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Effect of potassium fulvate and organic nitrogen rates on growth, yield and nutritional status of onion plants grown in sandy soil

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Abstract---Two field experiments were conducted during 2020 and 2021 growing seasons at the National Research Centre Experimental farm at El-Nubaria, El-Behira Governorate. The aim of the research was to study the effect of potassium fulvate and organic nitrogen on the growth, yield and nutritional status of onion plants grown in sandy soil. The factorial experiment was consisting of 12 treatments with four replicates. The experiment was arranged in split plot design. Four levels of K-fulvate (10% K₂O) (0, 25, 50 and 75 kg/fed.) were occupied at the main plots and the three concentrations of organic nitrogen (15 % N) (0, 1, 2 cm/L) were randomly allocated in the sub plots. The results indicated to increase in spraying the concentrations of organic nitrogen from 0 to 2 cm/L with the addition of different rates of potassium fulvate, the growth and yield parameters of onion plants increased significantly and morally during the two successive growing seasons. The best experimental treatments were which gave the highest yield and quality of onion bulbs when spraying the highest concentration of organic nitrogen (2 cm/L) with the highest addition of potassium fulvate (75 kg fed⁻¹), during the two successive growing seasons. Onion bulb content of nutrients (nitrogen, phosphorous, potassium) was greatly improved as a result of spraying organic nitrogen (especially the higher concentration of it) with an increase in the rate of potassium fulvate addition. We can point out the importance of organic nitrogen as one of the sources of organic nitrogen fertilization, which can be used to improve the quality and quantity of the onion yield, and this effective positive effect was clearly shown with the addition of potassium in an organic form, which is fulvate salts.

Keywords---onion plants, organic nitrogen, potassium fulvate, growth, yield, nutrients content, sandy soil.

Introduction

Onion (*Allium cepa* L.) is one of the most important crops grown in Egypt, attributed to its high values for local consumption and a big exportation commodity. The area harvested was about 63.723 hectares, while the national production was about 2304210 tons (FAO, 2018). Onion is a source of ascorbic acid and dietary fiber too. It also possesses a high content of flavanoids and sulphur compounds, both of which have a high level of antioxidant activity (Griffiths *et al.*, 2002). Our information of nitrogen nutrition in plants is still developing. Most plants can use a wide range of N sources: from inorganic N to amino acids, peptides, and also proteins. The future challenge is to find agricultural species that have a good ability to use proteins and then to establish a fertilization strategy (Näsholm *et al.*, 2009). This could limit the use of inorganic nitrogen fertilizers, which may be ecologically and economically problematic (Weigelt *et al.*, 2003). Use of proteins by plants could be of great importance in developing sustainable agriculture based on fertilization with organic nitrogen. For a long time it was assumed that inorganic nitrogen (in the form of NH_4^+ and NO_3^-) was the only source of N for plants. Some authors, during the 20th century, tried to broaden this view to include use of organic nitrogen (Rentsch *et al.*, 2007).

Egyptian soils are suffering from a shortage of nutrients, such as sandy soils. So the application of potassium fulvate can improve soil properties and led to increase their fertility through increasing the amounts of potassium in the soil, which boosts plant performance. Potassium is a crucial nutrient that could increase plant dry matter and enhance crop productivity (Liu *et al.*, 2019). Potassium fulvate is a necessary natural material that can be used to enhance the physio-biochemical properties of soils, its performance and the productivity of plants (Taha *et al.*, 2020). The objective of this study is to evaluate the response of onion plant grown in sandy soil to organic nitrogen and potassium fulvate rates on growth, yield parameters and nutrients content of onion plants.

Materials and Methods

Two field experiments were conducted during 2019/2020 and 2020/2021 growing seasons under newly reclaimed sandy soil conditions at the National Research Centre Experimental farm at El-Nubaria, El-Behira Governorate, North of Egypt. Soil sample was taken and analyzed before planting at two seasons according to standard procedures reported by Chapman and Pratt (1978) to be presented in (Table, 1)

Table 1
Some physical and chemical properties of the soil used

| Soil properties | | Values | |
|--|-------------------------------|--------------|---------------|
| | | First season | Second season |
| Particle size distribution (%) | Sand | 93.32 | 94.0 |
| | Silt | 4.68 | 3.56 |
| | Clay | 2.00 | 2.44 |
| | Texture | Sandy soil | Sandy soil |
| CaCO ₃ (%) | | 2.21 | 2.24 |
| pH _(1:2.5 soil suspension) | | 7.80 | 7.70 |
| EC (dS m ⁻¹) | | 1.74 | 1.80 |
| Soluble cations (mmol L ⁻¹) | Ca ⁺⁺ | 7.02 | 7.96 |
| | Mg ⁺⁺ | 2.88 | 3.16 |
| | Na ⁺ | 4.55 | 5.20 |
| | K ⁺ | 2.95 | 1.68 |
| Soluble anions (mmol L ⁻¹) | CO ₃ ⁻ | - | - |
| | HCO ₃ ⁻ | 1.52 | 1.52 |
| | Cl ⁻ | 7.30 | 7.82 |
| | SO ₄ ⁻ | 8.58 | 8.66 |
| Available nutrients (mg kg ⁻¹) | N | 24.2 | 26.5 |
| | P | 2.05 | 2.00 |
| | K | 68.6 | 59.5 |

This paper aimed to study the effect of K-fulvate and organic nitrogen on growth, yield and quality of onion plants grown in sandy soil. Four rates of K-fulvate (0, 25, 50 and 75 kg/fed.) were added as soil drench. Organic nitrogen (Organic nitrogen comes from the digestion of plant protein, according to Virtanen and Linkola, 1946). Concentrations were applied as a foliar spraying at rates of 0, 1 and 2 cm/L, three times per season (25, 50 and 75 days after seedling date). Onion seedlings cv. Giza 20 was transplanted at the 18th of November in the two seasons. Seedlings were planted on drip irrigated laterals that were 1 m apart and 25 m long with 25 cm between drippers (standard 4 L/h discharge at 1.5 bar drippers). Four seedlings were planted around each dripper with 10 cm apart.

Experimental design

The factorial experiment was consisting of 12 treatments with four replicates. The experiment was arranged in split plot design. Four levels of K-fulvat (10% K₂O) (0, 25, 50 and 75 kg/fed.) were occupied at the main plots and the three concentrations of organic nitrogen (15 % N) (0, 1, 2 cm/L) were randomly allocated in the sub plots. As for fertilization, 30 m³ compost per feddan plus 75 units per feddan of calcium superphosphate (15% P₂O₅) at were added during the soil preparation. Nitrogen fertilizer was added in the form of ammonium sulfate (20.6 % N) at 150 units/ fed. Potassium sulfate (48 % K₂O) was applied at a rate of 96 units per feddan at two times. The first dose (48 units) was added during preparation the soil for planting and the second dose (48 units) at the beginning

of the formation of the bulbs. Cultural practices, disease and pest control management were followed according to the recommendations of the Egyptian Ministry of Agriculture. Figures 1 and 2 showed to average temperatures and humidity per week in Nubaria region during two seasons.

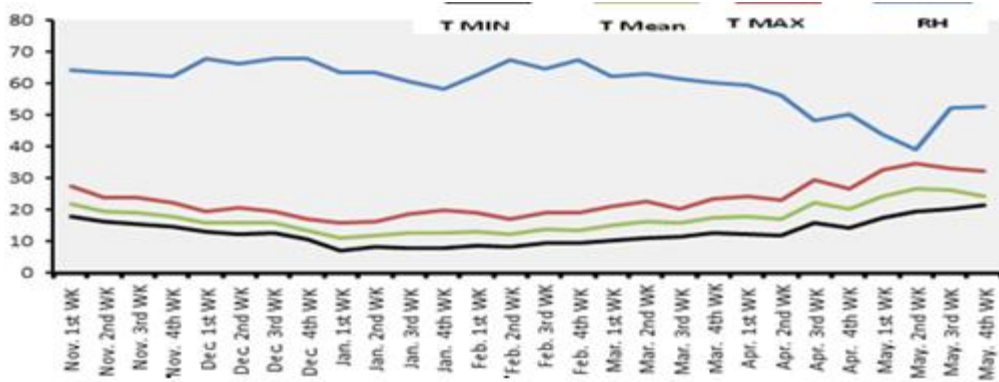


Fig (1): Average temperatures and humidity per week in Nubaria region during 2019/2020 season.

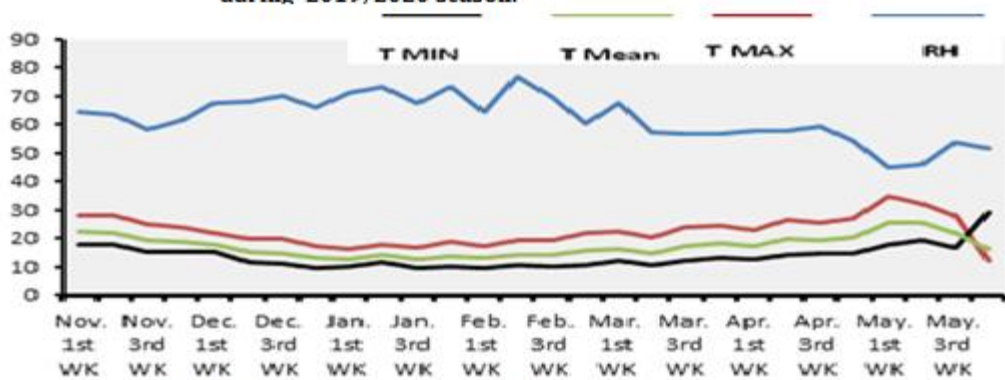


Fig (2): Average temperatures and humidity per week in Nubaria region during 2020/2021 season.

Studied characteristics

A random sample of 5 onion plants were taken from each experimental plot at 120 days after transplanting date and transferred to the laboratory to determine the following parameters:

- Plant length (cm).
- Number of leaves per plant.
- Plant dry weight (g/plant).

At harvesting time (when bulbs reach the variety normal bulb size and skin color which is about 150 days), onions were lifted by hand. Immediately after lifting, onions were subjected to field curing on the ground under shaded area for 10 days. After curing period bulbs were sorted and the following variables were measured:

- Average bulb weight (g)
- Dry matter percentage (D.M. %): Bulb tissue was oven dried at 70°C for 72 hours and weighed then attributed to the initial fresh weight.
- Bulb diameter (cm).
- Bulb length (cm).
- After harvesting and bulb curing the following variables were also measured:
- Total yield (ton fed⁻¹).

Onion fruit samples were taken from each experimental plot to determine fruit quality parameters, *i.e.*, total soluble solids (TSS) using hand held Brix meter, and ascorbic acid as described by A.O.A.C. (1990). Onion fruit samples dried at 70 °C and wet digested (Van Schouwenberg, 1968) for the determination of N, P and K (A.O.A.C., 1990). Data of the experiment was statistically analyzed using Mstatic (M.S.) software. The comparison among means of the different treatments was determined as illustrated by Snedecor and Cochran (1982).

Results and Discussion

Through the results obtained in Table (2), the significant effect is evident as a result of adding different rates of potassium fulvate with spraying various concentrations of organic nitrogen on growth of onion plants grown in sandy soil, with the comparison in the treatment that neither of them was added. Where it was found that increasing the addition of potassium fulvate to sandy soil from zero to 75 kg per feddan was increased the growth parameters of onion plants, but by a small amount, in the absence of spraying concentrations of organic nitrogen. However, with the increase in spraying the concentrations of organic nitrogen from 0 to 2 cm/L with the addition of different rates of potassium fulvate, the growth parameters of onion plants increased significantly and morally during the two successive growing seasons.

Table 2
Effect of K-fulvate and organic nitrogen rates on growth of onion plants at two seasons

| Treatment | | First season | | | | Second season | |
|----------------------|--------------------|-------------------|----------------------|----------------------|-------------------|----------------------|----------------------|
| Organic -N (cm/L) | K-fulvate (kg/fed) | Plant height (cm) | No. of leaves/plants | Dry weight/plant (g) | Plant height (cm) | No. of leaves/plants | Dry weight/plant (g) |
| 0 | 0 | 51.44 | 6.33 | 33.10 | 54.84 | 6.00 | 30.32 |
| | 25 | 53.40 | 7.22 | 35.61 | 58.90 | 7.22 | 31.10 |
| | 50 | 56.00 | 7.33 | 36.66 | 60.12 | 7.40 | 32.33 |
| | 75 | 59.00 | 8.00 | 38.45 | 62.32 | 8.33 | 33.55 |
| 1 | 0 | 54.82 | 8.00 | 38.60 | 57.95 | 8.33 | 36.52 |
| | 25 | 59.33 | 8.67 | 39.11 | 63.33 | 8.92 | 37.56 |
| | 50 | 64.70 | 9.01 | 40.11 | 67.80 | 9.00 | 38.91 |
| | 75 | 68.78 | 9.11 | 44.56 | 71.87 | 9.42 | 41.41 |
| 2 | 0 | 60.52 | 8.70 | 44.60 | 65.31 | 9.11 | 43.35 |
| | 25 | 65.67 | 8.90 | 47.52 | 70.65 | 9.33 | 45.62 |
| | 50 | 72.33 | 9.32 | 47.60 | 75.31 | 9.62 | 47.56 |
| | 75 | 81.31 | 9.50 | 48.65 | 80.25 | 9.85 | 48.99 |
| L.SD _{0.05} | | 3.50 | 0.71 | 1.40 | 3.52 | 0.78 | 1.35 |

Nitrogen being a master food for all plants is a primary constituent of protein (build from amino acids that involves in catalization of chemical responses and transportation of electrons) and chlorophyll present in many great portions of the plant body. Nitrogen plays a most important role in various physiological processes (Bloom, 2015). Foliar spray of nitrogen is a successful method which increases the accessibility of nitrogen to crop. Foliar spray of nitrogen is also very beneficial to get more growth of plants (Veesar *et al.*, 2017). The addition of potassium fulvate to the soil plays an effective role in improving the soil properties, whether physical or chemical, as the continuous addition of fulvic acids greatly improved the soil pH, which led to a decrease in its value, improving the formation of soil aggregates and increasing the soil content of organic carbon (Mayhew, 2004). Fulvic acid also influences the growth of soil microbial biomass and microbial activity. fulvic acids are the active ingredients and provides carbon and energy to microorganisms. Fulvic acids have COOH and OH groups and phenolic groups, which have ability to improve soil structure and fertility (Canellas *et al.*, 2008). All of which affects the effect of indirectly to further improve the growth of plants in general.

The improvement of the characteristics of the onion bulb in terms of length, diameter and dry weight, as well as a significant increase in the total yield of onion grown in the sandy soil, as a result of the use of potassium fulvate and foliar application of organic nitrogen (as shown in Table 3), during the two successive growing seasons. Where it was found that by increasing the spraying of organic nitrogen from 0 to 2 cmL⁻¹, the crop characteristics of onion plants increased significantly, both quantitatively and qualitatively, as a result of the increase in the addition of potassium fulvate from 0 to 75 kg fed⁻¹ to the sandy soil. The best experimental treatments were which gave the highest yield and quality of onion bulbs when spraying the highest concentration of organic nitrogen (2 cmL⁻¹) with the highest addition of potassium fulvate (75 kg fed⁻¹), during the two successive growing seasons.

Foliar application of N is discovered significant for maximizing of crop yield by enhancement of plant growth and development. Nitrogen is a main macronutrient that is taken by the plants in comparatively large quantities and this nutrient is usually deficient in most soils such as sandy soil. So foliar spray of N is the best method of fertilizer application to control their losses from the soil and make it more and easily available to the plant and in turn increase the yield and quality of plants (Hasina *et al.*, 2011).

Table 3
Effect of K-fulvate and organic nitrogen rates on yield of onion plants at two seasons

| Treatment | | First season | | | | Second season | | | |
|-----------------------|--------------------------------|---------------|-------------|-----------------|-----------------------|---------------|-------------|-----------------|-----------------------|
| Organic -N (cm/L) | K-fulvate kg fed ⁻¹ | Bulb diameter | Bulb length | Bulb dry weight | Total yield | Bulb diameter | Bulb length | Bulb dry weight | Total yield |
| | | cm | | g | ton fed ⁻¹ | cm | | g | ton fed ⁻¹ |
| 0 | 0 | 3.60 | 4.11 | 7.92 | 9.45 | 3.70 | 4.29 | 8.00 | 9.41 |
| | 25 | 3.82 | 4.23 | 8.18 | 9.66 | 3.95 | 4.34 | 8.48 | 9.77 |
| | 50 | 4.00 | 4.57 | 8.52 | 10.2 | 4.06 | 4.67 | 8.72 | 10.8 |
| | 75 | 4.10 | 4.67 | 8.68 | 10.9 | 4.18 | 4.78 | 8.88 | 11.0 |
| 1 | 0 | 4.11 | 4.82 | 8.70 | 10.1 | 4.26 | 4.91 | 8.90 | 10.6 |
| | 25 | 4.31 | 5.22 | 9.11 | 11.0 | 4.43 | 5.32 | 9.41 | 11.4 |
| | 50 | 4.55 | 5.76 | 9.33 | 11.8 | 4.66 | 5.85 | 9.53 | 11.9 |
| | 75 | 4.91 | 5.89 | 9.56 | 12.0 | 5.00 | 5.90 | 9.76 | 12.0 |
| 2 | 0 | 5.00 | 5.89 | 9.56 | 11.2 | 5.10 | 6.02 | 9.88 | 11.3 |
| | 25 | 5.21 | 6.12 | 10.2 | 11.4 | 5.31 | 6.22 | 10.4 | 11.6 |
| | 50 | 5.65 | 6.23 | 10.5 | 12.1 | 5.71 | 6.43 | 10.9 | 12.2 |
| | 75 | 5.80 | 6.31 | 10.9 | 12.5 | 5.88 | 6.50 | 11.2 | 12.6 |
| L.S.D _{0.05} | | 0.13 | 0.16 | 0.23 | 0.21 | 0.10 | 0.14 | 0.22 | 0.28 |

Potassium fulvate as an organic fertilizer, is a non-toxic mineral chelating additive and water binder that maximizes uptake through leaves and stimulates plant productivity (Malan, 2015). The effective effect of increasing the rates of soil addition of potassium fulvate and spraying concentration of organic nitrogen continued on the quality of onion fruits in terms of containing ascorbic acid and protein, as well as total soluble solids as shown in Table (4). The results showed that with an increase in the rates of potassium fulvate addition from zero to 75 kg per feddan, accompanied by an increase in the concentration of organic nitrogen spraying from zero to 2 cm/L, this led to a significant increase in the total soluble solids, protein and ascorbic acid content of onion bulbs during the two successive growing seasons. It was found that the addition of a high dose of potassium fulvate (75 kg fed⁻¹) with a higher concentration of organic nitrogen (2 cmL⁻¹) spraying is the best experimental treatment that can be applied to the onion yield to obtain an improvement in the quality of the bulbs obtained during the two successive growing seasons.

Table 4
Effect of K-fulvate and organic nitrogen rates on yield quality of onion plants at two seasons

| Treatment | | First season | | | Second season | | |
|----------------------|--------------------------------|----------------------------|---------------------------------|---------------------|----------------------------|--------------------------------|---------------------|
| Organic -N (cm/L) | K-Fulvate kg fed ⁻¹ | Total soluble solids (TSS) | ascorbic acid (mg./100 g. F.W.) | Protein content (%) | Total soluble solids (TSS) | ascorbic acid (mg./100 g.F.W.) | Protein content (%) |
| 0 | 0 | 9.90 | 3.88 | 6.69 | 9.88 | 3.90 | 6.50 |
| | 25 | 10.2 | 3.92 | 6.81 | 10.4 | 3.98 | 6.75 |
| | 50 | 10.5 | 4.11 | 6.88 | 10.7 | 4.23 | 6.94 |
| | 75 | 10.9 | 4.23 | 7.00 | 10.9 | 4.29 | 7.13 |
| 1 | 0 | 11.2 | 4.12 | 7.81 | 11.0 | 4.22 | 8.13 |
| | 25 | 11.8 | 4.62 | 8.13 | 11.6 | 4.71 | 8.25 |
| | 50 | 11.9 | 4.85 | 8.69 | 11.8 | 4.95 | 8.63 |
| | 75 | 12.1 | 5.11 | 9.00 | 12.0 | 5.08 | 8.88 |
| 2 | 0 | 12.0 | 4.90 | 8.88 | 12.2 | 5.11 | 9.25 |
| | 25 | 12.7 | 5.03 | 9.63 | 12.8 | 5.42 | 9.88 |
| | 50 | 12.9 | 5.88 | 10.06 | 13.0 | 6.00 | 10.13 |
| | 75 | 13.5 | 6.00 | 10.31 | 13.4 | 6.11 | 10.38 |
| L.SD _{0.05} | | 1.12 | 0.86 | 0.95 | 1.11 | 0.88 | 0.96 |

Increasing potassium absorption by potassium fulvate may affect the metabolism of N and carbohydrates and the synthesis of lipid, starch and protein as reported by (Moradi *et al.*, 2017). Aminifard *et al.*, (2012) were reported that fulvic acid enhanced multiple parameters of fruit quality, including total soluble solids, antioxidant activity, total phenolics, carbohydrates, capsaicin, and carotenoids of pepper. shafeek *et al.*, (2016) notify that foliar spraying by elevation levels of organic nitrogen (2%) significantly increased the most plant growth parameters, total yield and its ingredient as well as the seeds contents of the percentage of protein. The results showed in (Table, 5) the improved and good effect in increasing the content of the onion fruits of nutrients (nitrogen, phosphorous and potassium) during the two growing seasons as a result of increasing the addition of either potassium fulvate or organic nitrogen. The encouraging role of organic nitrogen spraying with the addition of potassium in the form of fulvic acid salts appears on improving the concentration of nitrogen, phosphorous and potassium inside the onion bulbs compared to the absence of both of them together. The effect is evident when high application rates and higher spraying concentration are added to each of potassium fulvate and organic nitrogen, respectively.

Table 5
Effect of K-fulvate and organic nitrogen rates on N, P and K content of onion bulbs at two seasons

| Treatment | | First season | | | Second season | | |
|-------------------------|---------------------------------------|--------------|------|------|---------------|------|------|
| Organic -N (cm/L) | K- Fulvate kg fed ⁻¹ | N | P | K | N | P | K |
| | | % | | | % | | |
| 0 | 0 | 1.07 | 0.51 | 0.84 | 1.04 | 0.52 | 0.88 |
| | 25 | 1.09 | 0.52 | 0.90 | 1.08 | 0.54 | 0.92 |
| | 50 | 1.10 | 0.54 | 1.01 | 1.11 | 0.56 | 1.09 |
| | 75 | 1.12 | 0.57 | 1.11 | 1.14 | 0.57 | 1.21 |
| 1 | 0 | 1.25 | 0.52 | 0.88 | 1.30 | 0.53 | 0.92 |
| | 25 | 1.30 | 0.57 | 0.98 | 1.32 | 0.58 | 1.01 |
| | 50 | 1.39 | 0.58 | 1.12 | 1.38 | 0.59 | 1.25 |
| | 75 | 1.44 | 0.61 | 1.14 | 1.42 | 0.60 | 1.28 |
| 2 | 0 | 1.42 | 0.60 | 0.91 | 1.48 | 0.61 | 1.11 |
| | 25 | 1.54 | 0.65 | 1.23 | 1.58 | 0.67 | 1.32 |
| | 50 | 1.61 | 0.66 | 1.28 | 1.62 | 0.68 | 1.36 |
| | 75 | 1.65 | 0.68 | 1.31 | 1.66 | 0.69 | 1.38 |
| L.SD _{0.05} | | 0.12 | 0.02 | 0.08 | 0.13 | 0.02 | 0.06 |

Potassium fulvate attracts water molecules, helping the soil to remain moist and aiding the movement of nutrients into plant roots. Potassium fulvate easily binds or chelates minerals, as it can deliver these elements to plant directly (Canellas *et al.*, 2015). Yazdani *et al.*, (2014), whom found higher nutrient uptake and accumulation of N, P, K, Ca, Fe and Zn in both leaves and fruits of gerbera by fulvic acid. shafeek *et al.*, (2016) notify that foliar spraying by elevated levels of organic nitrogen (2%) significantly increased the most plant growth parameters, total yield and its ingredient as well as the seeds contents of the, percentage of N, protein, P and K. Gutiérrez, *et al.*, (2013) recorded that the total N, P, K, Ca, Mg, and S content of leaves were increased with increasing N fertilizer rates.

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