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# IMPACT OF APPLIED SOME POTASSIUM OREGANO- AND ACTIVATOR SOURCES ON BOTH SOIL ; PLANTS YIELD AND THEIR GROWN QUALITY IN SANDY SOIL

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**ABSTRACT:** ***A field experiment was carried out on a sandy soil at Ismailia Agricultural Research Station, Kassasin, Egypt, cultivated with sweet pepper plants (Capsicum annuum L.) during the growing winter season of 2016 and spring 2017, to study the potential benefit of applied different forms of potassium as organo-K (fulvate and humate) and activator-K (citrate and gluconate) on sweet pepper yield and some fruit quality. The applied treatments of the studied potassium were foliar and soil application, with special reference to the control treatment (an initial nutritional status). The potassium compounds were sprayed with 1 kg/400 liter fed$^{-1}$ applied among three times, after 35, 50 and 75 days from planting.***

***The data obtained reveal that sweet pepper yields and their quality showed a superior effect for foliar spray compared to soil application. The potassium humate and citrate recorded the superior increases in both macro- micro nutrient content in sweet pepper fruit and vegetative parts with more availability in soil under investigation. It is evident that the applied potassium humate achieved many of the beneficial effects on soil hydro physical and fertility status as well as plant parameters, since K-humate acted like plant growth hormones and partially capable to retain water and nutrients for growing plants due to containing humic acid, which would act as complexing agent, thus minimizing the loss of nutrients by leaching. These chelating agents, through phenolic and carboxylic active groups for micronutrients and water molecules, are considered as a storehouse with easily or available to be taken by plant roots, and this reflected positively on development of yield and its attributes for studying sweet pepper crop.***

***From aforementioned results, it can be concluded that the application of potassium either in organo or activator sources specially potassium humate under both foliar spray and soil application increased sweet pepper crop yields and their quality as well as improved the nutritional status of both plants, fruit, with relatively higher ability for increasing availability macro- micronutrients in soil under soil application than foliar one.***

***Key words:*** ***Organo-K (fulvate and humate), activator-K (citrate and, gluconate), nutritional status, sweet pepper yield, fruit quality, soil, foliar spray application and sand soil.***

## INTRODUCTION

**Sweet pepper (*Capsicum annuum* L.) is one of the most valuable vegetables grown on newly reclaimed land in Egypt. Peppers are an important source of nutrients in the human diet and an excellent source of vitamins A and C as well as phenolic compounds that are important antioxidants. Levels of these compounds can vary by genotypes and maturities as well as growing conditions (Guil-Guerreo and Martinez-Guirado, 2006). Growth, yield and nutritional value of vegetable crops are largely affected by the applied fertilizers (Feleael and Mirdad, 2014) So, it is imperative to grow the crop under the most optimum nutrient conditions thus the producer can get the highest profitable yield and also to obtain fruits rich in the nutritional**

constituents which are vital for health (McNeal *et al*., 1995).

Salinity is one of the most serious environmental problems influencing crop growth. Salinity causes not only differences between the mean yield and the potential yield, but also causes a yield reduction from year to year. It affects the plant growth directly through its interaction with metabolic rates and pathways within the plants. It is estimated that about 20% of the irrigated land in the present world are affected by salinity that is exclusively classified as arid and desert lands comprising 25% of the total land of our planet (Amjad, *et al*, 2010)

Potassium fertilization became an important factor for potassium fertilization for plant production under Egyptian soils. However, farmers minimizing the used amount of 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 ( Kazemi., 2014).

The K-humate derived from lignite brown coal is alkaline; rich in carboxylic and phenolic groups, aromatic in nature provide favorable conditions for organo logical activity, chemical reactions and physical improvement of the soil. These groups promote chemical reactions for cation exchange, increase pH buffering capacity of soils, and from other hand these active groups bind and sequester phytotoxic elements and accelerate the transport of nutrients to plants (Organondi *et al.,* 1994).

Humic acid is a promising natural resource that can be used as an alternative to synthetic fertilizers to increase crop production. It exerts either a direct effect, such as on enzymatic activities and membrane permeability, or an indirect effect, mainly by changing the soil structure. (Ferrara and Brunetti, 2010). Humic acid Application at medium levels (250 g/m$^2$) increased yield and nutrient content of spinach (Ayas and Gulser, 2005). They concluded that humic acid application caused increased nitrogen uptake which was the main reason of enhanced vegetation growth of spinach. Zaky *et al.* (2006) found that the number of shoots/plant, average leaf area, total yield, average pod fresh weight and P content were increased by application of humic acid as a foliar fertilizer at a rate of 1 g/L.

Humic acid foliar application had a positive impact on tomato fruit quality and application of humic acid in moderate concentration (2 mg$^{-1}$) had good results in most of the tomato characteristics (Shahmaleki, 2014).

Fulvic acid is rapidly being recognized as one of the key elements in many outstanding health and scientific breakthroughs of the 21$^{st}$ century. Scientists and doctors throughout the world are beginning to discover fulvic acid and are starting to recognize its extraordinary potential (Nicola, 2009). Fulvic acid chelates and binds scores of minerals into an organ-available form used by cells. These trace minerals serve as catalysts to vitamins within the cell. Additionally, fulvic acid is one of the most efficient transporters of vitamins into the cell (Williams, 1977). Fulvic acid complexes have the ability to Organo-react one with another, and also inter-react with cells to synthesize or transmute new mineral compounds. Fulvic acid stimulates and balances cells, creating optimum growth and replication conditions (Khang, 2011).

The purpose of this work was to study the potential benefit of applied different forms of potassium Organo or Activator (i.e., citrate, gluconate, fulvate, humate) on sweet pepper yield and fruit quality through a soil and foliar spray application.

## MATERIALS AND METHODS

A field experiment was carried out on a sand soil at Ismailia Agricultural Research Station, Kassasin, Egypt cultivated with sweet pepper plants (*Capsicum annuum* L.) during the growing winter season of 2016 and spring 2017, to study the potential benefit of applied different forms of potassium. Potassium as organo-K (fulvate and humate) and Activator-K (citrate and gluconate) was added as soil and foliar spray application to study the effect of these treatment on soil nutrient, sweet pepper plant yield, macro-micro nutrient status, sweet pepper fruit yield and fruit quality.

Uniform germinated seedlings were sown in a 8×8×9 $cm^3$ plastic plate containing moist-autoclaved vermiculite soil and left to grow in a greenhouse under controlled conditions. Three weeks later, plants were transplanted into plots with an area of 10.5 m2 (3x3.5 m) for sweet pepper plants.in a randomized complete block design, three plots for each treatment and each plot had ten plants having inter row and inter plant spacing that were 70 and 40 cm, respectively. The applied treatments of the studied potassium were foliar and soil application, with special reference to the control treatment (an initial nutritional status). The potassium compounds were sprayed with 400 liter $fed^{-1}$ at two period, after 35, 50 and 75 days from planting. Ammonium sulfate was added to all treatments to overcome a total applied dose of 240 kg $ha^{-1}$. Potassium was added as different forms at a rate of 115 kg $K_2O$ $ha^{-1}$. Superphosphate was added at the equivalent to 96 kg $P_2O_5$ $ha^{-1}$.

Some soil properties in the initial state were determined according to Piper (1950) and Jackson *et al.* (1973), as shown in Table (1). At harvest stage, soil samples were taken from all the studied treatments at a depth of 0-30 cm for determining macro and micronutrients. Soil pH was determined in 1:2.5 soil, water suspensions according to the standard method described by Richards (1954). Total soluble salt (EC) was measured in soil paste extract described by Jackson *et al.* (1973). Nitrogen was determined by the Kjeldahl method according to AOAC (2005). Phosphorus was determined colorimetrically and potassium was determined using Flame-photometer, according to Jackson *et al.* (1973). Available micronutrients were extracted by DTPA and determined using Atomic Absorption Spectrophotometer according to. Lindsay and Norvell (1978).

The first ripened fruit was taken after 73 days of transplanting, and the followed ones were obtained every week. All fruit was picked, weighted to calculate the yield. At this stage the plant parts were determined as fresh and dry weights. The selected youngest fully expanded leaves were taken from each plot for determining nutrient contents (N, P, K, Fe, Mn and Zn) according to Van Schouwenberg (1968). Also sweet pepper fruits were subjected to the different analysis to estimate (*i.e.,* firmness using fruit pressure tester with a probe diameter of 0.8 cm and values expressed in kg $cm^{-1}$, Total acidity in fruits for each treatment was determined according to the method of Wills and Ku (2002). Total soluble sugars in fruit extracts were determined according to Yem and Willis (1954). Fruit carotenoids were extracted from the fruit pericarp by acetone (85%) and determined Spectro-photometrically according to Lichtenthaler and Weliburn (1983). The ion contents ($K^+$ and $Na^+$) were assayed using an atomic absorption spectrophotometer according to AOAC (2005). Pigment content as total chlorophyll and carotenoid content were determined according to Lichtenthaler (1987).

**Table 1: Some physical and chemical characteristics of the studied soil**

| Soil characteristics | Value | Soil characteristics | Value |
|---|---|---|---|
| *Particle size distribution%:* | | *Soluble cations (soil paste $mmole_cL^{-1}$):* | |
| Sand | 87.25 | $Ca^{2+}$ | 8.20 |
| Silt | 8.90 | $Mg^{2+}$ | 5.21 |
| Clay | 3.85 | $Na^{+}$ | 18.5 |
| Textural class | *Sandy* | $K^{+}$ | 0.14 |
| *Soil chemical properties:* | | *Soluble anions (soil paste $mmole_cL^{-1}$):* | |
| pH (soil paste extract) | 8.19 | $CO_3^{2-}$ | 0.00 |
| $CaCO_3$ % | 1.33 | $HCO_3^-$ | 6.40 |
| Organic carbon % | 0.21 | $Cl^-$ | 19.11 |
| ECe (dS/m, soil paste extract) | 3.25 | $SO_4^{2-}$ | 6.44 |
| *Soil physical properties:* | | | |
| Bulk density g $cm^{-3}$ | 1.68 | Soil moisture at wilting point % | 3.98 |
| Soil moisture at field capacity % | 9.09 | Avail. Water % | 5.11 |

| Available Nutrients mg $kg^{-1}$ | | | | | | |
|---|---|---|---|---|---|---|
| N | P | K | S | Fe | Mn | Zn |
| 7.54 | 3.22 | 33.41 | 0.99 | 3.08 | 0.50 | 0.23 |

The Total Soluble Solids (TSS) value expressed in °Brix and titrable acidity was determined according to Ranganna (1986). The data were statistically analyzed using one-way analysis of variance test by the least significant difference (LSD, at 0.05) according to the method described by Gomez and Gomez (1984) using Costat software (Cohort, Berkeley, CA).

## RESULTS AND DISCUSSIONS

### *I) Effect of different sources of potassium and application method on soil and plants nutrient contents*

#### *a) Soil fertility status as expressed by nutrient availability*:

Data illustrated in Table (2) revealed that K-humate containing basically humic acid when added as organo treatment was enhancing the availability of essential soil nutrients (N, P, K, Fe, Mn and Zn) content. This is true, since humic acid partially capable to retain nutrients for growing plants, where it would act as complexion agents (Mackowiak *et al*., 2001). Enhanced plant growth following addition of humic substances has sometimes been related to increased micronutrient availability especially iron and zinc. There are also numerous reports of metal concentration being reduced to non-toxic levels following addition of complexion humic substances. Soil pH and organic matter content significantly affect the solubility of Fe, Mn, Zn and Cu (Kazemi, 2014). Humic acid can incorporate iron into chelate, maintaining its availability to plants, although still in insoluble form (Ramasamy *et al.,* 2006).

Therefore, these chelating agents, through active groups for micronutrients,

**are considered as a storehouse with easily mobile or available for uptake by plant roots, and in turn reflected positively on development of yield and its attributes for both studied crops.**

**In general, the beneficial effects of the method of application on the studied different potassium sources under sweet pepper plants crop could be arranged for all soil nutrients (macro- or micro) in the following order: K-humatet > K- citrate > K-fulvaite >K-gluconate > control.**

**Again, it may be worth to suggest the K-humate and fulvate sources were a stable, non-toxic, water-soluble product which contains all major and minor plant nutrients, and all trace elements. Because of the chelating properties possessed by the starches, sugars and carbohydrates, the trace elements do not settle out, even in alkaline soils, but remain available to plants which need them.**

**Table 2: Effect of different sources of potassium and application method of macro- and micro nutrients contents in soil under sweet pepper plants plant grown**

| Potassium sources (S) | N | | | P | | | K | | |
|---|---|---|---|---|---|---|---|---|---|
| | Method of application | | | | | | | | |
| | Organo-potassium | | | | | | | | |
| | Soil | Foliar | Mean | Soil | Fowler | Mean | Soil | Foliar | Mean |
| Organo-potassium | | | | | | | | | |
| Control | 21.65 | 23.00 | 22.32 | 6.69 | 4.84 | 5.77 | 235.3 | 232.9 | 234.1 |
| Humate | 40.94 | 36.09 | 38.51 | 11.36 | 8.65 | 10.00 | 386.7 | 384.3 | 385.5 |
| Fulvate | 36.77 | 35.69 | 36.23 | 10.87 | 7.64 | 9.26 | 369.5 | 358.1 | 363.8 |
| Mean | 33.12 | 31. 59 | 32.36 | 9.64 | 7.04 | 8.34 | 330.5 | 325.1 | 327.8 |
| Activator-potassium | | | | | | | | | |
| Citrate | 40.38 | 33.67 | 37.07 | 8.79 | 8.49 | 8.64 | 379.9 | 374.8 | 377.3 |
| Gluconate | 31.36 | 30.87 | 31.11 | 7.58 | 7.21 | 7.39 | 358.7 | 348.7 | 353.7 |
| Mean | 31.79 | 32.27 | 34.09 | 7.35 | 7.18 | 7.26 | 324.9 | 318.4 | 321.7 |
| G- mean | 34.22 | 31.86 | 33.43 | 8.50 | 7.11 | 7.8 | 327.7 | 321.8 | 324.8 |
| LSD at 0.05 | T | S | S×T | T | S | S×T | T | S | S×T |
| | 2.82 | 2.31 | 2.10 | 0.32 | 0.54 | 0.31 | 21.41 | 20.65 | 22.1 |
| | Fe | | | Mn | | | Zn | | |
| Method of applications | | | | | | | | | |
| Organo-potassium | | | | | | | | | |
| Control | 4.15 | 3.70 | 3.92 | 1.20 | 1.02 | 1.11 | 1.02 | 0.62 | 0.82 |
| Humate | 7.07 | 3.80 | 5.65 | 1.60 | 1.25 | 1.42 | 1.35 | 0.95 | 1.15 |
| Fulvate | 6.95 | 3.76 | 5.35 | 1.50 | 1.20 | 1.35 | 1.25 | 0.90 | 1.07 |
| Mean | 6.05 | 3.75 | 4.97 | 1.43 | 1.15 | 1.29 | 1.20 | 0.83 | 1.01 |
| Activator-potassium | | | | | | | | | |
| Citrate | 7.00 | 3.78 | 5.39 | 1.55 | 1.23 | 1.39 | 1.30 | 0.91 | 1.10 |
| Gluconate | 5.18 | 3.75 | 4.46 | 1.25 | 1.07 | 1.16 | 1.10 | 0.64 | 0.87 |
| Mean | 5.44 | 3.74 | 4.59 | 1.33 | 1.10 | 1.22 | 1.14 | 0.72 | 0.93 |
| G- mean | 5.75 | 3.75 | 4.78 | 1.38 | 1.13 | 1.26 | 1.18 | 0.77 | 0.98 |
| LSD at 0.05 | T | S | S×T | T | S | S×T | T | S | S×T |
| | 0.21 | 0.17 | 0.15 | 0.026 | 0.021 | 0.022 | 0.018 | 0.011 | 0.020 |

***b) Nutritional status of sweet pepper plants*:**

**Irrespective of Organo- and Activator-potassium, data of N, P and K as macronutrients and ( Fe, Mn and Zn) as micronutrients content of sweet pepper plants at vegetative growth stage, which are presented in Table (3), exhibited pronounced increases for at studied macronutrients and micronutrients as a result of applied Organo- and Activator-potassium treatments as compared to the control treatment. The element's content by sweet pepper plants are more related to the released available nutrients and their easy mobility towards the plant roots. Such surpassed effect of the applied treatments, especially at K-humate and citrate ones, is more associated with ameliorated soil pH due to the added as form humate or citrate as well as to the relatively high contents released active organic substances that enhancing more released nutrients or their solubilization from both native and added sources, besides the favorable Organological conditions that are keeping them in available forms for extended period and their mobility for uptake by plant roots.**

**Table 3: Effect of different sources of potassium and application method of macro- and micro nutrients content of sweet pepper plants.**

| Potassium sources (S) | N | | | P | | | K | | |
|---|---|---|---|---|---|---|---|---|---|
| | Method of applications(T) | | | | | | | | |
| | Organo-potassium | | | | | | | | |
| | Soil | Foliar | Mean | Soil | Foliar | Mean | Soil | Foliar | Mean |
| Control | 2.00 | 2.15 | 2.08 | 0.241 | 0.199 | 0.22 | 1.854 | 1.900 | 1.877 |
| Humate | 4.32 | 5.21 | 4.77 | 0.512 | 0.587 | 0.559 | 3.711 | 4.994 | 4.352 |
| Fulvate | 3.50 | 4.12 | 3.81 | 0.441 | 0.458 | 0.449 | 3.011 | 3.845 | 3.428 |
| Mean | 3.27 | 3.82 | 3.55 | 0.398 | 0.414 | 0.452 | 2.858 | 3.579 | 3.219 |
| | Activator-potassium | | | | | | | | |
| Citrate | 4.54 | 5.01 | 4.78 | 0.506 | 0.511 | 0.553 | 3.541 | 4.000 | 3.770 |
| Gluconate | 3.00 | 4.23 | 3.62 | 0.354 | 0.400 | 0.377 | 3.011 | 3.224 | 3.117 |
| Mean | 3.18 | 3.79 | 3.49 | 0.367 | 0.370 | 0.383 | 2.802 | 3.041 | 2.921 |
| G-mean | 3.23 | 3.81 | 3.52 | 0.383 | 0.393 | 0.395 | 2.83 | 3.32 | 3.07 |
| LSD at 0.05 | T | S | S×T | T | S | S×T | T | S | S×T |
| | 0.13 | 0.18 | 0.16 | 0.050 | 0.054 | 0.057 | 0.12 | 0.54 | 0.58 |

| | Fe | | | Mn | | | Zn | | |
|---|---|---|---|---|---|---|---|---|---|
| | Method of applications(T) | | | | | | | | |
| | Organo-potassium | | | | | | | | |
| Control | 50.22 | 52.30 | 51.26 | 25.34 | 26.13 | 25.73 | 45.66 | 50.40 | 48.00 |
| Humate | 442.7 | 522.10 | 482.40 | 55.36 | 60.02 | 57.69 | 115.3 | 123.5 | 119.4 |
| Fulvate | 354.2 | 422.30 | 388.25 | 44.17 | 47.66 | 45.91 | 100.8 | 111.9 | 106.3 |
| Mean | 282.3 | 332.20 | 307.30 | 41.62 | 44.60 | 43.11 | 87.25 | 95.27 | 91.25 |
| | Activator-potassium | | | | | | | | |
| Citrate | 401.2 | 500.9 | 451.0 | 45.68 | 50.23 | 47.95 | 110.6 | 118.7 | 114.7 |
| Gluconate | 258.7 | 298.4 | 278.5 | 30.12 | 33.54 | 31.83 | 99.6 | 100.4 | 100.2 |
| Mean | 236.7 | 283.2 | 260.2 | 33.71 | 36.63 | 35.17 | 85.2 | 89.8 | 87.5 |
| G-mean | 259.5 | 308.1 | 283.8 | 37.77 | 40.62 | 39.14 | 86.2 | 92.5 | 89.4 |
| LSD at 0.05 | T | S | S×T | T | S | S×T | T | S | S×T |
| | 23.9 | 24.6 | 23.6 | 2.3 | 2.9 | 2.7 | 3.5 | 3.6 | 3.1 |

So, the potassium source exhibited a superior effect due to improving soil physic-chemical properties that positively affect the nutrient availability as well as maintaining a suitable soil moisture regime, which showed a pronounced positive effect on the Organological activity in soil. Also, such favorable effect extends to reduce soil pH, mainly due to the integrated action of the released active organic acids, besides the possible released phosphate ions by sulfate ions (El-Tapey and Hassan, 2002).

As shown in Table (3). It is noteworthy to mention that the nutrient contents in plant tissues were, in general, extending parallel close to the corresponding available nutrient contents in the studied soil, Also, such favorable effect may attributed to the reduction in soil pH one value which improved the solubility and availability of nutrients for plant roots which was positively reflected on the nutrient contents in plant tissues (Rady, 2011).

Regard to the method of potassium application data also indicated that the foliar application was the beast method than soil ones a significantly effect in macro- and or micronutrient contents in sweet pepper plants at the vegetative growth stage. This may be due to foliar spray is the ideal method of application of nutrients for intensive and profitable cultivation of the sweet pepper crop (Bidari and Hebsur, 2011).

### *c) Macro- and micro nutrients contents in sweet pepper fruit*:

Data in Table (4) showed that the contents of macro- and micronutrients (N, P, K, Fe, Mn and Zn) in sweet pepper fruit increased progressively as a result of applied potassium sources, with significant differences between soil application and foliar spray. Nutrient contents in sweet pepper fruit varied widely according to the applied treatments, where obtained values of increases followed an order of : K-humatet > K- citrate > K-fulvaite >K-gluconate > control under all nutrients content under study. These results are also affected by the influenced of soil and plant characteristics in plants and dry matter contents. Humic acids are especially beneficial in freeing up nutrients in the soil so that they are made available to the plant as needed. For instance, if an aluminium component is bound to phosphorus, humic acids detach them making the phosphorus available for the plant. Humic acids are also especially important because of their ability to chelate micronutrients, thus increasing their organo-availability (Khaled and Hassan, 2011).

It is worthy to mention that the positive effect of soil application and as K-humate together, may be due to these organic soil amendments enhanced crop production and fertilizer uptake by plants through its improvement of hydrophysical properties and thus increased soil's ability to supply plants with their requirements of water and air along the growing season. On the other hand, K-fulvate (K-fulvate is a fulvic acid salt) acts as a soil-conditioning agent. It combines with metal radicals in the soil, forming polymers of greatly increased molecular weight. Khang (2011) noticed that fulvic acid chelates and binds scores of minerals into an organo-available form used by cells. These trace minerals serve as catalysts to vitamins within the cell. Additionally, fulvic acid is one of the most efficient transporters of vitamins into the cell. Fulvic acid complexes have the ability to organo-react one with another, and also inter-react with cells to synthesize or transmute new mineral compounds.

**Table 4: Effect of different sources of potassium and application method on macro- and micro nutrient content of sweet pepper fruit**

| Potassium sources (S) | N | | | P | | | K | | |
|---|---|---|---|---|---|---|---|---|---|
| | Method of applications (T) | | | | | | | | |
| | Oregano-potassium | | | | | | | | |
| | Soil | Foliar | Mean | Soil | Foliar | Mean | Soil | Foliar | Mean |
| Control | 1.13 | 1.20 | 1.16 | 0.89 | 0.91 | 0.90 | 2.531 | 2.497 | 2.514 |
| Humate | 2.26 | 2.46 | 2.36 | 1.50 | 1.74 | 1.62 | 3.111 | 3.314 | 3.212 |
| Fulvate | 2.01 | 2.16 | 2.09 | 1.09 | 1.21 | 1.15 | 2.919 | 3.048 | 2.983 |
| Mean | 1.80 | 1.94 | 1.87 | 1.16 | 1.28 | 1.22 | 2.853 | 2.953 | 2.903 |
| Activator-potassium | | | | | | | | | |
| Citrate | 2.039 | 2.245 | 2.142 | 1.15 | 1.65 | 1.40 | 2.954 | 3.145 | 3.049 |
| Gluconate | 1.934 | 2.033 | 1.983 | 1.00 | 1.13 | 1.06 | 2.697 | 2.755 | 2.726 |
| Mean | 1.702 | 1.826 | 1.764 | 1.01 | 1.23 | 1.12 | 2.727 | 2.799 | 2.763 |
| G-Mean | 1.75 | 1.88 | 1.82 | 1.09 | 1.26 | 1.17 | 2.79 | 2.88 | 2.83 |
| LSD at 0.05 | T | S | S×T | T | S | S×T | T | S | S×T |
| | 0.016 | 0.023 | 0.021 | 0.41 | 0.052 | 0.046 | 0.46 | 0.050 | 0.048 |
| | Fe | | | Mn | | | Zn | | |
| | Method of applications (T) | | | | | | | | |
| | Organo-potassium | | | | | | | | |
| Control | 45.9 | 55.0 | 50.4 | 52.1 | 50.3 | 50.2 | 23.2 | 23.4 | 23.3 |
| Humate | 78.6 | 89.2 | 83.9 | 66.8 | 75.6 | 71.2 | 38.4 | 49.3 | 43.8 |
| Fulvate | 67.6 | 71.3 | 69.4 | 64.3 | 70.9 | 67.6 | 35.7 | 45.8 | 40.7 |
| Mean | 64.0 | 71.8 | 67.9 | 61.0 | 65.6 | 63.3 | 32.4 | 39.5 | 35.9 |
| Activator-potassium | | | | | | | | | |
| Citrate | 69.8 | 75.7 | 72.7 | 65.1 | 72.6 | 68.8 | 37.4 | 46.7 | 42.0 |
| Gluconate | 65.3 | 66.8 | 66.0 | 60.8 | 68.9 | 64.8 | 32.1 | 34.4 | 33.2 |
| Mean | 60.3 | 65.8 | 63.0 | 59.3 | 63.9 | 61.6 | 30.9 | 34.8 | 32.8 |
| G-Mean | 62.15 | 68.8 | 65.5 | 60.2 | 64.8 | 62.5 | 31.7 | 37.11 | 34.7 |
| LSD at 0.05 | T | S | TxS | T | S | TxS | T | S | TxS |
| | 3.5 | 3.8 | 3.4 | 2.9 | 3.6 | 3.4 | 2.3 | 2.8 | 2.4 |

## *II) Effect of both methods of application and different sources of potassium on sweet pepper plants:*

### *a) Vegetative parameters of sweet pepper plants:*

Data in Table (5) indicated that the vegetative parameters of sweet pepper plants as plant height and dry matter content increased as a result of all the tested treatments under both foliar spray and soil application, with significant differences among them.

As for the influence of both foliar spray and soil application of potassium, data in Table (5) showed that plant height

**and dry matter content as a result of applied potassium sources with superior effect to foliar spray method than soil application. Moreover, K-humate was found in similar effect with that of K-citrate source. Accordingly, the positive effect of potassium sources under both methods of application could be arranged as shown in a descending order of K-humatet > K- citrate > K-fulvaite >K-gluconate > control. It may be due to reasons that potassium has increased the foliage and indirectly increased the photosynthesis and thus ultimately enhanced the plant height of sweet pepper (Majumdar *et al.,* 2000). Humic acid can directly cause the positive effects on plant growth. Shoot and root growth is stimulated by humic acid, but its effect is more prominent on the roots. Farnia and Ezatollah (2015) proposed that humic acid increased root content and caused the root system effectiveness that lead to the higher plant growth and plant height. Samavat and Simin (2014) observed that the use of humic and fulvic acid in nutrient solution or spraying it increased the shoot growth in many plants this results may be due to fulvic acid has smaller molecules and more acidic groups than humic acids.**

### *b) Sweet pepper fruit yield:*

**Data in Table (6) showed that there was a positive increase in sweet pepper fruit yield with significant differences between sources of organo- and activator potassium application. The positive effects of applied treatments could be arranged in the following descending order: K-humatet > K- citrate > K-fulvaite >K-gluconate > control. It may be concluded that applying bio-potassium fertilizers as k-humate improved photosynthates assimilation, their translocation from leaves to root and increased enzyme activation (Guil-Guerrero and Martinez-Guirado 2006). Matersk *et al.* (2003) found that the application of humic acid can increase the absorption of some nutrients such as nitrogen, potassium, calcium, magnesium and phosphorus by plants and increased their yield.**

**As for the influence of both soil and foliar applications on sweet pepper plants fruit yield the different applied potassium sources, data in Table (6) showed that fruit yield increased as a result of applied potassium with significant differences between the test two methods of application.**

**Table 5: Effect of different sources of potassium and application method on some plant growth characteristics of sweet pepper plants**

| Potassium sources (S) | Plant characteristics | | | | | |
|---|---|---|---|---|---|---|
| | Plant height (cm) | | | Dry matter (%) | | |
| | Method of applications(T) | | | | | |
| | Organo-potassium | | | | | |
| | Soil | Foliar | Mean | Soil | Foliar | Mean |
| Control | 62.1 | 62.0 | 62.1 | 3.54 | 3.55 | 3.54 |
| Humate | 92.6 | 102.6 | 97.6 | 5.12 | 6.54 | 5.83 |
| Fulvate | 84.3 | 98.7 | 91.5 | 5.00 | 5.55 | 5.27 |
| Mean | 79.6 | 87.7 | 83.7 | 4.55 | 5.21 | 4.88 |
| Activator-potassium | | | | | | |
| Citrate | 88.7 | 99.10 | 93.30 | 4.68 | 6.01 | 5.34 |
| Gluconate | 76.3 | 85.60 | 80.90 | 4.33 | 5.16 | 4.74 |
| Mean | 75.7 | 82.20 | 78.90 | 4.18 | 4.90 | 4.54 |
| G-mean | 77.70 | 84.90 | 81.30 | 4.37 | 5.06 | 4.71 |
| LSD at 0.05 | T | S | TxS | T | S | TxS |
| | 4.5 | 4.9 | 4.7 | 0.30 | 0.43 | 0.39 |

**Table 6: Effect of different sources of potassium and application method on some fruit characteristics of sweet pepper plants**

| Potassium sources (S) | Fruit characteristics | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Fruit yield kg $ha^{-1}$ | | | Fruit firmness kg $cm^{-2}$ | | | Total soluble sugars mg/g dwt | | | TSS ºBrix | | |
| | Method of applications(T) | | | | | | | | | | | |
| | Soil | Foliar | Mean | Soil | Foliar | Mean | Soil | Foliar | Mean | Soil | Foliar | Mean |
| **Organo-potassium** | | | | | | | | | | | | |
| Control | 21.3 | 22.4 | 21.8 | 6.33 | 6.23 | 6.28 | 40.36 | 41.00 | 40.68 | 3.7 | 3.7 | 3.7 |
| Humate | 69.1 | 88.9 | 79.0 | 7.98 | 8.98 | 8.48 | 67.23 | 77.69 | 72.46 | 4.9 | 6.5 | 5.7 |
| Fulvate | 65.4 | 75.4 | 70.4 | 6.99 | 7.22 | 7.10 | 59.36 | 62.34 | 60.85 | 4.2 | 5.0 | 4.6 |
| Mean | 51.9 | 62.2 | 57.0 | 7.1 | 7.47 | 7.28 | 55.65 | 60.34 | 57.99 | 4.2 | 5.0 | 4.6 |
| **Activator-potassium** | | | | | | | | | | | | |
| Citrate | 68.6 | 85.4 | 77.0 | 7.01 | 8.56 | 7.78 | 62.98 | 65.78 | 64.38 | 4.6 | 5.7 | 5.1 |
| Gluconate | 64.8 | 70.6 | 67.7 | 6.98 | 6.84 | 6.91 | 55.98 | 59.58 | 57.78 | 4.0 | 4.8 | 4.4 |
| Mean | 51.6 | 59.6 | 55.5 | 6.77 | 7.21 | 6.99 | 53.10 | 55.45 | 54.28 | 4.1 | 4.7 | 4.4 |
| G-mean | 51.8 | 60.9 | 56.3 | 6.9 | 7.3 | 7.14 | 54.37 | 57.89 | 56.57 | 4.2 | 4.9 | 4.9 |
| LSD at 0.05 | T | S | TxS | T | S | TxS | T | S | TxS | T | S | TxS |
| | 2.2 | 2.8 | 2.3 | 0.9 | 0.51 | 0.6 | 2.61 | 2.91 | 2.88 | 0.5 | 0.9 | 0.3 |

Guertal (2000) reported that K-humate sprays increased fruit yield and reproductive growth of tomato. Farnia and Ezatollah (2015) noticed that to achieve to highest fruit yield in sweet pepper the humic acid as soil or foliar application could be before anthesis stage. Fagbenro and Agboola (1993) reported that soil humic acid applications increased the plant nutrient uptake. Likewise, humic acid has been shown to beneficial effects on nutrient uptake by plants, was particularly important for the transport and availability of micronutrients (Cox and Nelson, 1984). Thus, humic acid affect plant growth and caused to increase of sweet pepper yield and fruit quality (Yıldırım, 2007).

### *C) Sweet pepper fruit quality:*

Sweet pepper fruit quality can be controlled by different parameters, *i.e.*, titratable acidity, fruit firmness, total soluble sugars, TSS, carotenoid and total chlorophyll contents Tables (6 and 7) which showed markedly increases as a result of applied potassium organo- and activator as compared to the control treatments. Data indicated also that the potassium humate was the superior treatment for increasing all quality parameters of sweet pepper fruit at both tested methods, with significant differences among them. Furthermore, data in Table (6 and 7) pointed out the effect of the used potassium sources of increasing quality of sweet pepper fruit could be arranged into: K-humatet > K-citrate > K-fulvaite >K-gluconate > control.

These results can be explained on the basis as Ghoname *et al.* (2009) who noticed the increase in sweet pepper fruit weight by foliar application of K was significant that enhanced the concentration of K content under field conditions ring the reproductive phase of crop development. Additional foliar K applications during fruit development and maturation improves fruit marketable and human health quality by increasing sugar content, ascorbic acid, beta-carotene, and K levels (Lester *et al.,* 2007). An improvement of fruit quality due to appropriate K nutrition might be due to improved photosynthates assimilation, their translocation from leaves to fruit and increased enzyme activation (Guil-Guerrero and Martinez-Guirado, 2006). Fruit quality is directly affected by potassium supply (Lester *et al.,* 2005). If soil applied fertilizer K was compared to foliar K applications, the second approach consistently resulted in improved number of fruits and quality attributes, i.e. lycopene contents and ascorbic acid content (Jifon and Lester, 2009).

### *III) Effect of different sources of potassium and application method on sodium contents in sweet pepper fruit and the ratio with potassium:*

The results of the sodium contents in sweet pepper fruit and the ratio with potassium, as shown in Table (8), showed the potassium sources became more severe the Na+ content increased significantly and therefore the $K^+/Na^+$ ratio decrease. As the most potassium sources under experiment the $K^+/Na^+$ ratio a less than 1 in the K-humate and citric acid. Factors affecting the uptake and distribution of $Na^+$ within the plants can have a predominant role in the response to potassium (Munns, 2002 and Zhu, 2003). Significant entry of $Na^+$ resulted in a severe growth reduction or death of sensitive or glycophytic species (Noushin *et al.,* 2014).

In this study, the $Na^+$ content was significantly decreased about one folds less than in the control plants. This decrease caused greatly increase in the $K^+/Na^+$ ratio. As the plant, $Na^+$ and $K^+$ are competing ions. $K^+$ plays an important role in all kinds of cellular processes, so that metabolic processes that depend on the presence of $K^+$ become inhibited.

Table 7: Effect of different sources of potassium and application method on some contents of sweet pepper fresh fruits

| Potassium sources (S) | contents of sweet pepper fresh fruits | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Titratable acidity mg $l^{-1}$ | | | Carotinoid (µg/g fresh wt.) | | | *Total Chll. contents (µg $g^{-1}$ fresh fruits) | | |
| | Method of applications(T) | | | | | | | | |
| | Organo-potassium | | | | | | | | |
| | Soil | Foliar | Mean | Soil | Foliar | Mean | Soil | Foliar | Mean |
| Control | 1324 | 1333 | 1328 | 154 | 152 | 153 | 1603 | 1608 | 1605 |
| Humate | 2215 | 3845 | 3030 | 220 | 332 | 276 | 2509 | 3150 | 2829 |
| Fulvate | 2154 | 3012 | 2583 | 216 | 311 | 263 | 2340 | 2896 | 2618 |
| Mean | 1897 | 2730 | 2313 | 196 | 265 | 230 | 2150 | 2551 | 2350 |
| Activator-potassium | | | | | | | | | |
| Citrate | 2199 | 3128 | 2663 | 275 | 310 | 292 | 2506 | 3144 | 2825 |
| Gluconate | 2018 | 2134 | 2076 | 197 | 221 | 209 | 2241 | 2641 | 2441 |
| Mean | 1832 | 2159 | 2022 | 208 | 227 | 218 | 2116 | 2464 | 2290 |
| G-mean | 2108 | 2680 | 2171 | 203 | 246 | 228 | 2151 | 2507 | 2321 |
| LSD at 0.05 | T | S | TxS | T | S | TxS | T | S | TxS |
| | 66 | 75 | 60 | 10 | 16 | 12 | 55 | 70 | 67 |

*Total Chll. = Total Chlorophyll

**Table 8: Effect of different sources of potassium and application method on sodium contents in sweet pepper fruit and the ratio with potassium**

| Potassium sources | Contents of sweet pepper fresh fruit | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | $Na^+$ | | | $K^+$ | | | $K^+/Na^+$ ratio | | |
| | Method of applications | | | | | | | | |
| | Organo-potassium | | | | | | | | |
| | Soil | Foliar | Mean | Soil | Foliar | Mean | Soil | Foliar | Mean |
| Control | 3.113 | 3.109 | 3.111 | 2.531 | 2.497 | 2.514 | 1.197 | 1.183 | 1.190 |
| Humate | 2.207 | 2.267 | 2.237 | 3.111 | 3.314 | 3.212 | 1.409 | 1.461 | 1.435 |
| Fulvate | 2.191 | 2.256 | 2.223 | 2.919 | 3.048 | 2.983 | 1.332 | 1.351 | 1.341 |
| Mean | 2.504 | 2.544 | 2.524 | 2.853 | 2.953 | 2.903 | 1.313 | 1.331 | 1.322 |
| Activator-potassium | | | | | | | | | |
| Citrate | 2.223 | 2.239 | 2.231 | 2.954 | 3.145 | 3.049 | 1.328 | 1.404 | 1.366 |
| Gluconate | 2.216 | 2.220 | 2.218 | 2.697 | 2.755 | 2.726 | 1.217 | 1.241 | 1.229 |
| Mean | 2.517 | 2.523 | 2.520 | 2.727 | 2.799 | 2.763 | 1.247 | 1.276 | 1.262 |

*Na as non-nutritive

The capacity of plants to maintain a high cytosolic $K^+/Na^+$ ratio is likely to be one of the key determinants of the ability of plants to tolerate. In plants, a $K^+/Na^+$ ratio of around 1 is thought to represent a minimum value below which $K^+$ deficiency sets in this agree with Maathuis and Amtmann (1999) who noticed that a $K^+/Na^+$ ratio of around 1 provides a minimum value.

## CONCLUSION

Applied potassium at different sources and methods of application to sweet pepper crop indicates significant positive association with quality attributes. Obviously, K- humate and citrate application of an appropriate K can contribute to good nutritional status and higher yield with better quality of sweet pepper fruits. Among potassium methods, foliar spray of K maximally improved performance of sweet pepper plants of all sources under study. This study also indicates that growers can adopt this simple management tool for improving quality and yield of tomato in the world.

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# تأثير أضافة بعض المصادر العضوية و المحفزات البوتاسية علي التربة و انتاجية وجودة المحصول النامى فى الاراضى الرملية

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**الملخص العربي**

**أجريت تجربة حقلية في محطة بحوث الاسماعيلية بمركز البحوث الزراعية- القصاصين- مصر وذلك علي أرض ذات قوام رملية خلال الموسم الشتوي ٢٠١٦ و الربيعي ٢٠١٧ والمنزرعة بنباتات الفلفل الحلو (Capsicum annuum L.) وتهدف هذه الدراسة إلي تحديد مدي الأستفادة المباشرة وذلك من خلال أضافة بعض صور البوتاسيوم العضوية**

منها سترات البوتاسيوم و جلوكونات البوتاسيوم أو الحيوية كهيومات البوتاسيوم وفولفات البوتاسيوم والمضاف أما على الارض أو في صورة رش علي الأوراق وذلك علي بعض قياسات النمو الخضري من طول النباتات و المحتوي من الماده الجافة و المحصول وجودة المحصول من محتوه من نسبة سكريات و المادة الصلبة و حموضة العصير و نسبة المحتوي الكلي من الكلوروفيل و الكروتينويد ، في محصول الفلفل الحلو ، المحتوي من المغذيات الممتصة من النيتروجين و الفوسفور و البوتاسيوم و الحديد و المنجنيز والزنك في كل من المادة الجافة و ثمار الفلفل الحلو مع تيسر تلك العناصر في التربة. وكان معدل الأضافة الرش الورقي لجميع صور البوتاسيوم المضافة رشا علي الأوراق بمعدل ١,٠ كجم/ ٤٠٠ لتر/فدان وتم الرش علي ثلاثة دفعات بعد ٣٥ و ٥٠ و ٧٥ يوم من الزراعة أما المضاف أرضا فقد تم الخلط جيدا مع الطبقة السطحية للتربة حتي عمق ٥ سم من السطح وتمت الأضافة طبقا للموصي بة من قبل وزارة الزراعة المصرية لمحصول الفلفل الحلو.

**وقد أظهرا النتائج المتحصل عليها أن:**

اضافة البوتاسيوم في صورة هيومات البوتاسيوم و السترات كان لهما التاثير الأيجابي علي حالة نباتات الفلفل الحلو النامية تحت ظروف تاك التجربة, ولقد سجلت اقل استفادة في حالة الاضافة أرضا عن الرش الورقي

ومن الجدير بالملاحظة، أن أستخدام تلك الصور من البوتاسيوم وخاصة هيومات البوتاسيوم قد حقق كثير من الثأثيرات المفيدة، و التي ربما ترجع إلي أن بما تحوية من حمض الهيوميك يعمل كهرمون منشط لنمو النبات، أو رفع قدرة التربة علي الأحتفاظ بالرطوبة الأرضية و المغذيات للنباتات النامية نتيجة انها كمواد خالبة محتوية علي حمض الهيوميك و تكون معقدات تحد من الفقد بالغسيل، ومثل هذه المواد الخالبة للماء و المغذيات من خلال مجموعات الكربوكسيل و الفينول النشطة المعتبرة كمخزون للمغذيات أكثر حركة و صلاحية وتيسرا للأمتصاص بواسطة جذور النبات مما ينعكس إيجابيا علي زيادة إنتاجية محصول الفلفل الحلو وجودة في تلك التربة تحت الدراسة.

<u>أسماء السادة المحكمين</u>

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