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EFFECT OF PHOSPHORUS FERTILIZATION, FOLIAR APPLICATION WITH SEAWEED EXTRACTS AND MICRONUTRIENTS ON VEGETATIVE GROWTH AND DRY SEED YIELD OF OKRA (*ABELMOSCHUS ESCULENTUS* L.)

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ABSTRACT: This field trial was carried out at Sidi Salem district, Kafr El-Sheikh Governorate, Egypt during the two summer seasons of 2017 and 2018 on okra plants (*Abelmoschus esculentus* L.) cv. Baladi to study the beneficial effects of different levels of phosphorus fertilizer i.e. (0, 30 and 45kg P_2O_5) with micronutrients; Fe, Zn and Mn at 1g/L, or seaweed extract at 3cm/L on plant vegetative growth, dry seed yield and nutrient uptake of okra. All studied treatments were arranged in a split plot design with three replicates. The results showed that adding phosphorus fertilizer at 30kg P_2O_5 with seaweed extract at 3cm/L to okra plants produced significantly higher values of vegetative growth, total dry seed yield and chemical composition of okra plants followed by phosphorus fertilizer at 30kg P_2O_5 with Fe at the rate of 1g/L. This shows a significant improvement for okra cultivation by application of phosphorus fertilizer combined with seaweed extract or micronutrients

Key words: Okra, phosphorus fertilizer, seaweed extract, Fe, Mn, Zn, growth, dry seed yield, seed quality

INTRODUCTION

Okra (*Abelmoschus esculentus* L.) is an important fruit vegetable crop of the tropical and subtropical regions of the world. In Egypt, it is one of the most popular vegetables and considered a valuable source of vitamins and minerals with good medicinal properties. It has been grown for its edible green pods which can be used as fresh, canned, frozen or dried food. The seed is the prime factor that determines the quantitative and qualitative characteristics of the crop that is going to be harvested later on. Therefore; more attention must be directed towards increasing seed yield with good quality. Successful production of okra seed is conditional to certain agricultural practices.

Algae extract as a new bio-fertilizer containing minerals nutrition and some growth regulators, polyamines, natural enzymes, carbohydrates, proteins and vitamins which applied to improve vegetative growth and yield (Abd El-Moniem and Abd- Allah, 2008).

Algae are classified into three groups; namely green, brown and red based on their pigments. Different forms of algae have been reported to produce beneficial effects on some vegetable crops (Abd El-Mawgoud *et al*., 2010). They are a natural bioactive materials rich in minerals, protein, lipids, carbohydrates, vitamins and microelements (Co, B, Mo, Zn, Cu). In addition, seaweed fertilizer is a unique combination of N, P, K, trace elements and simple sugar that are in dissolved forms that are easily absorbed through roots and leaves besides releasing trace elements bound to the soil (Chapman and Chapman, 1980) and it is safe to human, animals and the environment (Sathya *et al*., 2010).

Phosphorus is an element key in the formation of high energy compounds, such as AMP, ADP and ATP, which play an essential role in photosynthesis and respiration. It is a vital component of nucleic acids and phospholipids. Plants take up phosphorus in the inorganic form, mainly as the orthophosphate H_2PO_4 ion. Phosphorus supports early phase of crop development, synchronizes the germination process and leading to enhance the final yield, especially in P deficient soil (Asgedom and Becker, 2001 and Arif *et al*., 2005). It increases crop resistance to diseases. In contrast to N, deficiency symptoms of P most often, occur in seedlings and young plants. Since P is mobile within the plant, symptoms appear on the lower leaves/parts of the plants (Khalil, 2006).

Micro nutrients are required for optimal growth (Ahmad *et al*., 2011 and Ahmad *et al*., 2009) specifically six micronutrients (Zn, B, Fe, cu, Mo, Mn) play vital roles in plant physiology and biochemical processes (Putra *et al*., 2012 and Rab and Haqm, 2012). Zinc influence on basic plant life processes, nitrogen metabolism, uptake of nitrogen and protein quality, photosynthesis, chlorophyll synthesis, soil is inaccessible to plant roots if carbon anhydrate activity; resistance to a biotic and biotic stresses, protection against oxidative damage Cakmak (2008), membrane integrity and phytochrome activities Shkolnik (1984).

Iron (Fe) is an important micronutrient for chlorophyll formation, photosynthesis, enzyme systems and respiration of plants (Havlin *et al.,*1999). Sometimes Fe application might cause nutritional disorder by its antagonistic effect with other cationic micronutrients, in particular with Mn (Ghasemi and Ronaghi, 2008). Besides, application of these nutrients in, soil is inaccessible to plant roots if soil pH is more (Rashid and Ryan 2004) and biotic. Foliar spray of micronutrients is more effective to control deficiency problem than soil application (Torun *et al.,* 2001).

This study aimed to investigate the influence of different phosphorus fertilizer levels and foliar applications of micronutrients or seaweed extract on vegetative growth, dry seed yield, seed quality and chemical constituents of okra plants.

MATERIALS AND METHODS

This field trials were conducted during the two summer seasons of 2017 and 2018 at Sidi Salem district, Kafr El-Sheikh Governorate, Egypt on okra (*Abelmoschus esculentus* L.) Baladi cv. Sample of the soil was taken to determine the physical and chemical properties according to (Black, 1965 and Page *et al*., 1982). Chemical analysis is shown in Table (1).

The plot area was 11.2 m^2 and included 4 ridges, each ridge of 0.7cm width and 4 m length. Seeds of okra were sown at the first week of April in both seasons in hills on one side of ridges at 25 cm apart.

Table (1): Chemical analysis of soil used in the present study

pH	E.C (dS/ m)	O.M	Soluble cations (M/L)				Soluble anions (M/L)				Macro elements (ppm)			Micro elements (ppm)			
			Ca^{+2}	Mg^{+2}	Na^{+}	K^{+}	CO_3^{-2}	HCO^{-3}	Cl^{-2}	SO_4^{-2}	N	P	K	Fe	Cu	Zn	Mn
8.25	2.31	2.19	5.34	4.12	12.3	0.16	-	3.48	14.2	4.23	81	6.3	58.8	3.0	6.8	2.18	2.17

The treatments were arranged in a split plot design as follows:

I. The main plots were assigned in tow levels of phosphorus fertilizer (calcium super phosphate, 15.5% P_2O_5) beside the control was added as soil application during soil preparation as follows:

A- 30Kg P_2O_5/fed. (200kg/fed. calcium super phosphate, 15.5% P_2O_5)

B- 45kg P_2O_5/fed. (300kg/fed. calcium super phosphate, 15.5% P_2O_5)

II. The sub plots were assigned for four foliar applications beside the control (without spraying) that applied at three times (after 30, 45 and 60 days from sowing date) as follows:

A- Algae extract at 3cm/L.

B- Fe at 1g/L.

C- Mn at 1g/L.

D- Zn at 1g/L.

Algae extract strain; *Spirulina platensis* was obtained from El-Natron valley, Algal Biotechnology Unit, National Research Center (N.R.C). The extract contains 40-60% of Algal biomass. Algae extract was analyzed before spraying and the algal chemical analysis is shown in Table (2).

The sources of microelements of Fe, Mn and Zn were Fe-chelated (12%), Mn-chelated (12%) and Zn-chelated (12%), respectively. All required agricultural managements of okra production such as irrigation, fertilization and pest control of studied area were followed according to the recommendations of Egyptian Ministry of Agriculture.

The following data were recorded in the present study.

1- Vegetative growth characteristics

At flowering stage (after 50 days from sowing date), five plants were randomly taken from each experimental plot to evaluate vegetative growth characteristics i.e. plant height (cm) , number of leaves/plant, leaf area (cm^2) and the total fresh as well as dry weight/plant (g). The plant organs of foliage (leaves, stems and branches) were dried at 70 C^o till constant weight and then the dry weight/plant was recorded.

2- Dry seed yield and its components

At full seed ripening stage (after 120 days from sowing date), a random sample of 5 plants were taken from each plot and dry pods were picked to estimate dry seed yield components i.e. number of dry pods/plant, number of dry seeds/pod, seed index (100 seeds weight) and dry seed yield, while the total dry seed yield (kg/fed) was calculated through dry seed yield / plot.

3- Chemical composition of dry seeds

A sample of 0.2 g from fine powder of dry seeds was digested in a mixture of sulphuric and perchloric acids according to Piper (1947) to estimate N, P, K and protein (%) in dry seeds. Total nitrogen (%) was determined by using the modified "Micro-Kjeldahl" method apparatus of Parnas and Wagner as described by Pregl (1945). Phosphorus (%) was estimated spectrophotometrically in dry seeds according to the method described by Murphy and Riley (1962) as modified by John (1970). Potassium was determined by flame-photometrically as described by Brown and Lilleland (1946). Iron (Fe) and Zinc (Zn) were extracted using DTPA, (Lindsay and Norvell, 1978).

Table (2): Algae extract analysis

Element	N%	P%	K%	Mg%	Ca%	Fe (ppm)	Zn (ppm)	Mn (ppm)	Cu (ppm)
Concentration	13.3	2.22	2.13	0.11	0.23	4644	21	954	1300

4- Seed germination test

Okra dry seeds were treated with fungicide (Topsin M 70%wp), then were put it in filter paper inside germination incubator at 25 C^{o}. Germination experiment was conducted to test i.e. germination % and germination rate as follows:

$$\text{Germination \%} = \frac{\text{No. of germinated seeds}}{\text{No. of sown seeds}} \times 100$$

$$\text{Germination rate} = \frac{(G1 \times N1) + (G2 \times N2) + \ldots\ldots\ldots\ldots\ldots (Gn \times Nn)}{G1 + G2 + \ldots\ldots\ldots\ldots\ldots Gn}$$

Where: G = Number of germinated seeds in certain day, N = Number of this certain day

5- Statistical analysis

The obtained data were subjected to the statistical analysis of variance and treatment means were compared according to the Less Significant Differences (L.S.D. at 0.05 %) as described by Snedecor and Cochran (1990).

RESULTS AND DISCUSSION

I- Vegetative growth parameters

Results in Table 3a showed that phosphorus fertilizer at 30kg (P_2O_5) increased significantly all vegetative growth parameters (plant height, number of leaves and branches, leaf area as well as fresh and dry weight/plant). However, increasing P-application at 45kg P_2O_5/fed did not significantly increase any growth parameters in both seasons. Such increment in plant growth by P-application could be referred to the role of P on root proliferation and growth (Tisdale and Nelson, 1975 and Ohlrogge, 1962) as well as its effect on cell energy through organic phosphate compounds; ADP and ATP. This favorable role of P-application level vegetative growth parameters are in agreement with those results obtained by, Uddin *et al.,* (2014) which illustrated adding phosphorus on okra plants with 80 or 90kg P_2O_5/ha. They found these rates significantly increased number of leaves and branches/plant. Also, El-Waraky (2014) found that increasing applied phosphorus fertilizer rate up to 45kg P_2O_5/fed gave the highest values of plant height, number of leaves and branches/pant of okra plants. Likewise, Ahmed *et al.,* (2015) mentioned that application of 75kg P_2O_5/fed to okra plants obtained the highest values of plant growth.

Foliar application of seaweed extract at the rate of (3cm/L) was the most effective treatment on growth parameters, as compared with the other treatments or the control, during the both seasons (Table 3a). The enhancement effect of algae extract on okra plants growth may be attributed to the auxin content of the algae extract which has an effective role in cell division and enlargement that leads to increase the shoot growth (Lopez *et al*., 2008), number of leaves and plant dry weight (Gollan and Wright, 2006) where it is a rich source of potassium and contains considerable amounts of Ca, Cu, Fe, Mg, Mn, P and Zn (Marrez *et al.,* 2014). It also contains macronutrients (N, P and K) which are very essential for growth and development of the plant (Chapman and Chapman, 1980 and Attememe, 2009). These obtained results agreed with those reported by Tensingh *et al.,* (2017) reported that **algae extract application significantly promoted the growth characters of Okra. Ismail (2016) on common bean showed that adding algae extract at 5cm/L resulted in the highest values of growth compared with untreated plants. Furthermore, similar results were found by Mohamed *et al.,* (2016) on chickpea, Abbas (2013) on *Phaseolus vulgaris*, Anna *et al.,* (2013) on common bean, Dalia and Sabreen (2014) on pea and Khattab *et al.,* (2015) on faba bean. Vyomendra and Kumar (2016)**

mentioned that algae play an important role on growth characters such as stem length, fresh and dry weight/plant.

Concerning interaction effects between phosphorus fertilizer levels and spraying treatments on vegetative growth characteristics, data in Table (3b) pointed out that higher vegetative growth parameters were obtained with the most superior treatment 30kg P_2O_5/fed with seaweed extract at the rate of 3cm/L followed by 30kg P_2O_5/fed with Fe at the rate of 1 gm/L as compared with the other tested treatments. The increment in growth parameter may be due to that Algae extract containing minerals nutrition, some growth regulators, polyamines, proteins and vitamins applied to improve vegetative growth (Abd El- Moniem and Abd- Allah, 2008), and the importance role of phosphorus is an element key in the formation of high energy compounds, which play an essential role in photosynthesis which improve vegetative growth (Asgedom and Becker, 2001; Arif *et al*., 2005).

2- Dry seed yield and its components

Results of dry seeds and its components were presented in Table (4a). These indicated that, all dry seed yield components (number of dry pods/plant, number of dry seeds/pod, seed index and dry seed yield) were significantly improved by adding P-fertilizer level from at 30kg P_2O_5/fed. However, increasing P-application level up to 45kg P_2O_5/fed did not increase dry seed yield components as shown in both seasons. The favorable effect of increasing phosphorus application level on dry seed yield is mainly due to its effect on improving plant growth, minerals uptake as shown in Table 5a which consequently improved dry seed yield and its components. The obtained results are in harmony with those of Amjad *et al.* (2001), Chattopahyay *et al.* (2001), Patton *et al.* (2002), Singh (2002), El-Shaikh (2005), El-Shaikh and Mohammed (2009) who observed significant increases in seed yield with phosphorus application to okra plants. In the same line, Sajid *et al.,* (2012), Uddin *et al.,* (2014) El-Waraky (2014) and Ahmed *et al.,* (2015) on okra plants.

Dry seed yield could be considered to be the mirror of all growth features. The results are given in the same Table (4a) cleared that spraying plants with 3cm/L seaweed extract gave the highest dry seed yield components followed by foliar treatment of 1g/L Fe as compared with unsprayed plants. The obtained resulted may be attributed to that the importance effects of seaweed extract is a unique combination of N, P, K, trace elements and simple sugar that are in dissolved forms that are easily absorbed through roots and leaves besides releasing trace elements bound to the soil (Chapman and Chapman, 1980) and it is safe to human, animals and the environment (Sathya *et al*., 2010). However, Fe is an important micronutrient for chlorophyll formation, photosynthesis, enzyme systems and respiration of plants (Havlin *et al.,* 1999).

The obtained results of the favorable effect of algae extract on yield and its components were in harmony with reported by Tensingh *et al.,* (2017) reported that **algae extract application significantly promoted the okra dry seed yield characters. Also, Anna *et al.,* (2013) and Latique *et al.,* (2013) on common bean revealed that foliar application with seaweed gave the highest dry seed yield characters i.e. number of seeds/pod, seed index and shell out. In the same line, Dalia and Sabreen (2014) cowpea plants, Ismail (2016) on common bean. Vyomendra and Kumar (2016) illustrated that spraying cowpea plants with algae improved dry seed yield components (number of dry seeds/pod, 100 seeds wt. and dry seed yield/ha).**

Table (3a): Vegetative growth of okra as affected by phosphorus fertilizer levels and foliar application with seaweed extract and micronutrients during the two summer seasons of 2017 and 2018

Seasons / Treatments	1st Season						2nd Season					
	Plant height (cm)	No. of leaves/ plant	No. of branches / plant	Leaf area (cm^2)	Fresh weight (g/plant)	Dry weight (g/plant)	Plant height (cm)	No. of leaves/ plant	No. of branches/ plant	Leaf area (cm^2)	Fresh weight (g/plant)	Dry weight (g/plant)
Phosphorus fertilizer												
Control (0 P_2O_5)	73.84	18.17	4.83	482.4	77.90	13.5	75.84	19.17	5.22	521.7	80.51	13.00
30kg P_2O_5	98.27	26.33	6.60	566.1	95.91	21.69	100.4	27.91	7.07	654.1	98.35	25.69
45kg P_2O_5	87.32	25.91	5.08	506.4	84.47	18.22	89.06	25.59	6.79	582.4	85.55	19.23
L.S.D at 0.05	2.24	1.53	N.S	42.35	6.15	4.99	1.50	1.39	N.S	34.01	3.34	4.99
Foliar application												
Control (without)	79.19	14.06	5.50	464.9	75.57	13.80	81.19	17.67	5.72	594.90	79.04	13.80
Algae extract (3cm/L)	118.07	27.23	7.55	644.0	104.98	28.45	119.59	28.21	7.65	744.00	115.33	28.45
Fe (1g/L)	94.09	22.61	6.07	599.1	96.78	21.30	92.32	23.06	6.28	699.10	107.74	21.30
Mn (1g/L)	88.07	18.72	5.77	578.7	83.20	16.88	30.18	21.82	5.81	678.70	94.88	18.32
Zn (1g/L)	90.51	20.22	5.11	580.12	90.12	20.23	88.24	20.31	6.53	681.30	97.21	19.22
L.S.D at 0.05%	2.02	1.86	0.49	11.84	6.58	2.81	1.86	1.59	0.65	31.68	3.82	2.81

Table (3b): Vegetative growth of okra as affected by the interaction between phosphorus fertilizer levels and foliar application with seaweed extract and micronutrients during the two summer seasons of 2017 and 2018

Treatments \ Seasons		1st season						2nd season					
		Plant height (cm)	No. of leaves/ plant	No. of branches/ plant	Leaf area (cm2)	Fresh weight (g/plant)	Dry weight (g/plant)	Plant height (cm)	No. of leaves/ plant	No. of branches/ plant	Leaf area (cm2)	Fresh weight (g/plant)	Dry weight (g/plant)
Control (0 P_2O_5)	Control (without)	80.27	15.16	3.83	369.0	74.6	11.9	87.5	16.5	4.5	379.1	88.2	17.9
	Algae extract (3cm/L)	103.77	20.33	6.17	541.0	90.4	19.0	102.2	21.3	6.4	544.0	103.3	18.2
	Fe (1g/L)	97.00	18.83	5.00	505.9	84.4	17.2	93.0	19.7	5.5	512.2	95.0	21.1
	Mn(1g/L)	86.97	16.66	5.33	466.8	78.8	16.9	91.0	19.7	5.8	496.2	89.5	18.5
	Zn (1g/L)	91.47	17.00	4.66	488.6	71.4	17.4	89.0	19.6	5.2	470.4	95.8	19.4
30kg P_2O_5	Control (without)	86.87	18.30	5.50	482.0	89.3	17.0	92.5	18.5	5.6	441.4	93.2	18.8
	Algae extract (3cm/L)	106.83	27.17	8.33	634.7	105.5	28.6	106.0	28.0	8.3	617.4	103.4	28.8
	Fe (1g/L)	98.73	25.33	7.66	601.3	95.8	29.8	91.3	25.2	8.1	595.9	98.5	25.3
	Mn(1g/L)	92.80	22.66	6.83	548.6	93.6	25.9	89.3	21.8	7.7	555.0	86.2	26.2
	Zn (1g/L)	94.47	23.33	6.33	555.8	95.4	27.1	90.0	23.4	7.81	542.5	98.2	25.1
45kg P_2O_5	Control (without)	84.85	17.66	4.17	443.7	72.9	15.5	83.5	18.0	4.0	401.3	85.8	19.3
	Algae extract (3cm/L)	101.00	25.20	6.16	556.2	99.1	22.7	106.0	25.3	6.2	562.1	107.3	22.3
	Fe (1g/L)	94.26	22.66	5.56	539.1	90.2	21.9	93.3	22.3	5.3	520.5	99.7	22.0
	Mn (1g/L)	90.45	20.83	5.16	490.8	87.2	20.9	90.2	19.3	5.6	489.5	88.9	19.9
	Zn (1g/L)	92.58	21.20	5.33	512.2	92.9	21.2	87.7	20.12	5.9	495.7	96.0	19.2
L.S.D at 0.05%		3.50	3.12	1.72	56.92	12.66	5.46	3.11	2.84	1.13	36.92	6.43	3.46

Table (4a): Dry seed yield and its components of okra as affected by phosphorus fertilizer levels and foliar application with seaweed extract and micronutrients during the two summer seasons of 2017 and 2018.

Seasons / Treatments	1st Season					2nd Season				
	No. of pods/ plant	No. of seeds/pod	Seed index 100 seeds wt. (g)	Dry seed yield (g/plant	Dry seed yield (kg/fed)	No. of pods/ plant	No. of seeds/ pod	Seed index 100 seeds wt. (g)	Dry seed yield (g/plant	Dry seed yield (kg/fed)
Phosphorus fertilizer										
Control (0 P_2O_5)	8.11	49.25	6.47	22.54	654.3	9.14	51.21	6.84	24.32	705.3
30kg P_2O_5	17.35	73.11	11.35	47.35	1121.3	18.12	74.35	11.64	48.36	1165.7
45kg P_2O_5	13.45	61.35	9.23	38.27	864.3	14.25	62.54	9.54	40.21	964.3
L.S.D at 0.05	3.57	11.1	2.31	7.23	51.36	2.25	10.32	2.47	6.51	45.87
Foliar application										
Control (without)	10.24	53.00	7.21	27.35	687.4	11.35	53.58	7.44	28.63	712.5
Algae extract (3cm/L)	17.84	73.22	11.45	45.58	1134.2	18.64	74.24	12.10	46.35	1154.8
Fe (1g/L)	14.65	62.68	10.24	37.25	864.1	15.68	63.57	10.88	38.52	904.2
Mn (1g/L)	13.57	60.21	9.84	34.64	831.7	14.38	62.14	10.21	36.21	881.7
Zn (1g/L)	12.55	59.44	8.57	33.57	736.4	13.57	60.57	9.57	35.27	814.6
L.S.D at 0.05%	3.57	6.42	1.01	4.34	47.21	2.57	4.12	2.11	3.54	52.47

Concerning to the interaction, the results in Table (4b) further proved that the highest dry seed yield with the best components were obtained by fertilizing okra plants with 30kg P_2O_5/fed and spraying with 3cm/L seaweed extract. That was the best interaction treatment which produced the highest means values over the other interactions treatments which provided the best characters.

3- Chemical composition of dry seeds

The effect of different levels of phosphorus fertilizer i.e. (0, 30 and 45kg P_2O_5) on okra chemical composition of dry seeds are presented in Table (5a). Data illustrated that macro elements; N, P and K and micro elements (Fe, Zn and Mn) of dry seeds were significantly higher by increasing P-fertilizer level at 30 kg P_2O_5/fed. Whereas, increasing P-application level up to 45 kg P_2O_5/fed did not increase chemical composition of dry seeds in both seasons. Such increment in okra dry seed chemical composition by adding phosphorus could be referred to the role of P on root proliferation and growth (Tisdale and Nelson, 1975 and Ohlrogge, 1962) as well as its effect on cell energy through organic phosphate compounds; ADP and ATP. This favorable role of P- application level vegetative growth parameters and consequently enhances elements of okra dry seeds. These results coincided with those reported by Uddin *et al.,* (2014). Also, Ahmed *et al.,* (2015) mentioned that application of 75kg P_2O_5/fed gave higher values of N, P and K in okra dry seeds.

As for the effect of foliar application with algae extract and micronutrients, data in Table (5a) showed that that the highest values of elements content (%) in dry seeds were observed when okra plants sprayed by seaweed extract at the rate of 3 cm/L followed by Fe at the rate 1 gm/L as compared with the other treatments or the control. These results are consistent with those of Hegazi *et al.,* (2010) on common bean they found that using of algae as bio-fertilizer greatly enhances N, P and K content in seeds. Also, Abbas (2013) on bean cv. Giza 3 mentioned that the algae extraction treatment recorded the highest values of phosphorus compared with untreated plants. Moreover, Anna *et al*., (2013) and Latique *et al.,* (2013) on common bean, Dalia and Sabreen (2014) on pea, Khattab *et al*., (2015) on faba bean and Vyomendra and Kumar (2016) on *Vigna radiata* all revealed similar results.

Concerning to the interaction effects among different phosphorus fertilizer levels and foliar application treatments on chemical composition of okra dry seeds, the results presented in Table (5b) further proved that the highest chemical composition of okra dry seed expressed as, N, P, K, Fe, Zn and Mn were obtained when okra plants fertilized by phosphorus at the rate 30 kg P_2O_5 / fed and seaweed extract at the rate of 3cm/L. These treatments were the best interactions, whichproduced the highest means values for most of characters.

4- Seed germination tests

Seed germination tests as affected by phosphorus fertilizer levels on okra i.e. seed germination ratio (%), germination rate (days), and sprout length (cm) are shown in Table (6a). Such data revealed that increasing P-fertilizer level led to a significant increase in seed germination ratio, germination rate, and sprout length at 30kg P_2O_5/fed in both seasons. However, heavy application of P up to 45kg P_2O_5/fed significantly decreased seed germination, as compared with that of plants supplied with 30 kg P_2O_5 / fed in both seasons. These results coincided with those reported by El-Waraky (2014) Sajid *et al.,* (2012) on okra.

Table (4b): Dry seed yield and its components of okra as affected by the interaction between phosphorus fertilizer levels and foliar application with seaweed extract and micronutrients during the two summer seasons of 2017 and 2018

Treatments / Seasons		1st season					2nd season				
		No. of pods /plant	No. of seeds/pod	Seed index 100 seeds wt. (g)	Dry seed yield (g/plant)	Dry seed yield (kg/fed)	No. of pods/plant	No. of seeds/pod	Seed index 100 seeds wt. (g)	Dry seed yield (g/plant)	Dry seed yield (kg/fed)
Control (0 P_2O_5)	Control (without)	7.35	44.21	6.54	23.47	611.1	7.65	46.51	7.11	23.86	632.5
	Algae extract (3cm/L)	15.35	66.54	9.64	37.21	813.3	15.88	67.24	9.87	37.55	847.3
	Fe (1g/L)	13.71	63.57	8.34	32.45	744.5	13.87	64.11	8.64	33.57	771.3
	Mn(1g/L)	12.36	61.87	7.94	30.58	711.8	12.95	62.21	8.11	31.28	741.6
	Zn (1g/L)	11.84	61.37	8.01	28.21	677.4	12.11	61.25	8.14	29.57	691.4
30kg P_2O_5	Control (without)	10.24	53.00	7.21	27.35	687.4	10.64	53.24	7.35	28.11	700.4
	Algae extract (3cm/L)	18.82	73.22	12.45	45.58	1134.2	19.01	74.25	12.74	46.01	1140.7
	Fe (1g/L)	15.66	66.68	10.24	37.25	864.1	16.12	67.54	10.86	37.58	887.6
	Mn(1g/L)	14.57	63.21	9.84	34.64	831.7	15.64	64.35	10.15	35.11	841.7
	Zn (1g/L)	13.60	59.44	8.57	33.57	736.4	14.21	60.27	9.54	34.13	774.5
45kg P_2O_5	Control (without)	8.54	50.11	7.10	25.24	664.5	9.11	50.29	7.22	26.55	698.4
	Algae extract (3cm/L)	16.35	70.52	11.12	41.35	1000.7	16.55	71.67	11.51	41.88	1107.2
	Fe (1g/L)	14.35	64.55	9.13	35.57	811.7	15.02	65.23	10.52	36.24	841.3
	Mn (1g/L)	13.58	57.64	9.11	32.28	797.5	14.31	60.11	10.33	33.56	811.7
	Zn (1g/L)	12.87	53.51	8.87	31.56	711.3	13.54	68.51	9.12	33.11	764.8
L.S.D at 0.05%		1.54	3.54	1.24	2.14	51.4	1.25	2.54	1.22	2.17	54.2

Table (5a): Chemical constituents of okra as affected by phosphorus fertilizer levels and foliar application with seaweed extract and micronutrients during the two summer seasons of 2017 and 2018

Seasons / Treatments	1st Season						2nd Season					
	N	P	K	Fe	Mn	Zn	N	P	K	Fe	Mn	Zn
Phosphorus fertilizer												
Control (0 P_2O_5)	2.24	0.35	1.12	4.14	2.88	3.17	1.58	0.29	1.12	4.22	2.91	3. 12
30kg P_2O_5	3.24	0.62	1.88	6.54	4.58	4.73	3.57	0.71	1.77	6.70	4.77	4.78
45kg P_2O_5	3.01	0.52	1.51	5.47	4.11	4.57	2.58	0.54	1.51	5.88	4.64	4.11
L.S.D at 0.05	0.24	0.11	0.44	0.66	0.11	0.17	0.51	0.12	0.24	0.41	0.42	0.23
Foliar application												
Control (without)	1.57	0.34	1.21	4.27	2.57	3.37	1.61	0.31	1.14	4.45	2.74	3.42
Algae extract (3cm/L	3.21	0.71	1.94	6.84	4.77	4.71	3.34	0.74	1.84	6.91	4.84	4.81
Fe (1g/L)	2.87	0.63	1.78	6.14	4.32	4.43	3.02	0.61	1.61	6.44	4.44	4.61
Mn (1g/L)	2.55	0.51	1.64	5.73	4.01	4.02	2.66	0.54	1.40	5.87	4.11	4.21
Zn (1g/L)	2.48	0.52	1.53	5.24	3.47	4.04	2.57	0.44	1.34	5.47	3.86	4.13
L.S.D at 0.05%	0.45	0.14	0.22	0.35	0.52	0.12	0.46	0.22	0.21	0.34	0.47	0.14

Table (5b): Chemical constituents (%) of okra as affected by the interaction between phosphorus fertilizer levels and foliar application with seaweed extract and micronutrients during the two summer seasons of 2017 and 2018

Seasons / Treatments		1st season						2nd season					
		N	P	K	Fe	Mn	Zn	N	P	K	Fe	Mn	Zn
Control (0 P_2O_5)	Control (without)	1.57	0.34	1.32	3.87	2.57	3.37	1.61	0.37	1.36	3.92	2.61	3.41
	Algae extract (3cm/L)	3.21	0.71	1.71	6.00	4.77	4.71	3.32	0.75	1.74	6.14	4.80	4.86
	Fe (1g/L)	2.87	0.63	1.66	5.67	4.42	4.43	2.91	0.66	1.70	5.78	4.52	4.57
	Mn(1g/L)	2.55	0.51	1.51	5.22	4.21	4.32	2.62	0.56	1.58	5.36	4.36	4.39
	Zn (1g/L)	2.57	0.54	1.53	5.31	4.12	4.22	2.68	0.58	1.55	5.38	4.28	4.31
30kg P_2O_5	Control (without)	1.87	0.39	1.41	4.27	2.74	3.51	1.91	0.41	1.46	4.31	2.83	3.55
	Algae extract (3cm/L)	3.65	0.82	1.94	6.84	4.91	4.92	3.61	0.84	1.97	6.91	5.02	4.96
	Fe (1g/L)	3.11	0.71	1.78	6.14	4.56	4.72	3.18	0.75	1.81	6.28	4.74	4.77
	Mn(1g/L)	2.74	0.63	1.64	5.73	4.36	4.56	2.81	0.64	1.68	5.93	4.52	4.62
	Zn (1g/L)	2.77	0.60	1.61	5.70	4.28	4.59	2.80	0.64	1.69	5.87	4.59	4.60
45kg P_2O_5	Control (without)	1.74	0.35	1.37	4.11	2.58	3.46	1.78	0.37	1.40	4.21	2.66	3.52
	Algae extract (3cm/L)	3.52	0.74	1.83	6.63	4.74	4.73	3.56	0.77	1.84	6.66	4.81	4.77
	Fe (1g/L)	2.77	0.68	1.68	6.01	4.42	4.59	2.82	0.70	1.70	6.24	4.56	4.62
	Mn (1g/L)	2.61	0.59	1.60	5.54	4.28	4.33	2.68	0.62	1.64	5.78	4.37	4.47
	Zn (1g/L)	2.54	0.54	1.55	5.59	4.19	4.26	2.60	0.58	1.60	5.63	4.28	4.31
L.S.D at 0.05%		0.11	0.13	0.06	0.14	0.18	0.13	0.14	0.11	0.04	0.22	0.22	0.17

Table (6a): Germination ratio (%) , germination rate(days) and sprout length(cm) of okra dry seeds as affected by phosphorus fertilizer levels and foliar application with seaweed extract and micronutrients during the two summer seasons of 2017 and 2018.

Seasons / Treatments	1st season			2nd season		
	Germination ratio%	Germination rate(days)	Sprout length(cm)	Germination ratio%	Germination rate(days)	Sprout length(cm)
Phosphorus fertilizer						
Cont.(0 P_2O_5)	77.9	5.47	15.4	78.7	5.22	16.1
30kg P_2O_5	92.5	2.51	20.1	93.5	2.31	21.3
45kg P_2O_5	86.1	3.47	18.3	87.1	3.24	19.4
L.S.D at 0.05	4.05	0.43	1.3	3.82	0.34	2.4
foliar application						
Control (without)	78.8	5.35	15.4	79.2	5.86	16.1
Algae extract (3cm/L)	92.7	2.37	21.7	93.1	2.36	22.1
Fe(1g/L)	87.8	3.47	18.3	88.2	3.54	19.5
Mn (1g/L)	84.5	4.23	17.5	85.3	4.31	18.6
Zn (1g/L)	83.7	4.15	16.5	84.4	4.11	17.2
L.S.D at 0.05	2.31	0.47	1.63	2.87	0.21	2.4

As for the influence of foliar spraying on okra seed germination tests with seaweed extract and micronutrients, it can be noticed from the same data Table (6a) that the application of seaweed extract at the rate of 3 cm/L followed by Fe at the rate 1 g/L gave the highest seed quality as compared with the other treatments or the control. Thus, the stimulation effect of algae extraction on plant growth and seed yield might reflect on seed quality leading to an increase in germination percentage and subsequently seedling criteria. The positive effect of Iron is an important micronutrient for chlorophyll formation, photosynthesis, enzyme systems and respiration of plants (Havlin *et al.,* 1999), which led to increment of seed germination ratio and rate. The obtained results are in harmony with those of Hegazy *et al.,* (2010) on common bean, El- Nahas and Abd El-Azeem (1999) stated that pretreatment of *Vicia faba* seeds with the extract of *Anabaena variabilis* induced an increase in germination percentage, root growth, seedling dry weight and soluble proteins as compared with untreated seeds. Ismail (2016) on common bean revealed that adding algae extract at 5cm/L resulted in the highest values of seed germination ratio (%), germination rate (days), and sprout length (cm).

According to the interaction effect among phosphorus fertilizer levels and foliar application treatments, the results in Table (6b) obviously showed that the highest germination ratio, germination rate, and sprout length were obtained by adding phosphorus fertilizer at the rate of 30kg P_2O_5 / fed with spraying 3cm/L seaweed extract followed by Fe at the rate 1g/L. as compared with other tested treatments or the control.

Table (6b): Germination ratio, germination rate and sprout length of okra dry seeds as affected by the interaction between phosphorus fertilizer levels and foliar application with seaweed extract and micronutrients during the two summer seasons of 2017 and 2018.

Seasons / Treatments		1st season			2nd season		
		Germination ratio%	Germination rate(days)	Sprout length(cm)	Germination ratio%	Germination rate(days)	Sprout length(cm)
Control (0 P_2O_5)	Control (without)	76.1	5.61	15.7	76.7	5.51	16.7
	Algae extract (3cm/L)	87.4	3.22	17.7	88.0	3.24	18.7
	Fe (1g/L)	85.4	3.91	16.7	86..3	3.82	17.7
	Mn (1g/L)	83.2	4.23	16.3	83.7	4.17	17.3
	Zn (1g/L)	81.7	4.11	16.0	82.7	4.22	17.0
30kg P_2O_5	Control (without)	78.8	5.35	16.3	78.0	3.51	17.7
	Algae extract (3cm/L)	92.7	2.37	21.3	93.7	2.71	22.7
	Fe (1g/L)	87.8	3.47	19.7	88.7	3.44	19.7
	Mn (1g/L)	84.5	4.23	18.7	85.3	4.61	18.7
	Zn (1g/L)	83.7	4.15	17.7	84.7	4.57	18.0
45kg P_2O_5	Control (without)	77.5	5.51	16.7	78.1	5.61	181
	Algae extract (3cm/L)	90.7	2.71	20.8	91.7	2.63	21.3
	Fe (1g/L)	86.0	3.22	18.3	88.7	3.81	19.0
	Mn (1g/L)	82.7	4.66	17.3	84.7	3.94	18.3
	Zn (1g/L)	82.1	4.54	17.3	83.0	3.98	18.7
L.S.D at 0.05		3.9	1.63	1.7	3.2	0.39	24

Conclusion

The current study showed a general positive impact of phosphorus fertilizer with foliar application of micronutrients or seaweed extract on okra plants cv. Balady. Phosphorus fertilizer at the rate of 30kg P_2O_5/fed with spraying seaweed extract at the rate of 3cm/L resulted the highest values of vegetative growth character, total dry seed yield/fed. and chemical constituents in okra dry seeds.

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تأثير التسميد الفوسفاتي والرش الورقي بمستخلص الطحالب البحرية والعناصر الصغرى على النمو الخضرى و المحصول البذري للباميا

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الملخص العربى

اجريت هذه التجربه بمنطقة سيدي سالم بمحافظه كفرالشيخ – جمهوريه مصر العربية خلال الموسمين الصيفين 2017 و 2018 وذلك لدراسة تأثير مستويات مختلفة من التسميد الفوسفاتي هي (صفر،30 ،45كجم P_2O_5 /فدان) بالتداخل مع الرش الورقي بمستخلص الطحالب بمعدل 3سم/ لتر والعناصر الصغري وهي الحديد و المنجنيز والزنك بمعدل 1جم/لتر لكل منها علي النمو الخضري والمحصول البذري الجاف ومكوناته وكذا المحتوي الكيميائي لنباتات الباميه (الصنف البلدي). وقد صممت التجربة بتصميم القطاعات المنشقة مرة واحدة في ثلاث مكررات حيث وزعت مستويات التسميد الفوسفاتي في القطع الرئيسية بينما وزعت معاملات الرش الورقي في القطع المنشقة. وقد اوضحت النتائج ان الرش الورقي بمستخلص الطحالب بمعدل 3سم/لتر مع التسميد الفوسفاتي بمعدل 30كجم P_2O_5 كانت افضل معاملة حيث ادت للحصول علي اعلى قيم للنمو الخضري والمحصول البذري الجاف ومكوناته وكذا المحتوي الكيميائي لبناتات الباميه متبوعا بالرش الورقي بالحديد بمعدل 1 جم/ لتر.

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