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Impact of pre-harvest nitrogen and potassium fertilizers rate on growth and longevity and some chemical constituents of sunflower (*Helianthus annuus* L.) cut flowers

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ABSTRACT

The objective of this study was to investigate two of the key factors likely to influence growth and longevity and flower quality *i.e.*, nitrogen fertilization rate (0.0, 5.0 and 10.0 g/pot as ammonium sulphate) and potassium fertilization rate (0.0, 2.5, 5.0 and 7.5 g/pot as potassium sulphate) as well as their interactions on growth, flower longevity and some chemical constituents of sunflower (*Helianthus annuus* L.) plants. This study was conducted in lath house at Ornamental Nursery, Faculty of Agriculture, Zagazig University, Egypt, during two summer consecutive seasons of 2014 and 2015. Sunflower growth parameters [plant height (cm), stem diameter (cm), fresh and dry weights of stem/plant (g), number of leaves/plant, fresh and dry weights of leaves/plant (g), root length (cm) and fresh and dry weights of roots/plant (g)], flower parameters [flower diameter (cm), fresh weight of flower/plant (g) and longevity (days)] were recorded. Also, total chlorophyll (SPAD unit), total carbohydrates (%) in the leaves and carthamin content/plant petals (mg/100g) were determined. Results showed that in most cases the maximum values of the above mentioned characters were obtained by treating plants with nitrogen + potassium fertilization rates at 5 g/pot + 7.5 g/pot, respectively.

***Keywords*:** *Helianthus annuus*, nitrogen, potassium, fertilization, growth, longevity.

Introduction

In the flower sector, a growing importance is being given in the last years to sunflower both as in view of a flower pot and use a cut flower, with the objective of a more diversified productive offer. Sunflower is an agronomic crop that is cultivated widely throughout the world (Groove and Summer, 2005). *Helianthus annuus* L. is a species belonging to the family *Asteraceae* and is characterized by a considerable decoratively, as production of heads varying in the different cultivars by colour of the flower, from cream to yellow as far as deep brown and flower size (Devecchi, 2005). According to Han (2000), the harvest of sunflowers must be carried out when the flowers are almost completely open.

Nitrogen (N) has many functions in plant life. It is an important constituent of protoplasm enzymes, the biological catalytic agent which speed up life process. Nitrogen is present in chlorophyll phosphatides, alkaloids, glycosides and many other organic substances of plant cell (Vopyan, 1984). Similarly, potassium (K) has an important role in regulation of the osmotic potential of the plant cells. K also helps in activation of many enzymes involved in respiration and photosynthesis. Potassium also improves the strength of cell wall, hence strengthening the tissues (Taiz and Zeiger, 1991). Nitrogen and potassium are because of these characters of the two nutrients that might contribute in the extension of postharvest life of cut flowers.

The aim of the present study was designed to investigate the effect of pre-harvest nitrogen and potassium fertilizer rates for better growth parameters, quality sunflower cut flowers and some chemical constituents of *Helianthus annuus* plants.

Materials and Methods

This study was conducted at Ornamental Nursery, Faculty of Agriculture, Zagazig University, Egypt, in lath house during two summer consecutive seasons of 2014 and 2015. This experiment included 12 treatments, which were the interactions between three nitrogen rates (0.0, 5.0 and 10.0 g/pot as ammonium sulphate 20.5%N) and four potassium fertilization rate (0.0, 2.5, 5.0 and 7.5 g/pot as potassium sulphate 48.5 $\%K_2O$). These treatments as pre-harvest were examined on growth

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parameters, flower longevity and some chemical constituents on sunflower. Seeds of sunflower (*Helianthus annuus* L.) cv. "Sunrich Orange" were sown in pots 40 cm filled with 14 kg of soil on the 15th April during both days. Upper layer of (0-15 cm) of a cultivated field was collected to be the soil of the experiments. The collected soil was air dried, crushed and sieved through a 2 mm sieve and homogeneously mixed before subjecting to different treatment. The physical and chemical properties of the used soil are shown in Table A according to Chapman and Pratt (1978).

Table A: Physical and chemical properties of experimental farm soil (average of both seasons)

Physical analysis			Soil texture
Clay (%)	**Silt (%)**	**Coarse sand (%)**	**Clayey**
48.90	27.60	23.50	

Chemical analysis												
pH	**E.C. (dsm^{-1})**	**Soluble cations (m.mol/l)**					**Soluble anions (m.mol/l)**			**Available (ppm)**		
		Ca^{++}	Mg^{++}	Na^{+}	Zn^{++}	Mo^{++}	Cl^{-}	HCO_3^{-}	SO_4^{--}	N	P	K
7.70	0.58	3.80	1.80	0.40	1.80	1.72	3.40	2.12	0.84	175	68	74

Impact of nitrogen and potassium fertilizers rates on sunflower was evaluated under pots culture conditions. Five seeds were sown per pot. The seedlings were thinned to be two plants per pot after three weeks from sowing date. The plot contained about 15 pots; three plants from each replication were randomly selected for observing growth parameters, flower longevity and some chemical constituents of sunflower.

The rates of nitrogen (N) and potassium (K_2O) were divided into two equal doses and applied in each pot through ammonium sulphate and sulphate of potash respectively, at two times, after 30 and 45 days from sowing date. The statistical layout of this experiment was a split-plot design experiment between nitrogen rate (three rates) as main plot and potassium rate (four rates) as sub-plot in randomized complete blocks design (RCBD) with three replicates. The interaction treatments between nitrogen and potassium rates were consisted of 12 treatments.

Data Recorded

Growth parameters: After 50 days from sowing, plant height (cm), stem diameter (cm), fresh and dry weights of stem/plant (g), number of leaves/plant and fresh and dry weights of leaves/plant (g) were determined.

Root system parameters: After 50 days from sowing, root length (cm) and fresh and dry weights of roots /plant (g) of sunflower plant were recorded.

Cut flowers parameters: At harvest stage (about 55-67 days after sowing), flower diameter (cm), fresh weight of flower/plant (g) as well as flower longevity.

Chemical constituents: After 50 days from sowing, total chlorophyll content (SPAD unit) was determined in sunflower fresh leaves by using SPAD- 502 meter Markwell *et al*. (1995). In addition, at harvest stage, carbohydrate percentage in flower was determined according to the method described by Dubois *et al.* (1956). Sunflower flowers were dried at 70°C till constant weight and carthamin content (mg/100g) was assessed according to the method described by Harborne (1973).

Statistical Analysis

The complete randomized block design (CRBD) in a split-plot design was used in this experiment with three replicates. Where, three nitrogen fertilization rates were randomly arranged in the main plots and four potassium fertilization rates were distributed randomly in the sub plots. The obtained data were statistically analyzed and the means were compared using least significant difference (L.S.D) at 5% level as reported by Gomez and Gomez (1984). The means were compared using computer program of Statistix version 9 (Analytical software, 2008).

Results and Discussion

Growth parameters:

Data recorded in Table 1 indicated that the means of plant height, stem diameter, fresh and dry weights of stem per plant were significantly increased with all nitrogen fertilization rate to reach the maximal values with the high rate compared to control (untreated plants) during both seasons. Also, the rates of 5 and 10 g ammonium sulphate/pot significantly increased number of leaves/plant and fresh and dry weights of leaves per plant compared to control (Table 2). However, the highest values in this regard were obtained from the highest rate of nitrogen in the first and second seasons. It is well known that chemical fertilizer especially N element could enhance plant growth due to the role of nitrogen in nucleic acids and protein synthesis (Helgi and Rolfe, 2005).

Table 1: Effect of nitrogen (N) and potassium (K) fertilization rate as well as their interactions (N×K) on plant height, stem diameter and stem fresh and dry weights per plant of sunflower during 2014 and 2015 seasons

Potassium fertilization rate (g/pot)	Nitrogen fertilization rate (g/pot)							
	Control	5	10	Mean (K)	Control	5	10	Mean (K)
	2014 season				2015 season			
	Plant height (cm)							
Control	91.33	94.00	101.67	95.67	103.67	101.33	103.00	102.67
2.5	98.67	100.67	107.33	102.22	108.67	102.33	106.67	105.89
5.0	102.00	107.33	110.00	106.44	106.33	105.33	111.00	107.56
7.5	106.33	113.00	113.33	110.89	108.33	109.00	114.00	110.44
Mean (N)	99.58	103.75	108.08		106.75	104.50	108.67	
LSD at 5%	**(N)= 2.65**	**(K)= 3.42**	**(N×K)= 5.75**		**(N)= 2.43**	**(K)= 1.82**	**(N×K)= 3.62**	
	Stem diameter (cm)							
Control	0.66	0.70	0.74	0.70	0.69	0.73	0.78	0.73
2.5	0.72	0.76	0.78	0.75	0.75	0.79	0.82	0.79
5.0	0.76	0.81	0.84	0.80	0.79	0.84	0.87	0.83
7.5	0.78	0.83	0.88	0.83	0.78	0.86	0.87	0.84
Mean (N)	0.73	0.77	0.81		0.75	0.80	0.83	
LSD at 5%	**(N)= 0.01**	**(K)= 0.02**	**(N×K)= 0.04**		**(N)= 0.01**	**(K)= 0.01**	**(N×K)= 0.02**	
	Fresh weight of stem/plant (g)							
Control	27.26	29.61	31.31	29.40	28.11	30.03	31.76	29.97
2.5	29.28	32.41	36.00	32.56	29.38	33.73	34.12	32.41
5.0	30.09	36.81	37.78	34.89	30.76	38.20	37.37	35.45
7.5	31.75	39.36	40.28	37.13	32.56	40.43	42.21	38.40
Mean (N)	29.60	34.55	36.34		30.20	35.60	36.36	
LSD at 5%	**(N)= 0.92**	**(K)= 0.95**	**(N×K)= 1.69**		**(N)= 0.67**	**(K)= 1.00**	**(N×K)= 1.63**	
	Dry weight of stem/plant (g)							
Control	5.40	5.85	6.77	6.01	5.64	5.91	6.93	6.16
2.5	5.97	6.88	7.27	6.70	6.14	7.35	7.24	6.91
5.0	6.38	7.50	7.46	7.11	6.52	7.57	7.23	7.10
7.5	6.66	8.01	8.05	7.57	6.87	8.06	8.45	7.80
Mean (N)	6.10	7.06	7.38		6.29	7.22	7.46	
LSD at 5%	**(N)= 0.25**	**(K)= 0.28**	**(N×K)= 0.49**		**(N)= 0.15**	**(K)= 0.18**	**(N×K)= 0.32**	

Moreover, Crimson Shade cultivar of zinnia (*Zinnia elegans*) was fertilized with different levels of NPK. The maximum plant height, number of lateral shoots, number of leaves, leaf area, number of flowers per plant and 100 seed weight was recorded with the application of nitrogen at 30 g/m^2 (Javid *et al*., 2005). In addition, Thaneshwari (2014) reported that the highest dose of N and K obtaining good vegetative growth, profuse flowering attributes of hydrangea for commercialization.

Table 2: Effect of nitrogen (N) and potassium (K) fertilization rate as well as their interactions (N×K) on number of leaves/plant and fresh and dry weights of leaves per plant of sunflower during 2014 and 2015 seasons

Potassium fertilization rate (g/pot)	Nitrogen fertilization rate (g/pot)							
	Control	5	10	Mean (K)	Control	5	10	Mean (K)
	2014 season				2015 season			
	Number of leaves /plant							
Control	18.00	19.67	20.67	19.44	16.67	20.33	21.33	19.44
2.5	19.67	21.33	22.33	21.11	18.67	21.67	22.67	21.00
5.0	20.67	22.67	23.33	22.22	20.33	22.33	24.00	22.22
7.5	21.67	23.00	25.33	23.33	21.33	23.67	25.67	23.56
Mean (N)	20.00	21.67	22.92		19.25	22.00	23.42	
LSD at 5%	**(N)= 0.38**	**(K)= 0.61**	**(N×K)= 0.99**		**(N)= 0.89**	**(K)= 0.50**	**(N×K)= 1.15**	
	Fresh weight of leaves/plant (g)							
Control	19.48	21.28	25.30	22.02	19.08	21.67	26.82	22.62
2.5	20.37	23.16	28.32	23.95	20.22	26.36	29.71	25.43
5.0	22.16	26.31	32.75	27.07	24.37	29.83	34.42	29.54
7.5	24.71	27.22	36.96	29.63	25.94	34.10	37.67	32.57
Mean (N)	2.68	24.49	30.83		22.40	28.07	32.15	
LSD at 5%	**(N)= 2.34**	**(K)= 0.88**	**(N×K)= 2.67**		**(N)= 1.20**	**(K)= 0.92**	**(N×K)= 1.81**	
	Dry weight of leaves/plant (g)							
Control	3.67	3.70	4.97	4.11	3.47	3.69	5.31	4.16
2.5	3.86	4.28	5.52	4.55	3.81	5.13	5.68	4.87
5.0	4.48	5.06	6.38	5.31	4.95	6.31	6.54	5.93
7.5	5.04	5.66	7.21	5.97	5.24	7.33	7.39	6.65
Mean (N)	4.26	4.68	6.02		4.37	5.61	6.23	
LSD at 5%	**(N)= 0.37**	**(K)= 0.28**	**(N×K)= 0.55**		**(N)= 0.52**	**(K)= 0.33**	**(N×K)= 0.71**	

As shown in Tables 1 and 2 reveals that growth parameters of sunflower were gradually increased with increasing potassium fertilization rates in the first and second seasons. Furthermore, the potassium rate at 7.5 g/pot as potassium sulphate significantly increased plant height, stem diameter, fresh and dry weights of stem per plant, number of leaves/plant and fresh and dry weights of leaves per plant compared to the lowest rate and control in both seasons. Very and Sentenac (2003) reported that potassium (K), which is necessary for efficient plant growth and development, exists predominantly as a free or absorptive bound cation.

Data of both seasons in Tables 1 and 2 indicate that growth parameters of sunflower were significantly increased with all interaction treatments between nitrogen and potassium fertilization rates compared with control [control N (0.0 rate) and control K (0.0 rate)] in the first and second seasons, in most cases. Furthermore, under each treatment of nitrogen rates sunflower growth parameters were increased with increasing potassium fertilization rates. However, the interaction treatment between high rate of nitrogen (10 g/pot) and high rate of potassium (7.5 g/pot) was superior in this respect compared to the other ones under study in both seasons. In this regard, Ali and Muhammad (2013) studied the influence of different concentrations of soil fertilizers as nitrogen, potassium and phosphorus (5 % N, 30 % P and 0 % K) at (0.0, 0.5, 0.7 and 1 g per plant, respectively) on the growth and flowering of *Dianthus caryophyllus* applied three times during the growing season. Results showed that the effect of NPK was significant on plant height, number of branches/plant, number of leaves/plant, stem diameter compared to control.

Root system parameters:

The data described in Table 3 indicate that, the maximum increase in root length and fresh and dry weights of root/plant of sunflower were produced from the treatment of high rate (10 g per pot) compared with the other ones under study. Furthermore, root system parameters of *Helianthus annuus* were significantly increased with all nitrogen fertilization treatments compared with control in

the two seasons. In addition, increasing nitrogen rates increased sunflower root length and weights. Similar results were found by Maryada *et al.* (2001) and Kaushal and Rana (2006) on *Withania somnifera*. The increase in root length and weights due to nitrogen fertilization treatments might be attributed to the enhancing effects of them on root elongation and growth resulting in longer and heavier roots.

Data presented in Table 3 demonstrate that potassium fertilization treatment at 7.5 g/pot showed an increase in root system parameters of sunflower (root length and fresh and dry weights of roots per plant) compared with the other rates under study. Also, increasing potassium rates gradually increased root system parameters in both seasons. Moreover, the above mentioned parameters were increased with potassium rate treatments compared to untreated plants in the first and second seasons. However, higher amounts of potassium are required by radish for tuberous root formation (Brintha and Seran, 2009). These results are in line with those reported by Seghatoleslami *et al.* (2013) on fenugreek plant.

Table 3: Effect of nitrogen (N) and potassium (K) fertilization rate as well as their interactions (N × K) on root length and fresh and dry weights of roots per plant of sunflower during 2014 and 2015 seasons

Potassium fertilization rate (g/pot)	Nitrogen fertilization rate (g/pot)							
	Control	5	10	Mean (K)	Control	5	10	Mean (K)
	2014 season				2015 season			
	Root length (cm)							
Control	9.67	11.00	11.67	10.78	10.67	11.33	12.33	11.44
2.5	12.33	12.33	13.67	12.78	12.67	13.33	14.33	13.44
5.0	14.67	13.33	15.67	14.56	15.33	14.33	16.67	15.44
7.5	16.67	15.67	18.00	16.78	15.67	16.67	19.00	17.11
Mean (N)	13.33	13.08	14.75		13.58	13.92	15.58	
LSD at 5%	**(N)= 0.60**	**(K)= 0.54**	**(N×K)= 1.00**		**(N)= 0.85**	**(K)= 0.39**	**(N×K)= 1.03**	
	Fresh weight of root / plant (g)							
Control	3.72	4.25	4.61	4.19	3.77	4.13	4.72	4.21
2.5	4.61	4.73	5.50	4.95	4.81	4.52	5.19	4.84
5.0	5.13	5.34	5.96	5.48	5.11	5.58	6.14	5.61
7.5	5.33	6.61	6.88	6.27	5.75	6.44	6.98	6.39
Mean (N)	4.70	5.23	5.73		4.86	5.16	5.76	
LSD at 5%	**(N)= 0.42**	**(K)= 0.30**	**(N×K)= 0.61**		**(N)= 0.14**	**(K)= 0.18**	**(N×K)= 0.30**	
	Dry weight of root / plant (g)							
Control	0.76	0.84	0.96	0.85	0.79	0.85	0.98	0.87
2.5	0.94	0.98	1.19	1.04	0.96	0.97	1.14	1.02
5.0	1.03	1.15	1.35	1.18	1.04	1.18	1.38	1.20
7.5	1.20	1.44	1.50	1.38	1.21	1.32	1.46	1.33
Mean (N)	0.68	1.10	1.25		1.00	1.08	1.24	
LSD at 5%	**(N)= 0.06**	**(K)=0.04**	**(N×K)= 0.09**		**(N)= 0.06**	**(K)= 0.05**	**(N×K)= 0.10**	

It is evident from the obtained data in Table 3 that, under each treatment of potassium fertilization root length and fresh and dry weights of root/plant of sunflower were increased gradually with increasing nitrogen fertilization rates. Furthermore, abovementioned parameters was significantly increased with all interaction treatments between intercropping systems and nitrogen fertilization rates compared with control in most cases in the first and second seasons. However, the interaction treatment between the highest rates of nitrogen and potassium was superior in this respect compared to the other ones under study in the first and second seasons. Similar results were stated by Zhang *et al.* (2002) on wheat when intercropped with faba bean and Toaima (2006) on fodder beet intercropped with onion.

Cut flowers parameters:

From data recorded in Table 4 it is obvious that, flower diameter, fresh weight of flower and longevity of sunflower flowers were increased gradually with increasing nitrogen rates. Moreover, all nitrogen fertilization treatments significantly increased cut flower parameters compared with control. Furthermore, the maximum increase in this connection was obtained from the treatment of high rate of nitrogen (10 g/pot as ammonium sulphate) compared with the other ones under study. These results hold true in the two seasons. These results are in line with those stated by Singh *et al.* (2015) on carnation cut flowers.

Table 4: Effect of nitrogen (N) and potassium (K) fertilization rate as well as their interactions (N×K) on flower diameter, flower weight per plant and longevity of sunflower during 2014 and 2015 seasons

Potassium fertilization rate (g/pot)	Nitrogen fertilization rate (g/pot)							
	Control	5	10	Mean (K)	Control	5	10	Mean (K)
	2014 season				2015 season			
	Flower diameter (cm)							
Control	8.33	9.33	9.67	9.11	9.33	10.33	10.00	9.89
2.5	9.33	10.33	10.33	10.00	9.33	11.33	11.33	10.67
5.0	10.33	10.67	11.67	10.89	9.67	11.67	12.33	11.22
7.5	10.67	11.67	12.67	11.67	11.33	12.33	13.67	12.44
Mean (N)	9.67	10.50	11.08		9.92	11.42	11.83	
LSD at 5%	**(N)= 0.61**	**(K)= 0.30**	**(N×K)= 0.75**		**(N)= 0.64**	**(K)= 0.46**	**(N×K)= 0.93**	
	Flower fresh weight/plant (g)							
Control	25.33	27.87	30.93	28.04	25.99	28.77	30.96	28.57
2.5	27.70	30.56	33.39	30.55	27.48	31.83	33.29	30.87
5.0	29.85	32.69	35.77	32.77	29.36	32.83	35.91	32.70
7.5	31.81	32.91	38.04	34.25	32.05	35.19	38.95	35.40
Mean (N)	28.67	31.01	34.53		28.72	32.16	34.78	
LSD at 5%	**(N)= 0.65**	**(K)= 0.76**	**(N×K)= 1.30**		**(N)= 0.63**	**(K)= 0.77**	**(N×K)= 1.31**	
	Longevity (days)							
Control	5.67	6.67	7.33	6.55	5.33	6.33	6.67	6.11
2.5	6.67	7.33	7.33	7.11	6.33	6.67	7.33	6.78
5.0	7.33	7.33	8.33	7.67	6.67	6.67	7.67	7.00
7.5	7.33	7.67	8.67	9.89	7.33	7.67	8.33	7.78
Mean (N)	6.75	7.25	7.92		6.42	6.83	7.50	
LSD at 5%	**(N)= 0.68**	**(K)= 0.56**	**(N×K)= 1.08**		**(N)= 0.33**	**(K)= 0.48**	**(N×K)= 0.78**	

However, the response of the plant characteristics to the rates of nitrogen fertilization might be due to the ability increase of the plant to produce dry matter and / or the increase in meristemic cells growth as reported by Abdul Al-Kiyyam *et al.* (2008).

Data listed in Table 4 suggest that, flower diameter, fresh weight of flower and longevity were increased with increasing potassium rates. Furthermore, the maximum increase in this regard was obtained from the treatment of 7.5 g/pot of potassium compared with the other ones under study. Likewise, all potassium fertilization rates increased cut flowers parameters of sunflower compared with control. Such increase was significant in the two seasons, in most cases. The previous benefits of potassium were documented before by Shahin *et al*., (2006) who affirmed that dressing *Rudbeckia hirta* plants bimonthly with 3 g/pot of K_2SO_4 is necessary to obtain a good display flowering *Rudbeckia* plant.

It is evident from the obtained data in Table 4 that, the interaction treatment between and the highest rates of each of nitrogen or potassium was superior in sunflower cut flowers parameters compared to the other ones under study in both seasons. Also, under each nitrogen fertilization rate treatment these parameters were increased with increasing potassium fertilization rates. In addition, abovementioned parameters were significantly increased with all interaction treatments between

nitrogen and potassium fertilization rates compared with control, in most cases, in both seasons. Furthermore, Sajid and Amin (2014) on chrysanthemum plants, reported maximum total number of flowers per plant, flower size and flower fresh weight with the application of N+P+K (at 520 mg + 430 mg + 400 mg/pot). Also, the vase life of hydrangea cut stems was reported to be better, when plants were fertilized with 40 g N, 30 g P and 50 g K per meter square (Thaneshwari, 2014).

Chemical constituents:

Results under discussion in Table 5 indicate that, all nitrogen fertilization rate treatments significantly increased total chlorophyll content (SPAD unit) in leaves, total carbohydrates percentage and carthamin pigments content (mg/100g) in flowers of sunflower compared with control. Moreover, chemical constituents of *Helianthus annuus* were gradually increased with increasing nitrogen rates. Furthermore, the maximum increase in this regard was obtained from the treatment of (10 g/ pot as ammonium sulphate) compared with the other ones under study. Also, Treder (2005) fertilized oriental lilies plants were dark green leaves compared with non-fertilized control. Bi *et al*. (2008) observed that florist's hydrangeas plants grown with 210 and 280 mg/l N during first season had the more leaf quality (chlorophyll content) than the forcing in the second one.

Table 5: Effect of nitrogen (N) and potassium (K) fertilization rate as well as their interactions (N×K) on total chlorophyll in leaves and total carbohydrates % and carthamin content in petals of sunflower during 2014 and 2015 seasons

Potassium fertilization rate (g/pot)	Nitrogen fertilization rate (g/pot)							
	Control	5	10	Mean (K)	Control	5	10	Mean (K)
	2014 season				2015 season			
	Total chlorophyll (SPAD unit)							
Control	33.00	35.33	37.00	35.11	34.00	35.00	38.00	35.67
2.5	35.33	37.33	40.67	37.78	36.33	38.33	40.33	38.33
5.0	36.67	38.67	40.67	38.67	37.67	40.33	41.33	39.78
7.5	39.67	41.00	43.67	41.44	39.00	41.67	43.33	41.33
Mean (N)	36.17	38.08	40.50		36.75	38.83	40.75	
LSD at 5%	**(N)= 0.61**	**(K)= 0.50**	**(N×K)= 0.96**		**(N)= 0.64**	**(K)= 0.50**	**(N×K)= 0.98**	
	Total carbohydrates percentage in flower							
Control	32.41	32.62	34.28	33.10	32.61	33.18	33.33	33.04
2.5	33.24	34.00	35.19	34.14	33.65	34.16	34.03	33.95
5.0	33.84	34.86	35.03	34.58	35.11	35.67	34.79	35.19
7.5	35.00	35.73	36.30	35.67	35.89	36.74	35.36	36.00
Mean (N)	33.62	34.30	35.20		34.32	34.94	34.38	
LSD at 5%	**(N)= 0.62**	**(K)= 0.54**	**(N×K)= 1.01**		**(N)= 0.74**	**(K)= 0.26**	**(N×K)= 0.84**	
	Carthamin content / plant petals (mg/100g)							
Control	2.25	2.38	2.48	2.37	2.26	2.37	2.41	2.34
2.5	2.32	2.46	2.46	2.41	2.29	2.39	2.48	2.39
5.0	2.36	2.49	2.51	2.45	2.35	2.47	2.52	2.45
7.5	2.45	2.50	2.54	2.50	2.42	2.50	2.56	2.49
Mean (N)	2.35	2.46	2.50		2.33	2.43	2.49	
LSD at 5%	**(N)= 0.02**	**(K)= 0.03**	**(N×K)= 0.05**		**(N)= 0.01**	**(K)=0.02**	**(N×K)= 0.03**	

Table 5 pointed out that all potassium fertilization treatments significantly increased total chlorophyll content, total carbohydrates percentage and carthamin pigments content of sunflower compared with control [K (0 rate)]. Moreover, chemical constituents of sunflower leaves and flower were increased gradually with increasing potassium rates. Furthermore, the maximum increase in this respect was obtained from the treatment of high rate of nitrogen (7.5 g/pot) compared with the other ones under study. Also, Castro *et al.* (2011) observed that K deficiency resulted in lower values of accumulation of carbohydrates in *Heliconia psittacorum* leaves. Such increase was significant in the two tested seasons. However, Garaie *et al*., (2016) who revealed that K_2SO_4 progressively increased

anthocyanin and chlorophyll content in the leaves of *Catharanthus roseus* as the rate of application was increased.

From data presented in Table 5 it is clear that, total chlorophyll content, total carbohydrates percentage and carthamin content were significantly increased with all interaction treatments between nitrogen and potassium fertilization rates compared with control, in most cases, in the first and second seasons. However, under each treatment of nitrogen fertilization chemical constituents of sunflower was increased with increasing potassium fertilization rates, in most cases. In addition, the interaction treatment between 10 g/pot of nitrogen with 7.5 g/pot of potassium in both seasons was superior in this respect compared to the other ones under study. Moreover, under each rates of potassium fertilization sunflower chemical constituents were increased by increasing nitrogen fertilization rates. Similar results were found by Chhune (2015) on hydrangea.

Conclusion

From above mentioned results, it is preferable to fertilize *Helianthus annuus* L. plants with 10 g/pot of ammonium sulphate with 7.5 g/pot of potassium sulphate three times a season to enhance the growth parameters, root system, cut flower parameters and total chlorophyll content as well as chemical constituents of sunflower plant under Sharkia Governorate conditions.

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