Influence of foliar application with phosphorus fertilizer and some bio stimulants extracts on yield and quality attributes of hot pepper

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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 fruit yield, and fruit quality of pepper (*Capsicum anuumm)*.during 2020/2021 and 2021/2022 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 of pepper, followed by moringa extract, phosphorus fertilizer and carnation extract, respectively. The highest level (4 ml /l) caused an increases in the studied character of fruit yield, fruit quality.

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

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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 flavour and aroma **(Nigrhat, 2017)**. 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 (**Alabi, 2006)**.

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 (**Aliyu, 2002).**

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 are 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 (**Nigrhat, 2017**).

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, **Jaggi et al., (2003) and Sarg *et al.,* (2007)** 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 **Jacob *et al.,* (2023). Mehboob., (2011)** 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, **Oluwagbenga and Odeghe (2015) and Abou El-Nour and Ewais (2017)** 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 alge 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 **(Khan *et al.,* 2009).**

Demir *et al.* (2006) 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 (**Fahey, 2005 , Marcu, 2005 and Castellanos *et al.* , 2020)).**

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

Materials and Methods

Plant Material

The study was conducted as field experiment to evaluate the effect of different phosphorus rates (phosphoric acid), leaf extract (MLE), seaweed extract , and clove extract on the growth, chemical composition and fruit yield of pepper (Capsicum frutescence).during 2020 and 2021 seasons at a private farm located in Al- Abassa, Sharqia, Egypt. In both seasons, seedlings will 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

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/m2).

All plants received their phosphorus needs in equal amounts (125 and 250 kg P2O5/ha).

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

The seaweed extract was used at rates of 0, 2, and 4 ml 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 (**Makkar and Becker, 1996)** 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.

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).

Data Recorded

Fruit yield and yield component:

The fruits were harvested five times when having attained full size for fresh use. Total number of fruits per plant and total fruit yield per plant (g/plant) were also recorded.

Chemical content:

a- Determination of vitamin C, TSS, and total carbohydrates:

Fruit samples were randomly taken at harvesting time to determine vitamin C (ascorbic acid) content in the fruit as mg per 100g fresh weight, and TSS with refractometer, and total carbohydrates (%) according to method described by **A.O.A.C. (2007) and Dubois (1956), respectively.**

d- Determination of mineral nutrients

Fruits samples were oven dried at 65°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 **Cottenie, (1980).** Potassium content was measured using flame photometer method (JENWAY, PFP-7, ELE Instrument Co. Ltd., UK) as described by **Chapman and Pratt, (1982).** Calcium was measured with atomic absorption spectrophotometer **A.O.A.C. (2007).**

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 /lof the main plot treatments as foliar application were distributed in the sub-plots.

All the data were subjected to Analysis of Variance (ANOVA) using **SAS Program (2004).**

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 **Snedecor and Cochran (1989).**

Results And Discussion

Fruit yield and its components:

Effect of plant extracts and phosphorus fertilizer :

Data for the influence of seaweed and moringa extracts, phosphorus fertilizer and carnation extract of fruit yield and its components of pepper, i.e. number of fruit/plant, fruit length, fruit diameter, average fruit weight, early yield (ton/fed.) and total yield (ton/fed.) are presented in Tables (4 and 5).

Regarding the treatment of seaweed extract, being the most effective treatment for increasing the fruit yield and its components of pepper plants. This results are true in both growing seasons, and followed by moringa leaf extract, phosphorus fertilizer and carnation extract, respectively.

These extracts are contain many hormones and minerals, like as cytokinins that stimulates cell division and enlargement and activities the biochemical compounds to increased vegetative growth, chemical and chlorophyll contents of leaves , and then increased the fruit yield and its components of pepper plants (Tables 4 and 5).

The same trend to the role of phosphorus fertilizer, which had an important role of biochemicals activities in increasing the fruit yield and its components of pepper **(Duan *et al.,* 2023).**

These results are accordance with those recorded **by Khan *et al.*, 2007 and Ashour *et al.*, 2021; Mehdawe *et al.,* 2023; Sudasinghe *et al.,* 2023; and Marcu, 2005**, on seaweed, moringa extracts; phosphorus fertilizer, and carnation extracts, respectively.

Effect of plant extracts and phosphorus levels:

Data in Tables (4 and 5) stated that the level of 2 and 4 ml /l from every extract and phosphorus fertilizer as foliar spray significantly increased the fruit yield and its components of pepper plant. The highest levels of all the plant extracts and phosphorus fertilizer caused highest values of fruit yield and its components of pepper plant.

These results are confirmed by those obtained by **Ashour *et al.,* 2021; Weerasingha and Harris, 2022; Duan *et al.,* 2023; and Fahey, 2005,** on seaweed, moringa extracts, phosphorus fertilizer and carnation extract, respectively.

Fruit quality:

Effect of phosphorus and plant extracts:

Data in Tables (6 and 7) revealed a significant variation in fruit quality of hot pepper, i.e. N , P , K, Ca contents, TSS (%), ascorbic acid (vitamin C) (mg/100g f.w.) Carbohydrates % as affected by foliar spray with plant extracts and phosphorus fertilizer.

The maximum values of fruit quality of hot pepper were observed in both growing seasons as a result of the treatment with seaweed extract. This treatment followed by the treatments of moringa extracts, phosphorus fertilizer and clove extracts, respectively.

In this concern, these results due to the highest values of these treatments as sum on plant growth characters, chlorophyll pigment content , and fruit yield and its components, then increased the fruit quality of hot pepper.

These results sustained those recorded by **Ashour *et al.* (2021)** who working with seaweed extracts, **Segmen and Unlu (2023)** who working with moringa extracts, **Douras *et al.* (2024)** who working with phosphorus fertilizer and **Hassan *et al.* (2021)** who working with clove extract.

Effect of plant extracts and phosphorus levels:

From the results are shown in (Tables 6 and 7), there were a steady fruit quality in hot pepper of both levels (2 and 4 ml/L) compared to the control treatment (0.0).

It was observed that by the level of 4 ml /l as foliar spray, being the most effective in recorded highest values in fruit quality of hot pepper.

The results are in conforming with the findings of **Segmen and Unlu (2023)**, **Weerasingha and Harris (2022), Sudasinghe *et al.* (2023) and Castellanos *et al.* (2020)** who working with seaweed extracts, moringa leaf extracts, phosphorus fertilizer and clove extracts, respectively.

Conclusively: It can be concluded that the level of 4 ml /las foliar spray, being the most effective in recorded highest values in growth characters , chemical content , fruit yield and fruit quality of hot pepper.

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Table (4): Effect of plant extracts and phosphorus fertilizer as foliar spray and their concentrations on fruit physical characters of pepper fruit during 2020/2021 and 2021/2022 seasons

		Number of fruits		Fruit length(cm)		Fruit diameter (cm)	
		2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022
A	**Foliar spray extracts:**						
1.	Phosphorus	13.98	13.97	6.56	6.66	3.05	3.06
2.	Moringa	14.79	14.78	6.70	6.62	3.14	3.22
3.	Seaweed	14.88	14.98	7.28	6.72	3.51	3.51
4.	Carnation	13.83	13.94	6.57	6.58	3.03	3.02
	LSD (0.05)	0.06	0.02	0.02	0.06	0.02	0.05
B	**Foliar spray concentrations (ml/l):**						
1.	0	13.07	13.07	5.73	5.81	2.59	2.60
2.	2	14.90	15.05	7.09	6.59	3.34	3.37
3.	4	15.14	15.15	7.52	7.53	3.62	3.64
	LSD (0.05)	0.04	0.02	0.01	0.14	0.02	0.02

Table (5): Effect of plant extracts and phosphorus fertilizer as foliar spray and their concentrations on fruit yield of pepper plants during 2020/2021 and 2021/2022 seasons

		Average Fruit weight (g)		Early yield (ton/fed)		Total yield(ton/fed)	
		2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022
A	Foliar spray extracts:						
1.	Phosphorus	47.5	50.6	6.03	6.06	6.99	7.26
2.	Moringa	54.1	54.2	6.55	6.85	7.86	7.95
3.	Seaweed	55.5	57.0	7.69	7.57	9.32	9.32
4.	Carnation	47.0	49.41	6.00	5.91	6.75	7.08
	LSD (0.05)	1.59	1.39	0.02	0.23	0.24	0.13
B	Foliar spray concentrations (ml/l):						
1.	0	46.2	48.57	5.78	5.66	6.66	6.69
2.	2	53.3	53.5	6.51	6.43	8.05	8.19
3.	4	53.7	56.3	7.40	7.70	8.63	8.83
	LSD (0.05)	1.97	1.20	0.02	0.20	0.17	0.15

Table (6): Effect of plant extracts and phosphorus fertilizer as foliar spray and their concentrations on micro nutrients contents of pepper fruit during 2020/2021 and 2021/2022 seasons

		N % Fruit		P % Fruit		K % Fruit		Ca% Fruit	
		2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022
A	Foliar spray								

	extracts:								
1.	Phosphorus	3.28	3.37	0.38	0.34	1.80	1.87	0.65	0.60
2.	Moringa	3.40	3.41	0.43	0.42	1.91	1.92	0.66	0.60
3.	Seaweed	3.46	3.46	0.48	0.42	1.96	2.07	0.75	0.64
4.	Carnation	3.12	3.25	0.35	0.36	1.61	1.70	0.60	0.58
	LSD (0.05)	0.03	0.20	0.03	0.02	0.03	0.05	0.03	0.01
B	**Foliar spray concentrations (ml/l):**								
1.	0	2.94	3.09	0.25	0.32	1.79	1.81	0.54	0.59
2.	2	3.34	3.46	0.41	0.40	1.83	1.86	0.71	0.58
3.	4	3.63	3.57	0.46	0.51	1.86	2.00	0.75	0.66
	LSD (0.05)	0.90	0.11	0.03	0.02	0.02	0.04	0.03	0.02

Table (7): Effect of plant extracts and phosphorus fertilizer as foliar spray and their concentrations on the nutritive value of pepper fruit during 2020/2021 and 2021/2022 seasons

		Total Carbohydrates (%)		Vitamin C (mg/100 F.W)		TSS%	
		2020/2021	2021/2022	2020/2021	2021/2022	2020/2021	2021/2022
A	**Foliar spray extracts:**						
1.	Phosphorus	6.91	6.88	2.22	2.25	4.60	4.58
2	Moringa	7.03	7.00	2.49	2.44	4.75	4.77

.							
3.	Seaweed	7.66	7.22	2.58	2.54	4.78	4.81
4.	Carnation	6.87	6.23	2.13	2.10	4.43	4.47
	LSD (0.05)	0.07	0.12	0.06	0.11	0.03	0.03
B	**Foliar spray concentrations (ml/l):**						
1.	0	6.24	6.24	2.13	2.16	4.32	4.31
2.	2	7.43	6.85	2.48	2.53	4.51	4.47
3.	4	7.68	7.41	2.58	2.63	4.66	4.63
	LSD (0.05)	0.09	0.22	0.05	0.09	0.07	0.05