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# RESPONSE OF GARLIC PLANTS TO HUMIC ACID AND DIFFERENT APPLICATION METHODS OF POTASSIUM FERTILIZER

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**ABSTRACT:** *This study was carried out at private farm under clay soil at Shoubra belola, Kotour, Gharbia governorate, Egypt during the two successive winter seasons of 2007-2008 and 2008-2009. The aim of this study was to evaluate the effect of humic acid, different application methods of potassium fertilizer and their combinations on the growth, yield, quality and storability of garlic (cv. Balady). Results showed 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/fed. plus foliar application of 3% $K_2O$ + 48 kg $K_2O$ /fed. as soil dressing (K4) resulted in the best results in this respect. By applying this treatment the producers can add the requirements of garlic from potassium fertilizer by an alternative method of application and cheaper potassium forms consequently, saving the quantity of potassium chemical fertilizer.*

**Keywords:** *Humic, potassium, productivity, storability, garlic (Allium sativum L.)*

## INTRODUCTION

Garlic (*Allium sativum* L.) is one of the most important vegetable for both local consumption and export. Therefore, increasing garlic yield and improving bulb quality are essential aims for both growers and consumers, but it usually depends on many factors especially that influence the plant growth throughout the growth period (El-Morsy, 2004).

Potassium nutrition is one of the major factors that affect growth, yield and quality of garlic. It play an important role in promotion of enzymes activity and enhancing the translocation of assimilates sugars, starch and protein synthesis (Marschner, 1995). Moreover, it increase root growth, improve drought resistance, builds cellulose, reduce loading, control plant turgidity (Black, 1960 and Bidwell, 1979).

Low levels of nutrients such as K is considered one of the major productions constrains of all types of soil. Furthermore, potassium forms are the third most important plant nutrient limiting plant growth and consequently bulb yield (Marschner, 1995 and Ali and Taalab, 2008).

Potassium uptake by plants from the soil solution is regulated by several factors including soil texture, moisture conditions, pH, aeration and temperature (Mengel and kirkby, 1980). Therefore, during growth and development the soil potassium supply is seldom adequate to support crucial processes such as sugar transport from leaves to bulbs, enzyme activation, protein synthesis and cell extension that ultimately determine bulb yield and quality (Williams and Kafkafi, 1998).

The K deficiency during bulb formation, bulb development and maturation can be mitigated through supplemental foliar K applications. In addition, foliar spray of potassium with the optimum dose had a significant effect on the dry weight of leaves and N % as well as K % in leaves tissues and significantly increased total yield and its quality (Howard *et. al.*, 1998; Fawzy *et. al.*, 2007 and Ghoname *et al.*, 2007).

Humic acid is particularly used for increasing the nutrient availability (Stevenson, 1994 and Abd El-Al, 2005). Moreover, humic substances (HS) can chelate most metals present in the soil, thereby increasing their availability to plants (Stevenson, 1994). Humic substances also have an effect on the growth of roots and root hairs (Pinton *et al.*, 1999). The increase of the root surface caused by humic substances promotes the uptake of elements such as potassium (K), phosphorus (P), and Fe (Marschner, 1995 and Cesco *et al.*, 2002).

There are different factors affecting production of garlic. The most important factor is fertilization, especially potassium fertilizers. However, the producers of garlic plant decreased the quantity of this fertilizer to minimize the production cost. These decrements in potassium element are negatively reflected on the yield. Therefore, it would be beneficial to use alternative methods of application and cheaper potassium forms. In addition, saving the quantity of potassium chemical fertilizer is still the main goal of several investigators.

Therefore, the aim of this study was to investigate the effect of humic acid and different application methods of potassium (soil dressing and foliar application) as well as their combinations on growth, yield, quality and storability of garlic bulbs.

## MATERIALS AND METHODS

This experiment was carried out during the two successive seasons of 2007-2008 and 2008-2009 at a private farm under clay soil at Shoubra belola, Kotour, Gharbia governorate, Egypt to study the effect of humic acid and different application methods of potassium (soil dressing and foliar application) as potassium sulphate (48 $K_2O$) as well as their combinations on growth, yield and its components as well as chemical composition, and storability of garlic plants (cv. Balady).

The chemical properties of the soil are presented in Table (1). Samples of the soil were obtained from 25 cm soil surface.

Table (1). Chemical analysis of soil before sowing according to Ryan *et al.* (1996).

| | | 1st season | 2nd season |
|---|---|---|---|
| | Soluble cations in saturation extract 1:5 (meq /L) | | |
| $Ca^{++}$ | | 6.00 | 5.91 |
| $Mg^{++}$ | | 4.99 | 5.02 |
| $Na^{+}$ | | 10.99 | 10.07 |
| $K^{+}$ | | 0.32 | 0.35 |
| | Soluble anions in saturation extract 1:5 (meq /L) | | |
| $CO_3^{--}$ | | 0.0 | 0.0 |
| $HCO_3^{-}$ | | 5.04 | 4.92 |
| $Cl^{-}$ | | 8.10 | 7.49 |
| $SO_4^{--}$ | | 10.00 | 9.35 |
| pH | | 7.10 | 7.12 |
| EC /$25^0$ C (m mohos / cm) | | 2.99 | 3.09 |
| Organic matter % | | 1.48 | 1.61 |
| Nitrogen : | Total (mg / 100g soil) | 229.8 | 241.8 |
| | Available (mg/100g soil) | 39.0 | 40.2 |
| Phosphorus : | Total (mg / 100g soil) | 32.9 | 34.9 |
| | Available (mg / 100g soil) | 6.1 | 7.9 |
| Potassium : | Total (mg / 100g soil) | 848.1 | 795.8 |
| | Available (mg / 100g soil) | 199.2 | 188.9 |

The experimental unit area was 7.74 $m^2$. It contained three rows with 4.3 m in length and 60 cm in width. Garlic cloves were selected for uniformity in shape and size. The cloves were sown on both two sides of the rows at distance of 7 cm apart. Planting date was October $15^{th}$ and $10^{th}$ in the first and the second seasons, respectively. All agricultural practices were carried out as commonly followed in the district.

## Treatments used:

The experiment included 8 treatments, which were the combinations between two levels of humic acid and four levels of potassium as follows:

The humic acid (HA) treatments were:

1- Without humic acid (control).
2- Soil application of 5 kg humic acid / fed.

The potassium (K) treatments were:

1- 96 kg $K_2O$ /fed. (Soil dressing) recommended dose as check treatment (K1).
2- 48 kg $K_2O$ /fed. (Soil dressing) + 1% $K_2O$ (Foliar application) (K2).
3- 48 kg $K_2O$ /fed. (Soil dressing) + 2% $K_2O$ (Foliar application) (K3).
4- 48 kg $K_2O$ /fed. (Soil dressing) + 3% $K_2O$ (Foliar application) (K4).

Potassium sulphate (48% $K_2O$) was also used for foliar application

Potassium was added after 75, 105 and 135 days from sowing. While humic acid was added during soil preparation.

Humic acid was obtained from Egyptian Canadian for Humates Trade & Agricultural Consultancy Co.

The experimental design was a split – plot design with three replications. The humic acid levels were in the main plots and the potassium treatments were randomly arranged in the sub plots.

## Data recorded:

The following data were recorded:

### A- Vegetative growth:

10 plants were selected randomly from each treatment at 145 days after planting for measure the following vegetative growth characters of garlic plants expressed as follows:

Plant height (cm), number of leaves per plant, leaves fresh and dry weight (g) per plant and leaf area ($cm^2$)/ plant.

Leaf area was determined using the fresh weight method. The leaves were cleaned from dust and then weighted. Certain known disks were taken from the leaves with a cork puncher and weighted. The leaf area was calculated according to the following formula:

Leaf area in $cm^2$/plant = Fresh wt. of leaves x leaves area of disks / fresh wt. of disks

### B- Yield and its components:

At harvest time (190 days after sowing), all plants of each treatment were harvested and the total yield per feddan was calculated after curing for 7 days. Also, a random sample of 10 bulbs was taken from each treatment to determine: bulb fresh weight (g), number of cloves / bulb, T.S.S (%) and bulbing ratio.

Bulbing ratio = Neck diameter (cm) / Bulb diameter (cm), Mann (1952).

### C- Chemical constituents:

The chemical constituents of garlic plants as total nitrogen, phosphorus and potassium in dry matter of leaves and bulbs were determined according to the methods described in A.O.A.C (1995).

## D- Storability:

After curing, random samples of 10 kg of garlic plants were taken from each treatment and stored at the normal room conditions (25± 2°C and 65% ± 5 RH). The percentages of total weight loss, sprouting and decay were calculated after 1, 3, 5, 7 and 9 months (the storage period was 9 months).

## Statistical analysis:

Data were analyzed by MSTATC computer software program adopted by Bricker, (1991) using ANOVA with the least significant difference (LSD) at the 0.05 probability level.

# RESULTS AND DISCUSSION

## 1- Vegetative growth:

Results in Table (2) showe that leaves fresh and dry weights were significantly increased by application of humic acid at 5 kg/fed. But leaves fresh weight increase was significantly affected only in first season. Plant height and number of leaves per plant were not affected, in both seasons. These results may be due to the role of humic acid which enhance photosynthetic process, stimulate root growth and development of chlorophyll and proliferation of desirable micro-organisms in soil (Liu *et al.* 1998 and Awad and El-Ghamry, 2007).

Leaf area/ plant, plant height, leaves fresh and dry weights/plant were significantly increased by K1 treatment (96 kg $K_2O$ /fed. as soil dressing) and K4 treatment (48 kg $K_2O$ /fed. as soil dressing plus 3% $K_2O$ as foliar application), but number of leaves/plant was insignificant, in both seasons (Table 2). There were no significant differences between K1 and K4 treatments. Generally, the increase in plant growth parameters which caused by high rate of potassium fertilization might be due to its beneficial improvement of such level on plant growth and the important role of K in plant growth, which reflected on stimulate their absorption and utilization efficiency from soil nutrient solution. These trends of results are similar with the findings of Sharma *et al.* (2003), Yadav *et al.* (2005) and Ali, El-Bassiouny (2006) and Taalab (2008).

Data tabulated in Table (2) show also that, the interactions between humic acid and potassium treatments had a promoting effect on vegetative growth characters of garlic plants. The best treatments in this concern were humic acid at 5 kg/fed. plus K1 or K4 treatments, in both seasons.

Table (2). Response of garlic vegetative growth characters to humic acid and different application methods of potassium during 2007/2008 and 2008/2009 seasons.

| Treatments | 2007/2008 season | | | | | 2008/2009 season | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Leaf area/ plant ($cm^2$) | Plant height (cm) | No. of leaves / plant | Leaves fresh wt. (g) | Leaves dry wt. (g) | Leaf area/ plant ($cm^2$) | Plant height (cm) | No. of Leaves / plant | Leaves fresh wt. (g) | Leaves dry wt. (g) |
| Humic acid (HA) | | | | | | | | | | |
| HA at 0 kg | 523.9 | 88.83 | 8.28 | 36.30 | 5.34 | 419.76 | 81.05 | 7.62 | 34.09 | 4.73 |
| HA at 5 kg/fed. | 606.2 | 89.64 | 8.39 | 38.37 | 6.18 | 503.07 | 83.55 | 7.86 | 34.96 | 5.27 |
| L.S.D. at 5% | 12.96 | N.S | N.S | 0.89 | 0.05 | 15.9 | N.S | N.S | N.S | 0.09 |
| Potassium(K) | | | | | | | | | | |
| K 1 | 606.9 | 91.94 | 8.58 | 39.03 | 5.96 | 497.7 | 85.20 | 7.97 | 35.91 | 5.19 |
| K 2 | 511.0 | 84.33 | 8.11 | 34.72 | 5.44 | 410.7 | 78.57 | 7.60 | 32.72 | 4.78 |
| K 3 | 543.9 | 88.63 | 8.09 | 36.37 | 5.67 | 450.2 | 81.42 | 7.60 | 33.74 | 4.91 |
| K 4 | 598.5 | 92.04 | 8.58 | 39.23 | 5.98 | 487.1 | 84.02 | 7.79 | 35.74 | 5.12 |
| L.S.D. at 5% | 11.97 | 1.16 | N.S | 1.15 | 0.09 | 10.70 | 1.28 | N.S | 1.01 | 0.34 |
| The interactions | | | | | | | | | | |
| HA0 x K1 | 585.3 | 91.46 | 8.46 | 37.98 | 5.48 | 473.7 | 83.99 | 7.78 | 36.33 | 4.94 |
| HA0 x K2 | 444.3 | 83.48 | 7.98 | 34.26 | 5.09 | 348.5 | 77.38 | 7.52 | 32.65 | 4.53 |
| HA0 x K3 | 489.8 | 88.58 | 8.09 | 35.59 | 5.23 | 396.8 | 79.91 | 7.50 | 32.80 | 4.61 |
| HA0 x K4 | 576.2 | 91.82 | 8.60 | 37.39 | 5.58 | 460.0 | 82.93 | 7.67 | 34.60 | 4.83 |
| HA5 x K1 | 628.5 | 92.42 | 8.70 | 40.09 | 6.44 | 521.6 | 86.40 | 8.16 | 35.48 | 5.43 |
| HA5 x K2 | 577.8 | 85.19 | 8.24 | 35.18 | 5.79 | 472.8 | 79.75 | 7.68 | 32.78 | 5.02 |
| HA5 x K3 | 598.0 | 88.69 | 8.09 | 37.14 | 6.10 | 503.6 | 82.94 | 7.70 | 34.68 | 5.21 |
| HA5 x K4 | 620.7 | 92.27 | 8.56 | 41.07 | 6.38 | 514.2 | 85.11 | 7.92 | 36.88 | 5.40 |
| L.S.D. at 5% | 16.93 | 1.64 | 0.23 | 1.63 | 0.14 | 15.13 | 1.80 | 0.14 | 1.43 | 0.48 |

## Yield and its components:

Results illustrated in Table (3) indicate that application of humic acid at 5 kg/fed. was generally more effective than control (without humic acid), and resulted in a significant increase on total bulb yield and bulb fresh weight.

On the other hand, cloves number, T.S.S and bulbing ratio were not affected affected, in both seasons. These results may suggest that humic acid (HA) is useful for regulating plant growth and improving physical and chemical of soil properties. The beneficial effects of HA on plant growth may be related to its indirect effect on increase of fertilizer efficiency or reducing soil compaction or direct effect on improvement of overall plant biomass. In particular, the increase of root growth is generally more apparent than that of the shoot (Vaughan and Malcom, 1985). Also HA have been correlated to maintenance of Fe and Zn in the soil solution at effective concentration (Clapp *et al.*, 2001), display hormone - like activity (Nardi *et al.*, 2002).

Table (3). Response of garlic bulbs yield and its component to humic acid and different application methods of potassium during 2007/2008 and 2008/2009 seasons.

| Treatments | 2007/2008 season | | | | | 2008/2009 season | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Total bulb yield (ton /fed.) | Bulb fresh wt. (g) | Cloves No. / bulb | T.S.S (%) | Bulbing ratio | Total bulb yield (ton /fed.) | Bulb fresh wt. (g) | Cloves No. / bulb | T.S.S (%) | Bulbing ratio |
| Humic acid (HA) | | | | | | | | | | |
| HA at 0 kg | 6.742 | 34.42 | 38.72 | 20.43 | 0.23 | 6.439 | 32.53 | 36.58 | 18.96 | 0.22 |
| HA at 5 kg/fed. | 6.931 | 44.45 | 40.46 | 22.30 | 0.22 | 6.642 | 41.55 | 40.06 | 22.03 | 0.23 |
| L.S.D. at 5% | 0.071 | 0.55 | N.S | N.S | N.S | 0.054 | 0.35 | N.S | N.S | N.S |
| Potassium (K) | | | | | | | | | | |
| K 1 | 7.328 | 42.08 | 41.01 | 23.39 | 0.22 | 6.962 | 39.80 | 41.02 | 21.81 | 0.22 |
| K 2 | 6.071 | 36.48 | 38.04 | 19.56 | 0.23 | 5.894 | 35.01 | 36.74 | 19.78 | 0.23 |
| K 3 | 6.653 | 38.56 | 38.70 | 20.13 | 0.22 | 6.429 | 35.86 | 36.84 | 19.87 | 0.23 |
| K 4 | 7.294 | 40.62 | 40.60 | 22.37 | 0.22 | 6.878 | 37.48 | 38.69 | 20.52 | 0.22 |
| L.S.D. at 5% | 0.063 | 1.02 | 0.78 | 0.59 | N.S | 0.085 | 0.83 | 0.55 | 0.38 | N.S |
| The interactions | | | | | | | | | | |
| HA0 x K1 | 7.228 | 36.32 | 39.99 | 22.21 | 0.22 | 6.893 | 34.64 | 39.40 | 20.64 | 0.21 |
| HA0 x K2 | 5.992 | 31.29 | 37.09 | 18.68 | 0.23 | 5.784 | 30.52 | 35.12 | 18.14 | 0.23 |
| HA0 x K3 | 6.529 | 33.56 | 37.88 | 19.61 | 0.23 | 6.299 | 31.76 | 35.29 | 18.23 | 0.23 |
| HA0 x K4 | 7.126 | 35.88 | 39.91 | 21.21 | 0.23 | 6.727 | 33.19 | 36.52 | 18.81 | 0.22 |
| HA5 x K1 | 7.428 | 47.20 | 42.02 | 24.58 | 0.22 | 7.032 | 44.96 | 42.63 | 22.97 | 0.23 |
| HA5 x K2 | 6.149 | 41.68 | 38.99 | 20.44 | 0.23 | 6.005 | 39.51 | 38.36 | 21.41 | 0.23 |
| HA5 x K3 | 6.777 | 43.56 | 39.52 | 20.64 | 0.22 | 6.559 | 39.97 | 38.39 | 21.50 | 0.22 |
| HA5 x K4 | 7.370 | 45.37 | 41.29 | 23.52 | 0.21 | 6.974 | 41.78 | 40.86 | 22.22 | 0.22 |
| L.S.D. at 5% | 0.075 | 1.44 | 1.10 | 0.84 | N.S | 0.055 | 1.17 | 0.78 | 0.54 | N.S |

From data of Table (3) it could noticed that, different application methods of potassium (soil or foliar application) had significant increase on the total yield, bulb fresh weight, number of cloves/bulb and T.S.S. On the other side, bulbing ratio was not significant affected, in both seasons. The highest values in this respect were obtained by K1 treatment (96 kg $K_2O$ /fed. as soil dressing) and K4 treatment (48 kg $K_2O$ /fed. as soil dressing + 3% $K_2O$ as foliar application), without significant differences between them. The promoting effect of potassium fertilizer on bulbs yield may be due to the role of potassium as a prevalent cation in plant and involved in maintenance of ionic balance in cells and its bounds ionically to pyruvate kinase enzyme which is essential in respiration and carbohydrate metabolism. These results could be also explained through the effect of potassium on vegetative growth promotion and increasing the mineral uptake by bulb crops (Marschner, 1995; El-Bassiony 2006; Fawzy *et. al.* 2007 and Ghoname *et al.* 2007).

The increases in bulbs yield could be attributed to the response of all tested growth characters of bulb crops previously discussed, whereas, yield can be affected by all physical processes including growth and nutrient supply. Obtained results are in agreement with those reported on bulb crops by Mohanty and Das (2002); Sharma et al. (2003), Yadav, *et al.* (2005), Abd El-Al *et al.* (2005), El-Bassiouny (2006) and Ali and Taalab, (2008).

Concerning the interactions, data presented in Table (3) reveal that the total bulb yield of garlic and its component was enhanced by the treatment of HA at 5 kg/fed combined with K1 or HA at 5 kg/fed combined with K4 which recorded 7.42, 7.03 and 7.37, 6.97 ton/fed. for the two treatments in the first and second seasons, respectively compared with application of humic acid or potassium, each alone.

## Chemical constituents:

Application of humic acid at 5 kg/fed. had significant effects on K contents of bulbs in comparison with untreated control (check plants) Table (4), but K content of leaves, N, P contents in leaves and bulbs were insignificant, in both seasons. These results may be attributed to the effect of humic acid on enhancing of root growth and hence increasing the uptake of nutrients (Liu *et al.*, 1998 and Awad and El-Ghamry, 2007).

Method of potassium application was affected the percentage N, P and K of both leaves and bulbs. The treatments of K1 (96 kg $K_2O$ /fed. as soil dressing) and K4 (48 kg $K_2O$ /fed. as soil dressing plus 3% $K_2O$ as foliar application) resulted in the highest percentages of N,P and K during the two experimental seasons (Table 4). But P content in leaves, K content of leaves and bulbs were significant, in both seasons

The percentages of N, P and K in both leaves and bulbs were significantly affected by the interactions between humic acid and potassium treatments. Garlic plants treated with humic acid at 5 kg/fed. combined with K1 treatment (96 kg $K_2O$ /fed. as soil dressing) resulted in the highest values without significant difference between it and K4 (Table 4).

**Table (4). Response of chemical contents of garlic plants to humic acid and different application methods of potassium during 2007/2008 and 2008/2009 seasons.**

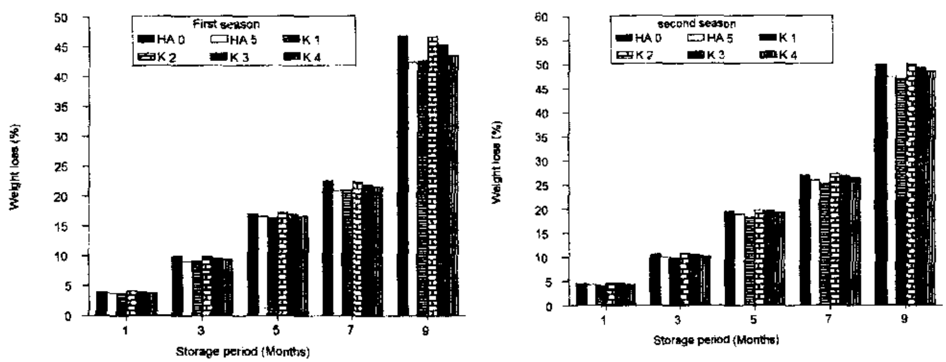
| Treatments | 2007/2008 season | | | | | | 2008/2009 season | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Leaves | | | Bulbs | | | Leaves | | | Bulbs | | |
| | N (%) | P (%) | K (%) | N (%) | P (%) | K (%) | N (%) | P (%) | K (%) | N (%) | P (%) | K (%) |
| Humic acid (HA) | | | | | | | | | | | | |
| HA at 0 kg | 1.78 | 0.79 | 1.82 | 1.36 | 0.54 | 1.57 | 1.67 | 0.79 | 1.59 | 1.29 | 0.52 | 1.45 |
| HA at 5 kg/fed. | 1.82 | 0.81 | 1.85 | 1.37 | 0.56 | 1.62 | 1.69 | 0.80 | 1.59 | 1.35 | 0.52 | 1.53 |
| L.S.D. at 5% | N.S | N.S | N.S | N.S | N.S | 0.03 | N.S | N.S | N.S | N.S | N.S | 0.03 |
| Potassium (K) | | | | | | | | | | | | |
| K 1 | 1.82 | 0.84 | 1.86 | 1.39 | 0.58 | 1.63 | 1.71 | 0.83 | 1.67 | 1.36 | 0.55 | 1.54 |
| K 2 | 1.78 | 0.76 | 1.78 | 1.35 | 0.52 | 1.54 | 1.65 | 0.76 | 1.52 | 1.32 | 0.52 | 1.43 |
| K 3 | 1.78 | 0.78 | 1.82 | 1.36 | 0.54 | 1.58 | 1.67 | 0.78 | 1.57 | 1.28 | 0.53 | 1.48 |
| K 4 | 1.81 | 0.82 | 1.87 | 1.37 | 0.56 | 1.63 | 1.68 | 0.81 | 1.62 | 1.34 | 0.55 | 1.53 |
| L.S.D. at 5% | N.S | 0.03 | 0.02 | N.S | N.S | 0.03 | N.S | 0.03 | 0.04 | N.S | N.S | 0.04 |
| The interactions | | | | | | | | | | | | |
| HA0 x K1 | 7.228 | 36.32 | 39.99 | 22.21 | 0.22 | 6.893 | 34.64 | 39.40 | 20.64 | 0.21 | 7.228 | 36.32 |
| HA0 x K2 | 5.992 | 31.29 | 37.09 | 18.68 | 0.23 | 5.784 | 30.52 | 35.12 | 18.14 | 0.23 | 5.992 | 31.29 |
| HA0 x K3 | 6.529 | 33.56 | 37.88 | 19.61 | 0.23 | 6.299 | 31.76 | 35.29 | 18.23 | 0.23 | 6.529 | 33.56 |
| HA0 x K4 | 7.126 | 35.88 | 39.91 | 21.21 | 0.23 | 6.727 | 33.19 | 36.52 | 18.81 | 0.22 | 7.126 | 35.88 |
| HA5 x K1 | 7.428 | 47.20 | 42.02 | 24.58 | 0.22 | 7.032 | 44.96 | 42.63 | 22.97 | 0.23 | 7.428 | 47.20 |
| HA5 x K2 | 6.149 | 41.68 | 38.99 | 20.44 | 0.23 | 6.005 | 39.51 | 38.36 | 21.41 | 0.23 | 6.149 | 41.68 |
| HA5 x K3 | 6.777 | 43.56 | 39.52 | 20.64 | 0.22 | 6.559 | 39.97 | 38.39 | 21.50 | 0.22 | 6.777 | 43.56 |
| HA5 x K4 | 7.370 | 45.37 | 41.29 | 23.52 | 0.21 | 6.974 | 41.78 | 40.86 | 22.22 | 0.22 | 7.370 | 45.37 |
| L.S.D. at 5% | 0.075 | 1.44 | 1.10 | 0.84 | N.S | 0.055 | 1.17 | 0.78 | 0.54 | N.S | 0.075 | 1.44 |

## Storability:

Concerning the effect of humic acid on storability of garlic bulbs, data in Figs (1, 2 & 3) show that, storability of garlic bulbs was markedly influenced by the application of humic acid. Generally plants applied with humic acid had better storability than untreated plants. i.e., reduced total weight loss, decay and sprouting percentages of garlic bulbs during storage periods compared to untreated plants, in both seasons.

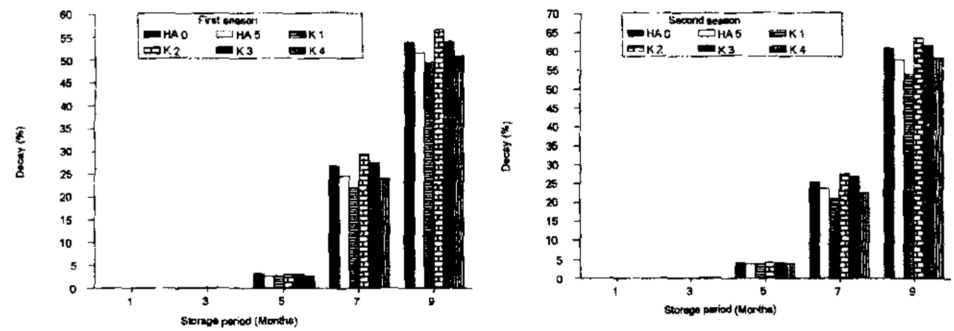
Different application methods of potassium fertilizer significantly decreased the total weight loss, decay and sprouting percentages of garlic bulbs during storage periods, in both seasons (Figs 1, 2 & 3). The lowest values in this respect were obtained by K1 and K4. Without significant differences between them.

The interactions between humic acid and potassium treatments significantly enhanced the storability and quality parameters during the two experimental seasons (Figs 4, 5 & 6). The total weight loss, decay and sprouting percentages of garlic bulbs were significantly reduced during storage periods, in both seasons. By the treatment of humic acid at 5 kg/fed. plus 96 kg $K_2O$ /fed. as soil dressing and treatment of humic acid at 5 kg/fed. plus 48 kg $K_2O$ /fed. as soil dressing with 3% $K_2O$ as foliar application gave the best results, in both seasons.



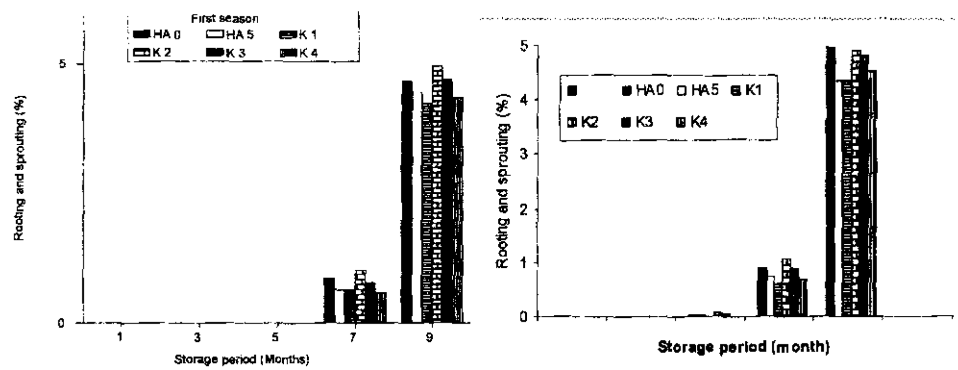

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| L.S.D at 5% | HA | 0.09 | 0.12 | 0.06 | 0.15 | 1.15 | 0.14 | 0.07 | 0.06 | 0.08 | 0.17 |
| | K | 0.04 | 0.13 | 0.05 | 0.09 | 0.69 | 0.08 | 0.04 | 0.05 | 0.06 | 0.14 |

**Fig. (1): Response of weight loss percentage of garlic bulbs to humic acid and different application methods of potassium.**



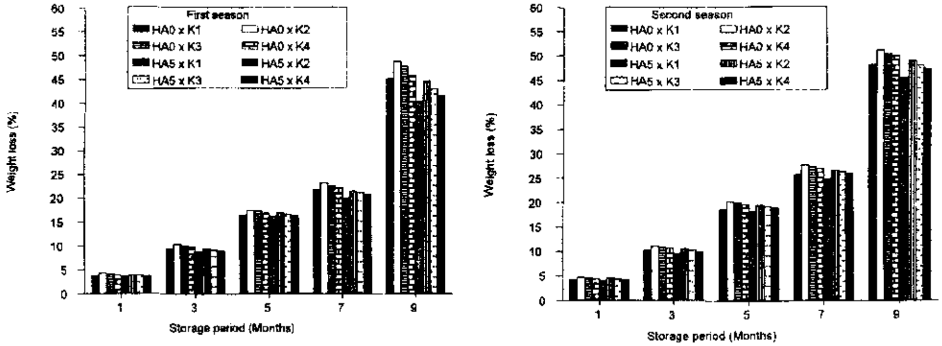

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| L.S.D | HA | - | N.S | 0.09 | N.S | N.S | - | N.S | N.S | N.S | N.S |
| at 5% | K | - | N.S | 0.41 | 1.78 | 2.16 | - | N.S | 0.1 | 2.35 | 2.99 |

**Fig. (2): Response of decay percentage of garlic bulbs to humic acid and different application methods of potassium.**



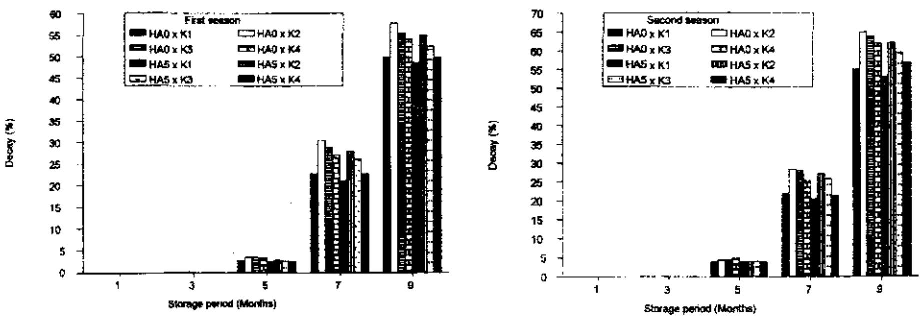

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| L.S.D | HA | - | - | - | 0.19 | 0.06 | - | - | 0.09 | 0.12 | N.S |
| at 5% | K | - | - | - | 0.08 | 0.09 | - | - | 0.05 | 0.18 | 0.13 |

**Fig. (3). Response of rooting and sprouting percentage of garlic bulbs to humic acid and different application methods of potassium.**



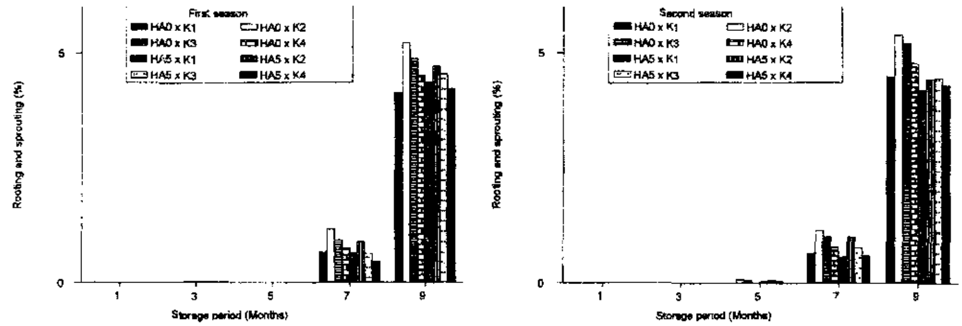

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| L.S.D at 5% | 0.05 | 0.18 | 0.07 | 0.14 | 1.0 | 0.11 | 0.1 | 0.07 | 0.09 | 0.20 |

**Fig. (4): Response of weight loss percentage of garlic bulbs to humic acid and different application methods of potassium.**




| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| L.S.D at 5% | - | 0.02 | 0.07 | 1.15 | 3.9 | - | 0.04 | 0.8 | 3.85 | 5.99 |

**Fig. (5): Response of decay percentage of garlic bulbs to humic acid and different application methods of potassium.**




| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| L.S.D at 5% | - | - | - | 0.11 | 0.14 | - | - | 0.07 | 0.25 | 0.18 |

Fig. (6): Response of rooting and sprouting percentage of garlic bulbs to humic acid and different application methods of potassium.

These results may be due to the promotion effect of HA on growth parameters which may be reflected on enhancing the quality and storability of garlic bulbs during storage (Table 3). This simulative effect may also be due to the role of potassium on enzymes promotion activity and enhancing the translocation of assimilates and protein (Ali and Taalab, 2008).

## Conclusion

From the previous results it could be concluded that the application of HA at 5 kg/fed. plus foliar application of potassium (at 3% $K_2O$ as foliar application + potassium at 48 kg $K_2O$ /fed. as soil dressing) can be recommended to inhance yield, quality and storability of garlic. By applying these treatments the producers can add the requirements of garlic from potassium fertilizer by an alternative method of application and cheaper potassium forms consequently, saving the quantity of potassium chemical fertilizer.

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# استجابة نباتات الثوم للمعاملة بحمض الهيوميك وطرق مختلفة لاضافة البوتاسيوم

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## الملخص العربى

أجريت هذه الدراسة خلال موسمى ٢٠٠٧/٢٠٠٨ و ٢٠٠٨/٢٠٠٩ بمزرعة خاصة بقرية شبرا بلوله – قطور – محافظة الغربية – مصر. بهدف دراسة تأثير استخدام طرق مختلفة لاضافة البوتاسيوم (اضافة الكمية الموصى بها اضافة ارضية (٩٦ كجم بو ٢ أ) واضافة نصف الكمية ارضيا مع رش النباتات بسلفات البوتاسيوم بتركيزات ١ و٢ و٣% بو ٢ أ) وكذلك المعاملة بحمض الهيوميك (صفر أواضافة ٥ كجم /فدان) على نمو وانتاجية والقدرة التخزينية لنباتات الثوم(الصنف البلدى). وقد وزعت المعاملات فى قطع منشقة مرة واحدة فى ثلاثة مكررات. ويمكن تلخيص النتائج المتحصل عليها فيما يلى:-

١- اضافة كمية البوتاسيوم كلها اضافة ارضية وكذلك اضافة نصف الكمية اضافة ارضية مع رش النباتات بتركيز٣% بوتاسيوم أدت الى الحصول على أعلى القيم لصفات النمو الخضرى و المحصول ومكوناتة ومحتوى الاوراق والابصال من النتروجين والفوسفور والبوتاسيوم وكذلك أعطت أقل القيم للفقد فى الوزن وتزريع وعفن الابصال أثناء التخزين.

٢- أدت اضافة حمض الهيوميك بمعدل ٥ كجم /فدان الى الحصول على اعلى قيمة للوزن الطازج والجاف للأوراق والمحصول الكلى ووزن البصلة الطازج ومحتوى الابصال من النتروجين والفوسفور البوتاسيوم وكذلك أعطت أقل نسبة فقد فى وزن وتزريع الابصال أثناء التخزين.

٣- ادت المعاملة بحمض الهيوميك بمعدل ٥ كجم /فدان مع اضافة نصف كمية البوتاسيوم اضافة ارضية ورش النباتات بالبوتاسيوم بتركيز ٣% الى الحصول على أعلى القيم لصفات النمو الخضرى و المحصول ومكوناتة ومحتوى الاوراق والابصال من النتروجين والفوسفور والبوتاسيوم وكذلك أعطت أقل نسبة فقد فى وزن وتزريع وعفن الابصال أثناء التخزين.

عموما يمكن التوصية باضافة نصف كمية السماد البوتاسى الموصى بها أرضيا مع رش النباتات بالبوتاسيوم بتركيز ٣% للحصول على نفس تأثير اضافة الكمية الموصى بها ارضيا مما يؤدى الى تقليل تكاليف التسميد البوتاسى وكدلك اضافة حمض الهيوميك بمعدل ٥ كجم / فدان تؤدى الى تحسين النمو والمحصول والقدرة التخزينية للثوم.