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RESPONSE OF PRODUCTIVITY AND CHEMICAL CONSTITUENTS OF CLUSTER BEAN (*Cyamopsis tetragonoloba* Taub.) PLANT TO POTASSIUM FERTILIZATION AND HUMIC ACID RATES

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RESEARCH PAPER

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ABSTRACT

Two field experiments were carried out at Experimental Farm, Fac. Agric., Zagazig University, Egypt to study the influence of potassium fertilization rates (0.0, 25 and 50 kg K_2O/faddan), humic acid rates (0.0, 1.0, 2.0 and 3.0 ml/l) and their combination treatments on growth parameters, yield components, chemical constituents and glactomanan production of cluster bean plant. These trials were conducted during the 2017 and 2018 summer seasons. Plant height, number of branches and leaves/plant and total dry weight /plant increased significantly by using 50 kg K_2O /faddan. Also, the highest values of pods number/plant, seed yield /plant and /faddan as well as glactomanan yield/plant and /faddan were achieved with the same rate of potassium. Total chlorophyll content and nitrogen, phosphorus and potassium percentages increased by the highest rate of potassium under study. Moreover, the highest rate of humic acid (3 ml/l) recorded the maximum values of abovementioned parameters compared to the other rates (1.0 and 2.0 ml/l) and control. The present study recommends that using potassium at 50 kg K_2O /fad. combined with 3 ml/l of humic acid for increasing seeds and glactomanan yields per faddan of cluster bean plants grown under similar field conditions.

Keywords: *Cyamopsis tetragonoloba, potassium, humic acid, growth parameters, yield components, glactomanan.*

INTRODUCTION

Cluster bean (*Cyamopsis tetragonoloba*, Taub) is hardy and drought tolerant crop having deep root system which enables to utilize the available moisture more efficiently and it belongs to *Leguminosae* family (**Kherawat *et al*., 2013**). The commercial importance of cluster bean is due to the gum (guaran or galactomanan) that is extracted from the seed and used in food processing, paper manufacturing, pharmaceuticals, and as an emulsifier in drilling muds for the petroleum industry (**Whistler and Hymowitz, 1979**). Guar is used as Laxative, antibilious. However, taking cluster bean gum orally with meals was found to lower post-prandial glucose levels in patients with type 1 diabetes (**Khare, 2007**).

Potassium (K) is a major plant nutrient, which is needed by the plants in large amount and is supplied by the fertilizers. It is available to the plants in the form of cation (k^+). Actually potassium is essential for a variety of process i.e. photosynthesis, winter hardiness, fruit formation and disease resistance. It stiffens straw and thus reduces lodging and plays an important role in protein formation especially in grain filling (**Wiedenhoeft, 2006**). However, **Taha *et al*. (2016)** on faba bean, found that the mean values of vegetative growth parameters, pods and seeds fresh weight and N, P, K in plant foliage and seeds were increased significantly with increasing rates of potassium fertilizers.

Humic acid (HA) is a promising natural resource that can be used as an alternative to synthetic fertilizers to improve crop production. **Biondi *et al*. (1994)** indicated that it exerts either a direct effect, such as on

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membrane permeability and enzymatic activities, or an indirect effect, mainly by changing the soil structure. **Mikkelsen (2005)** reported that humic acid has a high molecular weight and high complexation ability. In specific, it is found that humic acid application led to a significant increase in soil organic matter which improves plant height and crop production (**Magdi *et al*., 2011**).

The aim of the present study was to investigate the response of growth, yield and some chemical constituents of *Cyamopsis tetragonoloba* plant to different rates of potassium fertilizer and humic acid under Sharkia Governorate conditions.

MATERIALS AND METHODS

In order to investigate the effect of different rates of potassium fertilization and humic acid on vegetative growth, yield components and chemical constituents as well as glactomanan production of cluster bean, an experiment was conducted using split plot design with three replications in Experimental Farm (Ghazala), Fac. Agric., Zagazig University, Egypt, during two consecutive seasons of 2017 and 2018. Main plots were adopted for potassium fertilization as K_2O in three rates (0.0, 25 and 50 kg/fad.) and sub plots included foliar fertilizers by humic acid (0.0, 1, 2 and 3 ml/l) and their combinations to consist 12 treatments. Vegetarian humic acid fertilizer (Abo Zaabal Company to Fertilizers) contains 86 % humic acid. Humic acid was added to the plant as foliar spray during the vegetative period in three equal rates after 30, 50 and 70 days from sowing.

Seeds of cluster bean (*Cyamopsis tetragonoloba*, Taub.) were obtained from Research Centre of Medicinal and Aromatic Plants, Dokky, Giza and were sown on 18th May during both seasons. Seeds were sown then immediately irrigated. After three weeks from planting, seedlings were thinned to be two plants per hill. The physical and chemical properties of the experimental soil site are shown in Table 1, according to **Chapman and Pratt (1978)**.

The plot area was 3.00 × 7.20 m included six ridges; each ridge was 60 cm apart and three meters in length. The seeds were sown on ridge in hills on one side. The distances between hills were 30 cm. Two ridges (1st and 6th) were for samples to measure vegetative growth and the other ridges were used for yield determination. All plants received normal agricultural practices whenever they needed. All plants were fertilized with nitrogen as ammonium sulphate (20.5%N) at the rate of 200 kg/fad. (4200 m^2) as well phosphorus fertilization as calcium super phosphate (15.5% P_2O_5) at the rate of 200 kg/fad. Phosphorus fertilizer was added during soil preparation as a soil dressing application. While, nitrogen and potassium fertilizers were divided into three equal portions and were added to the soil after 35, 55 and 75 days from sowing. The source of K_2O was potassium sulphate (48 % K_2O).

Recorded Data

Plant growth parameters: After 105 days from sowing of cluster bean seeds growth parameters were recorded: plant height (cm), number of branches and leaves/plant and total dry weight/plant (g).

Yield components: Pods of cluster bean were harvested after 150 days of seed sowing and the following data were recorded: number of pods/plant, seed yield/plant (g), seed yield/faddan (kg).

Chemical constituents: Total nitrogen, total phosphorus and potassium percentages in cluster seeds were determined according to **Chapman and Pratt (1978)** at the end of experiment. Also, total chlorophyll content (SPAD unit) was determined in cluster bean fresh leaves after 105 days from sowing by using SPAD- 502 meter as reported by **Markwell *et al*. (1995)**.

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Glactomanan production: Glactomanan percentage was determined in cluster bean seeds according to the method described by **Anderson (1949)**. Total glactomanan yield/plant (g) was calculated by multiplying glactomanan percentage by yield of seeds/plant. Yield of glactomanan /fad. (kg) was calculated by multiplying the glactomanan yield per plant by number of plants/fad. . for each treatment.

Statistical Analysis: The statistical layout of this experiment was a split-plot experiment in completely randomized block design. Where, potassium fertlization were randomly distributed in the main plots, while humic acid rates were randomly arranged in sub-plots. Each treatment was included 3 replicates. Collected data were analyzed according to **Gomez and Gomez (1984)**. Least significance difference (L.S.D.) was used to differentiate means at the at 5 % level of probability. The means were compared using computer program of Statistix version 9 (**Analytical software, 2008**).

RESULTS:

Effect of potassium fertilization, humic acid rates and their combinations on vegetative growth parameters of cluster bean

Data in Table 2 indicate that the highest values of plant hieght, number of branches/plant, number of leaves/plant and total dry weight/plant of cluster bean were significantly increased by potassium fertilization rates compared to control (unfertilized plants) in both seasons. Furthermore, potassium fertilization rate at (50 kg K_2O/fad.), significantly increased vegetative growth parameters of *Cyamopsis tetragonoloba* plants compared the other one and control during the two seasons.

In addition, humic acid rates significantly increased cluster bean plant height (cm), branch and leaf number per plant and total dry weight per plant (g) compared to control (Table 2). Moreover, humic acid at the rate of (3 ml/l) recorded higher increase in growth parameters compared with the other treatments under study with significant differences with the other two ones.

The combination between potassium fertilization and humic acid rates showed that the highest values of cluster bean vegetative growth parameters were recorded when the highest potassium fertilization rate (50 kg K_2O/fad.) was combined with the highest rate of humic acid (Table 2) in both seasons. However, under each treatment of potassium rate plant hieght, number of branches/plant, number of leaves/plant and total dry weight/plant of cluster bean were increased with increasing humic acid rates.

Effect of potassium fertilization, humic acid rates and their combinations on yield components of cluster bean

Increasing of potassium fertilization rate significantly improved the number of pods/plant, seed yield/plant and seed yield/faddan of cluster bean (Table 3). The highest values of yield components of cluster bean were recorded with the highest rate of potassium fertilization (50 kg K_2O /fad.) during both seasons.

It can be noticed that pod number/plant and seed yield/plant as well as seed yield /faddan were increased with increasind humic acid rates and the highest mean values were recorded at the rate of 3 ml/l (Table 3).

Data presented in Table 3 show the influence of the combination treatments between potassium and humic acid rates on cluster bean yield components. The obtained results showed that number of pods/plant, seed yield/plant and seed yield/faddan were significantly affected by the combination treatments. Results also indicate that the highest values in this regard were observed with application of 50 kg K_2O/faddan with 3 ml humic acid/l. In contrast, the lowest values were observed with 00 potassium fertilization plus 0.0 humic acid.

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Effect of potassium fertilization, humic acid rates and their combinations on leaves total chlorophyll content and seeds N, P and K percentages of cluster bean

Fertilizing *Cyamopsis tetragonoloba* plants with 50 kg K_2O/faddan gave a significant increment in total chlorophyll content in plant leaves and total nitrogen, total phosphorus and potassium percentages in seeds compared to control treatment (Table 4). Furthermore, increasing potassium fertilization rates gradually increased abovementioned parameters.

In this connection, Table 4 reveals that fertilizing cluster bean plants with humic acid was the superior treatments concern chemical constituents especially at 3 ml/l and gave the significant increment in comparison with other treatments under study. These results hold true in the first and second seasons.

Combination treatments between potassium fertilization and humic acid (Table 4) reveal that potassium fertlilization at 50 kg K_2O /fad. combined with 3 ml/ l humic acid gave the highest values of N, P and K (%) in seeds and total chlorophyll content in leaves with significant differences with the other combination treatments under study in the both seasons.

Effect of potassium fertilization, humic acid rates and their combinations on glactomanan production of cluster bean

Table 5 indicate that potassium fertilization of cluster bean had significant effect on glactomanan percentage, glactomanan yield/plant (g) and glactomanan yield/fad. (kg) in both seasons. It is clear that potassium sulphate application had a general marked positive trend glactomanan production. In addition, application of 50 kg K_2O/fad. gave the highest values in this connection in both seasons, respectively. The increase in glactomanan yield/ fad. was about 46.07 and 43.99 % for potassium at 50 kg/ fad. over the control in the first and second seasons, respectively.

Data in Table 5 show that the application of humic acid as foliar spray reflected a significant effect on glactomanan production of *Cyamopsis tetragonoloba* plants in both seasons. However, application of humic acid at 3 ml/l, recorded the maximum values of glactomanan percentage, glactomanan yield/plant and glactomanan yield/fad. compared to control and the other ones under study in both season.

Application of potassium at the highest rate 50 kg K_2O / fad. and combined with 3 ml/l humic acid was the superior combination treatment for increasing glactomanan percentage, glactomanan yield/plant and glactomanan yield/fad., in addition, this treatment recorded 132.40 and 133.47 kg/fad. in the 1^{st} and 2^{nd} seasons, respectively (Table 5). Finally, it could be concluded that, the best combination treatment for increasing glactomanan production was obtained by fertilization of cluster plants with 50 kg K_2O / fad. and treated of plants with 3 ml /l humic acid.

DISCUSSION:

Effect of potassium fertilization on vegetative growth parameters, yield components, chemical constituents and glactomanan production of cluster bean

Consulting the above mentioned results which indicated that all applied potassium fertilization rates gave higher plant hieght, number of cluster bean branches and leaves/plant, seed yield/plant, seed yield/faddan, total chlorophyll content and galctomanan production compared with control with significant differences between them. Potassium fertilizers proved its role in plant metabolism, carbohydrate synthesis, water transport in xylem, cell elongation. Potassium was found to serve a vital role in photosynthesis by direct increasing in growth and leaf area index and hence CO_2 assimilation and increasing the outward translocation of photosynthates (**Gardener *et al*.,1985** and **Mengel and Kirkby, 1987**). However, **Pal *et al*.**

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(2016) reported that addition of potassium resulted in higher herb yields of *Thymus serphyllum*. **Beckmann-Cavalcante *et al*. (2016)** demonstrated that K fertilization favored the increase in leaf K content and yield (number of flower stems per square meter) heliconias plant. Potassium fertilizer application at different levels showed significant effects on onion growth, yield and quality parameters (**Bekele, 2018** and **Yassen *et al*., 2018**).

Effect of humic acid on vegetative growth parameters, yield components, chemical constituents and glactomanan production of cluster bean

In the present study, it was reported that the highest values of cluster bean growth parameters, yield components and chemical constituents as well as glactomanan production were recorded with 3 ml humic acid/l. Humic acid make important contributions to improve soil stability, fertility, improves flower quality that lead to exceptional plant growth and micronutrient uptake which reflected in herb dry weight (**Knicker *et al*., 1993**). This result confirmed the findings reported earlier by **Mohammad (2009)** on *Catharansus roseus*, **Parakash *et al.* (2011)** on *Spirulina plantisis* and **Nasiri *et al.* (2015)** on geranium plant. These augmentations may be due to the role of humic acid which is a product contains many elements which improve the soil fertility and increase the availability of nutrient elements by holding them on mineral surfaces and consequently affect plant growth leading to more growth and yielding (**Akinci *et al*., 2009**). Also, **Puttanna *et al*. (2010**) showed that addition of potassium to the soil in the fertilizer form became necessary for obtaining maximum yields. At the end of harvests, exchangeable K in soil was significantly lower as application of K decreased from 100 to 50 and 0 kg per hectare per year. Soil fertility could be maintained and oil yields of rosemary from four harvests could be increased by application of 100 kg K. Moreover, **Shafeek *et al*. (2014**) suggested that, hot pepper plants which received 2 g/l of humic acid resulted highest vegetative growth characteristics i.e. plant height, stem number and leaf chlorophyll content and reproductive factors expressed as fruits number and weight per plant as well as total yield / m^2 as well as N percentage values in two seasons.

Effect of combination between potassium fertilization and humic acid rates on vegetative growth parameters, yield components, chemical constituents and glactomanan production of cluster bean

Obtained data in this research suggested that as humic acid rates are increased under any potassium fertilization rate gradually the above mentioned characters are increased. These results are in line with those stated by **El-Bassiony *et al*. (2010)** on snap bean and **Ali *et al*. (2014)** on *Tulipa agesneriana*. Moreover, as mentioned just before, both humic rates and NPK levels treatments (each alone) increased growth parameters of stevia plant, in turn, they together might maximize their effects leading to more growth and yield of cluster bean plants. **Ahmed *et al*. (2010)** on garlic reported that vegetative growth, yield, quality, storability and N, P, K contents of bulbs and leaves were increased by applying humic acid (HA) or potassium fertilizer (K) and their combinations. Soil application of HA at 5 kg/fad. plus foliar application of 3% K_2O + 48 kg K_2O /fad. as soil dressing resulted in the best results in this respect. Furthermore, **Radwan and El- Shall (2011)** found that the best combination treatment for increasing yield and its components was obtained by fertilization of potato plants with 100 kg K_2O /fad. and treated of plants with 2 kg /fad. humic acid. Also, **Khater and Abd El-Azim (2016)** demonstrated 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 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 of *Plantago psyllium* plant.

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CONCLUSION:

From the previous results it could be concluded that the application of potassium fertilization at 50 kg K_2O /faddan as potassium sulphate plus foliar application of humic acid at 3 ml /l can be recommended to enhance growth, seed yield components, and glactomanan production of *Cyamopsis tetragonoloba* plant under Sharkia Governorate conditions.

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Table 1. Physical and chemical properties of experimental soil

Physical analysis				Soil texture
Clay (%)	Silt (%)	Fine sand (%)	Coarse sand (%)	
56.36	9.26	17.62	16.76	Clay

Chemical analysis											
pH	E.C. m.mohs/cm	Organic matter (%)	Soluble cations (meq./L)			Soluble anions (meq./L)			Available (ppm)		
			Mg^{++}	Ca^{++}	Na^{+}	Cl^{-}	HCO_3^{-}	SO_4^{--}	N	P	K
7.86	0.98	0.58	2.7	1.6	4.1	4.5	1.7	3.5	18	20	71

Table 2. Influence of potassium fertilization, humic acid rates and their combinations on growth parameters of cluster bean at 105 days from sowing during the two seasons of 2017 and 2018

Treatments		Plant height (cm)		Number of branches/plant		Number of leaves/plant		Total dry weight/plant (g)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Potassium fertilization rates (kg K_2O/fad.)									
00		104.75	106.00	6.92	7.17	83.00	83.00	47.29	48.98
25		113.75	110.83	8.58	8.50	88.75	90.42	56.94	58.43
50		118.75	122.92	10.08	10.83	114.08	117.17	63.37	63.58
LSD 5%		**3.77**	**1.03**	**0.50**	**0.61**	**3.26**	**2.90**	**1.94**	**1.65**
Humic acid rates (ml/l)									
0.0		106.22	106.33	6.33	6.78	87.44	89.78	47.24	49.03
1.0		111.11	111.44	8.11	8.22	94.22	94.67	54.02	54.26
2.0		114.00	116.22	9.33	9.44	99.00	100.44	58.41	59.97
3.0		118.33	119.00	10.33	10.89	100.44	102.56	63.79	64.72
LSD 5%		**2.20**	**2.44**	**0.56**	**0.47**	**1.72**	**1.65**	**1.11**	**2.00**
Interaction between potassium fertilization and humic acid rates									
00	**0.0**	102.67	104.33	4.33	4.67	77.67	80.67	40.08	43.16
	1.0	103.67	105.00	7.00	6.67	81.67	81.33	45.02	46.09
	2.0	106.00	106.67	7.67	8.00	85.33	83.33	46.67	49.13
	3.0	106.67	108.00	8.67	9.33	87.33	86.67	57.38	57.53
25	**0.0**	105.00	100.67	6.33	7.00	81.00	82.67	49.53	49.67
	1.0	112.67	109.67	7.67	7.67	86.67	89.00	54.19	54.90
	2.0	116.67	116.00	9.67	9.00	93.67	95.00	60.64	63.67
	3.0	120.67	117.00	10.67	10.33	93.67	95.00	63.38	65.47
50	**0.0**	111.00	114.00	8.33	8.67	103.67	106.00	52.10	54.27
	1.0	117.00	119.67	9.67	10.33	114.33	113.67	62.86	61.78
	2.0	119.33	126.00	10.67	11.33	118.00	123.00	67.92	67.12
	3.0	127.67	132.00	11.67	13.00	120.33	126.00	70.60	71.16
LSD 5%		**4.96**	**3.80**	**0.98**	**0.92**	**4.12**	**3.78**	**2.53**	**3.40**

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Table 3. Influence of potassium fertilization, humic acid rates and their combinations on yield components of cluster bean during the two seasons of 2017 and 2018

Treatments		Number of pods/plant		Seed yield/plant (g)		Seed yield/faddan (kg)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season
Potassium fertilization rates (kg K_2O/fad.)							
00		79.67	80.33	6.14	6.10	286.54	384.91
25		84.83	88.75	6.68	6.92	311.63	323.02
50		106.58	105.25	8.06	8.05	376.41	375.75
LSD 5%		**4.14**	**2.72**	**0.23**	**0.23**	**10.92**	**10.70**
Humic acid rates (ml/l)							
0.0		80.44	80.67	6.38	6.35	297.64	296.60
1.0		89.00	87.78	6.87	6.85	320.87	319.52
2.0		94.44	97.11	7.23	7.37	337.62	344.00
3.0		97.56	100.22	7.36	7.53	343.32	351.46
LSD 5%		**1.84**	**1.46**	**0.08**	**0.15**	**3.73**	**6.98**
Interaction between potassium fertilization and humic acid rates							
00	**0.0**	71.67	69.33	5.90	5.62	275.34	262.12
	1.0	79.67	80.33	6.12	6.11	285.45	285.14
	2.0	82.33	85.33	6.25	6.31	291.83	294.32
	3.0	85.00	86.33	6.29	6.39	293.54	298.06
25	**0.0**	78.67	82.33	6.17	6.35	288.25	296.34
	1.0	81.00	86.67	6.33	6.87	295.57	320.45
	2.0	87.33	91.00	7.00	7.18	326.68	335.23
	3.0	92.33	95.00	7.20	7.28	336.01	340.05
50	**0.0**	91.00	90.33	7.06	7.10	329.32	331.34
	1.0	106.33	96.33	8.18	7.56	381.59	352.97
	2.0	113.67	115.00	8.45	8.62	394.34	402.43
	3.0	115.33	119.33	8.58	9.92	400.41	416.28
LSD 5%		**4.93**	**3.47**	**0.26**	**0.32**	**12.18**	**14.83**

Table 4. Influence of potassium fertilization, humic acid rates and their combinations on N, P and K percentages and total chlorophyll content (SPAD) of cluster bean at 105 days from sowing during the two seasons of 2017 and 2018

Treatments		Total nitrogen percentage		Total phosphorus percentage		Potassium percentage		Total chlorophyll Content (SPAD unit)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Potassium fertilization rates (kg K_2O/fad.)									
00		3.052	2.940	0.497	0.491	2.954	2.939	43.00	42.42
25		3.117	3.000	0.499	0.496	2.987	2.980	44.08	44.25
50		3.190	3.122	0.514	0.510	3.067	3.097	45.42	46.42
LSD 5%		**0.037**	**0.033**	**0.006**	**0.003**	**0.026**	**0.033**	**0.65**	**0.60**
Humic acid rates (ml/l)									
0.0		2.978	2.874	0.491	0.490	2.959	2.912	41.67	41.56
1.0		3.051	2.968	0.500	0.496	2.992	2.990	43.89	43.78
2.0		3.179	3.079	0.510	0.502	3.024	3.030	45.22	45.33
3.0		3.271	3.161	0.513	0.508	3.034	3.088	45.89	46.78
LSD 5%		**0.031**	**0.015**	**0.003**	**0.002**	**0.029**	**0.027**	**0.64**	**0.60**
Interaction between potassium fertilization and humic acid rates									
00	**0.0**	2.950	2.733	0.488	0.479	2.933	2.852	40.67	39.67
	1.0	2.983	2.913	0.496	0.491	2.956	2.941	42.67	41.67
	2.0	3.107	2.987	0.499	0.496	2.970	2.974	44.33	43.33
	3.0	3.167	3.087	0.506	0.499	2.956	2.988	44.33	45.00
25	**0.0**	2.960	2.880	0.491	0.489	2.957	2.902	41.33	41.00
	1.0	3.043	2.913	0.497	0.494	2.951	2.954	44.00	44.00
	2.0	3.203	3.070	0.502	0.499	3.003	2.994	45.33	45.67
	3.0	3.263	3.137	0.504	0.504	3.035	3.069	45.67	46.33
50	**0.0**	3.023	2.970	0.495	0.503	2.986	2.983	43.00	44.00
	1.0	3.127	3.077	0.506	0.504	3.069	3.075	45.00	45.67
	2.0	3.227	3.180	0.527	0.512	3.101	3.123	46.00	47.00
	3.0	3.383	3.260	0.529	0.522	3.111	3.208	47.67	49.00
LSD 5%		**0.059**	**0.040**	**0.008**	**0.004**	**0.050**	**0.052**	**1.152**	**1.076**

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Table 5. Influence of potassium fertilization, humic acid rates and their combinations on glactomanan production of cluster bean during the two seasons of 2017 and 2018

Treatments		Glactomanan percentage		Glactomanan yield /plant (g)		Glactomanan yield /faddan (kg)	
		1st season	2nd season	1st season	2nd season	1st season	2nd season
Potassium fertilization rates (kg K_2O /faddan)							
00		28.28	28.31	1.74	1.73	81.11	80.86
25		29.54	29.36	1.98	2.04	92.28	95.09
50		31.39	30.89	2.54	2.49	118.48	116.43
LSD 5%		**0.20**	**0.53**	**0.06**	**0.06**	**2.88**	**2.78**
Humic acid rates (ml/l)							
0.0		28.07	27.61	1.79	1.76	83.81	82.21
1.0		29.34	29.09	2.02	2.00	94.59	93.25
2.0		30.17	30.42	2.20	2.25	102.52	105.12
3.0		31.35	30.96	2.32	2.34	108.24	109.26
LSD 5%		**0.27**	**0.33**	**0.03**	**0.04**	**1.52**	**2.11**
Interaction between potassium fertilization and humic acid rates							
00	**0.0**	26.69	26.34	1.57	1.48	73.49	69.04
	1.0	28.13	27.83	1.72	1.70	80.29	79.36
	2.0	28.52	29.19	1.78	1.84	83.24	85.90
	3.0	29.77	29.90	1.87	1.91	87.41	89.12
25	**0.0**	28.00	27.33	1.73	1.73	80.72	80.98
	1.0	29.15	28.97	1.85	1.99	86.17	92.87
	2.0	29.78	30.22	2.08	2.17	97.32	101.33
	3.0	31.21	30.93	2.25	2.25	104.91	105.19
50	**0.0**	29.53	29.16	2.08	2.07	97.21	96.61
	1.0	30.74	30.47	2.51	2.30	117.32	107.51
	2.0	32.21	31.85	2.72	2.75	126.99	128.14
	3.0	33.07	32.07	2.84	2.86	132.40	133.47
LSD 5%		**0.45**	**0.72**	**0.08**	**0.09**	**3.64**	**4.18**