Furthermore, the highest values were detected due to irrigating henna plants with three weeks interval of irrigation plus FYM_2, in comparison with those given by other combination treatments, during both seasons, as clearly indicated in Table (10).

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