EFFECT OF FERTILIZATION AND HUMIC ACID TREATMENTS ON SEEDS PRODUCTION OF *PLANTAGO PSYLLIUM* L.

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This experiment was carried out during two consecutive seasons of 2014/2015 and 2015/2016 in the Baluza Research Station of the Desert Research Center, North Sinai Governorate, to study the effect of different rates of chemical fertilization (control without fertilization, 25, 50 and 75% of recommended rates) with different levels of humic acid (0, 2 and 4 kg/feddan) and their interaction, on the growth, seed yield, active ingredient and chemical constituents of *Plantago psyllium* L. plants. The treatment of chemical fertilizers gave significant effect on the plant height, number of branches per plant, the fresh and dry weights per plant, seeds yield per plant and per feddan also mucilage content and percentage per plant and per feddan. The treatment of 75% from the recommended dose gave the beast result. Treatment as well as humic acid gave significant effect for data recorded and the best treatment was obtained by adding humic acid at a level of 4 kg/feddan. The obtained results indicated that the interaction between chemical fertilizers at 75% from the recommended dose combined with addition of humic acid at 4 kg/feddan gave a significant effect for all data recorded.

Keywords: *Plantago psyllium*, L., chemical fertilization, humic acid, seed yield, mucilage

Plantago psyllium L. belongs to the Family *Psylliuminaceae*. It contains a good percentage of carbohydrates, rich in β-carotene, linoleic acid, oleic acid and oxalic acid. Seeds contain certain nutrients, such as Cr, Co, Ca, Mg, Mn, P, K, Na, Zn and some vitamins such as riboflavin, thiamine, niacin and ascorbic acid and high fiber percentage (Zargari, 1993).

The plant has medicinal importance due to its mucilage; the main component found in seeds. There are many uses of the mucilage, but the most important use is to overcome chronic diarrhea and dysentery by relieving irritation, and also to treat kidney and bladder complaints, gonorrhea, urethritis and hemorrhoids. *P. pysllium* seeds are used to soften the skin and strengthen hair follicles as well. These seeds also help one lose

weight because it helps the absorption of cholesterol, excess fat, toxic waste and heavy metals from the body to the outside of the gastrointestinal tract (Koocheki et al., 2007).

The fertilization is the most important influencing factor in improving and increasing agricultural crop yields, especially under reclamation land conditions. Excessive chemical fertilizers has become a threat to the lives of citizens as a result of unjust and indiscriminate use by peasants, behind the negative impacts on the environment and the health of humans and animals (Subba Rao, 1984), so it is important to decrease the use of chemical fertilizers.

Humic acids are considered organic acids that are naturally produced in the organic matter in the soil. The humic acids are used to improve plant growth by improving absorption of elements and making them available to plant. Humic acids improve plant hormones and responsiveness as they inhibit the activity of IAA oxidase, leading to increase activity of the IAA hormone, which encourages plant growth. Also, they have a similar effect to auxins, which encourage root growth (Tatini et al., 1991 and Çimrin et al., 2010) as humic acid works to improve the physical, chemical and biological properties of soil and reduces the salinity problems and damage of water and soil. It is also working to minimize the effect of water stress on the plant and thus increases the ability of the root system of plants to absorb nutrients (Shaaban et al., 2009).

Therefore, the present work was carried out to study the effect of chemical fertilizer rates as well as different humic acid levels aiming to the highest seeds production, which have more mucilage of *P. pysllium* plants.

MATERIALS AND METHODS

This experiment was carried out during the two successive seasons of 2014/2015 and 2015/2016 at Baluza Research Station of the Desert Research Center, North Sinai Governorate. Current study was conducted to determine the effect of chemical fertilizer rates with different humic acid levels and the interaction among them on the growth, yield and active ingredients of *P. pysllium* plants.

The seeds of *P. pysllium* were obtained from the Department of Medicinal and Aromatic plants, Agricultural Research Center, Dokkey, Cairo, Egypt. The seeds were sown on October 12th in both seasons. The physical and chemical analyses of experimental farm soil in Baluza Research Station are shown in table (1).

This experiment included twelve treatments, which were the combinations of four levels of chemical fertilizer rates; i.e. 0, 25, 50 and 75% of the recommended rate (CFR) and three levels of humic acids (0, 2 and 4 kg/feddan) The treatments were arranged in a split plot design with three replicates, where chemical fertilizer rates were randomly arranged in

the main plots and the humic acid levels were randomly distributed in the sub-plots. Each plot (4 m^2) contained four rows at 50 cm apart. The distance between plants were 25 cm and each plot contained 32 plants (feddan contained 33600 plants). The chemical fertilizer recommended rates for *P. pysllium* are 200 kg ammonium sulphate (20.5% N) per feddan and 100 kg potassium sulphate (48% K_2O) per feddan (Karimzadeh and Omiddaigi, 2004 and Jajoria et al., 2013). They were divided into three equal partitions and added trench plot after sowing and 100 kg calcium superphosphate was added during soil preparation with compost of 20 m^3 per feddan. The normal agricultural practices were followed in this district.

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

Particle size distribution (%)			Texture soil	EC (ds/m)	pH	Available nutrients (cations)					Available nutrients (anions)			
Sand	Silt	Clay				P %	Na^+ %	K^+ %	Ca^{++} (meg/l)	Mg^{++} (meg/l)	CO_3^{--}	HCO_3^- (meg/l)	SO_4^{--}	Cl^-
90	5	5	Sand	1.37	8.20	0.42	4.78	0.54	3.65	4.40	-	3.85	6.5	3.3

The plants received humic acid treatments of 2 or 4 kg three times; after 30, 60 and 90 days from planting as a soil drench. Humic acid was obtained from Tabarak Company for Fertilizers and Chemicals (www.tabarakfert.com).

The following data were recorded:

1. Plant growth: plant height (cm.), number of branches per plant and fresh and dry weights (g) per plant.
2. Yield and production: seed yield (g) per plant and feddan (kg) at harvest date (20^{th} of May).
3. Active ingredients:
   - Mucilage percentage was determined according to Anderson (1949) and mucilage content (g)/plant were calculated by multiplying the mucilage percentage by weight of seeds/plant for each treatment, mucilage content/feddan was calculated by multiplying the mucilage content/plant by number of plants/feddan for each treatment.
   - Fixed oil percentage was estimated according to the method of A.O.A.C. (1964).
   - Total protein percentage was calculated in either seeds of *P. pysllium* by multiplying total nitrogen percentage by the factor 6.25 to obtain the percentage of total protein.
4. Chemical constituents determination in *P. pysllium* seeds: total carbohydrate percentage was determined according to Dubios et al. (1956), total nitrogen percentage was determined according to that reported by Naguib (1969), total phosphorus percentage was determined

according to the methods adapted by Hucker and Catroux (1980) and potassium percentage was determined by using flame photometer according to the method described by Brown and Lilleland (1964).

The recorded data were statistically analyzed and means were compared using least significant difference L.S.D. test at 5% level according to Snedecor and Cochran (1980) by using computer program of Statistic version 9 (http://www.statistix.com/freetrial.html) Analytical Software (1985).

RESULTS AND DISCUSSION

1. Plant Growth

1.1. Effect of chemical fertilizer rates

It is apparent from data in table (2) that the different chemical fertilizer rates recommended (CFR) significantly influenced the plant growth characters; i.e. plant height (cm), number of branches per plant and fresh and dry weights (g/plant) of *P. pysllium* plants during the two seasons, compared to control plants. Moreover, increasing chemical fertilizer rates increased plant growth characters. The application of 75% of the chemical fertilizer recommended (CFR) recorded the highest value of the plant growth characters.

The simulative effect of chemical fertilizer on different plant growth characters could be explained by increasing metabolic activities that led to increasing cell division and elongation in the meristematic zones of plants under the effect of fertilization treatments. These results are in accordance with those obtained by Abdou et al. (2004) on *Foeniculum vulgare* Mill., Kandeel (2004) on *Ocimum basilicum* L. and Gomaa and Youssef (2007a) on *Levisticum officinale*. They concluded that application of chemical fertilizers to plants significantly increased plant growth characters.

1.2. Effect of humic acid levels

Soil drench application of humic acid; i.e. 2 or 4 kg/feddan significantly increased plant growth characters; i.e. plant height (cm), number of branches/plant and fresh and dry weights/plant (g) compared to control plants (Table 2).

The maximum values, in this respect, were recorded with 4 kg/feddan compared with control in both seasons. Otherwise, increasing humic acid levels increased plant growth characters. The enhancement effect of humic acids rate on *P. pysllium* plants growth characteristics may be attributed to increasing the content of the soil nutrients that are available for the growth and stimulate meristems tissue growth by increasing the biological processes related to photosynthesis, which is reflected in the increase in plant height and number of branches, and fresh and dry weight of the plant. The results are in conformity with those reported by Pizzeghello et al. (2001) on *Fagus sylvaticae* and Nikbakht et al. (2008) on gerbera.

Table (2). Effect of chemical fertilizer rates and humic acid levels on the growth of *Plantago psyllium* L. plant during 2014/2015 and 2015/2016 seasons.

Characters / Treatments	Plant height (cm)	Number of branches/plant	Fresh weight/plant (g)	Dry weight/plant (g)
Chemical fertilizer recommended rates (CFR)				
		Season 1		
Control	41.63	12.41	57.62	26.26
25% CFR	52.33	15.27	68.38	29.66
50% CFR	59.42	17.83	78.09	33.63
75% CFR	66.59	21.75	80.22	38.16
L.S.D. at 5%	1.78	0.74	1.02	1.31
		Season 2		
Control	46.25	16.15	61.25	28.73
25% CFR	53.47	18.67	70.82	33.22
50% CFR	60.63	21.17	80.30	37.66
75% CFR	67.84	23.69	89.85	42.14
L.S.D. at 5%	0.49	0.17	0.65	0.31
Humic acid levels (HAL)				
		Season 1		
Control	52.05	15.90	68.92	30.45
2 kg/fed	54.73	16.73	70.24	31.88
4 kg/fed	58.20	17.82	74.08	33.45
L.S.D. at 5%	1.52	0.59	0.63	1.06
		Season 2		
Control	54.69	19.10	72.44	33.98
2 kg/fed	56.93	19.88	75.39	35.36
4 kg/fed	59.52	20.79	78.83	36.98
L.S.D. at 5%	0.26	0.09	0.34	0.16

1.3. Effect of the interaction

Data in table (3) reveal that, the interaction between different chemical fertilizer and humic acid levels reflected significant effect on plant growth characters. The interaction treatment of 75% of CFR, when combined with 2 or 4 kg humic acid/feddan found significantly superior to the rest of combination treatments regarding plant growth characters, it recorded the maximum values of plant growth characters in the first and second seasons. This effect may be due to plant compensation of nutrients by the use of humic acid with chemical fertilizers that impacts on the further growth of the roots by producing auxin for root growth, which has led to the

production of strong roots able to absorb a lot of nutrients for growth. This reflects on the increase in the rate of photosynthesis and rate meristem tissue division, and thus an increase in the plant growth characters. These results were also reported by El-Bassiony et al. (2010) on snap bean plants.

Table (3). Effect of interaction between chemical fertilizer rates and humic acid levels on the growth of *Plantago psyllium* L. plant during the 2014/2015 and 2015/2016 seasons.

Characters / Treatments			Plant height (cm)		Number of branches per plant		Fresh weight of plant per plant (g)		Dry weight of plant per plant (g)	
			Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Chemical fertilizer recommended rates (CFR)	75% CFR	4 kg/fed	70.14	70.56	22.74	24.64	83.43	93.45	40.72	43.83
		2 kg/fed	66.72	67.70	21.61	23.64	81.22	89.66	38.27	42.05
		Control	62.91	65.27	20.90	22.79	80.06	86.44	35.49	40.55
	50% CFR	4 kg/fed	61.40	63.09	18.67	22.03	77.18	83.55	34.99	39.19
		2 kg/fed	58.71	60.48	17.83	21.12	76.77	80.11	33.55	37.57
		Control	58.15	58.32	17.00	20.37	76.27	77.24	32.35	36.23
	25% CFR	4 kg/fed	54.62	55.77	16.43	19.47	70.86	73.86	30.93	34.64
		2 kg/fed	51.88	53.44	15.17	18.66	67.44	70.77	29.64	33.20
		Control	50.50	51.21	14.20	17.88	66.86	67.83	28.40	31.81
	Without CFR	4 kg/fed	46.65	48.68	13.44	17.00	60.80	64.47	27.17	30.24
		2 kg/fed	41.60	46.09	12.30	16.09	56.70	61.04	26.07	28.63
		Control	36.63	43.98	11.50	15.36	55.37	58.25	25.55	27.32
L.S.D. at 5 %			3.05	0.65	1.22	0.23	1.44	0.85	2.16	0.40

Humic acid levels (HAL)

2. Yield and Production

2.1. Effect of chemical fertilizer rates

Data in table (4) show that chemical fertilizer rates caused a significant increase in all yield and production parameters; i.e. seed yield (g) per plant and feddan (kg). The application at 75% CFR significantly increased seed yield per plant (g) and feddan (kg) in the first and second seasons. The increase in yield and production of *P. pysllium* plants supplemented with chemical fertilizer rates may be due to the availability of minerals to the plant roots, which ultimately resulted in better root growth and increased mineral absorption that lead to the increase in number of branches/plant and this in turn increased total yield.

Table (4). Effect of chemical fertilizer rates and humic acid levels on the seed yield per plant (g) and feddan (kg) of *Plantago psyllium* L. plant during 2014/2015 and 2015/2016 seasons.

Characters / Treatments	Seeds yield/plant (g)		Seeds yield/fed (kg)	
Chemical fertilizer recommended rates (CFR)				
	Season 1	**Season 2**	**Season 1**	**Season 2**
Without CFR	4.58	5.89	153.89	197.90
25% CFR	5.44	6.65	182.93	223.40
50% CFR	6.30	7.05	211.68	236.77
75% CFR	7.16	7.34	240.69	246.74
L.S.D. at 5%	0.06	0.08	1.85	2.64
Humic acid levels (HAL)				
Control	5.59	6.58	187.85	221.06
2 kg/fed	5.86	6.72	196.81	225.76
4 kg/fed	6.17	6.90	207.23	231.78
L.S.D. at 5%	0.03	0.04	1.06	1.31

On the other hand, increasing chemical fertilizer rates increased yield and production parameters. These results are in harmony with those obtained by Kandeel et al. (2001) on *Foeniculum vulgare* Mill., Lee et al. (2005) on *Chrysanthemum boreale* and Mostafa (2006) on *Matricaria chamomilla.*

2.2. Effect of humic acid levels

Soil drench application on *P. psyllium* plants with different levels of humic acid significantly increased all studied yield and production parameters; i.e. seed yield per plant (g) and feddan (kg) (Table 4). Since *P. psyllium* plants received 2 or 4 kg humic acid /feddan were characterized by the highest values of these parameters as compared to control plants. Furthermore, increasing humic acid levels increased yield and production parameters, therefore the application of 4 kg humic acid /feddan resulted in the highest values of these parameters.

The increment at *P. psyllium* yield may be due to the increase in plant growth parameters (Table 2), which lead to increment of the number of branches per plant that reflected on yield per plant and feddan. The increase in the number of branches per plant treated with humic acid might be due to its role in increasing growth parameters (Table 2).

Sanchez-Sanchez et al. (2002), Abdel-Mawgoud et al. (2007) and Iftikhar et al. (2013) found similar results on lemon trees, tomato and

gladiolus, respectively, regarding to humic acid soil drench application in improving total yield in the different plants. The simulative effect of humic acid might be attributed to that it contains macro and micro elements, plant growth hormones, high levels of organic matters and fatty acids available to plant, which enhances yield parameters.

2.3. Effect of the interaction

It is evident from the data in table (5) that the interaction between chemical fertilizer rates and humic acid levels had significant effect on all yield and production parameters in both seasons of study. The treatment of 75% CFR with 4 kg humic acid/ feddan produced the highest values of seed yield, while the lowest seed yield was obtained by control plants.

Table (5). Effect of interaction between chemical fertilizer rates and humic acid levels on the seed yield per plant (g) and feddan (kg) of *Plantago psyllium* L. during 2014/2015 and 2015/2016 seasons.

Treatments		Characters	Seeds yield/ plant (g)		Seeds yield/fed (kg)	
			Season 1	Season 2	Season 1	Season 2
Chemical fertilizer recommended rates (CFR)	75% CFR	4 kg/fed	7.49	7.44	251.55	250.10
		2 kg/fed	7.15	7.34	240.13	246.74
		Control	6.86	7.24	230.38	243.38
	50% CFR	4 kg/fed	6.59	7.12	221.54	239.23
		2 kg/fed	6.28	7.04	211.12	236.66
		Control	6.02	6.98	202.38	234.41
	25% CFR	4 kg/fed	5.72	6.90	192.19	231.84
		2 kg/fed	5.44	6.64	182.78	223.22
		Control	5.17	6.40	173.83	215.15
	Without CFR	4 kg/fed	4.87	6.13	163.63	205.97
		2 kg/fed	4.56	5.85	153.21	196.45
		Control	4.31	5.69	144.81	191.30
L.S.D. at 5 %			0.08	0.10	2.53	3.39

The previous results might be due to the use of humic acid with chemical fertilizers to improve sandy soil structure and increase its ability to retain water. Also, they are working to improve soil fertility and stimulate root growth for increasing the production of auxin, which facilitate the nutrients in soil, and increasing the root absorption of the elements and photosynthesis, which appeared in an increase in the number of branches

that increase seed yield per plant and feddan. Similar results were obtained by Dileep et al. (2014) on *Oryza sativa* plant**.**

3. Active Ingredients

3.1. Effect of chemical fertilizer rates

Application of chemical fertilizer rates (75% CFR) significantly enhanced active ingredients characters; i.e. mucilage percentage and mucilage content (g) per plant and per feddan (kg), fixed oil percentage and total protein percentage in both seasons, when compared with control plants, (Table 6). Moreover, increasing chemical fertilizer rates increased these characters. This is may be due to the fact that NPK fertilization caused an increase in photosynthesis process, which in turn stimulates the biosynthesis leading to more branches and seeds yield (as already mentioned in this study for the effect of fertilization) as well as the increase in the active ingredients. These results are in agreement with those found by Badran et al. (2003) on *Pimpinella anisum* L. and Gomaa and Youssef (2007b) on *Foeniculum vulgare* Miller. They reported that plant seeds quality were significantly enhanced by increasing the applied rate of chemical fertilizer.

3.2. Effect of humic acid levels

Data in table (6) reveal that active ingredients characters; i.e. mucilage percentage and mucilage content per plant (g) and per feddan (kg), fixed oil percentage and total protein percentage were significantly increased due to humic acid soil drench application in both seasons compared with control plants.

In addition, treating *P. psyllium* plants with all humic acid levels, 2 or 4 kg/ feddan significantly increased these parameters in the second season compared to control. On the other hand, increasing humic acid levels increased active ingredients characters, so the application of 4 kg humic acid/feddan gave the highest values of these parameters.

The increase in active ingredients could be explained by increasing the content of the soil nutrients that led to the increased activity of microorganisms, which led to an increase of plant nutrients that improved the efficiency of photosynthesis. All these effects positively reflected on the plant yield and also increased the active ingredients characters.

These results are in agreement with those reported by Sharif et al. (2002) on maize, Attememe (2009) on *Rosmarinus officinalis* L., Aydin et al. (2012) on *Phaseolus vulgaris* L. and Khattab et al. (2012) on pomegranate trees.

3.3. Effect of the interaction

Data presented in table (7) show that the interaction between chemical fertilizer rates and humic acid levels had a significantly effect on all studied parameters. It is obvious from the data that the treatment of 75% CFR with 4 kg humic acid/feddan gave the highest values of active ingredients characters; i.e. mucilage percentage and mucilage content (g) per

plant and per feddan (kg), fixed oil percentage and total protein percentage in both seasons of study. So, the physiological activities as photosynthesis and providing plants by nutrients could be the reasons for increasing active ingredients characters. The availability of the crisis for plant growth elements to increase the activity of beneficial microbes in the soil indirectly reflected an increase in the active substances in plant. Similar results were reported by Bama and Selvakumari (2005) on rice plants.

Table (6). Effect of chemical fertilizer rates and humic acid levels on the active ingredients characters of *Plantago psyllium* L. plant during 2014/2015 and 2015/2016 seasons.

Characters / Treatments	Mucilage percentage	Mucilage content per plant (g)	Mucilage content per fed (g)	Fixed oil percentage	Total protein percentage
Chemical fertilizer recommended rates (CFR)					
		Season 1			
Without CFR	16.38	0.75	25.25	10.09	14.62
25% CFR	18.76	1.02	34.36	11.46	16.57
50% CFR	21.13	1.33	44.79	12.81	18.44
75% CFR	23.53	1.69	56.70	14.20	20.28
L.S.D. at 5%	0.15	0.02	0.67		0.28
		Season 2			
Without CFR	16.36	0.96	32.41	10.01	14.83
25% CFR	18.99	1.26	42.47	11.51	17.13
50% CFR	21.58	1.52	51.10	13.00	20.00
75% CFR	24.21	1.78	59.76	14.51	22.11
L.S.D. at 5%	0.21	0.03	0.92	0.10	0.40
Humic acid levels (HAL)					
		Season 1			
Control	19.17	1.10	36.84	11.69	16.81
2 kg/fed	19.91	1.19	40.05	12.12	17.53
4 kg/fed	20.78	1.31	43.94	12.61	18.09
L.S.D. at 5%	0.09	0.01	0.38	0.06	0.17
		Season 2			
Control	19.43	1.29	43.51	11.77	17.84
2 kg/fed	20.24	1.38	46.24	12.23	18.37
4 kg/fed	21.18	1.47	49.56	12.77	19.34
L.S.D. at 5%	0.10	0.01	0.37	0.05	0.20

Table (7). Effect of interaction between chemical fertilizer rates and humic acid levels on the active ingredients characters of *Plantago psyllium* L. plant during 2014/2015 and 2015/2016 seasons.

Treatments: Chemical fertilizer recommended rates (CFR)	Humic acid levels (HAL)	Mucilage percentage		Mucilage content per plant (g)		Mucilage content per fed (kg)		Fixed oil percentage		Total protein percentage	
		Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
75% CFR	4 kg/fed	24.43	25.20	1.83	1.87	61.46	63.02	14.70	15.07	20.88	22.56
	2 kg/fed	23.50	24.17	1.68	1.77	56.43	59.63	14.17	14.48	20.31	22.15
	Control	22.67	23.27	1.55	1.68	52.22	56.63	13.73	13.97	19.65	21.63
50% CFR	4 kg/fed	21.93	22.47	1.45	1.60	48.59	53.75	13.30	13.52	19.02	21.02
	2 kg/fed	21.10	21.53	1.33	1.52	44.55	50.96	12.77	12.98	18.46	19.69
	Control	20.37	20.73	1.23	1.44	41.22	48.60	12.37	12.52	17.85	19.29
25% CFR	4 kg/fed	19.53	19.83	1.12	1.37	37.54	45.98	11.87	11.99	17.15	18.19
	2 kg/fed	18.73	18.97	1.02	1.26	34.24	42.34	11.47	11.50	16.50	16.69
	Control	18.00	18.17	0.93	1.16	31.29	39.09	11.03	11.04	16.06	16.50
Control	4 kg/fed	17.20	17.23	0.84	1.05	28.14	35.50	10.57	10.51	15.33	15.60
	2 kg/fed	16.30	16.30	0.74	0.95	24.97	32.02	10.07	9.97	14.85	14.96
	Control	15.63	15.53	0.67	0.88	22.64	29.71	9.63	9.53	13.67	13.92
L.S.D. at 5 %		0.21	0.27	0.03	0.03	0.91	1.09	0.14	0.14	0.39	0.51

4. Chemical Composition and Total Carbohydrates in *P. pysllium* Seeds

4.1. Effect of chemical fertilizer rates

Data in table (8) show that application of chemical fertilizer rates at 75% on *P. psyllium* plants significantly increased nitrogen, phosphorous, potassium and total carbohydrate in seeds compared to control and other treatments. The increment in chemical composition and total carbohydrates resulted from the NPK fertilization treatments might be directly or indirectly due to the activation of the nutrients and carbohydrates metabolism. These nutrients participate in chlorophyll anabolism, leading to more chlorophyll content, which participates directly in nutrients and carbohydrates metabolism. Similar results were also obtained by Nofal et al. (2001) on *Ammi visnaga* L., Safwat and Badran (2002) on cumin plants and Niakan et al. (2004) on *Mentha piperita* L. They found that the plant content of NPK and total carbohydrates is significantly increased by increasing chemical fertilizer rates.

4.2. Effect of humic acid levels

Soil drench application of 2 or 4 kg humic acid/feddan significantly increased nitrogen, potassium and total carbohydrates percentages in *P. psyllium* seeds. On the other hand, application of different humic acid levels to plants increased all these parameters under study. While, application of different humic acid levels to *P. psyllium* plants did not reflect any significant effect on phosphorus percentage in seeds (Table 8).

These results are supported with those reported by Sanchez-Sanchez et al. (2002) on lemon trees and Ashraf et al. (2005) on *Vigna radiate* L. They found that soil drench plants with humic acid levels showed increase in nitrogen, phosphorus, potassium and total carbohydrates percentages. The effect of humic acid on improving biochemical characters of seed protein content was reported by Aydin et al. (2012) on *Phaseolus vulgaris* L. It is obvious from the same data in table (7) that the soil drench application of 2 and 4 kg humic acid/feddan increased significantly.

The obtained results are in accordance with those previously recorded by Cangi et al. (2006) on *Vitis vinifera* L. and Rajpar et al. (2011) on *Brassica comestris* L., who reported that humic acid contains organic matters, which induce the physiological activities and increase total chlorophyll in plants. This will positively reflect in the activity of photosynthesis and the synthesized materials that will positively reflect on shoots characteristics.

Table (8). Effect of chemical fertilizer rates and humic acid levels on the chemical composition and total carbohydrates of *Plantago psyllium* L. plant during 2014/2015 and 2015/2016 seasons.

Characters / Treatments	Total nitrogen percentage	Total phosphorus percentage	Total potassium percentage	Total carbohydrate percentage
Chemical fertilizer recommended rates (CFR)				
		Season 1		
Control	2.34	0.224	0.15	15.86
25% CFR	2.65	0.513	0.46	18.16
50% CFR	2.95	0.818	0.75	20.57
75% CFR	3.24	1.069	1.90	22.94
L.S.D. at 5%	0.05	0.031	0.02	0.23
		Season 2		
Control	2.37	0.243	1.71	17.45
25% CFR	2.74	0.536	2.14	19.97
50% CFR	3.20	0.848	2.48	22.63
75% CFR	3.54	1.108	2.72	25.24
L.S.D. at 5 %	0.06	0.029	0.03	0.25
Humic acid levels (HAL)				
		Season 1		
Control	2.69	0.568	0.50	18.40
2 kg/fed	2.81	0.656	0.91	19.29
4 kg/fed	2.90	0.744	1.04	20.45
L.S.D. at 5%	0.03	0.015	0.02	0.31
		Season 2		
Control	2.85	0.597	2.13	20.24
2 kg/fed	2.94	0.688	2.29	21.22
4 kg/fed	3.10	0.767	2.37	22.50
L.S.D. at 5%	0.03	0.016	0.03	0.34

4.3. Effect of the interaction

Data presented in table (9) show that nitrogen, phosphorus, potassium and total carbohydrates percentages in *P. psyllium* seeds were significantly influenced by the interaction between chemical fertilizer rates and humic acid levels. The treatments of 75% CFR with 2 or 4 kg humic acid/feddan increased these parameters, but the treatment of 75% CFR with 4 kg humic acid/ feddan gave the highest values of tested parameters and this increase is significant in the both seasons.

The increment in the chemical composition and total carbohydrates in *P. psyllium* seeds could be attributed to the presence of organic material with a chemical fertilizer available in the soil, which led to the possibility of increasing the absorption of crisis elements for plant growth. This increased protein and sugars and carbohydrates representation and thus increases the essential nutrients (NPK) in plant tissues. These results are in agreement with those reported by Shehata et al. (2011) on strawberry plants.

Table (9): Effect of interaction between chemical fertilizer rates and humic acid levels on the chemical composition and total carbohydrates of *Plantago psyllium* L. plant during 2014/2015 and 2015/2016 seasons.

Characters / Treatments			Nitrogen percentage		Phosphorus percentage		Potassium percentage		Total carbohydrate percentage	
			Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Chemical fertilizer recommended rates (CFR)	75% CFR	4 kg/fed	3.34	3.61	1.127	1.170	2.49	2.80	23.91	26.30
		2 kg/fed	3.25	3.54	1.073	1.113	2.28	2.73	22.94	25.23
		Control	3.14	3.46	1.007	1.040	0.93	2.64	21.98	24.18
	50% CFR	4 kg/fed	3.04	3.36	0.913	0.927	0.86	2.55	21.72	23.89
		2 kg/fed	2.95	3.15	0.817	0.850	0.74	2.48	20.50	22.54
		Control	2.86	3.09	0.723	0.767	0.66	2.40	19.49	21.44
	25% CFR	4 kg/fed	2.74	2.91	0.600	0.620	0.56	2.28	19.29	21.21
		2 kg/fed	2.64	2.67	0.513	0.547	0.47	2.18	18.11	19.92
		Control	2.57	2.64	0.427	0.440	0.35	1.95	17.08	18.79
	Control	4 kg/fed	2.45	2.50	0.337	0.350	0.24	1.86	16.90	18.59
		2 kg/fed	2.38	2.39	0.220	0.240	0.14	1.75	15.62	17.18
		Control	2.19	2.23	0.117	0.140	0.07	1.53	15.06	16.57
L.S.D. at 5%			0.06	0.08	0.040	0.039	0.04	0.05	0.56	0.61

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تأثير التسميد والمعاملة بحامض الهيومك على إنتاجية بذور نبات القاطونة

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أجريت هذه التجربة خلال عامين متتالين ٢٠١٥/٢٠١٤ و٢٠١٦/٢٠١٥ في محطة بحوث بالوظة التابعة لمركز بحوث الصحراء، وذلك لدراسة تأثير مستويات من التسميد الكيماوى (كنترول بدون تسميد، ٢٥، ٥٠ و٧٥٪ من جرعة السماد الموصى بها) مع مستويات مختلفة من حامض الهيومك (صفر، ١ و٢ كيلوجرام/ فدان) والتفاعل بينهم على النمو ومحصول البذور والمادة الفعالة لنبات القاطونة .

ومن النتائج التي تم الحصول عليها كانت للمعاملة بالأسمدة الكيماوية تأثير معنوي على كلًا من طول النبات، عدد الفروع، زيادة الوزن الطازج والجاف، وزن البذور للنبات والفدان، محصول النبات الواحد والفدان من الأصماغ ونسبتها. حيث أعطت المعاملة ٧٥٪ من جرعة السماد الموصى بها أفضل النتائج. كذلك أعطت المعاملة بحامض الهيومك تأثير معنوي على جميع الصفات محل الدراسة. حيث تم الحصول على أفضل نتائج عند إضافة حامض الهيومك بمعدل ٢ كجم/ فدان. أما تأثير التفاعل بين الأسمدة الكيماوية وحامض الهيومك فكانت أفضل النتائج المتحصل عليها عند التسميد الكيماوي بمعدل ٧٥٪ من الجرعة السمادية الموصى بها مع إضافة حامض الهيومك بمعدل ٢ كجم/الفدان.