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# The influence of foliar and soil fertilization of potassium on growth, yield and quality of garlic plants (*Allium sativum* L.).

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**Abstract :** Two farm testing were completed in the empirical terminal of National Research Centre at Nubaria, Behira Governorate, Egypt through the two winter seasons of 2013/2014 and 2014/2015 to research the effect of various levels of potassium fertilization (0, 100 and 200 unites of potassium) as potassium sulfate in addition to foliar application by water (control) or potassium thiosulfat (KTS) at (1 %) and (2%) and their interaction on output and goodness of garlic cv. "Chinese.". Potassium foliar employment was made 3 times at 15 days period during the growing interval (30, 45 and 60 days after planting). The acquired results display that:
1-The elevated potassium fertilization rate (200 unites of potassium soil fertilizer) grant the tallest plant, the highest number of leaves per plant and the bigest fresh and dry weight of plants as well as the towering total bulb yield / fed. Also, the gained effect notify that the cloves measure i.e. (number, weight and TSS) as well as cloves chemical synthesis (N, P, K and protein) were increased with increasing potassium fertilization rate.
2- Spraying garlic plants with potassium thiosulfate at a rate of (2%) markedly increased vegetative growth, yield, bulbs quality and cloves chemical structure.
3-The suitable belongings of the potassium on the growth, total yield and bulb parameters were acquired when garlic plants soil fertilized with 200 units of potassium fertilizer excessive elevation standard of foliar application of potassium thiosulfate (2%).
**Key words***:* Garlic, potassium soil fertilizer, foliar potassium thiosulfate (KTS), growth, total bulb yield, cloves quality.

## Introduction

Garlic (*Allium sativum* L.) is one of the generality substantial bulb vegetable crops and is following to onion (*Allium cepa)* in significance Hamma etl [1.] It is generally applied as a spice or in the medicinal objective. In Egypt, it has been mostly plowed for both local consuming and exordium. Egypt was status the fourth major country in the world for garlic product (244.626 MT) after China, India and Korea FAO [2.] However, increasing garlic yield and improving bulb goodness are fundamental target for both planters and consumers, but it commonly consist on many laborers especially that effectiveness the plant growth throughout the growth time. Growing garlic in the latterly reclaimed soils is countenance by various problems, like low amounts of obtainable nutrients and destitute organic matter content as well as poor hydrophsic, chemical and biological possession.

Potassium is a leading plant alimentary, which is necessary by the plants in large offset and is provide by the fertilizer. It is obtainable to the plants in the form of cation (k+). In fact potassium is fundamental for a assortment of operation i.e. photosynthesis, fruit forming, winter audacity and disease impedance. It harden chaff and thus decrease stay, and plays an substantial function in protein fashioning. Moreover, all the root crops considerably reply to the potassium fertilizer. Therefore, Yadav et al[3] observed significantly great onion

yield and fresh weight of bulbs by soil fertilizer with 150 kg potassium/ha through other potassium levels. Improved bulb yield of garlic was gained with soil fertilizer by 150 kg potassium/ha. Moreover, taking into consideration economics of crops equiponderant fertilizer by potassium at 50 kg/ha grant the optimum returns Tiwari [4.] Increasing concentrations of potassium significantly improved the TSS satisfaction of onion bulb. Great TSS (11.99%) content of onion bulb was acquired in the treatment extradite potassium fertilizer by 125 kg/ha which was on equivalent with potassium fertilizer by 150 kg/ha. while the superior vitamin C content (9.93 mg /100g) was listed with 50 kg potassium/ ha. Much examiners reported the repayment of onion plant to the potassium levels like Abd El-Aal et al[5,] El-Bassiouny[6,] El-Desuki et al.[7.] Moreover, Abou El-Nasr and Ibrahim[8] notified that the highest potassium fertilization rate (75 kg potassium /fed.) gave the tallest shoot, the highest number of leaves per plant and the highest fresh weight of shoots as well as the highest total yield per fed. Also, the gained results found that the root measure expressed as (root length, root diameter, root weight, TSS and carotenoids content, as well as leaves chemical composition (N, P and K levels) were increased with increasing potassium fertilization rate. The favorable effects of the potassium on the growth, total yield and root parameters were obtained when plants fertilized with 75 kg potassium /fed. as potassium sulfate plus foliar application of potassium humate (3 ml/ L). However, Saud et al [9] reported that the ultimate onion plant height (51.6 cm), number of leaves plant (9.89), bulb diameter (5.93), average bulb weight (64.89 g), leaf width (1.33 cm) and yield (22.91 ton/ ha) were spotted with the potassium fertilizer by (120 kg potassium / ha). In the same respect, Shafeek et al[10,] Awatef Behairy et al[11] reported that the elevated onion plant growth parameters (the tallest plant, the biggest leaves number, the vigorous fresh, dry weight of plant, bulbs yield per unit area and magnitude of bulb as well as its medium weight) were revealed with fertilizer by potassium sulfate at elevated level (300 kg/fed.). Also, the application of potassium fertilizer at the biggest rate acquired the towering supplement values of bulb tissues from the percentage of TSS, protein, N, P, K, Fe, Mn, Zn and Cu. In the same times, collect the biggest rate of potassium fertilizer (300 kg/fed.) obtained the highest bulb values of growth elevated photo hormones specific as mg /g fresh weight of gibberellins and IAA and the less value of ABA as growth dilatory.

Nowadays, potassium foliar application befit an substantial operator for garlic production under Egyptian soils. However, farmers reduce the used amount to the minimum dosage or ignored using it because chemical potassium fertilizer became a high costly fertilizer in Egypt. In addition to use any other recently and frugal potassium sources through foliar application to conquer such problem and to maximize their grid returning to cover the additional cost of this K fertilizer provenance. Foliar fertilization is further frugal than soil fertilization due to the competence and minimize cost. The foliar mode of fertilizer application is commonly outshine because very little amounts of fertilizers are utilized per hectare. It also decrease the number of push through of the demand, that way reducing problem of soil density. Foliar application is also minimal probable to effect in ground water pollution. John et al[12] reported that foliar K thiosulfate (KTS) treatments fulfill in higher plant tissue K levels, higher soluble solids levels, total sugars, and bioactive synthesis (ascorbic acid and β-carotene) on cantaloupe fruits. However, foliar spraying of K thiosulfate has been connected with increased yields, fruit size, increased soluble solids and ascorbic acid levels, improved fruit color, increased shelf life, and shipping quality of much horticultural crops Lester et l [13,] Lester et al[14.] However, foliar application of potassium increased the growth and yield of vegetable plants El-Tohamy etal[15.] Potassium in organic cheated form (potassium borate citrate and Humate) can be used as a inexpensive source for potassium and it could be used as foliar application. Moreover, [(11)] reported that spraying onion plants with potassium thiosulfate at a rate of (2L\fed.) markedly increased plant growth, yield, bulb quality and bulb chemical composition. Also, the favorable effects of the potassium on the growth, total yield and bulb parameters were obtained when onion plants fertilized with 300 kg /fed. as potassium sulfate plus high level of foliar application of potassium thiosulfate (2L\fed.). It was reported by many investigators that they increased the plant growth, nutrient uptake and plant yield as well as quality Fathy and El-Hamady[16,] Karakurt et al[17.]

The major objective of this study was to research the effect of various potassium fertilization levels pay in addition to foliar application of potassium thiosulfate (KTS) on the growth characters, total bulbs yield and its physical and chemical ingredients of garlic cloves.

## 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 2014 and 2015 in order to study the

effect of three application rates of potassium sulfate, i.e. 0 , 100 and 200 unites of potassium fertilizer and 3 levels of potassium thiosulfate (KTS) spraying (0, 1 and 2 %) on the vegetative growth, total yield and the nutritional values of cloves tissues of garlic plants (*Allium sativum* L.) cv. Chinese. The experimental site had a sandy soil texture with pH of 7.6, Ec of 0.19 and the organic matter was 0.21% with 14.00, 8.90 and 15.60 mg/100g soil of N, P and K respectively. Phosphorus ($P_2O_5$) was applied 100 kg/fed. at the time of soil preparation. The experimental design used in the two growing seasons was split plot with three replicates the three levels of potassium sulfate (0, 100 and 200 unites of potassium fertilizer) were arranged at random in main plots while the three levels of potassium thiosulfate (KTS) spraying (0, 1 and 2 %) were distributed within the subplots. Each plot area was 12.8 $m^2$ consisted of four ridges; each was 0.8 m in width and 4 m in length. Whereas, potassium thiosulfate (KTS) spraying and applied at three levels, i.e. 0, 1 and 2 % and divided into three equal portions, first portion was added at 45 days from sowing and the second was added at 60 days and the third was added at 75 days from sowing. The normal agriculture practices of garlic under drip irrigation system were followed according to the recommendations of Agriculture Ministry. The organic manure fertilizer was applied during soil preparation. But the chemical phosphorus and nitrogen fertilizer were added at rate of 200 and 150 kg/fed. as calcium super phosphate and ammonium sulphate respectively. The Chinese cv. of garlic cloves was planted on the second week of November month in the seasons of 2014 and 2015. The gloves were sown at 20 cm distances on the two sides of each ridge. 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 harvest after 5 months and after curing period (15 days) the total yield per feddan as ton were accounted also number of cloves/ bulb and weight of clove and TSS% 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 Jackson[18,] Troug and Mayer [19,] Brown and Lilleland[20] respectively. In addition, the protein percentages in tissues of garlic cloves were calculated by multiplying nitrogen content by 6.25. All data values were subjected to the analysis of variance to Gomez and Gomez.[21.]

## Results and Discussion

### Growth characters

### Effect of potassium soil fertilizer:

Data presented in Table (1) show that potassium as soil fertilizer had a significant effect on plant growth characters, *i.e.*, plant length, number of leaves/plant, fresh and dry weight of garlic plants compared to control treatment. However, the elevated plant growth characters were recorded with soil fertilizer of 200 unites of potassium fertilizer compared to all treatments. These returns were right in jointly seasons. This consequence may be due to the role of potassium element in metabolism and much practicability prerequisite to tolerate and elevate plant vegetative growth and development. Moreover, K plays a major role in many physiological and biochemical practicability likes cell segmentation and protraction and metabolism of carbohydrates and protein synthesis Marschner[22.] The acquired results are in a good conformity with those registered by Abd El-Aal et al[5,] Abou El-Nasr and Ibrahim[8,] Saud et al[9,] Shafeek et al[10,] Awatef Behairy et al [11] who found that increasing potassium fertilizer levels increased plant height, number of leaves per plant and leaves fresh weight of onion plants.

### 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 1). However, foliar spraying garlic plants with the elevated level of potassium thiosolfate (2 %) generated the highest values of growth characters followed by spraying plants with low level (1 %) in together seasons.

**Table (1): Effect of foliar and soil application of potassium fertilizer on growth characters of garlic plants during 2014 and 2015 seasons.**

| Soil fertilizer Units | Foliar spraying % | Plant length (cm) | No. of leaves /plant | Weight (g) | | Plant length (cm) | No. of leaves /plant | Weight (g) | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Fresh | Dry | | | Fresh | Dry |
| 0 | 0 | 50.00 | 6.67 | 71.78 | 9.00 | 51.00 | 5.67 | 68.67 | 8.33 |
| | 1 | 52.00 | 7.33 | 79.00 | 9.67 | 52.33 | 6.33 | 79.33 | 9.00 |
| | 2 | 53.00 | 7.67 | 82.67 | 10.67 | 54.33 | 7.33 | 82.00 | 10.00 |
| mean | | **51.67** | **7.22** | **77.82** | **9.78** | **52.56** | **6.44** | **76.67** | **9.11** |
| 100 | 0 | 52.00 | 8.67 | 89.67 | 10.33 | 53.33 | 7.67 | 86.00 | 10.67 |
| | 1 | 58.33 | 9.00 | 98.00 | 12.67 | 54.67 | 9.00 | 97.33 | 12.00 |
| | 2 | 60.67 | 9.33 | 118.00 | 14.67 | 57.33 | 9.67 | 101.67 | 13.33 |
| mean | | **57.00** | **9.00** | **101.89** | **12.00** | **55.11** | **8.78** | **95.00** | **12.00** |
| 200 | 0 | 53.33 | 9.33 | 125.00 | 15.67 | 55.00 | 9.67 | 113.33 | 14.67 |
| | 1 | 60.67 | 9.67 | 128.67 | 17.00 | 59.33 | 10.33 | 115.33 | 16.33 |
| | 2 | 64.00 | 10.67 | 143.67 | 18.00 | 62.67 | 11.00 | 122.67 | 17.67 |
| mean | | **59.33** | **9.98** | **132.44** | **16.22** | **59.00** | **10.33** | **117.11** | **16.22** |
| Average | 0 | 51.78 | 8.22 | 95.48 | 11.67 | 53.11 | 7.67 | 89.33 | 11.22 |
| | 1 | 57.00 | 8.67 | 101.89 | 13.11 | 55.44 | 8.56 | 97.33 | 12.44 |
| | 2 | 59.22 | 9.22 | 114.78 | 14.44 | 58.11 | 9.33 | 102.11 | 13.67 |
| LSD at 5% level | Soil | **1.80** | **0.74** | **6.29** | **1.42** | **3.34** | **0.36** | **4.34** | **0.44** |
| | Foliar | **1.52** | **0.36** | **3.83** | **0.54** | **1.00** | **0.31** | **3.36** | **0.46** |
| | interaction | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** |

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 thiosulphate (KTS) 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 l [23.] The most growth promote effect of potassium thiosulphate may be due to that this formalization contain K and S of the comparable and consistent synergetic action, congregation with organic moiety, include powerful K and S feeding for more growing of carbohydrates, proteins, enzymes and energy synthesis Marschner[22.] Another major role of foliar application of K is in photosynthesis Huber[24] by immediately increasing leaf growth and leaf area index, and therefore, CO2 absorption Wolf et al [25.] Potassium foliar application increases the external translocation of photosynthetic from the foliate Ashley and Goodson [26.] These results are in convention with those of Subrahmanyam and Raju [27], Zhang et al [28].

**Effect of the interaction compared potassium soil application and potassium foliar application:**

Regarding the interaction impact, there were significant impact on growth characters i.e. (plant height, number of leaves /plant, fresh and dry weight of leaves) in jointly seasons (Table, 1). The elevated values of these parameters were registered by using 200 unites of potassium fertilizer with foliar spraying by towering concentration of potassium thyosolfate at (2%). These returns were proper in together experimental seasons. Comparable results were gained by El-Bassiouny[6,] El-Bassiony et al[29] who reported that the highest growth characters of onion and sweet pepper plants were listed when used potassium in the towering level as soil application with foliar application of K and S.

**Total bulb yield and its components**

**Effect of potassium soil fertilizers:**

The imply data for potash detected that superior yield (9.78 and 9.49 ton/ fed.) for 1st and 2nd seasons, respectively with supplement soil potassium fertilizer at rate of 200 unites of potassium sulfate (Table 2) pursue by (8.92 and 8.87 ton / fed.) with using of 100 unites while the least yield (7.97 and 8.01 ton / fed.) was restricted in control treatment. The repayment of number and weight of cloves and TSS % of garlic cloves pursue the same style of adjustment like that aforementioned above. It could be consummated that, the massive bulbs yield and its ingredient it might be impute to the best activity of plant growth parameters which acquired

by soil fertilizer by 200 unites of potassium sulfate (Table 1). Also, potassium element is very important in outright metabolism of plant enzymes efficiency, it was found to avail a indispensable role in photosynthesis by forthright increasing in growth and total bulb yield. Also, potassium has a advantageous effect on water exhaustion [22]. The same conclusion was also consummated by Ghaffoor et al[30], Khan et al[31], Pervez et al [32], Ali et al [33] who declared that as potash level increases up to optimum rates the yield (ton / fed.) and its ingredient increases.

**Effect of potassium foliar application:**

Foliar fertilizer by potassium thiosulfate (KTS) had a significant effectiveness on total garlic yield and its synthesis as liken with control treatment in jointly seasons (Table, 2). The towering increases were performed from foliar application with potassium thiosulfate at highest level (2%). However, the mean data for potash foliar spraying of thiosulfate (KTS) manifest that farthest yield (9.19 and 9.07 ton/ fed.) for

**Table (2): Effect of foliar and soil application of potassium fertilizer on yield and its components of garlic plants during 2014 and 2015 seasons.**

| Soil fertilizer Units | Foliar spraying % | Total yield (ton/fed.) | Cloves | | | Total yield (ton/fed.) | Cloves | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | No. | Weight (g) | TSS % | | No. | Weight (g) | TSS % |
| 0 | 0 | 7.64 | 7.33 | 2.23 | 30.00 | 7.75 | 7.33 | 2.31 | 29.00 |
| | 1 | 7.91 | 10.33 | 2.47 | 30.67 | 8.00 | 8.00 | 2.63 | 29.67 |
| | 2 | 8.34 | 12.00 | 2.97 | 31.33 | 8.27 | 9.33 | 3.08 | 30.67 |
| mean | | **7.97** | **9.89** | **2.56** | **30.67** | **8.01** | **8.22** | **2.67** | **29.78** |
| 100 | 0 | 8.71 | 13.00 | 2.45 | 30.00 | 8.68 | 11.00 | 2.45 | 29.67 |
| | 1 | 8.94 | 15.00 | 3.56 | 31.00 | 8.85 | 12.33 | 3.70 | 30.33 |
| | 2 | 9.12 | 15.67 | 4.62 | 31.33 | 9.07 | 13.33 | 4.70 | 30.67 |
| mean | | **8.92** | **14.56** | **3.54** | **30.78** | **8.87** | **12.22** | **3.62** | **30.22** |
| 200 | 0 | 9.50 | 13.33 | 2.88 | 31.00 | 9.18 | 14.33 | 2.99 | 31.33 |
| | 1 | 9.66 | 15.67 | 3.64 | 33.67 | 9.43 | 15.00 | 3.64 | 32.67 |
| | 2 | 10.12 | 18.00 | 5.63 | 33.67 | 9.87 | 16.00 | 5.67 | 33.33 |
| mean | | **9.78** | **15.67** | **4.05** | **32.78** | **9.49** | **15.11** | **4.10** | **32.44** |
| Average | 0 | 8.62 | 11.22 | 2.52 | 30.33 | 8.54 | 10.89 | 2.58 | 30.00 |
| | 1 | 8.84 | 13.67 | 3.22 | 31.77 | 8.76 | 11.78 | 3.32 | 30.89 |
| | 2 | 9.19 | 15.22 | 4.40 | 32.11 | 9.07 | 12.89 | 4.48 | 31.56 |
| LSD at 5% level | Soil | **0.20** | **1.46** | **0.48** | **0.56** | **0.10** | **1.52** | **0.48** | **0.47** |
| | Foliar | **0.16** | **0.94** | **0.55** | **0.55** | **0.19** | **0.86** | **0.56** | **0.57** |
| | Inter. | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** |

1st and 2nd seasons, respectively with spraying potassium thiosulfate (KTS) at concentration by 2% (Table 2) pursue by (8.84 and 8.76 ton / fed.) with foliar spraying by 1% while the lower yield (8.62 and 8.54 ton / fed.) was registered in control treatment. The restraint of number and weight of cloves and TSS % of garlic cloves 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 [22]. Also, this improved may be concerning to increased bulb tissue compressing possibility [14] 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 [34]. The gained results were in conformity with those obtained by [11], [15], [27], [35] and found that, increase of crop yield was highest after foliar treatment with potassium thiosulfate (KTS).

**Effect of the interaction compared potassium soil application and potassium foliar application;**.

The interaction amidst potassium as a soil and foliar application had effects on garlic yield and its composition (Table, 2). The elevated values were listed by using 200 unites of potassium fertilizer with foliar spraying of potassium thiosulfate (KTS) at altitude level (2%) yielded (10.12 and 9.87 ton\fed.) for 1st and 2nd seasons, respectively followed by low concentration of soil potassium fertilizer (100 unites) with low level of

thiosulfate (1%) and control treatment (7.64 and 7.75 ton\fed.) for 1st and 2nd seasons, respectively. These returns were correct in together seasons. The statistical analysis of the acquired data restrictive insignificant in total bulb yield (ton\fed.), number and weight of cloves and TSS % in both seasons

**Bulb nutritional values**

**Effect of potassium soil fertilizers:**

Information registered in Table (3) clearly reported that amount of the percentage of N, protein, P and K in cloves tissues were increased with increasing potassium fertilizer rates from 0 to 200 unites of potassium fertilizer. The nutritional values in garlic cloves tissues advanced to amplitude the elevated amount with using the high potassium sulfate rate (200 unites.). These feedbacks are in good stratification with the two seasons. Moreover, the statistics test of the acquired data detected that the variation during various potassium levels were major sufficient to be significant in jointly seasons. It is clear from data clarify in Table (3) that the high level of potassium fertilizer (200 unites.) significantly improved N, Protein, P and K contents in both seasons contrast to the depressed potassium fertilizer rate (100 unites.) and control. It could be consummated that, increasing rates of potassium fertilizer in soil solution advanced the handiness of nutrient elements which preferable to growing their absorption and as a consequence increased its focus in storage members. The gained results are in good conformity with former interrogator like.[5,6,10,11,36.]

**Effect of potassium foliar application:**

Results in Table (3) reported that, the percentage of N, protein, P and K in cloves tissues were significantly increased by potassium foliar spraying (thiosulfate) as compared with the control treatment. The summit values of chemical synthesis were obtained whereas garlic plants foliar sprayed with potassium thiosulfate at high level (2 %.) followed by potassium thiosulfate at low level (1%) and control treatment

**Table (3): Effect of foliar and soil application of potassium fertilizer on nutritional values of garlic bulbs during 2014 and 2015 seasons.**

| Soil fertilizer Units | Foliar spraying % | 2014 season % | | | | 2015 season % | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | N | protein | P | K | N | protein | P | K |
| 0 | 0 | 0.58 | 3.63 | 0.16 | 0.63 | 0.57 | 3.58 | 0.14 | 0.62 |
| | 1 | 0.60 | 3.96 | 0.18 | 0.65 | 0.62 | 3.86 | 0.15 | 0.64 |
| | 2 | 0.65 | 4.09 | 0.19 | 0.69 | 0.62 | 3.90 | 0.16 | 0.65 |
| mean | | **0.61** | **3.89** | **0.17** | **0.66** | **0.60** | **3.78** | **0.15** | **0.64** |
| 100 | 0 | 0.69 | 4.33 | 0.21 | 0.71 | 0.64 | 4.21 | 0.18 | 0.67 |
| | 1 | 0.75 | 4.69 | 0.22 | 0.74 | 0.72 | 4.50 | 0.21 | 0.70 |
| | 2 | 0.83 | 5.17 | 0.24 | 0.76 | 0.78 | 4.86 | 0.23 | 0.73 |
| mean | | **0.67** | **4.73** | **0.22** | **0.74** | **0.71** | **4.52** | **0.21** | **0.70** |
| 200 | 0 | 0.83 | 4.98 | 0.25 | 0.79 | 0.81 | 5.06 | 0.25 | 0.75 |
| | 1 | 0.88 | 5.48 | 0.27 | 0.82 | 0.86 | 5.38 | 0.27 | 0.77 |
| | 2 | 0.90 | 5.63 | 0.30 | 0.85 | 0.88 | 5.50 | 0.28 | 0.80 |
| mean | | **0.87** | **5.36** | **0.28** | **0.82** | **0.85** | **5.31** | **0.27** | **0.77** |
| Average | 0 | 0.70 | 4.31 | 0.21 | 0.71 | 0.68 | 4.29 | 0.19 | 0.68 |
| | 1 | 0.74 | 4.71 | 0.22 | 0.74 | 0.73 | 4.58 | 0.21 | 0.70 |
| | 2 | 0.79 | 4.96 | 0.24 | 0.77 | 0.76 | 4.75 | 0.22 | 0.73 |
| LSD at 5% level | Soil | **0.03** | **0.32** | **0.02** | **0.02** | **0.04** | **0.18** | **0.02** | **0.03** |
| | Foliar | **0.02** | **0.17** | **0.01** | **0.01** | **0.03** | **0.16** | **0.01** | **0.02** |
| | Inter. | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** |

in the two experimental seasons. Increasing nutritional values of cloves could be referring to the quick absorption of these elements by the plant surface, particularly the leaves and their translocation within the plant [22.] Comparable results were gained by[6,11] on onion, [16]on cowpea, [29]on sweet pepper and [15]on carrot. They reported that potassium foliar spraying significantly improving 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 promote the photosynthetic efficacy and enzymes of carbohydrates diversion.

**Effect of the interaction compared potassium soil application and potassium foliar application:**

The interaction amidst soil and foliar potassium application had effect on N, protein, P and K percentage contents in cloves tissues (Table, 3). The bigest values were reported when use 200 unites of potassium as soil fertilizer with potassium foliar spraying as potassium thiosulfate in both experimental seasons. These results may be due to the function of potassium in plant metabolism and many important regulatory practicability in the plant. Moreover, potassium and sulfur could be increased mineral uptake by plants [(22).] Also, the interaction effect between potassium fertilization rates and potassium foliar application had insignificant effect on nutrients content in garlic cloves. These results are comparable in both seasons. From data presented in Table (3) it could be clearly briefed that the biggest values of nutrients content were reported when garlic plants received 200 unites as fertilization plus potassium thiosulfate at high level as foliar application followed by other treatments. These increases may be ascribed to the situation of potassium and sulfur on increasing photosynthetic activity which computation much for high translocation of photo assimilates from leaves to the cloves.

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