J. Soil Sci. and Agric. Engineering, Mansoura Univ., Vol.1 (10): 985-997, 2010

ROLE OF HUMIC SUBSTANCES, SEAWEEDS AND MINERAL FERTILIZERS IN IMPROVEMENT OF CUCUMBER PRODUCTION

El-Hadidi, E. M.; A. A. Taha and M. A. Soliman
Soil Science Department, Faculty of Agriculture, Mansoura University, Mansoura.

ABSTRACT

A field experiment was conducted to evaluate the effect of humic and fulvic acids as well as seaweeds in combination with different rates of mineral fertilizers (NPK) on production of cucumber plants. Humic and fulvic acids were added at two rates i.e. 16 and 12 L fed^{-1}, while dry seaweed was added at rates of 3 and 2 kg fed^{-1}. Untreated control was included. Mineral fertilizers (NPK) were added at 100%, 75% and 50% of the recommended rates required for cucumber plants. Different combinations between organic additives and mineral fertilizers were undertaken. Data show that sole application of organic acids and mineral fertilizers has an effective role on enhancement of cucumber fruits. Since there was a little bit significant difference between the different mineral fertilizers doses we can recommend, from the economical view point, the use of medium dose (75%) in combination with any of the used organic additives as an appropriate treatment that gave remarkable yield of cucumber fruits. N uptake by fruits was enhanced by either individual or combined treatments. This phenomenon was pronounced at high rate of mineral fertilizers and organic additives. Application of mineral fertilizers at rate of 75% in combination with each of the organic additives could be selected, from the economical view, as the most appropriate treatment that induced higher P uptake by cucumber fruits. Sole application of humic acid or seaweeds resulted in highly significant increase in K uptake by cucumber fruits as compared to the untreated treatment. This was more pronounced at high rate of organic addition. Combination between each of the organic substances and medium rate of mineral fertilizers could be selected as suitable strategy for potassium nutrition of cucumber. In addition, this strategy is economically profitable for farmers.

Keywords: Cucumber fertilization, Fulvic acid, Humic acid, Mineral fertilizers, Seaweeds

INTRODUCTION

Excessive application of chemical fertilizers may affect soil health and sustainable productivity. Addition of organic manure, which can supplement nutrient requirement of crops to some extent, releases nutrient in gradual and controlled way allowing greater production of vegetables with minor environmental impact. It is imperative to search for possible alternate organic source that can sustain soil health and crop production. Humic acid from lignite is the most concentrated form of organic material and it is a ready source for carbon and nitrogen. Humic acid improves the physical, chemical and biological properties of the soil and influences plant growth (Adani *et al*., 1998).

It has long been recognized that humic substances have many beneficial effects on soil and plant growth. These heterogeneous and complex molecules, ubiquitous in the environment, can produce various morphological, physiological and biochemical effects on higher plants (Olfati *et al*., 2010). Humic substances (HS) are natural organic polyelectrolytes present in the soil humus and stabilized soil organic matter (Chen *et al*., 2004b). These molecules have ecological importance, as they intervene in the regulation of a large number of chemical and biological processes that occur in natural ecosystems (Chen *et al*., 2004b). However, although these functional actions of HS are directly influenced by their chemical configuration in solution, the relationships between HS structure and biological activity are not clear (Piccolo, 2002; Garcia-Mina, 2007; Baigorri *et al.*, 2007a; b). Thus, the same humic system can present different functional properties depending on its molecular configuration in solution (molecular aggregation, molecular conformation) (Garcia-Mina, 2007).

Among the different functional actions of HS, their ability to improve plant growth has been well established in diverse plant species and growth conditions (Chen and Aviad, 1990; Chen *et al*., 2004b). However, the mechanism responsible for this HS biological action is poorly understood. Whereas some authors propose that HS promote plant growth by improving the soil bioavailability of certain nutrients, principally iron and zinc (Chen et al., 2004a;b), others suggest that HS can also directly affect plant metabolism (Nardi *et al.,* 2002). However, it is possible that the two mechanisms are interconnected. In fact, a number of studies have reported the signal effect of some nutrients controls plant development by affecting hormone metabolism (Rubio *et al*., 2009). Likewise, the role of specific plant hormones in root nutrient uptake and further translocation and assimilation is very well documented (Rubio *et al*., 2009). Among the effects of HS described in different plant species are their abilities to both activate the root PM-ATPase activity and increase nitrate uptake rates in roots (Pinton *et al*., 1999; Nardi *et al.*, 2002; Quaggiotti *et al*., 2004). On the other hand, a number of studies have shown that nitrate can act as a type of pseudo-hormonal signal, promoting shoot growth under different conditions (Sakakibara, 2006; Sakakibara *et al*., 2006; Rubio *et al*., 2009; Garnica *et al*., 2009). These studies have reported that these effects of nitrate were linked to significant changes in the root-to-shoot distribution of certain active cytokinins (CKs) (Sakakibara, 2006), polyamines (PAs) (Garnica *et al*., 2009) and abscisic acid (ABA) (Brewitz *et al*., 1995). It is therefore possible that the HS shoot promoting effect is related to a primary effect inducing changes in the root-to-shoot distribution of nitrate through the enhancement of root PMH^+-ATPase activity. This HA effect could cause, in turn, concomitant changes in the root-to-shoot distribution of certain CKs, Pas and ABA affecting plant growth.

The results obtained by Mora et al., (2010) supported the hypothesis that the shoot growth promoting effect of HA in cucumber plants is associated with a primary action on NO_3^- root-to-shoot distribution. This effect on NO_3^- causes significant changes in root-to-shoot distribution of several active CKs, and PAs, which promote shoot growth. The changes in CK plant distribution would also be associated with the induction of the root-to-shoot translocation of mineral nutrients. The effect on NO_3^- root–shoot distribution is most likely linked to the activation of root PMH^+-ATPase activity caused by HA.

Results derived by Selim *et al*., (2009) showed that increasing humic substances application rates up to 120 kg ha^{-1} enhanced potato tubers yield quantity, starch content and total soluble solids. The increase of humic substances application rates was associated with the decrease of nutrients leaching, which was reflected on increasing macro- and micronutrients concentration in potato tubers, as well as increasing concentration of these nutrients in soil after tubers harvesting.

In a glass greenhouse in 2008 in the Agricultural Faculty of Guilan University, Rasht, Iran, results after Olfati *et al*., (2010), showed that humic acid did not affect fruit; root and leaf dry matter of cucumber. Humic acid significantly affected yield attributes. Plant yield was higher when plants were treated with complete nutrient solution. Humic acid have significant effect on nutritional elements uptake by cucumber and as a result they can decrease element content in nutrient solution due to this humic acid positive effect.

Study carried out by Eyheraguibel *et al*., (2008) indicated that humic-like substances (HLS) do not increase the percentage and rate of germination but enhance the root elongation of seeds. Positive effects were also observed on the whole plant growth as well as on root, shoot and leaf biomass. These effects can be related to the high water and mineral consumption of plants undergoing this treatment. The high water efficiency indicated that such plants produce more biomass than non-treated plants for the same consumption of the nutrient solution. Furthermore, the use of HLS induced a flowering precocity and modified root development suggesting a possible interaction of HLS with developmental processes. Considering the beneficial effect of HLS on different stages of plant growth, their use may present various scientific and economic advantages.

Among humic substances formed by organic matter decomposition process, fulvic acids have been extensively studied because of their solubility and soil fertilizer properties. The study after Navarrete *et al*., (2004) describes how some mineral nutrient elements are absorbed by the root as well as the foliage of bean plants and how they move in both directions depending on their association to fulvic acids. In this study, radiotracers of phosphate and iron have been used ($H_2{}^{32}PO_4$, ${}^{59}Fe_2{}^{+}$). The results obtained are quantitative by instrumental detection and qualitative by autoradiography of the radiotracers. A very clear effect has been found about motion and fixation of phosphate and iron ions in bean plants brought about by fulvic acids commercially produced in Mexico by organic synthesis. This effect seems to be the more homogeneous distribution in the vegetable tissues of the mineral ions absorbed from the soil.

Cucumber (*Cucumis sativus*) plants were grown in Hoagland solution to which 20 to 2000 ppm of a soil fulvic acid (FA) were added. The addition of 100 to 300 ppm of FA produced highly significant increases in the growth and development of above and below ground plant parts, in the uptake of nutrient elements (N, P, K, Ca, Mg, Cu, Fe and Zn), and in the formation of numbers of flowers per plant. Effects of adding 500 and more ppm of FA were less beneficial (Rauthan and M. Schnitzer, 1981).

Some effects of humic acids, formed during the breakdown of organic wastes by earthworms (vermicomposting), on plant growth were evaluated (Atiyeh *et al*., 2002). In the first experiment, humic acids were extracted from pig manure vermicompost using the classic alkali/acid fractionation procedure and mixed with a soilless container medium (Metro-Mix 360), to provide a range of 0, 50, 100, 150, 200, 250, 500, 1000, 2000, and 4000 mg of humate per kg of dry weight of container medium, and tomato seedlings were grown in the mixtures. In the second experiment, humates extracted from pig manure and food wastes vermicomposts were mixed with vermiculite to provide a range of 0, 50, 125, 250, 500, 1000, and 4000 mg of humate per kg of dry weight of the container medium, and cucumber seedlings were grown in the mixtures. Both tomato and cucumber seedlings were watered daily with a solution containing all nutrients required to ensure that any differences in growth responses were not nutrient-mediated.

They found that the incorporation of both types of vermicompost derived humic acids, into either type of soilless plant growth media, increased the growth of tomato and cucumber plants significantly, in terms of plant heights, leaf areas, shoot and root dry weights. Plant growth increased with increasing concentrations of humic acids incorporated into the medium up to a certain proportion, but this differed according to the plant species, the source of the vermicompost, and the nature of the container medium. Plant growth tended to be increased by treatments of the plants with 50–500 mg/kg humic acids, but often decreased significantly when the concentrations of humic acids derived in the container medium exceeded 500–1000 mg/kg. These growth responses were most probably due to hormone-like activity of humic acids from the vermicomposts or could have been due to plant growth hormones adsorbed onto the humates.

Seaweeds have long been known to induce growth responses when applied to terrestrial plants, especially with regard to increased energy utilization. While the principal active component of seaweed is unknown, it is likely that a number of factors each play an important role. Of these factors, cytokinins have been signed out as being of particular importance (Nelson and Van Staden, 1984).

This study aiming at the impact assessment of humic acid, fulvic acid and sea weeds in combination with mineral fertilizers rates on nutrient availability and uptake by cucumber was undertaken.

MATERIALS AND METHODS

Location of the experiment and its layout

Field trial was conducted at the Badaway, Mansoura, Dakahlia Governorate, Egypt during the spring season of 2008, in a clay soil under drip irrigation system. The used experimental design was completely randomized block with three replicates. Treatments were assigned to the three organic additives i.e. humic acid, fulvic acid and seaweeds. Humic and fulvic acids were added at two rates i.e. 16 L fed^{-1} (H1 and F1) and 12 L fed^{-1} (H2 and F2), while dry seaweed was added at rates of 3 kg fed^{-1} (S1) and 2 kg fed^{-1} (S2). Untreated control was also included. Mineral fertilizers were added at rates of 100%, 75% and 50% of the recommended dose. Unfertilized control was included. Different combinations between mineral fertilizers and organic additives were undertaken. Cucumber plants (*Cucumis sativus* L Beit Alpha hayel f1 hybried), produced by Betoseed Company, was cultivated in rows with 50 cm between plants. Each hole contained two seedlings.

Experimental soil

Experimental soil samples were subjected to chemical and physical analysis and had pH, 7.9; EC, 1.82 dS m^{-1}; total K, 0.22 meq L^{-1}; total N, 0.2%; total P, 0.05%; sand, 14.50%, silt, 19.43%, clay, 66.07%. Soil texture is clay.

Organic additives

Humic acid

Humic acid was imported from HUMIN TECH GmbH Company, Germany and has the following gradient:

Potassium humate	97%
Humic acid	85%
Total potassium	12%
Iron	1%
pH	9-10.5
Density	0.55 kg L^{-1}

Fulvic acid

Fulvic acid	38%
N organic	1.5%
K_2O	2%
Fe	0.3%
Zn	0.2%
Mn	0.2%
Mo	0.5%
pH	4
Density	1.28 kg L^{-1}

Seaweeds

Algenic acid (dry matter basis w/w)	50%
K_2O (w/w)	16%
Fe	1%
P_2O_5	4%
S	2%

Mineral fertilization

Recommended doses of N, P and K fertilizers were applied as following:
100, 75 and 50 unit (kg) N was added (ammonium nitrate)
60, 45 and 30 unit P (kg) was added (Phosphoric acid)
100, 75 and 50 unit K (kg) was added (Potassium sulfate)
All fertilizers were applied through irrigation water (fertigation)

After harvest, the cucumber fruits were collected; dried and dry matter yield was recorded. Sub-samples were taken for chemical analysis. Plant analysis for N, P and K was carried out according to Hamdy (2005).

Statistical analysis

All the obtained data were subjected to ANOVA analysis followed by Duncan's multiple range test (DMRT) for comparison between means using SAS software program (2002).

RESULTS AND DISCUSSION

Fruits Dry Matter Yield

Application of organic acids and sea weeds significantly enhanced the dry matter yield of cucumber fruits as compared to the untreated control (Fig. 1).The increments of dry matter yield were pronounced when humic and fulvic acids applied at 16 L fed^{-1} comparing to 12 L fed^{-1}. Similar trend was observed with sea weeds where the dry matter yield was higher with application of 3 kg fed^{-1} than those recorded with application of 2 kg fed^{-1}.

Concerning the effect of mineral fertilizers, data revealed the superiority of fertilized treatment over the unfertilized one. This holds true with all of recommended doses. Among them, a little bit difference was noticed. In general, combinations between organic additives and mineral fertilizers seem to be more effective than individuals. These combinations induced higher dry matter yield of fruits, with some exception, when organic acids were applied at high rate than the low rates. Dry matter yield of fruits was fluctuated as affected by organic additives depending on different doses of mineral fertilizers.

In conclusion, application of organic acids and mineral fertilizers solely has an effective role on enhancement of cucumber fruits. Since there was a little bit significant difference between the different mineral fertilizers doses we can recommend, from the economical view point the use of medium dose (75%) in combination with any of the used organic additives as an appropriate treatment that gave remarkable yield of cucumber fruits.

In this regard, many workers indicated the effective role of humic substances on enhancement of plant growth (Adani *et al*., 1998; Chen and Aviad, 1990; Chen *et al*., 2004b). Similarly, it has been proved that cucumber (*Cucumis sativus*) plants grown in Hoagland solution and subjected to 100-300 ppm of FA produced highly significant increases in the growth and development of above and below ground plant parts (Rauthan and M. Schnitzer, 1981).

Some authors propose that HS promote plant growth by improving the soil bioavailability of certain nutrients, principally iron and zinc (Chen et al., 2004a;b), others suggest that HS can also directly affect plant metabolism (Nardi *et al*., 2002). However, it is possible that the two mechanisms are interconnected. In fact, a number of studies have reported the signal effect of some nutrients controls plant development by affecting hormone metabolism (Rubio *et al*., 2009). Likewise, the role of specific plant hormones in root nutrient uptake and further translocation and assimilation is very well documented (Rubio *et al.,* 2009). Among the effects of HS described in different plant species are their abilities to both activate the root PM-ATPase activity and increase nitrate uptake rates in roots (Pinton *et al*., 1999; Nardi *et al.*, 2002; Quaggiotti *et al.,* 2004). On the other hand, a number of studies have shown that nitrate can act as a type of pseudo-hormonal signal, promoting shoot growth under different conditions (Sakakibara, 2006; Sakakibara *et al*., 2006; Rubio *et al.,* 2009; Garnica *et al*., 2009). These studies have reported that these effects of nitrate were linked to significant changes in the root-to-shoot distribution of certain active cytokinins (CKs) (Sakakibara, 2006), polyamines (PAs) (Garnica *et al*., 2009) and abscisic acid (ABA) (Brewitz *et al*., 1995). It is therefore possible that the HS shoot promoting effect is related to a primary effect inducing changes in the root-to-shoot distribution of nitrate through the enhancement of root PMH^{+}-ATPase activity. This HA effect could cause, in turn, concomitant changes in the root-to-shoot distribution of certain CKs, Pas and ABA affecting plant growth.

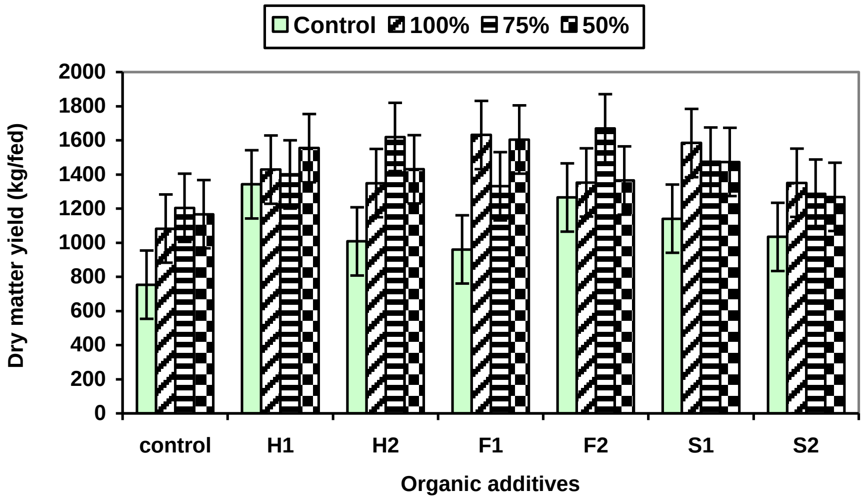

Figure 1: Effect of organic acids and sea weeds combined with different rates of mineral fertilizers on dry matter yield of cucumber fruits.

Nitrogen Uptake

Data illustrated by Fig. (2) indicated that nitrogen uptake by cucumber fruits was significantly increased by increasing N fertilizer doses as compared to the unfertilized treatment. The highest value of N uptake was recorded with 100% N fertilizer dose followed by 75%, then 50% of recommended fertilizer rates. Also, application of organic acids and sea weeds resulted in significant increases in N uptake by fruits as compared to the untreated control. Highly significant N uptake by fruits was occurred when sole humic acid and seaweeds were applied at high rate (16 L fed^{-1} and 3 kg fed^{-1}, respectively) as compared to the low rates. On the other hand, reversible trend was noticed in case of fulvic acid. In this respect, there was no significant difference between the three organic additives. These results indicated that both individual application of mineral fertilizers and organic substances had a positive effect on N uptake by cucumber fruits.

Regarding the combination between mineral and organic substances, data were proved much enhancement in nitrogen uptake by cucumber fruits as compared to individual applications. In this respect, combined application of high rate of humic, fulvic acids and sea weeds with 100% of the recommended rate of mineral fertilizers resulted in higher N uptake by fruits than those recorded with low additions of both of them.

In conclusion, organic substances additions and mineral fertilizers application either individually or in combinations were beneficial in increasing N uptake by fruits. This phenomenon was pronounced at high rate of addition of both of them.

Rauthan and M. Schnitzer, (1981) found that the addition of 100 to 300 ppm of FA produced highly significant increases in the growth and development of above and below ground plant parts, in the uptake of nutrient elements (N, P, K, Ca, Mg, Cu, Fe and Zn), and in the formation of numbers of flowers per plant. Effects of adding 500 and more ppm of FA were less beneficial. These results are in harmony with the results we have.

Atiyeh *et al*., (2002) found that the incorporation of vermicompost derived humic acids, into each type of soilless plant growth media, increased the growth of tomato and cucumber plants significantly, in terms of plant heights, leaf areas, shoot and root dry weights. Plant growth increased with increasing concentrations of humic acids incorporated into the medium up to a certain proportion, but this differed according to the plant species, the source of the vermicompost, and the nature of the container medium. Plant growth tended to be increased by treatments of the plants with 50–500 mg/kg humic acids, but often decreased significantly when the concentrations of humic acids derived in the container medium exceeded 500–1000 mg/kg. These growth responses were most probably due to hormone-like activity of humic acids from the vermicomposts or could have been due to plant growth hormones adsorbed onto the humates.

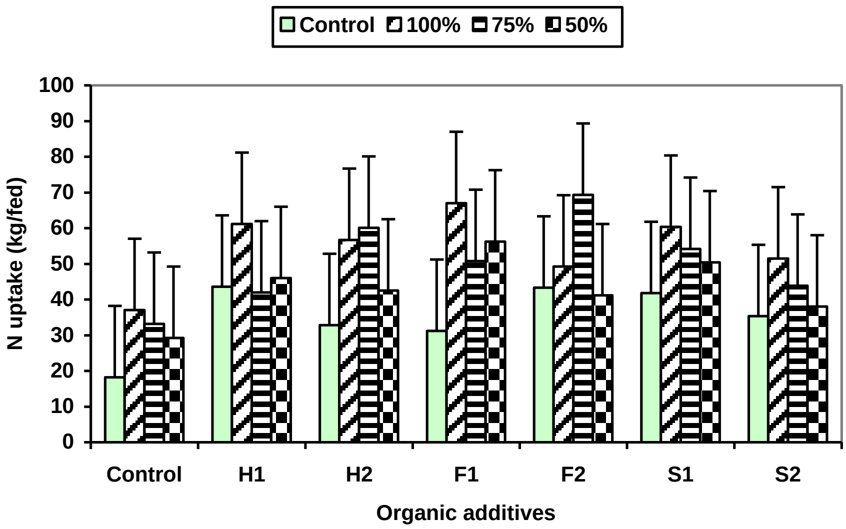

Figure 2: Effect of organic acids and sea weeds combined with different rates of mineral fertilizers on nitrogen uptake by fruits of cucumber plants.

Phosphorus Uptake

Phosphorus uptake by cucumber fruits was enhanced by addition of organic substances (Fig. 3). P values were varied according to organic additive form. In this regard, addition of humic acid and seaweeds resulted in increase of P uptake over those recorded with the untreated control (no organic, no mineral) especially when added at high rates than low rates. Reversible trend was noticed with fulvic acid application. Comparison held between the fertilized and unfertilized treatments show an increase of P uptake with application of different doses of mineral fertilizers. In this respect, there was no significant difference between mineral fertilizer doses. Similar trend was noticed when organic substances accompanied with mineral fertilizers. This result gave us the chance to conclude that application of mineral fertilizers at rate of 75% in combination with each of the organic additives could be selected, from the economical view, as the most appropriate treatment that induced higher P uptake by cucumber fruits.

Results derived by Selim et al., (2009) showed that increasing humic substances application rates up to 120 kg ha^{-1} enhanced potato tubers yield quantity, starch content and total soluble solids. The increase of humic substances application rates was associated with the decrease of nutrients leaching, which was reflected on increasing macro- and micronutrients concentration in potato tubers, as well as increasing concentration of these nutrients in soil after tubers harvesting.

Similarly, humic acid has significant effect on nutritional elements uptake by cucumber and as a result it can decrease element content in nutrient solution due to this humic acid positive effect (Olfati *et al.,* 2010).

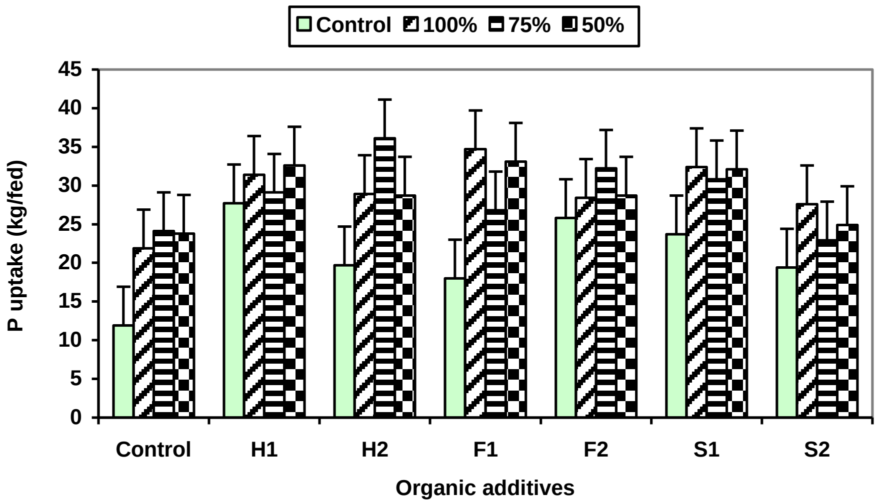

Figure 3. Effect of organic acids and sea weeds combined with different rates of mineral fertilizers on phosphorus uptake by fruits of cucumber plants.

Potassium uptake

Potassium uptake by cucumber fruits as affected by organic substances and mineral fertilizers rates was illustrated by Fig. (4). It seems that addition of mineral fertilizers at different rates had enhanced the uptake of potassium by cucumber fruits. In this regard, there was no significant difference between the different rates of fertilizers. Therefore, we assumed that low and medium rates were adequate, at least from the economical view, for cucumber growth and production as compared to unfertilized and 100% of recommended rate treatments. Similar trend, but to higher extent, was noticed with the application of organic substances. Application of humic acid and seaweeds solely resulted in highly significant increases in K uptake especially at high rate of addition as compared to the untreated control. The highest value of K uptake by fruits was recorded with application of 16 L fed^{-1} of humic acid. So, seaweeds came to the next followed by fulvic acid. Potassium uptake as affected by fulvic acid rates was higher in case of 12 L fed^{-1} than those recorded with 16 L fed^{-1}. Interaction between different mineral fertilizers rates and different rates of organic additives had enhanced potassium uptake comparable to those of individual treatments. In this respect, there were no significant differences between either fertilizers or organic substances rates.

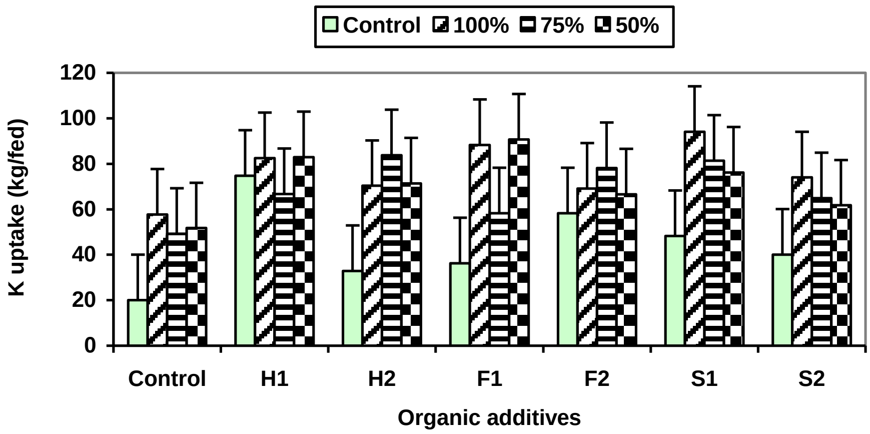

Figure 4. Effect of organic acids and sea weeds combined with different rates of mineral fertilizers on potassium uptake by fruits of cucumber plants.

In conclusion, combination between each of the organic substances and medium rate of mineral fertilizers could be selected as suitable strategy for potassium nutrition of cucumber. In addition, this strategy is economically profitable for farmers.

Our results are in agreement with Rauthan and M. Schnitzer, (1981) who stated that Cucumber (*Cucumis sativus*) plants treated with 100 to 300 ppm of fulvic acid (FA) produced highly significant increases in the growth and development of above and below ground plant parts, in the uptake of nutrient elements (N, P, K, Ca, Mg, Cu, Fe and Zn), and in the formation of numbers of flowers per plant. They found that effects of adding 500 and more ppm of FA were less beneficial.

Conclusion

The obtained results released from the present study gave us the chance to conclude that properly combinations of mineral fertilizers and organic acids or seaweeds were beneficial for remarkable production of cucumber. Economically, this strategy may save money and protecting the surrounding environment via reduction in mineral fertilizers rates. Organic farming concept applied in this work could be acceptable for increasing soil fertility as well as plant nutrition. This strategy has an important role in improving soil properties and consequently the elemental chemistry.

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دور المواد الهيوماتية ومستخلص الأعشاب البحرية والأسمدة المعدنية فى تحسين انتاجية الخيار

السيد محمود الحديدى ، أحمد عبد القادلر طه و محمد عدلى السيد سليمان
قسم علوم الأراضى - كلية الزراعة - جامعة المنصورة - المنصورة.

أقيمت تجربة حقلية بغرض تقييم أثر اضافة أحماض الهيوميك والفولفيك وكذلك مستخلص الأعشاب البحرية الجافة سواء منفردة أو فى مخاليط مع معدلات مختلفة من الأسمدة المعدنية (ن-فو-بو) على انتاجية نبات الخيار. أضيف كل من حمض الهيوميك وحمض الفولفيك بمعدلين (١٢، ١٦ لتر فدان-١) بينما أضيف مستخلص الأعشاب البحرية الجافة بمعدل ٢ و ٣ كجم فدان-١ . اشتملت المعاملات على معاملة شاهد خالية من المعاملة العضوية أو المعدنية. أضيفت الأسمدة المعدنية بمعدلات ١٠٠%، ٧٥% و٥٠% من الموصى به لنبات الخيار. تم اضافة مخاليط من الأسمدة المعدنية والأحماض العضوية. بينت النتائج أن اضافة الأحماض العضوية والأسمدة المعدنية منفردة كان له أثر فعال فى تنشيط انتاج ثمار نبات الخيار. طالما لم تكن هناك فروقات معنوية كبيرة بين المعدلات المختلفة من الأسمدة المعدنية – من الوجهة الاقتصادية- فاننا ننصح بأستخدام الجرعة المتوسطة (٧٥%) فى مخلوط مع أى من الأحماض العضوية أو مستخلص الأعشاب البحرية كمعاملة مناسبة تعطى انتاجية معتبرة من ثمار الخيار. فى نفس الوقت، تم تنشيط امتصاص النتروجين بواسطة الثمار عن طريق المعاملات المنفردة أو حتى المخاليط. هذه الظاهرة كانت اكثر وضوحا عنداضافة المعدلات العالية من كلا المصادر العضوية والمعدنية. اضافة حمض الهيوميك أو الأعشاب البحرية منفردة أدى الى زيادة معنوية عالية فى امتصاص البوتاسيوم بواسطة ثمار الخيار مقارنة بمعاملة الشاهد. هذه الزيادة كانت أكثر وضوحا عند الأضافات العالية من المواد العضوية. اضافة الأسمدة المعدنية بمعدل ٧٥% مخلوطة مع أى من المصادر العضوية يمكن انتقاؤه من وجهة النظر الأقتصادية كأنسب معاملة تزيد من امتصاص الفوسفور بواسطة الثمار. الخلط بين أى من المصادر العضوية والمعدل المتوسط من الأسمدة المعدنية يمكن انتقاؤه كأستراتيجية مناسبة لتغذية نبات الخيار بالبوتاسيوم. هذا بالأضافة الى أن تلك الاستراتيجية مفيدة أقتصاديا للمزارعين.

قام بتحكيم البحث

أ.د/ زكريا مسعد الصيرفى	**كلية الزراعة – جامعة المنصورة**
أ.د/ يحيى جلال محمد جلال	**مركز البحوث النووية**