Assiut J. Agric. Sci., (49) No. (1) 2018(159-188) ***ISSN: 1110-0486***
Website: *www.aun.edu.eg/faculty_agriculture/journals_issues_form.php* ***E-mail: ajas@aun.edu.eg***

Impact of Seaweed Extract and Phosphorus Application on Productivity of Dahlia Plants

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Received on: 16/1/2018 **Accepted for publication on:** 20/2/2018

Abstract

A pot experiment was conducted for two successive seasons on a sandy soil and *Dahlia pinnata* plants grown on it. The randomized block design was used with two factors, the first was seaweed extracts (SWE) 0.0, 0.5, 1 and 1.5 % and the second was phosphorus (P) element treatment through soil application technique at four levels 0.0, 100, 200 and 300 ppm. The objective of this study was to determine the effect of different treatments of seaweed extract on chemical behavior and uptake of phosphorus at different levels in the sandy soil and on plant growth, flowering and chemical composition of growing plants and how the net negative surface charge and phosphate adsorption processes in a sandy soil were affected by seaweed and inorganic fertilizer applications. Soil samples ware collected from a field experiment where seaweed (SWE) and triple superphosphate (TSP) were applied annually on an equivalent plant-available P basis. The results showed that adding seaweed extract (Oligo- x) at 1% and P at 200 ppm revealed significant increase in the studied parameters in both seasons. Significant increases were in the stem length, stem dry weight, number of leaves and their dry weight, leaf area as well as the flower diameter, duration and dry weight while a significant increase in number of days needed to reach flowering was recorded with all fertilizer treatments in both seasons. Tuberous root fresh weights and their number/Plant were obviously stimulated by the used treatments. Meanwhile the content of the leaves of N, P and K (%) as well as the total content of chlorophyll and carbohydrates were significantly stimulated in both seasons compared to the control. After 2 years, SWE-soils had 37% more negative surface charge in soil suspensions from pH 4 to 7 than TSP-fertilized soils. Phosphate adsorption was 23% lower in soils received SEW than TSP. The phosphate adsorption data (adsorption of added phosphate + native adsorbed phosphate) was modeled with the Langmuir 2-surface equation, which revealed that the binding strength for phosphate, including native adsorbed phosphate, was about 50% less in the SWE-fertilized soils than the TSP-fertilized soils. These results suggest that SWE applications increased the net negative surface charge also reduces the soil phosphate adsorption capacity. Phosphate adsorption isotherms showed that phosphate was weakly bound in SWE-fertilized soils, compared with TSP-fertilized soils. Data showed that seaweed not only decreased phosphate retention by the soil but also increased phosphate release into the soil solution. It could be recommended to grow dahlia bulbs in sandy soil by adding of seaweed extract (SWE) at rate (1%) with supplying phosphorus at a level of 200 ppm.

Keywords: *Seaweed, Algae extract (Oligo-x), Triple super phosphorous, dahlia plant.*

Introduction

Dahlia pinnata is a herbaceous plant and attractive with double large flower. It is a local cultivar. Dahlia is a member of family composite. It is an excellent cut flower for decoration purposes as a pot plant, bedding plants as well as exhibit plant. The flowering during summer months creates superiority and high valuable marketing among other ornamental summer flowering plants. Plant growth and development are greatly influenced by chemical growth substances and fertilizer application. To improve the productivity and quality of flowers and bulbs of bulbous plants, several studies recommended the application of chemical fertilizers. Most bulbs need more than two applications of chemical fertilizers during the growing season, but the most important point is that the greatest increase in size and weight of the new developing bulb takes place in the period during and mostly after flowering, as long as the foliage remains in good condition. Thus, chemical fertilization must be continuous for a good vegetative growth to produce a good flower and large new mature bulbs (Rees, 1992). In recent years, the use of natural seaweed as source of mineral elements has allowed for partial substitution of conventional chemical fertilizers (Khan *et al*., 2009; Zodape *et al*., 2009). Algae extract as a new bio fertilizer containing N, P, K, Ca, Mg, and S as well as Zn, Fe, Mn, Cu, Mo, and Co, some growth regulators like indole-3-acetic acid (IAA), indole-3-butyric acid (IBA), Cytokinins, polyamines and vitamins applied to improve nutritional status, vegetative growth, yield and fruit quality in different orchard as well as vineyards (Abd El-Migeed *et al*, 2004; Abd El-Moniem and Abd-Allah, 2008 ; Spinelli *et al*., 2009). In addition, bio-fertilization is very safe for human, animal and environment to get lower pollution and reduce soil salinity via decrease mineral usage of fertilizers as well as saving fertilization cost. Seaweed extracts have been reported to stimulate the growth and yield of plants, enhance tolerance to environment stress, and improve nutrients availability and nutrients uptake from the soil (Rathore, 2009; Aziz *et al*., 2011). Moreover, manure of seaweed is used as a soil amendment in agriculture in many parts of the world and they are an inexpensive local resource in coastal agricultural areas (Eyras *et al*. 1998). Phosphorus is the essential component of protoplasm and chlorophyll material which causes conversion of photosynthesis into phospholipids, resulting adequate vegetative growth. In a higher dose, i.e. 200 kg P_2O_5 per ha causes influence on flowering parameters like delay in the flowering, increasing in flower numbers and their sizes (Monish *et al*., 2008). Plant growth, number of flowers, flower size and flowers longevity were increased with highest doses of N and P_2O_5 rates (Bhattacharya and Mukherjee, 1983). Significant increase has been recorded in the most of plants on the vegetative characters like number of leaves, number of branches and stem diameter by phosphorus application (Singh and Sangama, 2000; Kumar and Misra, 2011). However, understanding the behavior of phosphorus in sandy soil is a prerequisite for selecting effective management proposals for controlling P losses. Initially we need to know the forms of P that already exist and their leach ability. When new management practices are introduced (such as use of less-soluble P fertilizer), we then need to assess the short and long-term changes in P storage from regular applications of new fertilizers and its effect on losses. Phosphorus losses from sandy soils are a major source of the P which causes algal blooms in the inlet and estuary (Kinhill Engineers, 1989). However, the effect of soil properties, environmental conditions and management practices on the extent of P losses is still not fully understood. Very little experimental work has been done on the nutritional requirements of Dahlia particularly seaweed and phosphorus. Therefore, the present investigation was conducted with seaweed extract and phosphorus at different levels and a combination between them to arrive to a proper nutrition for better flowering under the prevailing Egyptian climatic conditions.

Materials and Methods

Two pot experiments were carried out during two successive season's 2014/2015 and 2015/2016 in sandy soil:

1-Plant

The local cultivar *Dahlia pinnata* (summer flowering type) brought from a commercial nursery in El Kanater El Khayria, Cairo, Egypt. The clumps were divided into uniform divisions of tuberous roots. Each division had an average fresh weight of 30 g and contained 5 tuberous roots (TR). The average length and diameter of each were 6.80 and 2.50 cm. Clumps were immersed in a fungicide solution, respectively. On 5th April 2014, they were in PVC pots 30 cm diameter filled with sandy soil, the planted tuberous roots were irrigated thoroughly after planting. In the first pinching, the growing point was done on May 25th to stimulate better branching. To accelerate more basal branching, another pinching was done after two weeks later (Barrett and Hertogh, 1978). Three well distributed branches on each plant were selected, they were disbudded to allow only one terminal bud to develop per branch and they were tied to stalks and inserted in the soil of each pot to support them.

2-Soil

A surface soil samples (0-30 cm) were collected from El-Bostan region, El-Beheira Governorate. The physical and chemical analysis of the used soil listed in Table 1. Analysis was determined according to the standard methods outlined by Westerman (1990). Seaweed extract represented as Algae extract (Oligo-x) obtained from AGAS (Arabian group for agricultural service) company having the following chemical composition as Oligosaccharide (3%), algenic acid (5%), phytin (0.003%), menthol (0.001%), natural growth regulators such as cytokines (0.001 %), Indol acetic acid (0.0002%) and pepsin (0.02%) and minerals (potassium oxide 12%, phosphorus oxide 0.5%, N, 1%, Zn, 0.3%, Fe, 2% and Mn 0.1%). Application of different concentrations of seaweed extract (0.0, 0.5, 1.0 and 1.5%) and recommended rate of commercial fertilizers applied on the plants grown in pots. The plants were irrigated every week. Application of different concentrations of SWE were applied at rate 100ml/pot as soil drench on the first day and 30th day after transplantation as corresponding days of chemical fertilizer application. The seedlings were also used separately with different proportions of recommended rate of chemical fertilizers plus SWE on 1, 30, 60 days later and continued until the stage of the flower bud showing color. The SWE was taken and mixed with the respective proportions of chemical fertilizer thoroughly and distributed equally to plants in each pot (100 ml /pot). Phosphorus fertilization was triple super phosphate and used as a source of phosphorus and applied at four levels 0.0, 100, 200 and 300 ppm P. The requirements of nitrogen and potassium were added by the application of ammonium nitrate (33.5 % N) and potassium sulphate (48 % of K_2O) at the rates of 175 and 40 ppm, respectively. The other requirements from micronutrients like iron, zinc, copper and boron were added by the addition of their sulphate salt forms as $FeSo_4.4H_2O$ (24.7% Fe), $ZnSO_4.7H_2O$ (21.8% Zn), $CuSO_4.7H_2O$ and B in sodium borate, $NaBO_3.10H_2O$, respectively (Sing and Gupta, 1996). The volume of irrigation water added to each pot was 250 ml. To avoid excess of salts in the growing medium, the pots were washed once every two weeks, one liter used of tap water for each pot without mineral fertilizers addition. The experimental layout was designed to provide complete randomized blocks in factorial experiment with four replicates used to carry out this experiment. Statistical analysis of data was done using (SAS Institute, 1999).

The measured parameters:

1. Morphological vegetative growth characteristics:

The flowering date (number of days from planting to the date of coloring stage had been showed) represented in three flowers/plant, the flower diameter in (cm) at full opening stage, the flowering duration (number of days from color showing to the date of fading) and the flower dry weight (g).

2. Tuberous roots (TR) production:

Number of tuberous roots/plant and their fresh weight (g) were calculated at the end of the experiment.

3. Plant chemical analysis:

The total chlorophyll content in the leaves was determined as mg/100g leaves fresh weight of the sixth leaf beneath the terminal bud at color showing stage according to (Moran and Porath, 1980). Total carbohydrates content as mg/g leaves dry weight was determined in tuberous roots according to Dubois *et al.* (1956). Nitrogen, P and K contents in the leaves were determined as (%) according to the method of Westerman, (1990).

4. Soil chemical analysis:

Some routine analyses were conducted before starting the experiment (Table 1). Soil samples were collected from a pot experiment from four replicates of each treatment to the depth 10-cm after harvest, air-dried and gently ground to pass through a 2-mm sieve. Soils were analyzed for pH (1:2 soil/water suspension). The total P in soils was determined in hydrogen peroxide/sulfuric acid digests (Parkinson and Allen, 1975). The total inorganic phosphate was measured in 0.5 M H_2SO_4 extracts (O'Halloran, 1993). Mchlich-3 extractable phosphate and Fe were determined using the method described by Tran and Simard (1993). Labile phosphate, collected with an anion-exchange resin, and water extractable phosphate were also measured (Sibbesen, 1977); the difference between labile phosphate and water-extractable phosphate was considered to represent the native adsorbed phosphate in soils (Holford *et al*., 1974; Wolf *et al*., 1986). Phosphate in digests and extracts was quantified colorimetrically with the ammonium molybdate-ascorbic acid method (Murphy and Riley, 1962). Iron was analyzed by atomic absorption spectrometry (AAS). Characteristics of soil from algae and phosphorus plots are provided in Table 6. Also, a back-titration method was used to evaluate the soil surface charge (Duquette and Hendershot, 1993). Phosphate Adsorption: A batch adsorption experiment was performed to assess phosphate adsorption in algae and P-fertilized soils (Koopmans *et al*., 2003). The initial solution with different phosphate concentrations was adjusted to pH 6 with 0.1 *M* KOH. The phosphate adsorption of one replicate soil from each treatment was determined with the same range of phosphate concentrations (from 0.1 to 1 ML^{-1}), but adjusted to pH 4 (with 0.1 *M* HCl) and pH 10 (with 0.1 *M* KOH). The adsorption of added phosphate was calculated as the difference between the amount of phosphate added and the phosphate remaining in solution. The Langmuir 2-surface equation (Langmuir, 1918; Holford *et al*., 1974) was used to generate phosphate adsorption parameters.

$$Q= Q_{max1} \times K_1C/ 1+K_1C+ Q_{max2} \times K_2C/1+K_2C..(1)$$

Table (1). Some chemical properties of the used sandy soil before experiment:-

EC, dSm^{-1} (1:2)	pH-soil suspension (1:2)	Soluble anions (meq/l)				Soluble cations (meq/l)				SAR	CEC (Meq/100 soil)	Particle size distribution (%)			Texture Grade	$CaCO_3$ (%)
		CO_3^{--}	HCO_3^-	Cl^-	SO_4^{--}	Mg^{++}	Na^+	K^+	Ca^{++}			sand	silt	Clay		
1.50	8.15	-	3.85	8.4	1.25	2.43	6.25	1.72	2.65	3.92	5	90	5	5	Sandy	3.20

*SAR: Sodium adsorption ratio calculated from $Na^+/\sqrt{(Ca+Mg)/2}$

Where *Q* = phosphate adsorbed (mg P kg−1) = adsorption of added phosphate + native adsorbed phosphate, Q_{max} adsorption maxima (mg kg−1), *K* = adsorption constant, *C* = phosphate concentration in equilibrium solution (mg P L^{-1}), and subscripts 1 and 2 denote the high-energy surface and the low-energy surface, respectively. The distribution of native adsorbed phosphate on the high-energy surface and the low-energy surface (*Q*nat.P1 and *Q*nat.P2) was calculated based on parameters (Q_{max} and *K*) generated from Eq. (1) and solution phosphate concentration (*C*) Obtained by *Q* = *Q*nat. P.

Statistical analysis

The paired *t* test in the SAS program (SAS Institute, 1999) was used to test the differences in soil properties, phosphate adsorption and DOC released between SWE and triple superphosphate TSP treatments. The SAS nonlinear procedure (PROC NLIN) was used to generate the Langmuir 2-surface model.

Results and Discussion

A- **Vegetative Growth Characteristics:**

1- Effect of seaweed extract:

The data showed in Table (2), proved the significant enhancement in the studied vegetative growth parameters of *dahlia* plants as a result of applied the seaweed into the sandy soil. Generally the maximum increase in each character was recorded at the 200 ppm P and 1 % of the seaweed extract compared to control treatment in both seasons. The rate of significant increase in stem length (cm) recorded as 74.41 and 70.92, the stem dry weight (g) were 6.39 and 6.49, while number of leaves/branch recorded 19.32 and 19.03, the leaves dry weight (g) were 41 and 7.43 as well as leaf area/branch (cm^2) was recorded as 787.04 and 735.43 relative to the control of each parameter in the both seasons, respectively. The stimulating effect of seaweed extract on growth characters might be attributed to its essential action on enhancing cell division because it contains higher amounts of nutrients namely (N, P, K, Mg, Ca, S, Cu, Fe, Mn, B and hormones like cytokines, Indole acetic acid (IA A) and GA3, amino acids, vitamins and antioxidants) according to James, 1994 and Soliman *et al*., 2000. These constituents play important roles in protecting plants cells from damage and all stresses around plants and improving cell division and biosynthesis of the organic foods (Kulk, 1995; Strick and Staden, 1997). These results with regard to the effect of seaweed extract on growth characters are in agreement with those obtained by El-Sawy, 2005 and Oraby, 2013.

2- Effect of phosphorous levels

It is clear from the data in Table (2) that P application had a considerable effect on the vegetative growth traits of *dahlia* plant. Adding P at the rate 200 ppm was more effective in stimulating the studied growth characters of plants. Generally, the maximum values are found at 200 ppm P followed by the second P level 100 ppm in most cases, while the lower values are recorded at the control and 300 ppm P treatments. The maximum stem length was 72.60 and 72.51 cm, the heaviest stem dry weight was 6.69 and 6.41 g, the number of leaves/branch was 18.42 and 20.15, the heaviest dry weight of leaves were 7.70 and 7.65 g and the maximum leaf area was 809.69 and 792.21 cm^2 in both seasons, respectively, compared with the control. These results may be attributed to effectiveness of P as essential macro element needed for metabolic processes as respiration, photosynthesis and controlling the osmotic potential as reported by Frank and Cleam, 1985, hence significant increasing of biomass and growth stimulation could be obtained. Similar results are in harmony with those investigated by Badran *et al*. 2001 on gladiolus and Barakat (2006) on geranium. They found that using P at the optimum level significantly promoted the vegetative growth and increased the dry matter accumulation.

B- Flowering Growth Characteristics:

Effect of seaweed extract (SWE) and phosphorus (P) levels:

1. Flowering time:

Data outlined in Table (3) demonstrate that adding of SWE significantly delayed the time required to reach flowering stage. It is obviously, that the *dahlia* plants received SWE at 1% recorded the earlier flowering time (142.37 and 142.68 days) compared to the plants received the highest rate 1.5% which listed (150.83 and 149.80 days) in both seasons, respectively. From this present study it is clear that the seaweed was most effective especially at high extract as a natural product containing organic matter, a lot of macro and micro elements and some plant growth regulators (Gallen and Hemingway, 1965). Phosphorus significantly affected the days of flowering. The comparison between treatments indicated that maximum days of the flowering were 163.63 and 163.60 in the plants grown under control treatment and minimum days of the flowering (142.37 and 148.07) were recorded in the pots applied with 200 ppm P in the 1stand 2nd seasons. This finding may be interpreted to the active role of P at the proper date outlined in Table (3) which demonstrate that adding of (SWE) significantly had early time to reach flowering stage. It is obviously that the Plants received SWE at 1% recorded the earlier flowering time (142.37 and 142.68 day) compared to the plants received the highest rat 1.5% which listed (150.83 and 149.80 days) in the both seasons, respectively. From this present study it seems to be clear that seaweed extract was most effective especially at high concentration (1%), that may be due to that seaweed extract as a natural product containing organic matter, a lot of macro and micro elements and some plant growth regulators (Shahira, 2015) on fenugreek plants in sandy soil. Regarding to P effect, data given in Table (3) show the role of P level (200 ppm) in stimulation formation of tuberous root which allow more absorption of elements necessary for flower bud initiation and development, consequently early flowering could be recorded. Similar results on gladiolus were recorded by Badran *et al*., (2001) and Adnan *et al.* (2014) on *dahlia*. The results are also in line with Khan and Amanulah (2007).

2. Flower diameter:

It is evident from results given in Table (3) that seaweed extract proved beneficial effect on stimulation of the flower diameter. In General, the maximum flower diameter (13.70 and 13.65 cm) was recorded at the rate of 1% SWE treatment in the both seasons compared to control, respectively. Observations in the present investigation confirm earlier reports showing that the seaweed extract SWE can improve accumulation of total carbohydrate, total protein and total lipid contents (Sridhar and Rengasamy, 2010) on *Tagates erecta***.** Concerning P levels, results showed its effect on the flowering diameter. It is evident from the data listed in Table (3) that P level of 200 ppm produced the maximum flower diameter (13.72 and 13.50 cm) followed by level of 300 ppm (13.62 and 13.32 cm) compared to the control in both seasons, respectively. These results may be due to the active role of P as macro element necessary for the synthesis of peptide bond, protein and carbohydrate metabolism. These compounds are necessary for development of flower. A significant and linear increase in the size of flower was observed due to increasing levels of phosphorus. The results are in conformity with the findings of Singh and Goyal (1993) on *dahlia*. Similar results were obtained by Gnyandev, (2006) on China aster and Barakat (2006) on geranium.

3. Flower duration:

Data given in Table (3) indicate that applying seaweed extract (SWE) at 1% significantly increased the flower duration period (6.80 and 8.50) compared to the control (5.40 and 6.25) in both seasons, respectively. These results might be attributed to the beneficial effect of seaweed extracts that contain naturally supplying nutrients, plant growth hormones (auxins, cytokines and gibberellins) as well as other plant biostimulants; e.g. amino acids, vitamins that could maintain photosynthetic rates, improve plant resistances, delay plant senescence and control cell division (Crouch and Van Standen ,1993). These results are in agreement with those obtained by Awad *et al.,* (2006) on potato and Dalia and Sabreen (2014) on *Dahlia*. In respect to effect of P levels, the data given in Table (3) proved efficiency of adding P at rate of 200 and 300 ppm in stimulating flower diameter especially the rate of 200 ppm in both seasons compared to the control. These results are due to the role of P in stimulating biosynthesis of protein, enhancing loading and translocation of sugar through organs of plant and controlling the osmotic potential of the cell (Frank and Cleam, 1985). Hence, more flower turgidity and longevity could be ensuring. Similar results are in complete agreement with those reported on *dahlia* plants by Adnan *et al*., (2014) on *dahlia*. The current findings are in correspondence of Hussain *et al.* (2011) who observed that maximum sprouting age percent was recorded in freesia cornel at highest level of phosphorus. The results are also similar with conclusions reported by Gowda *et al*., (1988) who observed the maximum survival age percent with higher dose of N and P fertilizers.

4. Flower dry weight (DW)

Data in Table (3) revealed that seaweed extract (SWE) at the two levels (1% and 1.5%) had the same effect and significantly increased the flower dry weight in the two seasons (3.76, 3.83, 3.75 and 3.82 g), respectively, compared to the control. These results interpret efficiency of SWE in providing with their requirement of essential elements and nutrient for biosynthesis and accumulating the products in plant tissues and consequently more increase in the flower dry weight (Soliman *et. al.,* 2000)**.** Concerning effect of P levels, it is evident from data given in Table (3) which approved that adding of Phosourus at level 200 ppm reflected a significant increasing in the flower dry weight (3.88 and 4.11 g), respectively, compared to the control in both seasons, respectively. These findings may be due to that P at the proper rate 200 ppm stimulates more loading and translocation of sugar through the plant organs. Hence more biosynthesis of protein and carbohydrates, consequently the flower dry weight could be increased. The results of this experiment are in close agreement with those of Shafi *et al*., (2001) and Panch *et al*., (2010) on chrysanthemum plant.

C. Effect of Seaweed and Phosphorous on Tuberous Roots Growth Characteristics:

Data given in Table (3) show that adding of seaweed extract (SWE) at rates of 1% and 1.5% significantly increased the fresh weight of tuberous roots (204.79, 186.08) and (204.05, 182.51g) compared to the control in both seasons, respectively. The same trend of results is obviously observed with the parameter number of TR/ plant (16.38, 17.41) and (15.59, 16.48) as showed in Table (3). As mentioned above, there has been an increase in vegetative growth parameters due to the application of seaweed extract. These increases may be due to the presence of phenyl acetic acid (PAA) and other closely related compounds. It was reported that the presence of plant growth regulators, trace elements, vitamins, micronutrients and amino acids in the low concentration of SWE and enhance the growth of root and shoot (Nedumaran, 2012). Auxin plays essential role on growth of plants by increasing and activating H-ATPase pumps that Auxin sends protons to apoplast space which resulting from decreasing pH, some enzymes will be activated which loosed cell wall. Auxin also increases some soluble materials inside the cell and decreases the water potential and finally let water enter to the cells. These procedures lead to growth of cell and finally growth of plant (Shahbazi *et al* 2015). Phosphorus fertilizer proved considerable effect at the level of 200 ppm on the three studied parameters. Significant increase in TR fresh weight was recorded (218.33 and 197.27g) and number of TR/plant (15.00 and 17.93) in the 1st and 2nd seasons, respectively. These results may be explain the vital role of P as essential element for photosynthesis, respiration and enzyme activation, controlling the osmotic potential and translocation of produced sugar and accumulation in the plant organs. Badran *et al* (2001), proved similar results on gladiolus and reported the efficiency of P in stimulating growth development.

D. Plant Chemical Constituents:

1- Total chlorophyll content :

Concerning the effect of seaweed extract (SWE) on the chlorophyll pigment contents in the leaves of *dahlia* plants, data given in Table (4) show that incorporation of seaweed (SWE) at rate of 1% was more effective. Maximum increase in chlorophyll content (425.18 and 417.88 mg/100g fresh weight of leaves) was recorded in the 1st and 2nd seasons, respectively, compared to the control. The promotional effect of added seaweed extract (SWE) at the proper rate 1% may be due to the higher content of seaweed extract from nutrients especially Mg as well as amino acids and vitamins that surely reflected on enhancing the biosynthesis of plant pigments and total carbohydrates (Soliman *et. al*., 2000). Phosphorus fertilization proved significant increases in the total chlorophyll content in both seasons, Table (4). Maximum chlorophyll pigment was recorded at P level of 200 ppm (467.7 and 462.45 mg/100 fresh weight of leaves) followed by the second level 300 ppm (383.65 and 380.82 mg/100 g fresh weight of leaves). These findings may interpret the vital role of phosphorus in enhancement of plastid pigment content, as essential element of photosynthesis, respiration and enzyme activation (Frank and Cleam, 1985). This finding was also reported by Badran *et al*., (2001) on gladiolus.

2- Total carbohydrate contents in leaves:

The data given in Table (4) generally indicated that adding of seaweed extract (SWE) at the rate of 1%, significantly increased accumulation of carbohydrates (343.34 and 308.16 mg/g dry weight of leaves) in both seasons, respectively, compared to the control. These SWE results could be due to the stimulatory effect of organic fertilizer rich in nutrient elements necessary for activating of vegetative growth as well as better photosynthesis, consequently more sugar and dry matter accumulation. The obtained results are in parallel line with those found by Soliman *et. al.,* (2000) and Sivasankari *et al* (2015) on solanum. Regarding to use P fertilizer, a promotional effect on carbohydrate contents was observed. The data given in Table (4) showed that using of P at the level of 200 ppm significantly increased the content of sugar accumulated in both seasons compared to the control. Maximum content of carbohydrates was recorded (364.66 and 357.08 mg/g leaves dry weight) in the 1st and 2nd seasons, respectively. These findings may explain the P action in activation of the enzymes of carbohydrates transformation or in the regulation of sugars consumption and promotion of water and CO_2 absorption, which can increase the capacity of plants in building of metabolites. These results agreed with those reported by Barakat (2006) on geranium and Samia *et al*., (2016) on zinnia. According to the results of Refaat and Naguib (1998) and Devlin (1969), application of amino acids on *Capsicum annum* L. leaves, increased carbohydrates in these plants. The increasing effect of amino acids may be related to their effect on the biosynthesis of chlorophyll molecules that influences the content of total carbohydrates. It is reported that succinyl-CoA (one of the metabolites of "Krebs cycle" and amino acid as glycine stimulate the biosynthesis pathway of chlorophyll. The obtained results are in line with the results of Abou El-Dahab and Nahed (2006) on Philodendron plant.

3- Leaf mineral content:

Data in Table (4) indicate that N, P, K were significantly increased due to increasing SWE concentrations in comparison to the control in both seasons. It is evident that application of SWE at rate 1% significantly increased and gave the best results on leaf N, P and K contents. Seaweed extract fertilizers improved nutrient uptake, and considered as good source of nutrients for the plants. This liquid provides slowly release of nutrients to the plants and enhances the yield of plants (Salwa, 2013). Utilization of seaweed as seaweed extract fertilizer is one of the excellent means to compensate the loss of nutrients from the soil. Application of SWE plays a significant role in improving the yield of plants by about 20-30 %. The value of seaweed as fertilizer is coming not only from the nitrogen, phosphorous, potassium and organic matter but also comes from its trace element contents (Booth, 1965; 1969). The analysis of seaweed extract revealed that amongst macronutrient, the values of total nitrogen were maximum followed by potassium, sulphur, magnesium, calcium and phosphorus as reported by Sekar *et al*., 1995, but in the present study, the analysis of seaweed extract showed that the value of magnesium was the highest followed by potassium, calcium, nitrogen and phosphorus and the micronutrients (Sridhar and Rengasamy, 2010). Concerning enhancement of N, P and K contents in the leaves of plants treated with P level of 200 ppm, this explain the active role of P and its synergistic effect or may related to the increased cation exchange capacity (CEC) of the treated soil and root of the plants resulting in elements adsorption on the root or soil surface (EL-Damaty *et al*., 1972). Consequently, the needed amount of elements could be easily absorbed, uptake and accumulated in the leaf tissues. Similar results were obtained by Doddagoudar *et al*. (2004) on gladiolus.

Interaction between seaweed extract and phosphorus levels on plant growth and Yield

Some interaction treatments between SWE and P levels resulted in a significant increase on some vegetative growth, yield and quality parameters. Interaction of seaweed extract (SWE) and phosphorus (P) levels on growth and yield are presented in Table (5). The highest stem length was recorded (75.73 and 75.32 cm) at level 200 ppm P with seaweed extract (SWE) 1 % in the 1stand 2nd seasons, respectively. The maximum stem dry weight was 7.43 g and number of leaves/branch recorded 19.46 in the first season only Table (5) as a result of combination between SWE at 1 % and P level of 200 ppm**.** However excess amounts of both factors have adverse effect on growth. The differences in plant growth might be due to genetic potential variation and favorable climatic factors, because their genetic constituent is significantly different in characteristics with respect to yield (Khan *et al*., 2004). Concerning the interaction of seaweed extract (SWE) and P levels which was not significant for the number of days to flower both seasons. The data presented in Table (3) indicated that the most effective combination stimulated the early flowering of *dahlia* was the seaweed extract at rate of 1% in the presence of P at level of 200 ppm.

Interaction of SWE and P levels are significant in the 1st season only Table (5). Table (5) shows the longest flower duration period as 7.56 and 8.92 days for the two growth seasons, respectively due to the Interaction between seaweed extract (SWE) and phosphorus (P) levels. There are significant different in the 1st season only for the tuberous roots (TR) fresh weight parameter indicating that maximum TR fresh weight is recorded (218.16 g) as a result of adding of SWE at 1% combined with P level of 200 ppm. Phosphorus uptake is more increasing in well aerated and warm soil so when soil temperature is high, phosphorus promotes root growth (McAfee, 2003). These results were in line with different scientists (Mantur, 1988; Khan and Amanulah (2007) who recorded maximized root length with optimum level of NPK. The yield per plant was increased with each increase in the SWE level up to SWE level of 1%. Supply of phosphorus could bring an improvement in these parameters up to P level of 200 ppm only. The Interaction effect was the highest at the combination of SWE and P. Therefore, it can be summarized that better yield per plant was recorded by the SWE and P treatments individually or in combination. Insignificant increase at higher dose of SWD (1.5%) and significant decrease at higher dose of phosphorus (300 ppm) were recorded. This combination could have encouraged the plant to give up more dry matter by increasing the photosynthetic surface area or number of leaves leading to better outturn of photosynthetic substances, which have stimulated more buds and lead to a better number of branches per plant. Not only more number of floral buds were stimulated but also the expansion of stem length and their axes at combination of SWE and phosphorus. Similar results were reported by Abd El-Raheem and Hamdoon (2014), Shaukat *et al.* (2012) and Dalvi *et al*. (2008) on gladiolus. The number of tuberous produced per plant was increased as the dose of seaweed extract and phosphorus at 1% and 200 ppm (P), respectively. After these levels there was still some marginal increment in the tuberous yield, but it was not significant. This might be due to the fact that there was increasing in the supply of photosynthates into tuberous roots as the external supply of nutrients when increased up to a threshold levels of SWE and P. An increase beyond SWE and P could not produce significant improvement, which might be due to their toxic effect at higher dosages or negative interactions with other nutrients suppressing their availability and consequently reducing the partitioning of assimilates into the tuberous and leaves. These results are in conformity with the findings of Shaukat *et al*. (2012), Patel *et al.* (2010), Zubair *et al.,* (2007) and Ramesh and Raman (2006) in gladiolus. From this present study, it seems to be clear that "SWE" was the most effective especially at the level concentration (1%), may be due to that seaweed extract as a natural product containing organic matter, a lot of macro and micro elements and some plant growth regulators (Gallen and Hemingway, 1965) which induce the plant to grow well, faster and early maturity leading to high plant productivity. Early maturity in *dahlia* plant is very important because it might avoid the crop from the diseases as reported by Potter, 2005. Seaweed extract has an important role to make the plant immunity stronger, so that lead to give healthy plant with high production. Some reports have indicated enhanced plant yield and health in different crops following application of the seaweed extract, although the mechanism of action have not been determined (Colapietra and Alexander, 2006 and Sivasankari*, et al*., 2006). It is possible to conclude that the application of "SWE" at 1% was the most effective concentration. So we can recommend using "SWE" as organic fertilizer to get more safety organic culture for human health and ecology.

E- Soil Properties:

Before P fertilizer application, the average of soil pH in the selected plots was 8.15. After applying the fertilizer treatments, the mean measured pH of the SWE-fertilized soil was 7.72, which is significantly ($P <$ 0.05) lesser than TSP-fertilized soils, which had a pH of 7.80 (Table 6). The TSP-fertilized and SWE-fertilized soils received ammonium nitrate each year. The treatment of SWE-fertilized soil at 1.5, 1 and 0.5 % levels increased total C by 74, 65 and 55 %, respectively, compared to the control. While, in the TSP-fertilized soil (100, 200 and 300 ppm) treatments, total C was increased by 29.8, 50.38 and 42.3 %, respectively, compared to the control, (Table 6). Also, total N was increased in SWE-fertilized soil (0.5, 1 and 1.5%) treatments by 53, 80.61 and 72.18 %, respectively, compared to the control. It recorded increasing in total N in the TSP-fertilized soil (100, 200 and 300 ppm) treatments by 28.89, 48.39 and 42.86 %, respectively, compared to the control and due to greater C and N inputs to soil from SWE than chemical fertilizers. We supplied about the same amount of plant-available phosphate to SWE and TSP treatments (30 kg Mehlich-3 P ha^{-1} yr^{-1}), but the total P input was higher in SWE-fertilized soils, about 80 kg total P ha^{-1} yr^{-1}. There were numerically higher total P and Mehlich-3 P concentrations in SWE-fertilized than TSP-fertilized soils, but these were not statistically different (Table, 6). Seaweed extract treatments (0.5, 1 and 1.5 %) increased the labile phosphate by 48.44, 62.5 and 52.86 % and water-extractable phosphate by 53.27, 72.08 and 64.76 %, respectively, compared to the control (Table, 6). If phosphate desorption, dissolution and mineralization from SWE was greater in soil than predicted from Mehlich-3 extracts, then the SWE-fertilized soil may contain more water-soluble phosphate than those added in the TSP form. Another explanation is assumed on the phosphate binding strength. SWE-P weakly interacts with soil Fe/Al hydroxides forming bonds on the external surface due to its association with organic macromolecules. Such macromolecules may be subject to gradual P decomposition by microbes, releasing P into solution. On the other hand, TSP-P may be strongly sorbed onto the functional groups of Fe/Al hydroxides or diffuse into soil particles, thus limit P availability with time (Linquist *et al*., 1997).

Soil Surface Charge

We chose one level from every fertilize, SWE-fertilized soil at level 1% and TSP-fertilized soil at 200 ppm on the basis of the two are the best. SWE-fertilized soil had more negative surface charge than TSP-fertilized soil in soil suspensions from pH 3 to 10 (Fig. 1). For example, at a soil suspension pH of 6, the relative surface charge in SWE-fertilized soil was 4.05 cmol (-) kg^{-1}, about 37% greater than in TSP-fertilized soils, where the relative surface charge was only 2.96 cmol (-) kg^{-1}. We speculate that SWE generates organic acids, which bind to soil surfaces, thus increasing the net negative charges on the surface of soil particles. This is consistent with the higher pH value in SWE-fertilized soils than TSP-fertilized soils (Table 6), which indicates more negative charge on the particle surface of soils amended with the SWE than TSP.

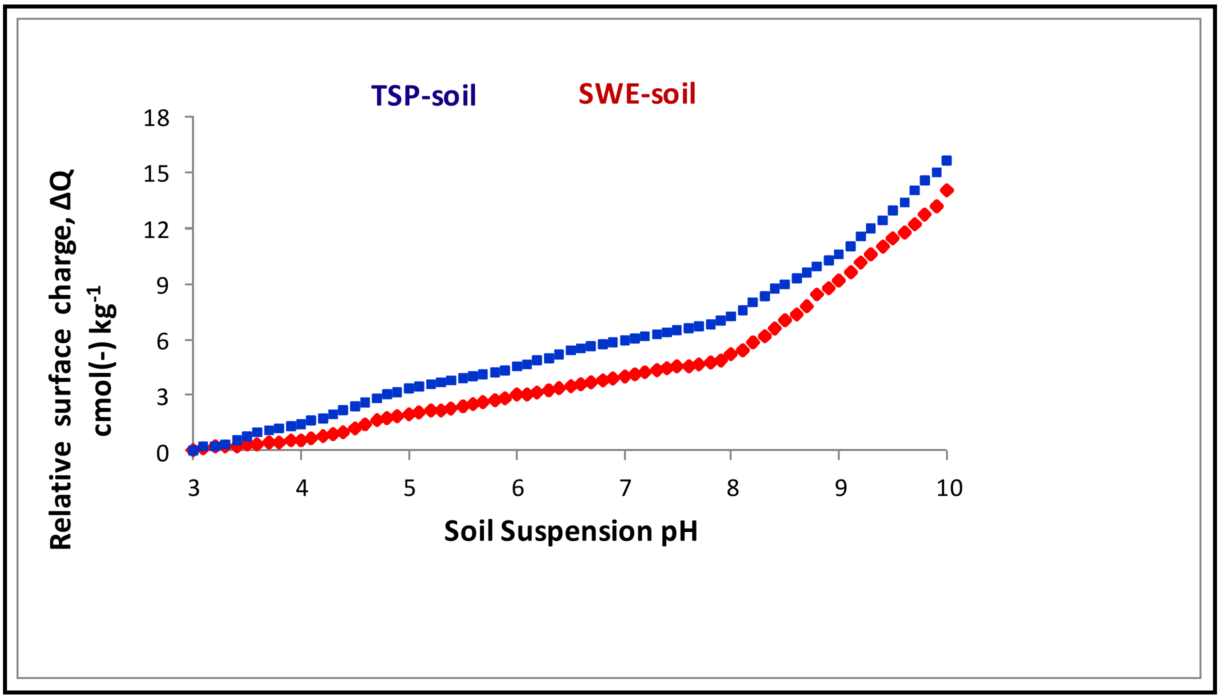

Fig. 1. Soil relative surface charge in SEW-fertilized soil (SWE-soil) and triple superphosphate-fertilized soil (TSP-soil). Data were pooled from four replicates of the field experiment.

Phosphate Adsorption

Soils treated with SWE had significantly lower phosphate adsorption than the TSP-fertilized soil (Table 7). At (pH = 6.0) or at extreme conditions (pH 3 or 10), SWE-soil demonstrated lower phosphate adsorption than TSP-fertilized soil (Fig. 2a, b and c). One explanation for the decrease in phosphate adsorption in SWE-amended soil is that some phosphorus adsorption sites in the SWE-soil were occupied by the negatively charged organic acids, as indicated more negative charges on the surface of SWE-soil (Fig. 1). To investigate phosphate binding strength, a Langmuir 2- surface model was used to fit adsorption data for SWE and TSP-fertilized soils (Fig. 2). The parameters generated from the 2-surface model showed that phosphate adsorption took place on two types of surface: the first type of phosphate adsorption is a high-energy surface ($SOH2^+$ discussed in Jiao *et al.*, 2004), which has high binding strength (K_1) but low adsorption maxima (Q_{max1}); another type of phosphate adsorption is low-energy surface (SOH discussed in Jiao, 2005), which has low binding strength (K_2) but high adsorption maxima (Q_{max2}) (Table 8). The binding strength on the high-energy surface (K_1) was about 50 times greater than on the low-energy surface (K_2). Thus, more than 90% of the native adsorbed phosphate ($Q_{nat.P}$) was distributed on the high-energy surface (Table 8). The obvious difference between SWE and TSP fertilizer treatments lies in the binding strength (K_1 and K_2) on both energy surfaces. The K_1 and K_2 values were about 50% lower for SWE- soil than TSP-fertilized soil (Table 8). Since the K_1 and K_2 values reflect not only the binding strength of observable adsorbed phosphate but also it reflects the native adsorbed phosphate, we suggest that native adsorbed phosphate ($Q_{nat\cdot P}$) in SWE-soil is less strongly retained, thus more easily released into soil solution. Numerous studies have suggested that phosphate adsorption is an inner sphere specific adsorption process, involving ligand exchange with anions such as OH^- (Hingston *et al.*, 1967; Bhatti *et al.*, 1998). Theoretically, phosphate adsorption should be accompanied by the release of OH^-, thus the solution pH value should increase. This was observed when phosphate solution with pH 10 was added to soil (Fig. 3c), but not with solutions having pH 3 (Fig. 3a) and pH 6 (Fig. 3b).When a KH_2PO_4 solution with pH 3 was added, 85% of the phosphate is $H_2PO_4^-$ and 15% is H_3PO_4 according to phosphate speciation calculated with Visual Minteq (Gustafsson, 2004). After 24-h reaction with soils, solution pH reached 5.17 with SWE-soil and 4.46 with TSP-fertilized soils (Fig. 3a). The pH change would shift all the solution phosphate to $H_2PO_4^-$ and release H^+ from H_3PO_4 into the solution. The release of H^+ from the dissociation of H_3PO_4 may compensate for the OH^- released from phosphate adsorption, thus there was no change in solution pH (Fig. 3a) despite the increase of phosphate adsorption at higher phosphate concentration in equilibrium solutions (Fig. 2a).

Assiut J. Agric. Sci., (49) No. (1) 2018 (159-188) ***ISSN: 1110-0486***
Website: *www.aun.edu.eg/faculty_agriculture/journals_issues_form.php* ***E-mail: ajas@aun.edu.eg***

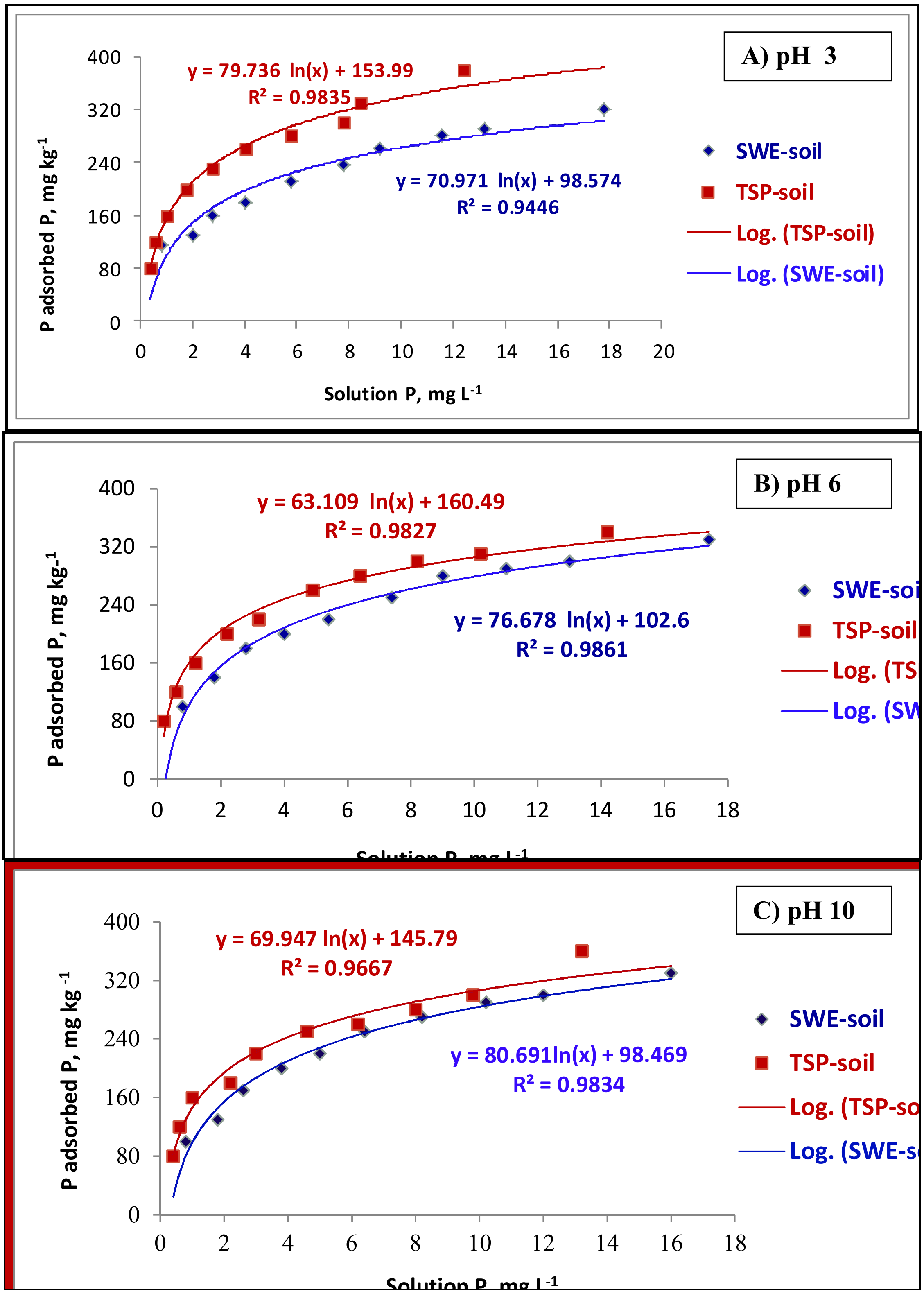

Fig.2. Phosphate adsorption (adsorption of added phosphate + native adsorbed phosphate) in SWE- fertilized soil (SWE-soil) and triple superphosphate-fertilized soil (TSP-soil) from phosphate solutions adjusted to (a) pH 3; (b) pH 6; and (c) pH 10. Dashed and solid lines were fitted using a Langmuir 2-surface model. Data points were from one replicate soil.

Table 7. Adsorption of added phosphate as affected by fertilizer sources.

Phosphate added✞	Adsorption of added phosphate SWE-soil#	TSP-soil§
mM	mg P kg^{-1}	
0	- 6.75 ± 2.66¶	-1.93 ± 0.82
0.1	32.2 ± 4.0	41.7 ± 1.8
0.2	66.6 ± 5.2	83.4 ± 3.0
0.3	94.1 ± 7.3	121 ± 4.0
0.4	121 ± 8.0	155 ± 5.0
0.5	142 ± 9.0	186 ± 6.0
0.6	161 ± 10	211 ± 6.0
0.7	183 ± 11	236 ± 6.0
0.8	200 ± 12	255 ± 9.0
1.0	229 ± 12	295 ± 11
t- test (2-sample paired, n = 40) : SEW-soil vs TSP-soil.		
Pr >t	*< 0.0001*	

✞ Phosphate solution pH = 6.0
 # SWE-soil: SEW-fertilized soil
§ TSP-soil: triple super phosphate-fertilized soil.
¶ Mean ± standard error of four replicate soils from the field experiment.

Table 8. Parameters obtained from the Langmuir 2-surface model for P adsorption data†

Parameter	SWE-soil ‡	TSP-soil§
	High-energy surface	
K_1	2.161	4.082
Q_{max1}, mg kg^{-1}	173	202
$Q_{nat.p1}$, mg kg^{-1} ¶	91	74
	Low-energy surface	
K_2	0.045	0.088
Q_{max2}, mg kg^{-1}	390	352
$Q_{nat.p1}$, mg kg^{-1} #	9	4
Model R^2	0.9999	0.9999

†Data of four replicate soils from the field experiment.
‡SWE-soil: SEW-fertilized soil.
§TSP-soil: triple superphosphate-fertilized soil.
¶Native adsorbed phosphate on high-energy surface.
#Native adsorbed phosphate on low-energy surface.

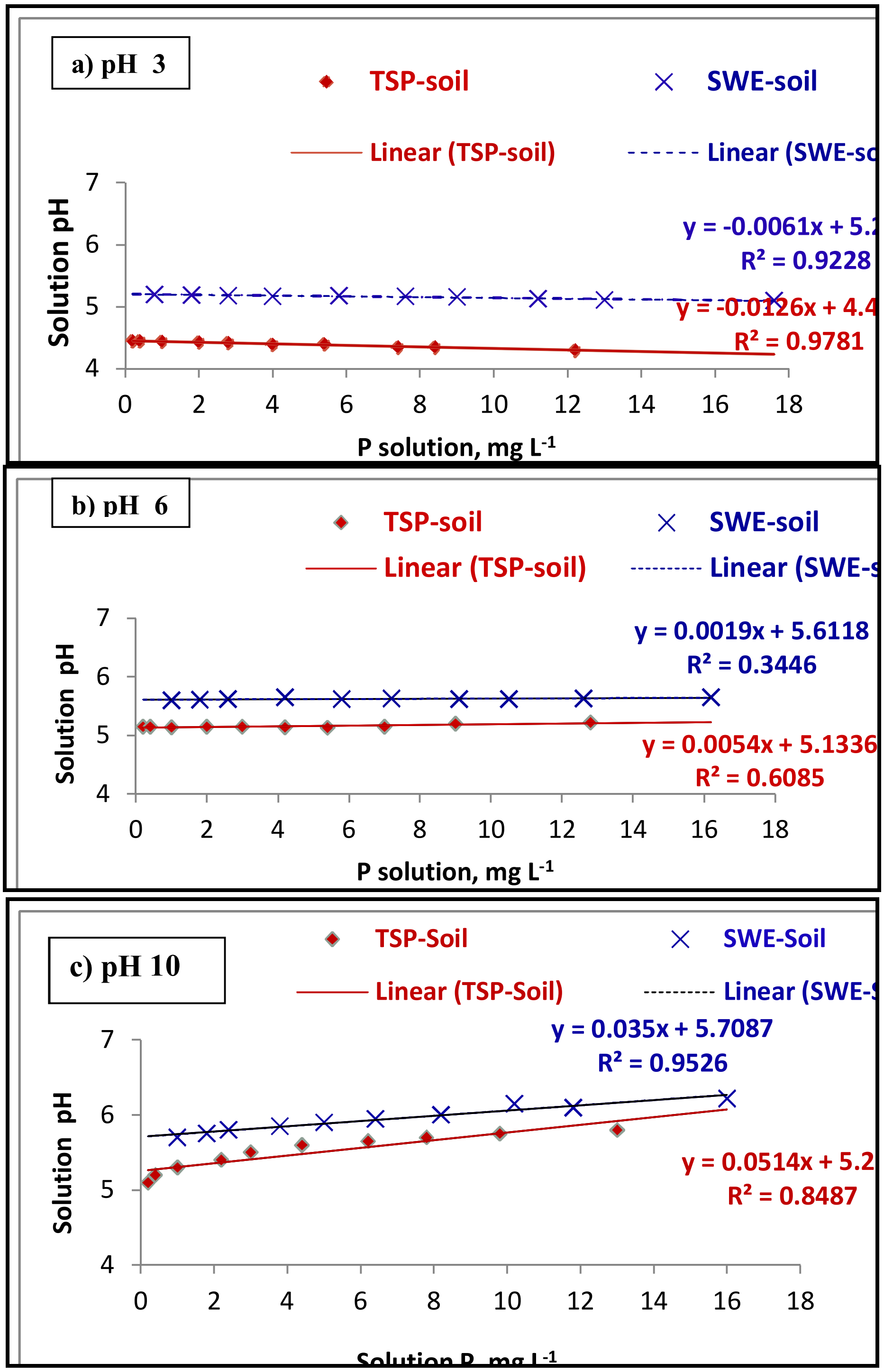

Fig. 3. The relationship between pH and phosphate concentration in the equilibrium solution from phosphate adsorption study. SWE-fertilized soil (SWE-soil) and triple superphosphate-fertilized soil (TSP-soil) are the same as in Fig. 1, and results are from one replicate soil. The added phosphate solution pH was: (a) pH 3 (b) pH 6; and (c) pH 10.

Conclusion

From the above mentioned results it can be concluded that, the application of some bio stimulants as phosphorus, seaweed extract (SWE) and their combinations positively enhanced plant growth, development, yield and the mineral composition of *Dahlia* plants cultivated in sandy soil. The promotion effect of such treatments (P, SWE and their combinations) on enhancing the growth, development and yield of *Dahlia* plants is due to enhance cultivation use efficiency of sandy soil by increasing water holding capacity, ion exchange and nutrients availability and can reduce the application of the chemical fertilizers. In a conventionally, SWE applications increased the net negative charge on soil particle surface, compared with TSP fertilizer. This may have caused more repulsion of phosphate anions and thus reduced the amount of phosphate adsorbed on surfaces of SWE-fertilized soils, relative to TSP-fertilized soils. Fitting phosphate adsorption data to the Langmuir 2-surface model revealed that the native adsorbed phosphate in SWE-fertilized soils was loosely retained compared with TSP-fertilized soils. Thus, SWE-soil had a greater phosphate desorption capacity and would release more phosphate into soil solution than TSP-fertilized soils. We propose that seaweed alters soil physiochemical properties in a way that elevates the soil solution phosphate level, making it a more efficient source of plant-available P than TSP when added on an equivalent soluble phosphate level to a high fertility soil.

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DOI: 10.21608/ajas.2018.8230
El-Alsayed, et al., 2018 *http://ajas.journals.ekb.eg/*

تأثير مستخلص الطحالب البحرية والسلوك الكيميائى للفوسفور المضاف على إنتاجية نباتات الداليا

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الملخص

اجريت تجربة أصص بأرض رملية لمدة موسمين متتاليين ٢٠١٤/٢٠١٥ ، ٢٠١٥/٢٠١٦ وإنماء نباتات الداليا فيها. وكان الهدف من الدراسة تاثير اضافة الفوسفور فى الأرض وسلوكه الكيميائى باربع تركيزات مختلفة : صفر ، ١٠٠ ، ٢٠٠ ، ٣٠٠ جزء فى المليون واضافة الطحلب Oligo – x فى الأرض باربع مستويات صفر، ٠,٥ % ، ١ % ، ١,٥% على النمو الخضرى والزهرى والدرنى والمحتوى الكيماوى للنباتات من العناصر (النتروجين–الفوسفور– البوتاسيوم) والمحتوى الكلى للكلورفيل والكربوهيدرات وكيفية تأثر الشحنة السالبة وعمليات إدمصاص الفوسفات بإضافة الطحالب البحرية والسوبر فوسفات سنويا. ومن أهم النتائج التى تم الحصول عليها: أنه بصفة عامة ادى اضافة مستخلص الطحالب البحرية عند مستوى ١% الى زيادة معنوية فى معظم الصفات الخضرية (زيادة فى طول الساق والوزن الجاف وعدد الاوراق/ فرع ووزنها الجاف والمساحة الورقية وكذلك الصفات الزهرية حيث ادى الى زيادة فى قطر النورات وطول فترة الازهار على النبات والوزن الجاف للنورات فى حين ادت هذه المعاملة الى تبكير موعد الازهار معنويا بالمقارنة الكنترول فى كلا الموسمين. كما أدى الى زيادة الوزن الطازج للدرنات الجذرية وعددها/ نبات وفى الوقت نفسه وجد أيضا زيادة معنوية فى محتوى الاوراق من العناصر كنسبة مئوية (نتروجين– فوسفور– بوتاسيوم) والمحتوى الكلى من الكربوهيدرات والكلوروفيل فى كلا الموسمين مقارنة بالكنترول. وبالتالى نلاحظ أن اضافة مستخلص الطحالب البحرية إلى التربة عند المعدل ١% أدى الى زيادة معنوية فى جميع الصفات السابقة بالمقارنة بمعاملة الكنترول فى كلا الموسمين ماعدا موعد الازهار الذى ادت المعاملة بمستخلص الطحالب البحرية الى تبكير موعد الازهار معنويا بالمقارنة بالكنترول. بالنسبة للارض نجد أنه بعد إضافة الطحلب البحرى لمدة موسمين أعطى شحنة سطحية سالبة أكثر فى معلقات التربة تزيد عن ٣٧ % من أرقام حموضة من٤ إلى ٧ بالمقارنة بالأرض المسمدة بالسوبر فوسفات. أما إدمصاص الفوسفات فكان أقل بنسبة ٢٣ % للأرض المعاملة بالطحالب الحمراء مقارنة بالأرض المعاملة بالسوبر فوسفات. تم نمذجة بيانات إدمصاص الفوسفات (إدمصاص الفوسفات المضاف والفوسفات المدمص الموجود طبيعيا)عن طريق معادلة لانجماير ذو السطحين التى أظهرت أن قوة الربط للفوسفات متضمنة الفوسفات المدمص الموجود طبيعيا كان أقل بنسبة ٥٠% فى الأرض المسمدة بالطحلب البحرى مقارنة باللأرض المسمدة بالسوبر فوسفات. تشير النتائج إلى أن الطحالب البحرية التى أدت إلى زيادة الشحنة السطحية السالبة خفضت أيضا من قدرة الأرض على إدمصاص الفوسفات. تظهر عمليات إدمصاص الفوسفات أن إرتباط الفوسفات كان ضعيفا فى الأرض المسمدة بالطحالب البحرية مقارنة بالأرض المسمدة بالسوبر فوسفات. نحن وجدنا أن الطحالب البحرية لم تنقص فقط إحتفاظ التربة بالفوسفات ولكن أيضا تزيد من تحرر الفوسفات إلى المحلول الأرضى. يتضح من هذه التجربة أنه يمكن إنماء نباتات الداليا فى أرض رملية بإضافة مستخلص الطحالب البحرية عند تركيز ١% والسوبر فوسفات عند تركيز ٢٠٠ ppm للحصول على نمو خضرى وزهرى ودرنى جيد وتراكم اعلى للعناصر الغذائية الاساسية والكلورفيل والكربوهيدرات الكلية.