World Journal of Agricultural Sciences 17 (6): 491-508, 2021
ISSN 1817-3047

DOI: 10.5829/idosi.wjas.2021.491.508

Potentiality Assessment of Fertilization Levels, Plant Population Densities and Cladodes Planting Direction on *Opuntia ficus-indica* as Non – Traditional Fodder Sources

M.A. Osman, A.M.S. Ibrahim, H.M.M. El-Naggar and S.A. Seif

Agronomy Department, Faculty of Agriculture, Benha University, Egypt

Abstract: This study was conducted at the Agricultural Research and Experiments Farm at the Faculty of Agriculture, Benha University during the seasons (2018/2019& 2019/2020). The experiment was designed with the objective of evaluating growth, yield and chemical content of *Opuntia ficus-indica* under three fertilization rates of (NPK), which were (30:20:10, 60:40:20 and 90:60:30 kg/fed.) in addition to the control (without fertilization), as well as three plant population densities 4200 plants/fed.(P1), 8400 plants/fed.(P2) and 16800 plants/fed.(P3). The third factor was cultivation trends of the cladodes (north to south & east to west) and their different interactions. The experimental design was split-split plot where fertilization rates were in the main plots and plant density in the sub plots, while the cultivation trends in the sub-sub. The obtained results showed that all data of the vegetative growth, yield and chemical content responded well all the three levels of fertilization and densities with the direction of cultivation of the cladodes from north to south in both seasons under study. The increase in the studied characters was significant with the high level of fertilization, which resulted in the highest productivity and high chemical content of plant cladodes and use them as non-traditional fodder to reduce the gap in the shortage of animal feed.

Key words: *Opuntia ficus-indica* · Fertilization · Densities · Cladodes · Reflection · Cultivation · Yield · Productivity and chemical content non-traditional

INTRODUCTION

In Egypt, the shortage of fodder resources is one of the main obstacles to development of animal production, the importance of non-traditional plants in reducing the fodder gap, which allows the use of non-traditional fodder to reduce the deficit in animal feeds, including Opuntia, according to the study, cacti are some of the best plants for the re-vegetation of arid and semi-arid areas because they are tolerant of scarce and erratic rainfall and high temperatures, the reasons behind the inclusion of cacti include simple cultivation practices required to grow the crop, its quick establishment soon after the introduction in a new area, ability to grow in harsh conditions characterized by high temperature, lack of water and poor soil, use of its stems as fodder for livestock [1].

Opuntia ficus-indica of non-traditional fodder source is a herbaceous with a family of cactaceae and native to the middle of the American continent, it is a tropical and subtropical plant, it is characterized by the fact that the water stored in the cladodes is connected, which is difficult to lose, the cladodes are also covered with a thick layer of cotin to reduce water loss by transpiration, also we find that acid metabolism (crassulacean acid metabolism), which is one of the methods of photosynthesis in plants, this method is used in the opuntia plants, it also contains of cladodes, 12% protein, 25% fat, 50% carbohydrate and 13% fiber, also contains nutrients to prevent water loss, can be cultivated in the dry land and the use of modern panels as fresh food or cooked for humans, according to the study [2]. To our knowledge, there are few previous studies related to reducing the gap of animal forage by using non-traditional plant fodder.

MATERIALS AND METHODS

This field study was conducted at the Agricultural Research and Experiments Farm, Faculty of Agriculture,

Corresponding Author: M.A. Osman, Agronomy Department, Faculty of Agric., Benha University, Egypt.

Moshtohor, Benha University, Qalyubia Governorate, Egypt, during successive cultivation seasons (2018/2019 and 2019/2020) to assess the possibility of evaluating non-traditional fodder sources.

The objective of this investigation is to study the potentiality response of the *Opuntia ficus-indica* cladodes to four levels of compound fertilization rates (NPK), plant population densities and plant direction of cladodes (north to south & east to west), each experiment included 24 treatment which were the combination of 4 levels of compound fertilization rates (NPK) x 3 plant population densities x 2 plant direction of cladodes in 3 replications in growing seasons (2018/2019&2019/2020).

The Treatments Were as Follows

Compound Fertilization Rates (NPK):

- Control (w/o).
- Low compound fertilization rates (30:20:10 kg NPK/fed.).
- Medium compound fertilization rates (60:40:20 kg NPK/fed.).
- High compound fertilization rates (90:60:30 kg NPK/fed.).

Whereas the sources of compound fertilization rates were nitrogen (ammonium sulfate 20.6%N), phosphorus (monocalcium superphosphate 15.5%P_2O_5) and potassium (potassium sulfate 48% K_2O), complex fertilization rates were applied into 6 doses before irrigation three before autumn harvest (20/9) and three before spring harvest (20/3) in growing seasons.

Three Population Densities of the Opuntia Cladodes as Follows:

- Light population density: (100 cm) between ridges and (100 cm) between cladodes (4 plants/4m^2) forming (4200 plant/fed.).
- Medium population density: (100 cm) between ridges and (50 cm) between cladodes (8 plants/4m^2) forming (8400 plant/fed.).
- Heavy population density: (100 cm) between ridges and (25 cm) between cladodes (16 plants/4m^2) forming (16800 plant/fed.).

Plant Direction of Cladodes:

- Cladodes plants direction (north to south).
- Cladodes plants direction (east to west).

Prickly pear (*Opuntia ficus-indica*) cladodes (18 cm height and weight 170 gm) were obtained from the farm of the Agricultural Research Center at the Faculty of Agriculture at Moshtohor, Benha University.

Planting Procedures: The experimental design was laid out in a spilt-spilt plot type with three replicates in each of two seasons, the compound fertilization rates (NPK) previously mentioned were distributed randomly in the main plots, whereas plant population densities were assigned randomly in the sub plots and the plant direction of cladodes were arranged at the random in the sub-sub plots, the area of each experiment unit was (4m^2) of about 1/1050 fed., area which contained 2 ridges of 2 m length and 1 m width, the other recommended agronomic practices of growing fodder *Opuntia ficus-indica* cladodes were applied regularly as practices in the region, cladodes of the plant which mainly used as fodder need to be harvest by hand, the cladodes used to be cut with knife detecting the cladodes from the plant in the joint.

Recorded Data

The Recorded Data Were on Vegetative Measurements: Two harvests were obtained for each study of the two growing seasons, the first harvest was obtained at 6 months from planting (20/3/2018), then each of the subsequent second harvest was obtained later at 6 months intervals.

Vegetative Growth Characteristics: Four plants were randomly selected from each experimental unit in each of the two seasons for studying the following parameters.

Plant Height (cm)

Fresh and Dry Fodder Yield Production of Cladodes: Fresh fodder yield productivity of the grown cladodes under study were determined for each plant of the subsequent harvests, in each experimental unit for each of the two studied seasons and recorded in ton/fed. using field scale of 0.5 gm sensitivity then fodder yield of cladodes were estimated and recorded in ton /fed.

Dry fodder yield productivity of the grown cladodes were estimated as follows:

Samples of about 200 gm of fresh fodder cladodes were selected randomly from each experimental unit, accurately weighted using an electric balance of 0.01 gm sensitivity, such obtained fresh samples were dried in an air forced drying oven at 70°C for 3 days till constant weight to determine the dry matter content, then dry yield of cladodes were estimated accordingly.

The Yield Measurements Were as Follows:

- Cladodes fresh weight ton/fed.
- Cladodes dry weight ton/fed.
- Cladodes yield (fresh and dry weight ton/fed.) for first and second harvests.

Chemical Constituents: The chemically analyzed samples of the proposed treatments were analyzed for the first and second harvest in dry samples of each treatment of the three replicates in the two growing seasons in both studies under investigation, this is to represent the general effect of the imposed treatments as an average of the whole seasonal environmental variation, in other words such first and second harvests were taken for each of the two seasons for each of the two studied subjects under study, the dried samples were mixed thoroughly for the obtained three replicates of the same treatment to from a composite sample, out of each of three samples, three analysis were done for each treatment, the average results of each analysis in study was recorded, chemical analysis was conducted and presented on dry matter basis, fresh fodder of cladodes samples were randomly taken from each experimental unit, an accurately weighted samples of the fresh fodder of cladodes about 200 gm were dried using an air forced drying oven at 70°C till a constant weight, samples were dried in a labeled kraft paper bags which laid in the drying oven all over the drying period, dried samples were then cooled at room temperature, then ground finely and screened through screen of 40 michs, the fine grounded samples were stored in sealed labeled plastic bags and stored in the refrigerator at 5°C till needed for the chemical analysis, the conducted chemical analysis of fodder cladodes quality components included the following:

Crude Protein Content Ratio: Total nitrogen percentage was determined according to the modified micro kjeldahl method [3], crude protein content was estimated by multiplying nitrogen percentage by 6.25 [3].

Crude Fiber Content Ratio: Crude fiber percentage was determined according to the (A.O.A.C. 1990).

Ash Content Ratio: Accurate weight of 2 gm of the dried composite samples for each treatment were put in weighted labeled-crucibles and placed in a muffle furnace at 550°C for about 6 hours, then cooled down to room temperature and weighted till constant weight [3].

Table 1: Physical and chemical properties of the experimental soil units at Moshtohor Agric. EXP. Station during each of the two growing seasons:

Properties	Seasons 2018
Physical analysis:	
Coarse sand (%)	2.09
Fine sand (%)	23.94
Silt (%)	21.74
Clay (%)	52.23
Textural class	Clay
Chemical analysis:	
$CaCo_3$ (%)	1.05
Organic matter (%)	2.09
N available (mg/kg)	0.88
P available (mg/kg)	0.31
K available (mg/kg)	0.71
E.C (ds. m^{-1})	0.93
pH	7.68

Ether Extract Content Ratio: Ether extract content was extracted using petroleum ether (40-60°C boiling point) in a Soccelt apparatus provided with cold water condenser for 9 hours at a rate of 96 siphons/hour [3].

Total Carbohydrates Content Ratio: It was estimated by subtracting the sum of the percentages of crude protein, crude fiber, ash and ether extract out of 100 [3].

{TCC % = 100- (CP %+CF %+ EE % +Ash %)}.

Physical and chemical characters of the used soil are shown in Table (a), physical analysis was estimated according to [4] whereas, chemical analysis was determined according to [5].

Statistical Analysis: The experiment was statistically analyzed according to the design presented for each of the two growing seasons (2018/2019 and 2019/2020) and analysis of variance was performed according to the procedure described by [6], LSD test at 5% level was used to compare the means.

RESULT AND DISCUSSION

Due to the doubling of the need for fodder resources in recent years, which has negatively affected livestock, whether in terms of their numbers or fluctuations in their prices, in addition to the need to import fodder in hard currency and as a result of the increasing demand for water resources in the world, especially in dry and semi-arid regions, where Egypt suffers from a shortage of feed used in livestock feeding, it is estimated at about 25% of the needs, which causes the price of fodder to rise and is reflected in the price of red meat on the market, to fill this gap.

Table 2: Effect of fertilization levels, population densities and cladodes planting directions of *Opuntia ficus-indica* plant height (cm) during (2018/2019 & 2019/2020) seasons

		Seasons					
		First season (2018/2019)			Second season (2019/2020)		
Treatments		D.1	D.2	Mean	D.1	D.2	Mean
				First harvest (summer - autumn)			
C. (0.0)	P.1	34.00	29.33	33.17	37.67	34.67	38.72
	P.2	34.33	32.67		40.67	36.67	
	P.3	35.00	33.67		43.33	39.33	
F.1 (L)	P.1	34.33	32.33	34.45	41.00	36.33	41.00
	P.2	35.67	33.67		43.67	38.67	
	P.3	36.00	34.67		45.67	40.67	
F.2 (M)	P.1	35.67	34.33	36.00	45.67	38.33	43.72
	P.2	36.67	35.33		46.67	40.33	
	P.3	37.67	36.33		48.67	42.67	
F.3 (H)	P.1	37.33	35.66	37.39	49.67	41.33	46.94
	P.2	37.67	36.33		51.33	42.33	
	P.3	39.67	37.67		52.67	44.33	
Mean		36.17	34.33	====	45.56	39.64	====
	P.1	35.33	32.91	34.12	43.50	37.67	40.59
	P.2	36.09	34.50	35.30	45.59	39.50	42.55
	P.3	37.09	35.59	36.34	47.59	41.75	44.67
LS D. at 5% for		F=0.87,	P=0.76,	D=0.62	F=0.56,	P=0.49,	D= 0.40
		FxP =1.51,	FxD =1.24,	PxD =1.07	FxP =0.98,	FxD =0.80,	PxD =0.69
			FxPxD =2.14			FxPxD =1.38	
				Second harvest (winter - spring)			
C. (0.0)	P.1	34.67	32.67	36.61	42.00	38.33	45.17
	P.2	38.33	34.67		47.00	42.67	
	P.3	41.67	37.67		53.67	47.33	
F.1 (L)	P.1	38.33	35.33	39.22	47.33	40.33	48.78
	P.2	40.67	36.67		51.33	45.33	
	P.3	45.33	39.00		56.67	51.67	
F.2 (M)	P.1	41.00	36.67	41.67	53.67	45.67	53.61
	P.2	44.33	39.67		57.33	49.67	
	P.3	47.67	40.67		59.67	55.67	
F.3 (H)	P.1	43.33	38.00	44.89	58.67	52.00	60.39
	P.2	49.33	42.67		65.33	57.33	
	P.3	52.00	44.00		68.67	60.33	
Mean		43.06	38.14	===	55.11	48.86	====
	P.1	39.33	35.67	37.50	50.42	44.08	47.25
	P.2	43.17	38.42	40.80	55.25	48.75	52.00
	P.3	46.67	40.34	43.51	59.67	53.75	56.71
LS D. at 5% for		F=0.70,	P=0.61,	D=0.50	F=0.58,	P=0.50,	D=0.41
		FxP =1.22,	FxD =1.00,	PxD =0.86	FxP =1.00,	FxD =0.82,	PxD =0.71
			FxPxD =1.73			FxPxD =1.42	

F.0.0 = Control
F.1=Fertilization low
F.2=Fertilization medium
F.3=Fertilization high

P.1=Light population density
P.2=Medium population density
P.3=Heavy population density

D.1=Direction (north to south)
D.2=Direction (east to west)

Vegetative Growth Characteristics

Plant Height (cm): Data presented in Table (2) showed that all studied levels of mineral NPK fertilization succeeded in increasing plant height (cm) of *Opuntia ficus-indica* as compared to un-fertilized plants in the two growing seasons of this study, in this concern fertilizing *Opuntia ficus-indica* with the high compound fertilization rates (90:60:30 kg NPK/fed.) was the most effective one for producing the tallest plants as it scored (37.39 and 46.94 (cm)) in the first harvest, (44.89 and 60.39 (cm)) in the second harvest, in the first and second seasons respectively, irrespective control plants, the lowest values of this parameter were recorded by those recorded the low compound fertilization rates (30:20:10 kg NPK/fed.), followed in ascending order by those supplemented with the medium compound fertilization rates (60:40:20 kg NPK/fed.), this trend was true in both harvests in the two seasons.

Regarding the effect of population densities data in Table (2) reveal that there was a positive relationship between the plant height values and population densities, so the values of plant height increased as the population densities increased until reach to the maximum increasing at the high density, this trend was true in both harvests in the two seasons.

Data in Table (2) clear that planting direction from north to south was superior for inducing the tallest plant when compared with planting direction from east to west in the two harvests of the two seasons, as for the interaction effect between mineral NPK fertilization, planting population and planting direction, data in the same table indicate that, the combination of planting direction from north to south (D1) resulted in the highest values of plant height, especially those planted at the highest density and recorded the high fertilization level as it registered (39.67 and 52.67 (cm)) in the first harvest, (52.00 and 68.67 (cm)) in the second harvest in the first and second seasons respectively, in the contrary, the lowest values of plant height were gained by the combinations of planting direction from east to west (D2), Particularly those planted at the lowest population (1 plant/m^2) and received no chemical fertilization. This trend was true in the two harvests in the two seasons, the other treatments occupied on intermediate position between the abovementioned treatments in the two seasons, These results were in agreement with [7, 8, 9, 10, 11, 12, 13] on *Opuntia ficus–indica*.

The Yield Measurements

Cladodes Fresh Weight Ton/Fed.: Data presented in Table (3) showed that all studied levels of mineral NPK fertilization succeeded in increasing cladodes fresh weight ton/fed. of *Opuntia ficus-indica* as compared to un-fertilized plants in the two growing seasons of this study, in this concern fertilizing *Opuntia ficus-indica* with the high compound fertilization rates (90:60:30 kg NPK/fed.), showed to be the most effective one for producing cladodes fresh weight ton/fed. as it scored (9.25 and 12.19 (ton)) in the first harvest, (8.36 and 10.96 (ton)) in the second harvest, in the first and second seasons respectively, irrespective control plants, the lowest values of this parameter were recorded by those recorded the low compound fertilization rates (30:20:10 kg NPK/fed.), followed in ascending order by those supplemented with the medium compound fertilization rates (60:40:20 kg NPK/fed.), this trend was true in both harvests in the two seasons.

Regarding the effect of population densities data in Table (3) reveal that there was a positive relationship between the cladodes fresh weight ton/fed. values and population densities, so the values of cladodes fresh weight ton/fed. increased as the population densities increased until reach to the maximum increasing at the highest density, this trend was true in both harvests in the two seasons, concerning the effect of planting direction on cladodes fresh weight ton/fed. of *Opuntia ficus indica,*

Data in Table (3) clear that planting direction from north to south was superior for inducing cladodes fresh weight ton/fed. when compared with planting direction from east to west in the two harvests of the two seasons, as for the interaction effect between mineral NPK fertilization, planting population densities and planting direction, data in the same table indicate that, the combination of planting direction from north to south (D1) resulted in the highest values of cladodes fresh weight ton/fed. especially those planted at the highest density and recorded the high fertilization level as it registered (16.21 and 22.12 (ton)) in the first harvest, (14.75 and 19.01 (ton)) in the second harvest in the first and second seasons respectively, in the contrary, the lowest values of cladodes fresh weight ton/fed. were gained by the combinations of planting direction from east to west (D2), particularly those planted at the lowest population (1 plant/m^2) and received no chemical fertilization, this trend was true in the two harvests in the two seasons, the other treatments occupied on intermediate position between the abovementioned treatments in the two seasons, These results were in agreement with [7, 8, 9, 10, 11, 12, 13] on *Opuntia ficus–indica.*

Cladodes Dry Weight Ton/Fed.: Data presented in Table (4) showed that all studied levels of mineral NPK fertilization succeeded in increasing cladodes dry weight ton/fed. of *Opuntia ficus-indica* as compared to un-fertilized plants in the two growing seasons of this

Table 3: Effect of fertilization levels, population densities and cladodes planting directions of *Opuntia ficus-indica* on cladodes fresh weight ton/Fed. during the subsequent two seasons (2018/2019 & 2019/2020)

				Seasons			
		First season (2018/2019)			Second season (2019/2020)		
Treatments		D.1	D.2	Mean	D.1	D.2	Mean
				First harvest (summer - autumn)			
C. (0.0)	P.1	3.43	2.87	6.26	3.98	3.72	8.35
	P.2	5.63	5.48		7.76	6.68	
	P.3	10.92	9.23		15.23	12.71	
F.1 (L)	P.1	3.64	3.33	7.31	5.18	4.22	9.94
	P.2	7.12	5.99		9.46	7.67	
	P.3	12.49	11.28		18.20	14.89	
F.2 (M)	P.1	4.12	3.89	7.96	5.99	5.01	11.20
	P.2	7.35	6.99		10.99	8.43	
	P.3	12.96	12.43		20.16	16.63	
F.3 (H)	P.1	4.61	4.06	9.25	6.51	5.45	12.19
	P.2	8.29	7.95		11.35	10.80	
	P.3	16.21	14.36		22.12	16.89	
Mean		8.06	7.32	=======	11.41	9.43	=======
	P.1	3.95	3.54	3.75	5.42	4.60	5.01
	P.2	7.10	6.60	6.85	9.89	8.40	9.15
	P.3	13.15	11.83	12.49	18.93	15.28	17.11
LS D. at 5% for		F=1.03,	P=0.89,	D=0.74	F=0.75,	P=0.65,	D=0.53
		FxP =1.79,	FxD =1.46,	PxD =1.27	FxP =1.30,	FxD =1.06,	PxD =0.92
			FxPxD =2.53			FxPxD = 1.84	
				Second harvest (winter - spring)			
C. (0.0)	P.1	3.05	2.80	5.80	3.57	3.37	7.43
	P.2	5.53	4.80		6.69	5.93	
	P.3	9.49	9.14		13.68	11.33	
F.1 (L)	P.1	3.51	2.93	6.86	4.40	3.81	8.72
	P.2	6.44	5.76		8.07	6.95	
	P.3	12.36	10.13		15.58	13.49	
F.2 (M)	P.1	3.68	3.53	7.63	5.53	4.27	10.02
	P.2	7.22	6.22		10.16	7.64	
	P.3	12.92	12.19		17.31	15.21	
F.3 (H)	P.1	4.47	3.71	8.36	5.65	4.71	10.96
	P.2	5.93	7.16		11.24	8.61	
	P.3	14.75	14.12		19.01	16.53	
Mean		7.45	6.87	=======	10.07	8.50	=======
	P.1	3.68	3.24	3.42	4.79	4.04	4.41
	P.2	6.28	5.99	6.32	9.04	7.28	8.20
	P.3	12.38	11.40	11.88	16.40	14.14	15.27
LS D. at 5% for		F=0.83,	P=0.72,	D=0.59	F=0.86,	P=0.75,	D=61
		FxP =1.44,	FxD =1.18,	PxD =1.02	FxP =1.49,	FxD =1.22,	PxD =1.05
			FxPxD = 2.04			FxPxD = 2.11	

F.0.0 = Control
F.1= Fertilization low
F.2=Fertilization medium
F.3=Fertilization high

P.1= Light population density
P.2= Medium population density
P.3= Heavy population density

D.1=Direction (north to south)
D.2= Direction (east to west)

Table 4: Effect of fertilization levels, population densities and cladodes planting directions of *Opuntia ficus-indica* on cladodes dry weight ton/Fed. during the subsequent two seasons (2018/2019 & 2019/2020)

		Seasons					
		First season (2018/2019)			Second season (2019/2020)		
Treatments		D.1	D.2	Mean	D.1	D.2	Mean
				First harvest (summer - autumn)			
C. (0.0)	P.1	0.51	0.43	0.94	0.60	0.56	1.25
	P.2	0.84	0.82		1.16	1.00	
	P.3	1.64	1.38		2.29	1.91	
F.1 (L)	P.1	0.55	0.50	1.10	0.78	0.63	1.49
	P.2	1.07	0.90		1.42	1.15	
	P.3	1.87	1.69		2.73	2.23	
F.2 (M)	P.1	0.62	0.58	1.19	0.90	0.75	1.68
	P.2	1.10	1.05		1.65	1.26	
	P.3	1.94	1.86		3.02	2.50	
F.3 (H)	P.1	0.69	0.61	1.39	0.98	0.82	1.81
	P.2	1.24	1.19		1.70	1.51	
	P.3	2.43	2.15		3.32	2.53	
Mean		1.21	1.10	====	1.71	1.40	===
	P.1	0.59	0.53	0.56	0.82	0.69	0.76
	P.2	1.06	0.99	1.03	1.48	1.23	1.36
	P.3	1.97	1.65	1.81	2.84	2.29	2.57
LS D. at 5% for		F=0.15 ,	P=0.13 ,	D=0.11	F=0.12 ,	P=0.10 ,	D=0.09
		FxP =0.27 ,	FxD =0.22 ,	PxD =0.19	FxP =0.21 ,	FxD =0.17 ,	PxD =0.15
			FxPxD=0.38			FxPxD =0.30	
				Second harvest (winter - spring)			
C. (0.0)	P.1	0.46	0.42	0.87	0.54	0.51	1.12
	P.2	0.83	0.72		1.05	0.89	
	P.3	1.42	1.37		2.05	1.70	
F.1 (L)	P.1	0.54	0.44	1.02	0.66	0.57	1.31
	P.2	0.97	0.86		1.21	1.04	
	P.3	1.85	1.52		2.34	2.02	
F.2 (M)	P.1	0.55	0.53	1.14	0.83	0.64	1.50
	P.2	1.08	0.93		1.52	1.15	
	P.3	1.94	1.83		2.60	2.28	
F.3 (H)	P.1	0.67	0.56	1.30	0.85	0.71	1.65
	P.2	1.12	1.07		1.69	1.29	
	P.3	2.20	2.12		2.85	2.48	
Mean		1.14	1.03	====	1.52	1.27	====
	P.1	0.56	0.49	0.53	0.72	0.61	0.67
	P.2	1.00	0.90	0.95	1.34	1.09	1.22
	P.3	1.85	1.71	1.78	2.46	2.12	2.29
LS D. at 5% for		F=0.13 ,	P=0.12 ,	D=0.09	F=0.13 ,	P=0.11 ,	D=0.09
		FxP =0.22 ,	FxD =0.18 ,	PxD =0.15	FxP =0.22 ,	FxD =0.18 ,	PxD =0.16
			FxPxD =0.31			FxPxD =0.32	

F.0.0 = Control | P.1= Light population density | D.1=Direction (north to south)
F.1= Fertilization low | P.2= Medium population density | D.2= Direction (east to west)
F.2=Fertilization medium | P.3= Heavy population density
F.3=Fertilization high

study, in this concern fertilizing *Opuntia ficus-indica* with the high compound fertilization rates (90: 60: 30 kg NPK/fed.), showed to be the most effective one for producing cladodes dry weight ton/fed. as it scored (1.39 and 1.81 (ton)) in the first harvest, (1.30 and 1.65 (ton)) in the second harvest in the first and second seasons respectively, irrespective control plants, the lowest values of this parameter were recorded by those recorded the low compound fertilization rates (30: 20: 10 kg NPK/fed.), followed in ascending order by those supplemented with the medium compound fertilization rates (60: 40: 20 kg NPK/fed.), this trend was true in both harvests in the two seasons.

Regarding the effect of population densities data in Table (4) reveal that there was a positive relationship between the cladodes dry weight ton/fed. values and population densities, so the values of cladodes dry weight ton/fed. increased as the population densities increased until reach to the maximum increasing at the highest density, this trend was true in both harvests in the two seasons, concerning the effect of planting direction on cladodes dry weight ton/fed. of *Opuntia ficus indica,* data in Table (4) clear that planting direction from north to south was superior for inducing cladodes dry weight ton/fed. when compared with planting direction from east to west in the two harvests of the two seasons. As for the interaction effect between mineral NPK fertilization, planting population densities and planting direction.

Data in the same Table (4) indicate that, the combination of planting direction from north to south (D1) resulted in the highest values of cladodes dry weight ton/fed. especially those planted at the highest density and recorded the high fertilization level as it registered (2.43 and 3.32 (ton)) in the first harvest, (2.20 and 2.85 (ton)) in the second harvest in the first and second seasons respectively, In the contrary the lowest values of cladodes dry weight ton/fed. were gained by the combinations of planting direction from east to west (D2), particularly those planted at the lowest population (1 plant/m^2) and received no chemical fertilization, this trend was true in the two harvests in the two seasons, the other treatments occupied on intermediate position between the abovementioned treatments in the two seasons. These results were in agreement with [7, 8, 9, 10, 11, 12, 13] on *Opuntia ficus–indica*.

Yield Cladodes Fresh and Dry Weight Ton/Fed.: Data presented in Table (5) showed that all studied levels of mineral NPK fertilization succeeded in increasing yield cladodes fresh and dry weight ton/fed. of opuntia as compared to un-fertilized plants in the two growing seasons of this study, in this concern fertilizing opuntia with the high compound fertilization rates (90:60:30 kg NPK/fed.), showed to be the most effective one for producing yield cladodes fresh and dry weight ton/fed. as it scored (17.85 and 23.03 (ton)) in yield cladodes fresh weight ton/fed., (2.68 and 3.45 (ton)) in yield cladodes dry weight ton/fed., the first and second seasons, in the first and second seasons respectively, irrespective control plants, the lowest values of this parameter were recorded by those recorded the low compound fertilization rates (30:20:10 kg NPK/fed.), followed in ascending order by those supplemented with the medium compound fertilization rates (60:40:20 kg NPK/fed.), this trend was true in both yield cladodes fresh and dry weight ton/fed., in the two seasons, regarding the effect of population densities.

Data in Table (5) reveal that there was a positive relationship between the yield cladodes fresh and dry weight ton/fed., values and population densities, so the values of yield cladodes fresh and dry weight ton/fed. increased as the population densities increased until reach to the maximum increasing at the highest density, this trend was true in both yield cladodes fresh and dry weight ton/fed., in the two seasons, concerning the effect of planting direction on yield cladodes fresh and dry weight ton/fed. of Opuntia.

Data in Table (5) clear that planting direction from north to south was superior for inducing yield cladodes fresh and dry weight ton/fed., when compared with planting direction from east to west in the two harvests of the two seasons, as for the interaction effect between mineral NPK fertilization, planting population densities and planting direction, data in the same table indicate that, the combination of planting direction from north to south resulted in the highest values of yield cladodes fresh and dry weight ton/fed. especially those planted at the highest density and recorded the high fertilization level as it registered (30.91 and 41.13 (ton)) in the yield cladodes fresh weight ton/fed., (4.64 and 6.17 (ton)) in the yield cladodes dry weight ton/fed. in the first and second seasons respectively, in the contrary, the lowest values of yield cladodes fresh and dry weight ton/fed. were gained by the combinations of planting direction from east to west (D2), particularly those planted at the lowest population and received no chemical fertilization. This trend was true in the two harvests in the two seasons, these results were in agreement with [7, 8, 9, 10, 11, 12, 13] on *Opuntia ficus–indica*.

Table 5: Effect of fertilization levels, population densities and cladodes planting directions of *Opuntia ficus-indica* on yield cladodes fresh and dry weight ton/fed. during the subsequent two seasons (2018/2019&2019/2020)

		Seasons					
		First season (2018/2019)			Second season (2019/2020)		
Treatments		D.1	D.2	Mean	D.1	D.2	Mean
				Yield cladodes fresh weight ton/fed.			
C. (0.0)	P.1	6.48	5.67	12.01	7.55	7.09	15.83
	P.2	11.16	10.27		14.76	12.61	
	P.3	20.13	18.37		28.91	24.04	
F.1 (L)	P.1	7.14	6.26	14.16	9.58	8.00	18.65
	P.2	13.55	11.75		17.53	14.63	
	P.3	24.85	21.41		33.78	28.38	
F.2 (M)	P.1	7.79	7.42	15.58	11.52	9.27	21.21
	P.2	14.57	13.20		21.15	16.03	
	P.3	25.88	24.62		37.47	31.84	
F.3 (H)	P.1	9.08	7.77	17.85	12.13	10.16	23.03
	P.2	15.74	15.10		22.60	18.69	
	P.3	30.91	28.48		41.13	33.45	
Mean		15.61	14.19	====	21.51	17.85	====
	P.1	7.62	6.78	7.20	10.20	8.63	9.42
	P.2	13.76	12.58	13.17	19.09	15.49	17.29
	P.3	25.44	23.22	24.33	35.32	29.43	32.38
LS D. at 5% for		F =1.25,	P =1.08,	D =0.88	F =3.62,	P =3.14,	D =2.56
		FxP =2.17,	FxD =1.77,	PxD =1.53	FxP =6.28,	FxD =5.12,	PxD =4.44
			FxPxD =3.07			FxPxD =8.88	
				Yield cladodes dry weight ton/fed.			
C. (0.0)	P.1	0.97	0.85	1.81	1.13	1.06	2.37
	P.2	1.67	1.54		2.21	1.89	
	P.3	3.06	2.75		4.33	3.61	
F.1 (L)	P.1	1.07	0.94	2.12	1.44	1.21	2.80
	P.2	2.03	1.76		2.63	2.19	
	P.3	3.73	3.21		5.07	4.26	
F.2 (M)	P.1	1.17	1.11	2.34	1.73	1.39	3.22
	P.2	2.19	1.98		3.17	2.62	
	P.3	3.88	3.69		5.62	4.78	
F.3 (H)	P.1	1.36	1.16	2.68	1.82	1.52	3.45
	P.2	2.36	2.27		3.39	2.80	
	P.3	4.64	4.27		6.17	5.01	
Mean		2.34	2.13	====	3.23	2.69	====
	P.1	1.14	1.02	1.08	1.53	1.30	1.42
	P.2	2.06	1.89	1.98	2.85	2.38	2.62
	P.3	3.83	3.48	3.66	5.30	4.42	4.86
LS D. at 5% for		F=0.14,	P=0.12,	D=0.10	F =0.19,	P =0.17,	D =0.13
		FxP =0.25,	FxD=20,	PxD=0.18	FxP =0.32,	FxD =0.26,	PxD =0.23
			FxPxD = 0.35			FxPxD = 0.46	

F.0.0 = Control
F.1= Fertilization low
F.2=Fertilization medium
F.3=Fertilization high

P.1= Light population density
P.2= Medium population density
P.3= Heavy population density

D.1=Direction (north to south)
D.2= Direction (east to west)

Table 6: Effect of fertilization levels, population densities and cladodes planting directions of *Opuntia ficus-indica* on crude protein content ratio during the subsequent two seasons (2018/2019 & 2019/2020)

		Seasons					
		First season (2018/2019)			Second season (2019/2020)		
Treatments		D.1	D.2	Mean	D.1	D.2	Mean
				First harvest (summer - autumn)			
C. (0.0)	P.1	4.07	4.04	4.04	4.13	4.09	4.07
	P.2	4.07	4.03		4.09	4.04	
	P.3	4.03	4.00		4.04	4.01	
F.1 (L)	P.1	4.07	4.07	4.05	4.28	4.17	4.13
	P.2	4.07	4.03		4.10	4.09	
	P.3	4.07	4.00		4.08	4.08	
F.2 (M)	P.1	4.11	4.07	4.07	4.49	4.27	4.21
	P.2	4.10	4.07		4.15	4.11	
	P.3	4.07	4.03		4.11	4.10	
F.3 (H)	P.1	4.12	4.07	4.07	4.65	4.40	4.30
	P.2	4.08	4.07		4.22	4.19	
	P.3	4.07	4.03		4.18	4.16	
Mean		4.08	4.04	====	4.21	4.15	====
	P.1	4.09	4.06	4.08	4.39	4.23	4.31
	P.2	4.08	4.05	4.07	4.14	4.11	4.13
	P.3	4.06	4.02	4.04	4.10	4.09	4.10
LS D. at 5% for		F=0.04, FxP =0.06,	P=0.03, FxD =0.05, FxPxD =0.09	D=0.03 PxD =0.05	F=0.07, FxP =0.12,	P=0.06, FxD =0.10, FxPxD =0.16	D=0.05 PxD =0.08
				Second harvest (winter - spring)			
C. (0.0)	P.1	4.03	4.00	3.99	4.12	4.11	4.08
	P.2	4.00	3.97		4.10	4.08	
	P.3	3.98	3.94		4.07	4.03	
F.1 (L)	P.1	4.07	4.03	4.03	4.22	4.17	4.17
	P.2	4.03	4.03		4.21	4.12	
	P.3	4.03	3.96		4.18	4.09	
F.2 (M)	P.1	4.07	4.03	4.03	4.33	4.21	4.23
	P.2	4.03	4.03		4.28	4.18	
	P.3	4.03	3.99		4.23	4.13	
F.3 (H)	P.1	4.10	4.07	4.06	4.37	4.31	4.29
	P.2	4.03	4.07		4.30	4.27	
	P.3	4.03	4.03		4.27	4.21	
Mean		4.04	4.01	====	4.22	4.16	====
	P.1	4.07	4.03	4.05	4.26	4.20	4.23
	P.2	4.02	4.03	4.03	4.22	4.16	4.19
	P.3	4.02	3.98	4.00	4.19	4.12	4.16
LS D. at 5% for		F=0.03, FxP =0.05,	P=0.03, FxD =0.04, FxPxD =0.07	D=0.02 PxD =0.04	F=0.03, FxP =0.05,	P=0.03, FxD =0.04, FxPxD =0.07	D=0.02 PxD =0.04

F.0.0 = Control P.1= Light population density D.1=Direction (north to south)
F.1= Fertilization low P.2= Medium population density D.2= Direction (east to west)
F.2=Fertilization medium P.3= Heavy population density
F.3=Fertilization high

Chemical Constituents

Crude Protein Content Ratio: Data presented in Table (6) showed that all studied levels of mineral NPK fertilization succeeded in increasing crude protein of *Opuntia ficus-indica* as compared to un-fertilized plants in the two growing seasons of this study, in this concern fertilizing *Opuntia ficus-indica* with the high compound fertilization rates (90:60:30 kg NPK/fed.), showed to be the most effective one for producing crude protein as it scored (4.07 and 4.30) in the first harvest, (4.06 and 4.29) in the second harvest in the first and second seasons respectively, irrespective control plants, the lowest values of this parameter were recorded by those recorded the low compound fertilization rates (30:20:10 kg NPK/fed.), followed in ascending order by those supplemented with the medium compound fertilization rates (60:40:20 kg NPK/fed.), this trend was true in both harvests in the two seasons, regarding the effect of population densities.

Data in Table (6) reveal that there was a positive relationship between the crude protein values and population densities, so the values of crude protein increased as the population densities increased until reach to the maximum increasing at the low density, this trend was true in both harvests in the two seasons, concerning the effect of planting direction on crude protein of *Opuntia ficus indica*.

Data in Table (6) clear that planting direction from north to south was superior for inducing crude protein when compared with planting direction from east to west in the two harvests of the two seasons, as for the interaction effect between mineral NPK fertilization, planting population densities and planting direction, data in the same table indicate that, the combination of planting direction from north to south (D1) resulted in the highest values of crude protein, especially those planted at the lowest density and recorded the high fertilization level as it registered (4.12 and 4.65) in the first harvest, (4.10 and 4.37) in the second harvest in the first and second seasons respectively, in the contrary, the lowest values of crude protein were gained by the combinations of planting direction from east to west (D2), Particularly those planted at the highest population (4plant/m^2) and received no chemical fertilization, this trend was true in the two harvests in the two seasons, the other treatments occupied on intermediate position between the abovementioned treatments in the two seasons. These results were in agreement with [7, 8, 9, 10, 11, 12, 13] on *Opuntia ficus–indica*.

Crude Fiber Content Ratio: Data presented in Table (7) showed that all studied levels of mineral NPK fertilization succeeded in decreasing crude fiber of *Opuntia ficus-indica* as compared to un-fertilized plants in the two growing seasons of this study, in this concern fertilizing *Opuntia ficus-indica* with the high compound fertilization rates (90:60:30 kg NPK/fed.), showed to be the least effective one for producing crude fiber as it scored (29.22 and 26.89) in the first harvest, (30.17 and 28.56) in the second harvest, in the first and second seasons respectively, irrespective control plants, the highest values of this parameter were recorded by those recorded the low compound fertilization rates (30:20:10 kg NPK/fed.), followed in ascending order by those supplemented with the medium compound fertilization rates (60:40:20 kg NPK/fed.), this trend was true in both harvests in the two seasons, regarding the effect of population densities.

Data in Table (7) reveal that there was a negative relationship between the crude fiber values and population densities, so the values of crude fiber decreased as the population densities increased until reach to the minimum decreasing at the high density, this trend was true in both harvests in the two seasons, concerning the effect of planting direction on crude fiber of Opuntia ficus indica.

Data in Table (7) clear that planting direction from north to south was not superior for inducing crude fiber when compared with planting direction from east to west in the two harvests of the two seasons, as for the interaction effect between mineral NPK fertilization, planting population densities and planting direction, data in the same table indicate that, the combination of planting direction from north to south (D1) resulted in the lowest values of crude fiber, especially those planted at the highest density and recorded the high fertilization level as it registered (27.33 and 25.00) in the first harvest, (29.00 and 27.33) in the second harvest in the first and second seasons respectively, in the contrary the highest values of crude fiber were gained by the combinations of planting direction from east to west (D2), Particularly those planted at the lowest population (1 plant/m^2) and received no chemical fertilization, this trend was true in the two harvests in the two seasons, the other treatments occupied on intermediate position between the abovementioned treatments in the two seasons, These results were in agreement with [7, 8, 9, 10, 11, 12, 13] on *Opuntia ficus–indica*.

Table 7: Effect of fertilization levels, population densities and cladodes planting directions of *Opuntia ficus-indica* on crude fiber content ratio during the subsequent two seasons (2018/2019 & 2019/2020)

Treatments		Seasons					
		First season (2018/2019)			Second season (2019/2020)		
		D.1	D.2	Mean	D.1	D.2	Mean
				First harvest (summer - autumn)			
C. (0.0)	P.1	32.67	33.67	32.00	30.33	31.67	29.67
	P.2	31.33	32.67		29.00	30.00	
	P.3	30.33	31.33		28.33	28.67	
F.1 (L)	P.1	31.67	32.33	31.06	29.33	30.67	28.56
	P.2	31.00	31.33		28.00	28.33	
	P.3	29.33	30.67		27.33	27.67	
F.2 (M)	P.1	30.67	31.67	30.34	28.33	29.33	27.78
	P.2	29.67	31.00		27.67	28.00	
	P.3	28.67	30.33		26.33	27.00	
F.3 (H)	P.1	29.67	30.67	29.22	27.67	28.33	26.89
	P.2	28.33	29.67		26.67	27.33	
	P.3	27.33	29.67		25.00	26.33	
Mean		30.06	31.25	====	27.83	28.61	====
	P.1	31.17	32.09	31.63	28.92	30.00	29.46
	P.2	30.08	31.17	30.63	27.84	28.42	28.13
	P.3	28.92	30.50	29.71	26.75	27.42	27.09
LS D. at 5% for		F=0.45,	P=0.39,	D=0.32	F=0.58,	P=0.50,	D=0.41
		FxP =0.78,	FxD =0.63,	PxD =0.55	FxP =1.00,	FxD =0.82,	PxD =0.71
			FxPxD =1.10			FxPxD =1.42	
				Second harvest (winter - spring)			
C. (0.0)	P.1	33.67	34.67	32.72	31.33	32.00	31.06
	P.2	32.67	33.33		30.67	31.33	
	P.3	30.67	31.33		30.33	30.67	
F.1 (L)	P.1	32.67	33.67	32.11	30.33	31.33	29.94
	P.2	31.67	33.33		29.33	30.33	
	P.3	30.33	31.00		28.67	29.67	
F.2 (M)	P.1	31.33	32.67	31.11	29.67	30.33	29.44
	P.2	30.67	31.67		29.33	29.67	
	P.3	29.67	30.67		28.33	29.33	
F.3 (H)	P.1	30.33	31.67	30.17	28.33	29.67	28.56
	P.2	29.33	30.67		28.00	29.33	
	P.3	29.00	30.00		27.33	28.67	
Mean		31.00	32.06	====	29.30	30.19	====
	P.1	32.00	33.17	32.59	29.92	30.83	30.38
	P.2	31.09	32.25	31.67	29.33	30.17	29.75
	P.3	29.92	30.75	30.34	28.67	29.59	29.13
LS D. at 5% for		F=0.47,	P=0.41,	D=0.33	F=0.44,	P=0.38,	D=0.31
		FxP =0.81,	FxD =0.66,	PxD =0.57	FxP =0.76,	FxD =0.62,	PxD =0.54
			FxPxD =1.14			FxPxD =1.08	

F.0.0 = Control
F.1= Fertilization low
F.2=Fertilization medium
F.3=Fertilization high

P.1= Light population density
P.2= Medium population density
P.3= Heavy population density

D.1=Direction (north to south)
D.2= Direction (east to west)

Table 8: Effect of fertilization levels, population densities and cladodes planting directions of *Opuntia ficus-indica* on ash content ratio during the subsequent two seasons (2018/2019 & 2019/2020)

		Seasons					
		First season (2018/2019)			Second season (2019/2020)		
Treatments		D.1	D.2	Mean	D.1	D.2	Mean
				First harvest (summer - autumn)			
C. (0.0)	P.1	27.57	26.20	27.33	27.67	25.67	27.22
	P.2	28.03	26.77		27.67	26.33	
	P.3	28.33	27.17		28.67	27.33	
F.1 (L)	P.1	27.70	26.37	27.95	28.33	26.33	27.56
	P.2	28.77	27.00		28.67	26.67	
	P.3	29.63	28.00		28.67	26.67	
F.2 (M)	P.1	28.33	26.83	28.29	28.67	26.67	28.17
	P.2	29.03	27.17		29.33	27.00	
	P.3	30.07	28.33		29.67	27.67	
F.3 (H)	P.1	28.83	27.73	29.03	29.67	27.67	29.22
	P.2	29.43	28.00		30.33	28.33	
	P.3	30.53	29.63		30.67	28.67	
Mean		28.86	27.43	====	29.00	27.08	====
	P.1	28.11	26.78	27.45	28.59	26.59	27.59
	P.2	28.82	27.24	28.03	29.00	27.08	28.04
	P.3	29.64	28.28	28.96	29.42	27.59	28.51
LS D. at 5% for		F=0.29,	P=0.25,	D=0.20	F=0.42,	P=0.36,	D=0.30
		FxP =0.49,	FxD =0.40,	PxD =0.35	FxP =0.72,	FxD =0.59,	PxD =0.51
			FxPxD =0.70			FxPxD =1.02	
				Second harvest (winter - spring)			
C. (0.0)	P.1	27.00	26.00	26.88	26.67	24.67	26.17
	P.2	27.13	26.03		27.00	25.33	
	P.3	28.07	27.00		27.67	25.67	
F.1 (L)	P.1	27.63	26.27	27.34	27.33	25.67	27.27
	P.2	27.27	26.33		27.67	27.00	
	P.3	28.60	27.97		28.67	27.33	
F.2 (M)	P.1	28.20	26.63	27.94	28.33	26.67	28.06
	P.2	28.37	27.03		28.67	27.33	
	P.3	29.10	28.33		29.67	27.67	
F.3 (H)	P.1	28.80	27.57	28.75	29.33	27.67	29.22
	P.2	29.17	27.90		30.67	28.33	
	P.3	29.80	29.30		30.67	28.67	
Mean		28.26	27.20	====	28.53	26.83	====
	P.1	27.91	26.62	27.27	27.92	26.17	27.05
	P.2	27.99	26.82	27.41	28.50	26.99	27.75
	P.3	28.89	28.15	28.52	29.17	27.34	28.26
LS D. at 5% for		F=0.17,	P=0.15,	D=0.12	F=0.49,	P=0.43,	D=0.35
		FxP =0.30,	FxD =0.24,	PxD =0.21	FxP =0.85,	FxD =0.69,	PxD =0.60
			FxPxD =0.42			FxPxD =1.20	

F.0.0 = Control
F.1= Fertilization low
F.2=Fertilization medium
F.3=Fertilization high

P.1= Light population density
P.2= Medium population density
P.3= Heavy population density

D.1=Direction (north to south)
D.2= Direction (east to west)

Ash Content Ratio: Data presented in Table (8) showed that all studied levels of mineral NPK fertilization succeeded in increasing ash content ratio of *Opuntia ficus-indica* as compared to un-fertilized plants in the two growing seasons of this study, in this concern fertilizing *Opuntia ficus-indica* with the high compound fertilization rates (90:60:30 kg NPK/fed.), showed to be the most effective one for producing ash content ratio as it scored (29.03 and 29.22) in the first harvest, (28.75 and 29.22) in the second harvest, in the first and second seasons respectively, irrespective control plants, the lowest values of this parameter were recorded by those recorded the low compound fertilization rates (30:20:10 kg NPK/fed.), followed in ascending order by those supplemented with the medium compound fertilization rates (60:40:20 kg NPK/fed.), this trend was true in both harvests in the two seasons.

Regarding the effect of population densities data in Table (8) reveal that there was a positive relationship between the ash content ratio values and population densities, so the values of ash content ratio increased as the population densities increased until reach to the maximum increasing at the high density, this trend was true in both harvests in the two seasons, concerning the effect of planting direction on ash content ratio of *Opuntia ficus indica*.

Data in Table (8) clear that planting direction from north to south was superior for inducing ash content ratio when compared with planting direction from east to west in the two harvests of the two seasons, as for the interaction effect between mineral NPK fertilization, planting population densities and planting direction, data in the same table indicate that, the combination of planting direction from north to south (D1) resulted in the highest values of ash content ratio, especially those planted at the highest density and recorded the high fertilization level as it registered (30.53 and 30.67) in the first harvest, (29.80 and 30.67) in the second harvest in the first and second seasons respectively, in the contrary the lowest values of ash content ratio were gained by the combinations of planting direction from east to west (D2), Particularly those planted at the highest population (4 plant/m^2) and received no chemical fertilization, this trend was true in the two harvests in the two seasons, the other treatments occupied on intermediate position between the abovementioned treatments in the two seasons. These results were in agreement with [7, 8, 9, 10, 11, 12, 13] on *Opuntia ficus–indica*.

Ether Extract Content Ratio: Data presented in Table (9) showed that all studied levels of mineral NPK fertilization succeeded in increasing ether extract of *Opuntia ficus-indica* as compared to un-fertilized plants in the two growing seasons of this study, in this concern fertilizing *Opuntia ficus-indica* with the high compound fertilization rates (90:60:30 kg NPK/fed.), showed to be the most effective one for producing ether extract as it scored (2.51 and 2.73) in the first harvest, (2.41 and 2.69) in the second harvest in the first and second seasons respectively, irrespective control plants, the lowest values of this parameter were recorded by those recorded the low compound fertilization rates (30:20:10 kg NPK/fed.), followed in ascending order by those supplemented with the medium compound fertilization rates (60:40:20 kg NPK/fed.), this trend was true in both harvests in the two seasons.

Regarding the effect of population densities data in Table (9) reveal that there was a negative relationship between the ether extract values and population densities, so the values of ether extract decreased as the population densities increased until reach to the maximum increasing at the low density, this trend was true in both harvests in the two seasons, concerning the effect of planting direction on ether extract of *Opuntia ficus indica*.

Data in Table (9) clear that planting direction from north to south was superior for inducing ether extract when compared with planting direction from east to west in the two harvests of the two seasons, as for the interaction effect between mineral NPK fertilization, planting population densities and planting direction, data in the same table indicate that, the combination of planting direction from north to south (D1) resulted in the highest values of ether extract, especially those planted at the highest density and recorded the high fertilization level as it registered (2.80 and 2.87) in the first harvest, (2.63 and 2.84) in the second harvest in the first and second seasons respectively, in the contrary the lowest values of ether extract were gained by the combinations of planting direction from east to west (D2), particularly those planted at the highest population (4plant/m^2) and received no chemical fertilization, this trend was true in the two harvests in the two seasons, the other treatments occupied on intermediate position between the abovementioned treatments in the two seasons. These results were in agreement with [7, 8, 9, 10, 11, 12, 13] on *Opuntia ficus–indica*.

Table 9: Effect of fertilization levels, population densities and cladodes planting directions of *Opuntia ficus-indica* on ether extract content ratio during the subsequent two seasons (2018/2019 & 2019/2020)

		Seasons					
		First season (2018/2019)			Second season (2019/2020)		
Treatments		D.1	D.2	Mean	D.1	D.2	Mean
				First harvest (summer - autumn)			
C. (0.0)	P.1	2.43	2.30	2.24	2.73	2.42	2.51
	P.2	2.30	2.23		2.62	2.38	
	P.3	2.17	2.00		2.53	2.35	
F.1 (L)	P.1	2.57	2.43	2.36	2.78	2.48	2.59
	P.2	2.40	2.33		2.73	2.44	
	P.3	2.27	2.13		2.72	2.38	
F.2 (M)	P.1	2.67	2.57	2.45	2.84	2.58	2.67
	P.2	2.53	2.43		2.81	2.52	
	P.3	2.33	2.17		2.77	2.48	
F.3 (H)	P.1	2.80	2.57	2.51	2.87	2.63	2.73
	P.2	2.57	2.53		2.85	2.62	
	P.3	2.33	2.27		2.82	2.61	
Mean		2.45	2.33	====	2.76	2.49	====
	P.1	2.62	2.47	2.55	2.81	2.53	2.67
	P.2	2.45	2.38	2.42	2.75	2.49	2.62
	P.3	2.28	2.14	2.21	2.71	2.46	2.59
LS D. at 5% for		F=0.06 ,	P=0.05 ,	D=0.04	F=0.08 ,	P=0.07 ,	D=0.06
		FxP =0.10 ,	FxD =0.08 ,	PxD =0.07	FxP =0.01 ,	FxD =0.01 ,	PxD =0.01
			FxPxD =0.18			FxPxD =0.02	
				Second harvest (winter - spring)			
C. (0.0)	P.1	2.27	2.07	2.09	2.70	2.40	2.47
	P.2	2.23	2.03		2.58	2.34	
	P.3	1.97	1.94		2.51	2.31	
F.1 (L)	P.1	2.43	2.23	2.24	2.76	2.43	2.56
	P.2	2.37	2.17		2.72	2.41	
	P.3	2.16	2.07		2.71	2.35	
F.2 (M)	P.1	2.47	2.37	2.32	2.80	2.51	2.63
	P.2	2.43	2.23		2.78	2.49	
	P.3	2.27	2.13		2.73	2.44	
F.3 (H)	P.1	2.63	2.43	2.41	2.84	2.58	2.69
	P.2	2.57	2.33		2.81	2.58	
	P.3	2.30	2.20		2.78	2.54	
Mean		2.34	2.18	====	2.73	2.45	====
	P.1	2.45	2.28	2.37	2.78	2.48	2.63
	P.2	2.40	2.19	2.30	2.72	2.46	2.59
	P.3	2.18	2.09	2.14	2.68	2.41	2.55
LS D. at 5% for		F=0.04,	P=0.04,	D=0.03	F=0.01,	P=0.01,	D=0.01
		FxP =0.07,	FxD =0.06,	PxD =0.05	FxP =0.01,	FxD =0.01,	PxD =0.01
			FxPxD =0.10			FxPxD =0.01	

F.0.0 = Control
F.1= Fertilization low
F.2=Fertilization medium
F.3=Fertilization high

P.1= Light population density
P.2= Medium population density
P.3= Heavy population density

D.1=Direction (north to south)
D.2= Direction (east to west)

Table 10: Effect of fertilization levels, population densities and cladodes planting directions of *Opuntia ficus-indica* on carbohydrate content ratio during the subsequent two seasons (2018/2019 & 2019/2020)

		Seasons					
		First season (2018/2019)			Second season (2019/2020)		
Treatments		D.1	D.2	Mean	D.1	D.2	Mean
				First harvest (summer - autumn)			
C. (0.0)	P.1	33.26	33.80	34.38	35.14	36.16	36.43
	P.2	34.27	34.33		35.96	37.24	
	P.3	35.13	35.50		36.43	37.63	
F.1 (L)	P.1	33.99	34.80	34.63	35.27	36.36	37.00
	P.2	33.77	35.30		36.50	38.47	
	P.3	34.70	35.20		36.20	39.21	
F.2 (M)	P.1	34.22	34.87	34.92	35.66	37.15	36.85
	P.2	34.70	35.33		34.04	38.37	
	P.3	34.90	35.47		37.12	38.75	
F.3 (H)	P.1	34.58	34.96	35.19	35.15	36.97	36.86
	P.2	35.73	34.40		35.93	37.52	
	P.3	35.76	35.73		37.43	38.23	
Mean		34.58	34.97	====	35.90	37.67	====
	P.1	34.01	34.61	34.31	35.31	36.66	35.99
	P.2	34.63	35.17	34.90	35.61	37.90	36.76
	P.3	35.12	35.14	35.13	36.80	38.46	37.63
LS D. at 5% for		F=0.50, FxP =0.87	P=0.44, FxD =0.71, FxPxD =1.23	D=0.36 PxD =0.62	F=0.88, FxP =1.52,	P=0.76, FxD =1.24, FxPxD =2.15	D=0.62 PxD =1.07
				Second harvest (winter - spring)			
C. (0.0)	P.1	33.00	33.27	34.33	35.18	36.82	36.22
	P.2	33.97	34.63		35.65	36.91	
	P.3	35.32	35.78		35.42	37.33	
F.1 (L)	P.1	33.20	33.83	34.29	35.35	36.40	36.22
	P.2	34.67	34.13		36.07	37.14	
	P.3	34.87	35.01		35.78	36.55	
F.2 (M)	P.1	33.93	34.27	34.48	34.86	36.28	35.64
	P.2	34.50	35.03		34.94	36.32	
	P.3	34.93	34.87		35.04	36.42	
F.3 (H)	P.1	34.10	35.27	34.77	34.80	35.77	35.19
	P.2	34.87	34.47		34.22	35.49	
	P.3	34.90	35.03		34.95	35.91	
Mean		34.35	34.58	====	35.19	36.45	====
	P.1	33.56	34.16	33.86	35.05	36.32	35.68
	P.2	34.51	34.71	34.61	35.22	36.47	35.84
	P.3	34.99	35.03	35.01	35.30	36.55	35.93
LS D. at 5% for		F=0.54, FxP =0.94,	P=0.47, FxD =0.77, FxPxD =1.33	D=0.38 PxD =0.67	F=0.64, FxP =1.11,	P=0.56, FxD =0.91, FxPxD =1.57	D=0.45 PxD =0.79

F.0.0 = Control; F.1= Fertilization low; F.2=Fertilization medium; F.3=Fertilization high
P.1= Light population density; P.2= Medium population density; P.3= Heavy population density
D.1=Direction (north to south); D.2= Direction (east to west)

Total Carbohydrates Content Ratio: Data presented in Table (10) showed that all studied levels of mineral NPK fertilization succeeded in increasing total carbohydrate content of *Opuntia ficus-indica* as compared to un-fertilized plants in the two growing seasons of this study, in this concern fertilizing *Opuntia ficus-indica* with the high compound fertilization rates (90:60:30 kg NPK/fed.), showed to be the most effective one for producing total carbohydrate content as it scored (35.19 and 36.86) in the first harvest, (34.77 and 35.19) in the second harvest, in the first and second seasons respectively, irrespective control plants, the lowest values of this parameter were recorded by those recorded the low compound fertilization rates (30:20:10 kg NPK/fed.), followed in ascending order by those supplemented with the medium compound fertilization rates (60:40:20 kg NPK/fed.), this trend was true in both harvests in the two seasons, regarding the effect of population densities.

Data in Table (10) reveal that there was a positive relationship between the total carbohydrate content values and population densities, so the values of carbohydrate content ratio increased as the population densities increased until reach to the maximum increasing at the high density, this trend was true in both harvests in the two seasons, concerning the effect of planting direction on total carbohydrate content of *Opuntia ficus indica*.

Data in Table (10) clear that planting direction from north to south was non superior for inducing total carbohydrate content when compared with planting direction from east to west in the two harvests of the two seasons, as for the interaction effect between mineral NPK fertilization, planting population densities and planting direction, data in the same table indicate that, the combination of planting direction from north to south (D1) resulted in the highest values of total carbohydrate content, especially those planted at the highest density and recorded the high fertilization level as it registered (35.76 and 37.43) in the first harvest, (34.90 and 34.95) in the second harvest in the first and second seasons, in addition to the highest values of total carbohydrate content were gained by the combinations of planting direction from east to west (D2), particularly those planted at the highest population (4plant/m^2) and received no chemical fertilization, this trend was true in the two harvests in the two seasons, the other treatments occupied on intermediate position between the abovementioned treatments in the two seasons. These results were in agreement with [7, 8, 9, 10, 11, 12, 13] on *Opuntia ficus–indica*.

CONCLUSION

The experiment was designed with the objective of evaluating the vegetative growth, yield and chemical content of *Opuntia ficus-indica* under three fertilization rates of (N:P:K), which are (90:60:30 kg/fed.) in addition to the control (without fertilization), as well as the effect of the intensity of plants (4200 plants/fed., 8400 plants/fed. and 16800 plants/fed.), in addition to the cultivation trends of cladodes (north to south & east to west) and their different interactions on growth, yield and chemical content, the split plot design was used twice, fertilization rates in the main plots and plant density in the sub-main plot, while the cultivation trends in the sub-sub main plot, the crop was taken in the autumn (20/9) and spring (20/3) during the two seasons of the study, the results obtained showed that all data of vegetative growth, yield and chemical content gave positive results with all the three levels of fertilization and densities with the direction of cultivation of the cladodes from east to west in both seasons under study and the increase was significant with the high level of fertilization, to obtain the highest productivity and high chemical content of plant cladodes and use them as non-traditional fodder to reduce the gap in the shortage of animal feed, these results were in agreement These results were in agreement with (7, 8, 9, 10, 11, 12 and 13) on *Opuntia ficus–indica*.

REFERENCES

1. Nefzaoui, A., M. Louhaichi and H. Ben-Salem, 2014. Cactus as a tool to mitigate drought and to combat desertification. Journal of Arid Land Studies, 24(1): 121-124.
2. Gajender, C., G. Singh, J.C. Dagar, K. Lal and R.K. Yadav, 2014. Performance of edible cactus (*Opuntia ficus-indica*) in saline environments. Indian Journal of Agricultural Sciences 84(4): 509-13.
3. A.O.A.C., 1990. Official methods of analysis of association of official agriculture chemists. Washington, D.C., 10th ed.
4. Jackson, M.L., 1973. Soil Chemical Analysis. Prentice-Hall of Indian Private, New Delhi.
5. Black, C.D., D.O. Evans, L.E. Ensminger, J.L. White, F.E. Clark and R.C. Dinauer, 1982. Methods of soil analysis part 2. chemical and microbiological properties 2nd ed. soil., soc. of am. inc. publ., madison, wisconsin, U.S.A.
6. Snedecor, G.W. and W.G. Corchran, 1982. Statistical Methods The Iowa State Univ. Press. Amers. Iowa, USA, pp: 507.
7. Park, S.N., C.E. Russell, P. Felker, J.G. Medina and E. Acuña, 1987. Nutrient relations and productivity of prickly pear cacti . Agronomy Journal, 79(3): 550-555.
8. Güsewell, S., U. Bollens, P. Ryser and F. Klötzli, 2003. Contrasting effects of nitrogen, phosphorus and water regime on first- and second-year growth of 16 wetland plant species. Functional Ecology, 17(6): 754-765.

9. Dubeux, J.C.B., M.V. Ferreirados Santos and M. De A.L. Cordeirodos, 2006. Productivity of *Opuntia ficus-indica* (L.) Miller under different N and P fertilization and plant population in North-East Brazil. Journal of Arid Environments, 67(3): 357-372.
10. Nalígia G., M.E. Silvamércia, V. Ferreira, S.C. Batista, D.V. Cunhamário and A.A. Authors, 2016. Effects of planting density and organic fertilization doses on productive efficiency of cactus pear. Zootecnia Rev. Caatinga, 29(4): 1590-1683.
11. Elbana M.M. Elwakeel and M. Rashad, 2020. On-farm water management and its impacts on productivity and quality of cactus pear (*Opuntia ficus-indica*). Alexandria Science Exchange Journal, 41(4): 513- 522.
12. Alex, A.L., S.L.R. Donato, I. Aspiazu, J.A. Silva, P.E.R. Donato and A.J. Carvalho, 2021. Nutrient concentration and nutritional efficiency in 'Gigante' cactus pear submitted to different spacings and fertilizations. Articles Rev. Bras. Eng. Agríc. Ambient, 24(3): 154-161.
13. Hernández-Vidal E., F. Blanco-Macías, A. González-Torres, F. Gerardo Véliz-Deras, L. Gaytán-Alemán and R.D. Valdez-Cepeda, 2021. Boundary-line approach macro-nutrient standards for *Opuntia ficus-indica* (L.) miller variety "rojo pelón" Fruiting. Journal of Soil Science and Plant Nutrition, 21(11): 467-475.