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Interaction effect of N fertilizer with foliar application of potassium on the growth, yield and yield attributes of Chinese garlic plant (*Allium sativum* L.).

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ABSTRACT

A field experiment was carried out on Chinese garlic (*Allium sativum* L.) with three replications and nine treatments in the experimental agriculture station of National Research Centre at Nobaria, Egypt to find out the efficacy of different combination of foliar application of potassium fertilizer (K 38%) at (0, 1 and 2 cm/l). with three levels of nitrogen fertilizers (100% N, 75%N+25% bio potassium and 50% N+ 50% bio potassium) in its growth, yield and yield attributes. Results strongly showed that the addition of the highest level of N fertilizers (100%) improved plant growth, fruit yield, physical and chemical characters of garlic plants. In the same respect, the highest level of foliar spry of potassium (2 cm/l) gave significantly the best growth characters, total bulbs yield, physical and chemical quality of garlic bulb. The interaction between foliar application of potassium and N fertilizers levels had no significant effect on all studied characters.

Keywords: Chinese garlic, foliar application, potassium fertilizer, bulbs yield, quality

1. Introduction

Garlic (*Allium sativum* L.) is the most important vegetable crop belonging to the family Alliaceae. Among various *Allium sps*., crop garlic ranks second next to onion in the world (Voigt, 2004). The oil of garlic is volatile in nature and contains Sulphur combining compounds that is responsible for its strong odor, unique flavor and pungency as well as for the benefit of health (Salomon, 2002). Generally, a fresh bulb of garlic is composed of moisture (62.8%), protein (6.3%), fat (0.1%), fibre (0.8%) and is a good source of carbohydrates, Vitamin C, Selenium, Phosphorus and Manganese (Pamplona-Roger,2001). Many people perceived and appreciated garlic for its many medicinal attributes (Rabinowitch and Currah, 2002) as it is used for the treatment and control of various diseases like hypertension, worms, germs, bacterial and fungal diseases, diabetes, cancer, ulcer, rheumatism etc. (Samavatean *et al.*, 2011).

Nitrogen is one of the major essential nutrients elements that contribute a lot for the production of crops. The crop growth and yield greatly depend on supply of soil N and its proper management (Adhikari *et al.*, 2016). The rate, time and method of nitrogen (N) fertilizer application are strongly related to growth, development, and yield of a crop (Shrestha *et al*., 2018). However, Naruka and Dhaka (2001) found that all growth parameters, yield attributing traits, bulb yield and contents of the garlic bulb increased significantly with the increasing level of nitrogen application.

The dry matter production of bulb and bulb yield increased due to nitrogen application (Hedge, 1988). The positive and significant response of garlic to applied nitrogen has also been reported by many authors (Brahma and Yousuf, 2008). In the same respect, Shafeek *et al* (2015) recorded that the highest level of N fertilizers (100%) application gave significantly the best growth characters, total fruit

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yield, physical and chemical quality of cantaloupe fruits. It seems that fruit total sugars, TSS and moisture were not affected by N fertilizer application. However, Sitaula *et al.* (2020) found that garlic plant height; number of cloves, diameter of bulbs, fresh bulb weight and total bulb yield were increased by increasing of N fertilizer levels. Moreover, microbial fertilizer competence scours the environment and promotes the profitable capability of land by reducing neutralize of chemical fertilizer consuming Pham, (2004). Different reports reported that the inoculation of some plants with bio-fertilizer particularly or in amalgamation with mineral fertilizers increased plant growth, yield and chemical synthesis (Osman, 2007). Many authors indicated that the vegetative growth of garlic plants and minerals uptake was increased with growing the level of N, P and K fertilizers Singh, *et al* (1989). Bio potassium fertilizer enforcement was hence the opposition of plant to root disease and minimize the environmental contamination from chemical fertilizer enforcement Rizk, and Shafeek, (2000). The fecundation with potassium dissolving bacteria led to upgrade plant growth and yield of garlic plants Abou El-Magd*, et al* (2014) reflected increases in the microbial intensity of the root zone, total bacterial numeration, total fungal; actinomyces and azotobacter as well as potassium dissolving bacteria recorded higher numeration in the root zone when the plants were sprayed with bio-fertilizers liken with mineral fertilizer treatments. However, bio potassium fertilizers have advantageous resumption to increase population of soil microorganisms, especially in the surface stratum of root rhizosphere, that inspire materials which catalyze plant growth Awad, (2002). Moreover, Hassan, (2015) reported that application of bio-enriched treatments increased vegetative growth of garlic plants i.e. plant length, number of leaves per plant, fresh and dry weight of whole plant as well as chemical composition and yield of garlic plants. Also, Shafeek (2016) reported that with increasing the supplement of bio-potassium rate (Potassine) up to 2 kg/fed. produced the strength plant growth of garlic and the elevated yield of bulbs which have the superior physical possession and the towering nutritional values (N, P and K) all of them were obtained if liken with the slash bio-potassium rates (1 kg/fed.) and without bio potassium fertilizer.

Nowadays, potassium fertilization became an important factor for garlic production under Egyptian soils. However, farmers minimizing the used amount to the minimum dose or ignored using it because chemical potassium fertilizer became a high expensive fertilizer in Egypt. In addition to use any other newly and cheapest potassium sources through foliar application to overcome such problem and to maximize their net return to cover the additional cost of this K fertilizer source. Foliar fertilization is more economical than root fertilization due to the efficiency and lower cost. The foliar method of fertilizer application is usually preferred because very small amounts of fertilizers are applied per hectare. It also reduces the number of passes of the applicant, thereby reducing problem of soil compactness. Foliar application is also less likely to result in ground water pollution. John, *et al* (2011) reported that foliar K thiosulfate (KTS) treatments resulted in higher plant tissue K concentrations, higher soluble solids concentrations, total sugars, and bioactive compounds (ascorbic acid and β-carotene) on cantalup fruits. However, foliar application of K thiosulfate has been associated with increased yields, fruit size, increased total soluble solids and ascorbic acid concentrations, improved fruit color, increased shelf life, and shipping quality of many horticultural crops (Lester *et al*., 2005 and 2006). However, foliar application of potassium increased the growth and yield of vegetable plants (El-Tohamy *et al*., 2011). Potassium in organic cheated form (potassium borate citrate and Humate) can be used as an inexpensive source for potassium and it could be used as foliar application. In the same respect, Awatef, *et al* (2015) reported that, spraying onion plants with potassium thiosulfate at a rate of (2L\fed.) markedly increased vegetative growth, yield, and bulb quality and bulb chemical composition. Moreover, Shafeek *et al* (2019) found that spraying onion plants with potassium (K 38%) liquid at a rate of (2 cm/l) markedly improved vegetative growth, total bulbs yield, bulb physical quality and bulb chemical texture.

2. Materials and Methods

Two field experiments were carried out at the experimental station of National Research Centre at Nubaria, Behira Governorate, Egypt during the two growing seasons of 2018 and 2019 in order to study the effect of designed altering the recommended nitrogen dose (ammonium sulfate) through different sources i.e. 100% N, 75% N+25% bio fertilizer (potassine) and 50% N+50% (potassine) with

foliar application of different level of potassium (K38%) ,(0, 1 and 2 cm/l) on plant vegetative growth, total yield and its components as well as bulb quality of garlic plants (*Allium sativum* L.) cv. Chinese. The experimental trails were conducted in sandy soil using drip irrigation system. Chemical analysis and physical properties of experimental soil are shown in Table (1).

Table 1: The physical and chemical properties of the experimental soil.

Physical properties							
Sand		**Clay**	**Silt**	**Texture**	**F.C. %**	**W.P. %**	
90.08		9.26	0.66	Sandy	16.57	5.25	
Chemical analysis							
E.C.	**pH**	**Meq/L**					
		Ca	**Mg**	**Na**	**K**	**HCO_3**	**Cl**
1.7	2.8	7.02	0.527	0.982	0.31	1.30	0.566

Each the experiment included 9 treatments which were the combinations between three levels of N and bio potassium fertilizer (potassine) with foliar spray of two levels of potassium (K38%) at rate of (1 and 2cm/l) plus control treatment (foliar spraying with water). The normal agriculture practices for garlic production under drip irrigation system were followed according to the recommendations of Ministry of Agriculture. The organic manure fertilizers were applied during soil preparation. But the chemical phosphorus and potassium fertilizer were added at rate of 200 and 150 kg/fed. as calcium super phosphate and potassium sulphate respectively. The experimental design was split plot design with 3 replications, where the N and bio fertilizer treatments were assigned in the main plots and foliar application of potassium fertilizer treatments were devoted randomly within the subplots. The garlic cloves of Chinese cv. were planted on the second week of November in both seasons of 2018 and 2019. The gloves were sown at 20 cm distances on the two sides of each ridge. Spraying of potassium (K38%) was conducted three times; first one after 30 days of planted and then every 15 days for the second and third spraying. Spraying was applied in early morning. After 3 months from planting samples of garlic plants from the three replicates were taken and vegetative growth characters were measured (plant length, number of leaves, fresh and dry weight of whole plant). At harvesting stage after 5 months and after curing period (15 days) the total yield per feddan as ton were account also the average weight of bulb, bulb and neck diameter, number of cloves/ bulb and weight of clove was recorded. The percentage of nitrogen, phosphorus and potassium content in tissues of garlic cloves were determined depending on the methods which were described by Cottenie, *et al* (1982). In addition, the protein percentages in tissues of garlic cloves were calculated by multiplying nitrogen content by 6.25. And for the quantification of total carbohydrate content (DuBois *et al.* 1956).

All data values were subjected to the analysis of variance according to Gomez and Gomez (1984).

3. Results and Discussion

3.1. Growth characters of garlic plant:

3.1.1. Effect of N fertilizer levels:

The data recorded on growth attributes of garlic plant (plant length, number of leaves per plant, fresh and dry weight of plant) are presented in table (2). The results showed that the growth parameters were affected by nitrogen level and were significantly higher at higher nitrogen level N (100%). In descending order application of (75%N+25% K bio) and the lowest value (50%N+ 50% K bio). This may be attributed to better nutritional environment in the root zone as well as in the plant system. The response to nitrogen fertilization in terms of overall improvement in growth parameters is further supported by the fact that the soil of experimental field was low in nitrogen status and its early supply corrected the deficiency and improved overall crop growth considerably. This result agrees with the findings of Grad *et al.* (1993) who reported that growth parameters increased significantly with the nitrogen fertilization. The increasing of all vegetative growth characters due to application of the highest level of N fertilizers (100%) might be referred to its favorable role in increasing the availability of nutrients to plant absorption and higher photosynthetic activity (Mengel and Kirkby, 1978). Also, may

be due to the role of these nutrients in the synthesis of plant proteins, chlorophyll and enzymes (N), many investigators came to similar results (Adebayo *et al.,* 2014 and Shaffek *et al* 2015).

Table 2: Effect of N fertilizer and foliar application of potassium level (K 38%) on growth characters of garlic plant to in 2018 and 2019 seasons.

N fertilizer levels + bio	Foliar use of potassium (cm/l)	2018 season				2019 season			
		Plant length (cm)	No of leaves/ plant	Weight (g)		Plant length (cm)	No of leaves /plant	Weight (g)	
				Fresh	Dry			Fresh	Dry
100% mineral N	**0**	52.67	8.67	24.33	2.82	53.00	8.33	22.17	2.77
	1	55.00	10.33	25.20	3.01	54.67	8.33	23.97	2.87
	2	58.00	10.67	26.20	3.33	59.33	8.33	27.90	3.48
Mean		**55.22**	**9.89**	**25.24**	**3.06**	**55.67**	**8.33**	**24.68**	**3.04**
75% N+25% K bio	**0**	49.00	7.33	20.13	2.32	45.67	6.67	19.50	2.43
	1	52.33	7.67	21.43	2.25	48.33	7.67	21.97	2.59
	2	56.67	8.67	24.13	2.89	53.00	8.33	25.20	3.26
Mean		**52.67**	**7.89**	**21.90**	**2.49**	**49.00**	**7.56**	**22.22**	**2.76**
50% N+50% K bio	**0**	43.00	6.33	18.40	2.18	43.33	6.67	17.23	2.21
	1	51.33	6.67	19.70	2.10	46.67	7.33	19.43	2.43
	2	51.67	7.33	21.90	2.68	51.67	8.33	22.60	2.86
Mean		**48.76**	**6.78**	**20.00**	**2.32**	**47.22**	**7.44**	**18.67**	**2.50**
Average K foliar	**0**	48.22	7.44	20.96	2.44	47.33	7.22	19.63	2.47
	1	52.89	8.22	22.11	2.45	49.89	7.78	21.79	2.63
	2	55.44	8.89	24.08	2.97	54.67	8.33	25.23	3.20
LSD at 5% level	**N**	**1.68**	**0.74**	**1.17**	**0.29**	**2.72**	**0.22**	**0.49**	**0.18**
	(K 38%)	**1.70**	**0.38**	**0.77**	**0.14**	**1.57**	**0.49**	**0.53**	**0.16**
	Interaction	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

3.1.2. Effect of potassium foliar application:

Concerning potassium foliar application treatments had a significant effect on growth characters (plant length, number of leaves/ plant, fresh and dry weight of garlic plant) in jointly seasons (Table 2). However, foliar spraying garlic plants with the elevated level of potassium k 38% (2 cm/l) generated the highest values of growth characters followed by spraying plants with low level (1 cm/l) in together seasons. While, control treatment (without potassium foliar application) gave the lowest values of these parameters in both seasons. The notability of plant growth with spraying potassium (K38%) might be impute to aside from the role of potassium in protein synthesis, nutrients translocation, anti oxidant enzymes, root generation and foliar growth Chen *et al* (2004). The most growth promote effect of potassium (K 38%) may be due to that this formalization contain K of the comparable and consistent synergetic action, congregation with organic moiety, include powerful K feeding for more growing of carbohydrates, proteins, enzymes and energy synthesis Marschner, (1995). Another major role of foliar application of K is in photosynthesis Huber, (1985) by immediately increasing leaf growth and leaf area index, and therefore, CO2 absorption Wolf *et al* (1976). Potassium foliar application increases the external translocation of photosynthetic from the foliate Ashley and Goodson, (1972). These results are in convention with those of Subrahmanyam and Raju, (2000) and Zhang *et al,* (2006).

3.1.3. Interaction compared N fertilizer levels and potassium foliar application:

Regarding the interaction impact, there were insignificant impact on growth characters i.e. (plant height, number of leaves /plant, fresh and dry weight of leaves) in jointly seasons (Table, 2). The elevated values of these parameters were registered by N fertilizer level with foliar spraying by towering concentration of potassium (K 38%) at (2cm/l). These returns were proper in together experimental seasons. Comparable results were gained by El-Bassiouny, (2006) who reported that the highest growth characters of onion plants were listed when used potassium foliar application of K.

3.2. Total bulb yield and its components

3.2.1. Effect of N fertilizer levels:

Increase in the level of nitrogen significantly increased the yield and yield attributing traits of the garlic plant (Table 3). The mean maximum total yield of bulb, fresh weight of bulb, number of cloves per bulb and weight of cloves (g) were recorded with higher level of nitrogen N fertilizer at (100%). The increase in the total fruit yield and bulb characters may be due to favorable effect of N fertilizer on the vegetative growth table (2). The heavy amount of total yield (7.9811 and 8.2480 ton/fed.) for 1st and 2nd seasons, respectively with supplement of ammonium sulfate fertilizer at level of (100 % N) compared with other treatments. These returns are in good conformity with the two empirical seasons except bulb weight in the second season only. Also, may be due to the work of improving in photosynthetic activity, dry matter collection and NPK uptake (Abou El-Magd, 1979). The way of gained results are in good conformity of past implementing such as Aisha *et al.* (2013), Magda *et al.* (2015) and Shafeek, *et al* (2020) reported that increase in the nitrogen fertilizers rate increased the total yield of crop vegetables.

3.2.2. Effect of potassium foliar application:

Foliar fertilizer by potassium (K38%) had a significant effectiveness on total garlic yield and its synthesis as liken with control treatment in jointly seasons (Table, 3). The towering increases were performed from foliar application with potassium at highest level (2cm/l).

Table 3: Effect of N fertilizer and foliar application of potassium level (K 38%) on total yield and yield attributes of garlic plant to 2018 and 2019 seasons.

N fertilizer levels + bio	Foliar use of potassium (cm/l)	2018 season				2019 season			
		Yield (ton/fed)	No. of cloves/ bulb	Fresh Weight (g)		Yield (ton/fed)	No. of cloves/bulb	Fresh Weight (g)	
				Bulb	Cloves			Bulb	Cloves
100% mineral N	0	6.6300	14.67	29.03	3.90	6.9633	15.00	27.34	4.25
	1	7.3033	13.33	37.13	4.12	8.1407	18.33	37.89	4.33
	2	10.0100	12.33	46.33	4.80	9.6400	19.67	41.74	5.50
Mean		7.9811	13.44	37.50	4.27	8.2480	17.67	33.69	4.69
75% N+25% K bio	0	6.1967	12.33	23.33	3.43	6.0887	13.67	21.15	3.63
	1	6.6400	11.33	33.67	3.70	6.9577	16.67	40.67	4.07
	2	8.7133	10.67	41.33	4.50	8.1633	18.00	45.00	4.42
Mean		7.1833	11.44	32.78	3.88	7.0699	16.11	32.83	4.04
50% N+50% K bio	0	5.8000	10.33	19.33	3.10	5.6200	11.33	19.00	3.19
	1	6.2367	9.67	30.33	3.50	6.3370	15.00	39.28	3.75
	2	8.2400	8.67	38.00	4.17	7.8063	16.33	43.72	3.90
Mean		6.7589	9.56	29.22	3.59	6.5878	14.22	31.67	3.62
Average K foliar	0	6.2089	12.44	23.9	3.48	6.2240	13.33	22.50	3.69
	1	6.7267	11.44	33.71	3.77	7.1451	16.67	39.28	4.05
	2	8.9878	10.56	41.89	4.49	8.5366	18.00	43.49	4.61
LSD at 5% level	N	0.3399	0.78	0.90	0.13	0.5657	0.49	NS	0.26
	K 38%	0.2342	0.43	2.56	0.16	0.5110	0.45	3.32	0.25
	Interaction	NS	NS	NS	NS	NS	NS	NS	NS

However, the mean data for potash foliar spraying of (K38%) manifest that farthest yield (8.9878and 8.5366 ton/ fed.) for 1st and 2nd seasons, respectively with spraying potassium (K38%) at concentration by 2cm/l (Table 3) pursue by (6.7267 and 7.1451 ton / fed.) with foliar spraying by (1cm/l) while the lower yield (6.2089 and 6.2240 ton / fed.) was registered in control treatment. The restraint of weight of bulb and cloves as well as number of cloves/bulb of garlic followed the same fashion of change like that aforesaid above. These increases may be ascribed to the function of foliar spray with potassium on increasing photosynthetic efficiency which calculation much for rise translocation of photo assimilates from leaves to the bulbs (Marschner, 1995). Also, this improved may be concerning to increased bulb tissue compressing possibility (Lester, *et al* 2006) as well as promote phloem transport of Ca to bulbs. Moreover, crop response to a foliar application of K sulfate at the V4, R1-R2, or R3-R4 stages of

development explain that soybean yield increased over 10 bu/acre when compared to a non-treated control (Nelson, *et al* 2005).

3.2.3 Interaction compared N fertilizer levels and potassium foliar application:

The interaction effect between N fertilizer levels and foliar application of potassium levels recorded no significant differences on total bulbs yield and bulb physical characters as shown in Table (3). Generally it could be declared that using height level of N fertilizer at (100%) with the highest level of foliar application of potassium fertilizers gave the highest values of total fruit yield and physical quality of garlic bulbs.

3.3. Physical bulb quality:

3.3.1. Effect of N fertilizer levels

Data in Table (4) showed clearly that the addition of height levels of N fertilizer (100%) caused an increase in physical bulb quality (bulb and neck diameter, TSS%, and total carbohydrates %) compared other treatments. These results are good in both seasons. It could be suggested that, the superiority of high level of N fertilizer these may be due to the effect of chemical nitrogen on producing good growth of garlic plants (Table 2) which reflected on the physical bulb quality. Similar results were obtained by (Abou El-Magd, 1979, Aisha *et al.* 2013, Magda *et al.* 2015 and Shafeek, *et al* 2015).

3.3.2. Effect of potassium foliar application:

Foliar application of potassium had a significant influence on physical bulb quality as compare with control treatment in both seasons (Table, 4). The highest increased were perform from foliar application with potassium 38% liquid at highest criterion (2 cm/l.). However, the response of garlic bulb quality (bulb and neck diameter, TSS% and total carbohydrates %) response the same pattern of modification like that mentioned above. These increased may be at respectable to the function of potassium on improving photosynthetic activity which calculation much for big translocation of photo assimilates from leaves to the bulbs (Marschner, 1995). Also, this increased may be regarding to improved root tissue pressure potential (Lester *et al*., 2006) as well as promote bark transmit of Ca to roots. The obtained results were in accordance with those acquired by Subrahmanyam and Raju (2000), El-Tohamy *et al*. (2011) and Shafeek, *et al* (2019) reported that, yield was improved by applying foliar application of potassium.

Table 4: Effect of N fertilizer and foliar application of potassium level (K 38%) on physical quality of garlic plant to 2018 and 2019 seasons.

N fertilizer levels + bio	Foliar use of potassium (cm/l)	2018 season				2019 season			
		Diameter (cm)		TSS %	Total Carbohydrate %	Diameter (cm)		TSS %	Total Carbohydrate %
		Bulb	Neck			Bulb	Neck		
100% mineral N	0	4.42	1.17	25.00	3.54	2.60	0.63	30.00	3.58
	1	4.57	1.33	28.33	3.52	2.93	0.73	32.67	3.56
	2	4.70	1.45	33.33	3.50	3.23	0.97	45.33	3.51
Mean		4.56	1.32	28.89	3.52	2.92	0.78	36.00	2.55
75% N+25% K bio	0	3.83	1.07	20.00	3.48	2.17	0.50	26.00	3.52
	1	4.23	1.23	21.67	3.51	2.53	0.63	29.33	3.55
	2	4.23	1.27	25.00	3.47	2.80	0.67	40.67	3.51
Mean		4.10	1.18	22.22	3.49	2.50	0.60	32.00	3.53
50% N+50% K bio	0	3.20	0.90	16.67	3.42	1.90	0.33	21.67	3.46
	1	3.60	1.00	20.00	3.38	2.23	0.40	25.67	3.42
	2	3.87	1.13	23.33	3.33	2.47	0.53	36.33	3.37
Mean		3.56	1.01	20.00	3.39	2.20	0.42	27.89	3.42
Average K foliar	0	3.82	1.04	20.56	3.48	2.22	0.49	25.89	3.52
	1	4.13	1.19	23.33	3.47	2.57	0.59	29.22	3.51
	2	4.27	1.28	27.22	3.43	2.83	0.72	40.78	3.46
LSD at 5% level	N	0.21	0.05	1.41	0.01	0.22	0.07	2.40	0.02
	K 38%	0.09	0.05	1.31	0.02	0.08	0.04	0.07	0.02
	Interaction	NS	NS	NS	NS	NS	NS	NS	NS

3.3.3. Interaction compared N fertilizer levels and potassium foliar application:

The interaction among the various criterions of N fertilizer and foliar spraying with potassium 38% liquid had insignificant belongings on garlic bulb physical quality (Table, 4). The highest quantities were recorded by used (N 100 %.) of ammonium sulfate with foliar application by potassium 38% at high concentration (2cm/l.). These returns were true in both seasons.

3.4. Chemical bulb characters

3.4.1. Effect of N fertilizer levels:

Data recorded in Table (5) clearly showed that values of the percentage of N, protein, P and K in garlic bulb tissues were increased with increasing N fertilizer level from (100%). The nutritional values in garlic bulb tissues raised to reach the highest values with addition the highest N fertilizer. These findings are in good accordance with the two seasons. However, the statistical analysis of the obtained data revealed that the differences within different N levels were great enough to be significant except P % in the first season. It is evident from data illustrated in Table (5). It be concluded that, increasing the levels of N fertilizer in soil solution raised the availability of nutrient elements which favored to enhancement their absorption and hence increased its concentration in storage organs. The obtained results are in good accordance with previous investigators such as Shafeek *et al* (2013) and (2020).

Table 5: Effect of N fertilizer and foliar application of potassium level (K 38%) on chemical quality of garlic plant to 2018 and 2019 seasons.

N fertilizer levels + bio	Foliar use of potassium (cm/l)	2018 season %				2019 season %			
		N	Protein	P	K	N	Protein	P	K
100% mineral N	0	0.46	2.88	0.21	1.73	0.42	2.63	0.28	2.15
	1	0.57	3.56	0.25	1.93	0.49	3.06	0.32	2.30
	2	0.74	4.65	0.28	2.03	0.60	3.75	0.39	2.46
Mean		0.59	3.70	0.24	1.90	0.50	3.15	0.33	2.30
75% N+25% K bio	0	0.44	2.75	0.19	1.75	0.40	2.50	0.23	1.87
	1	0.51	3.19	0.22	1.85	0.46	2.90	0.24	1.77
	2	0.61	3.80	0.25	1.87	0.57	3.54	0.26	1.92
Mean		0.52	3.25	0.22	1.82	0.48	2.98	0.24	1.85
50% N+50% K bio	0	0.40	2.50	0.16	1.47	0.36	2.23	0.17	1.29
	1	0.47	2.94	0.20	1.68	0.43	2.71	0.20	1.41
	2	0.55	3.46	0.23	1.80	0.54	3.42	0.22	1.61
Mean		0.47	2.97	0.20	1.65	0.44	2.79	0.20	1.44
Average K foliar	0	0.43	2.71	0.18	1.65	0.39	2.45	0.23	1.77
	1	0.52	3.23	0.22	1.82	0.46	2.89	0.25	1.83
	2	0.63	3.97	0.25	1.90	0.57	3.57	0.29	1.99
LSD at5% level	N	0.06	0.35	NS	0.04	0.02	0.16	0.03	0.13
	K 38%	0.03	0.17	0.03	0.05	0.03	0.17	0.02	0.08
	interaction	NS	NS	NS	NS	NS	NS	NS	NS

3.4.2. Effect of potassium foliar application:

Results in Table (5) show that, the percentage of N, protein, P and K in bulb tissues were significantly increased by potassium foliar application (K 38%) as compared with the control treatment. The highest values of chemical composition parameters were obtained when garlic plants sprayed with potassium (K 38%) at high level (2cm/l.) followed by potassium at low level (1cm/l) and control treatment in both seasons. Increasing nutritional values of bulbs could be attributed to the rapid absorption of these elements by the plant surface, especially the leaves and their translocation within the plant (Marschner, 1995). Similar results were obtained by El-Bassiony (2006) on onion and Shafeek, *et al* (2019). They proposed that potassium foliar application significantly affect N, P and K concentrations in plant leaves. The improvements in the nutritional bulb tissues could be attributed to the mode of action of SO_4 anions in enhancing the photosynthetic activity and enzymes of carbohydrates transformation.

3.4.3. Interaction compared N fertilizer levels and potassium foliar application:

The interaction effect between mineral fertilizers (100%N) and foliar application of potassium levels had no significant differences on the percentage of nitrogen, protein, P and K contents of garlic bulb tissues as shown in Table (5). It is of interest to note that using a higher level of N fertilizer (100%.) with high levels of foliar spray of potassium at (2 cm/l).

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