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Response of growth characters, chemical content and photosynthetic pigments of hot pepper to foliar application with phosphorus fertilizer and some bio- stimulants extracts

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Abstract

The study was conducted as field experiment to evaluate the effect of different phosphorus rates (phosphoric acid), leaf extract; moringa leaf extract, seaweed extract, and carnation (clove) extract on the growth, chemical composition and fruit yield of pepper (*Capsicum anumm)* during 2020 and 2021 seasons at a private farm located in Al- Abassa, Sharqia, Egypt. The experiment was conducted at the Private Farm and laid out split plot design in a Randomized Complete Block Design (RCBD) with three replicates and included 12 treatments, where the phosphorus fertilizer, and plant extracts (4) in the main plots, and the fertilizer and plant extracts levels (3), i.e. 0, 2, 4 ml / l are distributed in the sub plots. The obtained results are summarized as follows: The treatment of seaweed extract, being the most effective on plant growth characters, chemical content and photosynthesis pigments of pepper leaves, followed by moringa extract, phosphorus fertilizer and carnation extract, respectively. The highest level (4 ml /l) caused an increases in the studied character of growth, chemical content and photosynthetic pigments.

Keywords: Phosphorus fertilizer, moringa leaf extract, seaweed extract, carnation (clove) extract –hot pepper.

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1. Introduction

Hot pepper (*Capsicum annum* L.) belongs to genus capsicum and family solanaceae. It is one of the most important spice crops wisely cultivated around the world for its pungent flavor and aroma [1]. Pepper is the world's most important vegetable after tomato and used as fresh, dried or processed products, as vegetables and as spices or condiments [2]. Pepper fruits are Known to be very rich in vitamins, especially vitamins (A) and (C). It is also a good source of B- carotene, and green fruits contain chlorophyll A and chlorophyll B, which are probably synthesized during chloroplast development [3]. Increasing pepper production and improving fruit quality are important to increase the exported yield. Several factors affect plant growth, yield and fruit quality of pepper, among them the nutritional supplies with phosphorus fertilization and bio-stimulants extracts like as seaweed extracts, moringa leave and carnation extracts. Mineral fertilizer is the major nutrient input source of mineral phosphorus fertilizer improves dry weight of marketable yield and yield contributors through better nutrient uptake, growth and development [1].

Phosphorus is a constituent of nucleic acid and nuclei, P plays a good role in plant metabolism structure and reproduction that cannot be replaced by any other element. The phosphorus esters in plant growth has particular role in the conversion of carbohydrates and in the metabolism of starch. Furthermore, phosphorus is important for the ripening of seeds and fruits. In this concern, [4] and [5] indicated that phosphorus a plication increased pepper yield and improved fruit quality.

The moringa leaf extract is consider as a natural plant growth regulator where, it is a source of zeatin which it is natural derivative of cytokinm, proteins, vitamin E, phenolics, ascorbates, essential amino acid and several mineral elements, making to putting it as a potential natural growth stimulant, as mentioned by [6]. [7] illustrated that moringa extract as a plant hormone, which enhances seed germination, growth and yield of crops and foliar spray with moringa leaf extract improved crop performance, resulting from its role on vigorous plant growth, maintained optimum tissue water status, improved membranes stability, enhanced antioxidant content. Moreover, [8,9] stated that pepper plant height, number of leaves, fruit weight and yield were

significantly influenced by the foliar application moringa leaf extract.

Foliar application with alga and seaweed extract, is rich in natural plant hormones such as auxin and cytokinins, vitamins, and some macro and micronutrients. Seaweed extract is considered as one of modern means used to increase agricultural production away from the use of chemical fertilizers with its side disadvantages in term of health and environmental pollution. Also, it is known that foliar application has rapid impact in supplying plants with its requirements. There have been encouraging results using seaweed which had positive impact in stimulating the physiological events that leads to increase growth and development of plants [10].

A previous study [11] demonstrated that foliar spray with seaweed extract significantly increased plant height and per centage of total chlorophyll of pepper plants. Foliar spray with carnation (clove) extract accelerates plant growth, promotes resistance to stress and increases yield of crops [12,13,14].

This study aimed to investigating the effect of varying concentrations of phosphorus fertilizer, leaf extract of moringa, seaweed extract and carnation extract on the growth, chemical composition and fruit yield and fruit quality of pepper

2. Materials and Methods

2.1. Plant Material

The study was conducted as field experiment to evaluate the effect of different phosphorus rates (phosphoric acid), Moringa leaf extract (MLE), seaweed extract, and clove extract on the growth, chemical composition and fruit yield of pepper (*Capsicum anumm*) during 2020 and 2021 seasons at a private farm located in Al- Abassa, Sharqia, Egypt. In both seasons, seedlings were transplanted on 2nd week of March in a new soil field (sand physical properties was 89.4% sand, 6.9% silt, and 3.7% clay with a pH of 7.8, EC of 1.68 dS/m). The normal agricultural practices were used for the hot pepper production, i.e. irrigation, fertilization (except for P sources), diseases and pest control were followed according to the recommendation of the Egyptian Ministry of Agriculture.

Table 1: Chemical analysis of the used irrigation water

Characters	Value
Soluble cations	
K^+ (mel/ L):	1.19
Ca^{++}	9.7
Mg^{++}	12.59
N^+	38.6
Soluble anions (mel/ L):	
$NCO3^-$	9.33
$SO_4^=$	14.8
C1	38.9
pH	7.3
EC (dSm^{-1})	5.56

2.2. Treatments

The experiment tested the effect of four P-rates phosphoric acid (0,2 and 4 ml L^{-1}) started at one month after transplanting with 2 week intervals (the amount of solution sprayed for each treatment was 200 and 400 ml/m^2).

All plants received their phosphorus needs in equal amounts (125 and 250 kg P_2O_5/ha).

The seaweed extract (Basfoliar Kelp SL, Australia Company) contains; IAA mg.L^{-1}, cytokininmg.L^{-1}, Vitamin %, proteins% and carbohydrates % (Table 2).

The seaweed extract was used at rates of 0, 2 and 4 m. L^{-1}.

Seeds of sweet pepper were planted in the nursery containing peat moss. After the establishment of seedlings and having (2-3) true leaves, they transferred to the open field where they planted on both sides of lines 70 cm apart and 40 cm between plants. All agricultural practices were done as usual and as needed.

The seaweed extract concentrations were sprayed twice, the first one was done one month after the transfer of plants into plastic house, the other spray was done after one month from the first spray. Spray was done at the early morning. Three plants were randomly chosen at the beginning of blooming for anatomical study. Vegetative characters of plants such as; plant height, number of branches per plant, and shoot dry weight were taken on three plants of each replicates were measured.

Table 2: The chemical and biochemical analyses of seaweed extract

Seaweed Compost Characteristic	Value
Moisture %	30.4
pH	6.2
EC (ds/m)	1.5
Total Nitrogen %	2.1
Organic matter %	33
Organic Carbon %	19.12
C/N ratio	01:13
Total amino acid %	0.3
Total Phosphorus %	0.9
Total Potassium %	1.6
Calcium %	0.11
Magnesium %	0.10
Sulphur (%)	1.1
Fe (ppm)	1400
Mn (ppm)	160
Zn (ppm)	90
Cu (ppm)	130
I (ppm)	15
Weed seeds	Non Nematodes – Parasitic –
Total auxins (ppm)	125
Cytokinins (Adenine) (ppm)	80

Leaves of *Moringa oleifera* and carnation flower (*Dianthus caryophyllus* L.) were collected, washed, air dried and milled. 20 g of the milled leaves was mixed with 675 ml of 80% aq. ethanol [15] and this constituted the Moringa Leaf Extract (MLE). The extracts diluted in distilled water at ratio 1:10 and 1:20. MLE extracts were sprayed at the rate of 0 ml (control) and 25 ml of each dilution one and two weeks' interval in the three replicates. The chemical and biochemical analyses of moringa leaf extract are presented in Table 3.

Table 3: The chemical and biochemical analyses of moringa leaf extract

Moringa leaf contents Characteristic	Value
Moisture %	7.97
pH	6.6
EC (ds/m)	1.1
Organic matter %	88.35
Dry matter %	92.06
Ash %	11.65
Total lipids %	13.55
Nitrogen free extract %	14.05
Total protein %	28.59
Crude fiber %	32.15
Mineral composition (ppm):	
Calcium (ppm)	111.0
Magnesium (ppm)	147.5
Potassium (ppm)	559.0
Na (ppm)	21.5
Zn (ppm)	0.125
Cu (ppm)	0.53

A experiment are conducted at the Private Farm and laid out split plot design in a Randomized Complete Block Design (RCBD) with three replicates and included 12 treatments, where the phosphorus fertilizer, and plant extracts (4) in the main plots, and the fertilizer and plant extracts levels (3) are distributed in the sub- plots.

The main plot:

1- Phosphorus fertilizer
2- Leaves moringa extract
3- Alge and seaweed extract
4- Carnation (clove) extract

Sub plot: The foliar application levels;

1- 0 (tap water only)
2- 2 ml /l
3- 4 ml/l

The seedlings were later thinned to one seedling, a week after of transplanting (WAT).

2.3. Data Recorded

2.3.1. Vegetative growth parameters

Five plants were chosen randomly from each sub-plot at 90 days after transplanting and transferred to laboratory to record the following data: (plant height (cm); number of leaves and branches per plant, plant fresh and dry weight). Data were taken weekly on stem girth, plant height and number of leaves, one week after MLE application, a week after transplanting.

2.3.2. Determination of photosynthetic plant pigments

Carotenoids, chlorophyll a, b and total chlorophyll concentrations in fully expanded leaves were measured at 90 days after transplanting. Chlorophylls and carotenoids were extracted using 10 ml N, N dimethyl formamide according to the method of [16]. Formulae and coefficients used for the determination of chlorophylls were described by [17] the carotenoids were determined spectrophotometrically at 470 nm (CT 200 spectrophotometer) using the formula of [18]. The data was expressed as mg/g fresh weight.

2.3.3. Determination of mineral nutrients

Leaf samples were oven dried at 68°C for 72 hours, then fine grinded and used to determine mineral contents on a dry weight basis. Total nitrogen and phosphorus contents were determined using Kieldahl method and colorimetric method using spectrophotometer (SPECTRONIC 20D, Milton Roy Co. Ltd., USA), respectively, according to the procedure described by [19]. Potassium content was measured using flame photometer method (JENWAY, PFP-7, ELE Instrument Co. Ltd., UK) as described previously [20].

2.4. Experimental design and statistical analysis

The experiment was arranged in a split plot design with three replicates, where phosphorus fertilization, moringa extract, seaweed extract and carnation oil were arranged randomly within the main plots, while the concentrations;0, 2 and 4 ml/l of the sub- plot treatments as foliar application were distributed in the sub-plots. All the data were subjected to Analysis of Variance (ANOVA) using SAS Program [21]. Treatments were statistically analysed and means separation was carried out using Least Significant Difference (LSD) at $P < 0.05$ according to the method described by [22].

3. Results and Discussion

3.1. Vegetative growth characters

3.1.1. Effect of phosphorus fertilizer and plant extracts

Data in Tables (4 and 5) revealed that vegetative growth characters of pepper plants significantly increased with the studied treatments in this study, i.e. phosphorus fertilizer, seaweed, moringa and carnation extracts. The vegetative growth parameters of hot pepper plants, i.e. plant height, number of branches, number of leaves, leaf area, plant fresh weight and plant dry weight, were significantly increased by the extract of seaweed, where it recorded the highest values of the studied characters of pepper vegetative growth. These treatments followed by moringa extract phosphorus fertilizer and carnation extract, respectively. Regarding the important role of seaweed extract in increasing vegetative growth of pepper plant, [23] illustrated that the seaweed extracts have been reported to contain significant amounts of auxins, cytoksnins and betaines, which affect cell division during the early stages of growth, thus later in hanced growth and gave highest of different parts.

Respecting the role of moringa extract increment of plant growth**,** [7,24] demonstrated that moringa leaf extract is consider as a natural plant growth regulator where, it is a source of zeatin, which it is natural derivative of cytoksnin, proteins, vitamin E, phenolics, ascorbates, essential amino acid and several mineral elements, making to putting it as a potential natural growth stimulant. Moreover, the important role of phosphorus in plant growth, [25] confirmed that phosphorus has been established to be an essential nutrient for maintaining plant growth and development and plays an important role in multiple physiological processes, including those associated with nutrition and photosynthesis. As well as, [26] concluded that plants require P to synthesize adenosine triphosphate (ATP), sugars, and nucleic acids.

Regarding the effect of carnation extract on plant growth, [13] stated that carnation extract improved the plant growth, i.e. plant height, fresh and dry weight. These results supported by [10,6,27,28,29,12] on seaweed extract, Moring leaf extract, phosphorus fertilizer, and carnation (clove) extract, respectively.

Table 4: Effect of plant extracts and phosphorus fertilizer as foliar spray and their concentrations on vegetative growth characters of pepper plants during 2020/2021 and 2021/2022 seasons

Treatments	Plant height (cm)		No. of branches		No. of leaves	
	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022
Foliar spray extracts:						
1. Phosphorus	49.32	49.55	5.80	5.87	158.77	156.36
2. Moringa	50.41	50.0	6.22	6.18	159.75	156.43
3. Seaweed	52.11	52.36	6.23	6.20	165.35	156.54
4. Carnation	48.60	48.84	5.57	5.50	151.74	156.27
LSD (0.05)	0.18	0.30	0.12	0.14	0.08	0.09
Foliar spray concentrations (ml/l):						
1. 0	48.02	48.12	5.55	5.52	156.29	156.31
2. 2	50.85	50.44	6.03	6.03	162.47	156.40
3. 4	51.85	52.02	6.30	6.22	165.45	156.45
LSD (0.05)	0.15	0.35	0.19	0.24	0.18	0.16

Table 5: Effect of plant extracts and phosphorus fertilizer as foliar spray and their concentrations on leaf area, plant fresh and dry weight of pepper plants during 2020/2021 and 2021/2022 seasons

Treatments		Leaf area (cm2)		Fresh weight /plant (g)		Dry weight /plant (g)	
		2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022
A	Foliar spray extracts:						
1.	Phosphorus	7.86	7.78	212.78	214.67	48.55	48.61
2.	Moringa	8.19	8.11	213.78	219.67	49.91	49.99
3.	Seaweed	8.89	8.81	222.03	222.51	54.87	54.78
4.	Carnation	7.65	7.57	211.29	213.77	46.91	46.64
	LSD (0.05)	0.06	0.08	0.13	0.11	0.51	0.138
B	Foliar spray concentrations (ml/l):						
1.	0	5.52	5.46	209.78	210.07	45.16	45.01
2.	2	7.55	7.51	216.12	258.13	50.87	50.49
3.	4	10.49	10.44	219.02	222.07	54.59	54.51
	LSD (0.05)	0.05	0.03	2.19	71.80	0.44	0.11

3.1.2. Effect of plant extracts and phosphorus fertilizer levels

Data tabulated in Tables (4 and 5) show that all the levels of plant extracts and phosphorus levels had significantly increased in chemical contents (N, P and K) and chlorophyll a, b and total chlorophyll of pepper leaves. The highest level of any extract and phosphorus fertilizer, being the most effective on chemical content and chlorophyll pigment of leaves. There are a gradually increased from the lowest level (2 ml/l) to the highest level (4 ml/l) in chemical contents and chlorophyll pigment. These results are true in both growing see sons. Obtained results are in harmony with those reported by [11,30,31,13] on seaweed extract; phosphorus fertilizer; carnation extract, respectively.

3.2. Chemical content and chlorophyll pigment of pepper leaves

3.2.1. Effect of plant extracts and phosphorus fertilizer

Data in Tables (6 and 7) revealed that plant extracts and phosphorus fertilizer of significantly increased N, P and K contents and chlorophyll a, chlorophyll b and total chlorophyll (a + b) and carotenoids of pepper leaves. The treatment of seaweed extract, being the most effective on chemical content and chlorophyll pigment of pepper leaves, followed by moringa extract, phosphorus fertilizer and carnation extract, respectively. Regarding the important role of seaweed extract on chemical content and chlorophyll pigments, [32] confirmed that seaweed extract treatment enhanced plant chlorophyll content and chemical contents of plant leaves when used as spray.

Respecting the role of moringa leaves extract, [27] concluded that moringa extract significantly increased chlorophyll content of pepper leaves. Moreover, the role of phosphorus fertilizer increased the N, P, K and chlorophyll contents, where it is an important element in enhanced the bioactive processes in metabolism in tern increasing the pigments and minerals content [25]. In addition, carnation extract increased the N, P, K and contents of plant leaves [13]. These results are in accordance with those obtained by [33,9,5,12] on seaweed; moringa extracts; phosphorus fertilizer; and conation extract, respectively.

Table 6: Effect of plant extracts and phosphorus fertilizer as foliar spray and their concentrations on chemical content of pepper leaves during 2020/2021 and 2021/2022 seasons

Treatments		N % (Leaves)		P % (Leaves)		K % (Leaves)	
		2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022
A	Foliar spray extracts:						
1.	Phosphorus	1.25	1.21	0.18	0.23	1.62	1.66
2.	Moringa	1.31	1.24	0.21	0.19	1.71	1.72
3.	Seaweed	1.53	1.30	0.22	0.21	1.79	1.78
4.	Carnation	1.16	1.05	0.16	0.18	1.61	1.64
	LSD (0.05)	0.01	0.01	0.01	0.01	0.01	0.02
B	Foliar spray concentrations (ml/l):						
1.	0	1.21	1.09	0.18	0.18	1.55	1.55
2.	2	1.27	1.26	0.20	0.20	1.69	1.71
3.	4	1.32	1.31	0.21	0.21	1.80	1.82
	LSD (0.05)	0.01	0.01	0.004	0.001	0.02	0.02

Table 7: Effect of plant extracts and phosphorus fertilizer as foliar spray and their concentrations on photosynthesis pigments of pepper leaves during 2020/2021 and 2021/2022 seasons

Treatments		Chlorophyll a (mg/g F.W.)		Chlorophyll b (mg/g F.W.)		Chlorophyll (a +b) (mg/g F.W.)		Carotenoids (mg/g F.W.)	
		2020/2021	21/22	2020/2021	21/22	2020/2021	21/22	2020/2021	21/22
A	Foliar spray extracts:								
1.	Phosphorus	0.62	0.57	0.27	0.24	0.89	0.81	0.27	0.25
2.	Moringa	0.89	0.84	0.33	0.29	1.22	1.13	0.32	0.34
3.	Seaweed	0.96	0.91	0.38	0.33	1.34	1.24	0.37	0.36
4.	Carnation	0.48	0.43	0.23	0.20	0.81	0.63	0.23	0.28
	LSD (0.05)	0.13	0.11	0.03	0.03	0.07	0.09	0.03	0.01
B	Foliar spray concentrations (ml/l):								
1.	0	0.53	0.50	0.22	0.23	0.75	0.73	0.29	0.27
2.	2	0.67	0.63	0.31	0.29	0.98	0.91	0.36	0.34
3.	4	0.89	0.82	0.42	0.44	1.31	1.26	0.39	0.38
	LSD (0.05)	0.14	0.11	0.08	0.05	0.22	0.19	0.02	0.03

3.2.2. Effect of plant extracts and phosphorus fertilizer levels

Data in Tables (6 and 7) indicated that when the level of 2 ml/l increased up to 4 ml/l significantly increased the N, P, K and chlorophyll contents of pepper leaves. These results are true in both growing seasons. The level of 4 ml/l enhanced the chemical and chlorophyll contents of peppers leaves. These results are agreement with those reported by [32,34,35,12] on seaweed, moringa, phosphorus fertilizer, and carnation extracts, respectively.

4. Conclusions

It can be concluded that the treatment of seaweed extract, being the most effective on plant growth characters, chemical content and photosynthesis pigments of pepper leaves, followed by moringa extract, phosphorus fertilizer and carnation extract, respectively. The highest level (4 ml /l) caused an increases in the studied character of growth, chemical content and photosynthetic pigments.

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