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Research Paper

Effect of combination foliar spraying of seaweed (*Padina pavonica*) with GA3 or/and IBA on the growth parameters of *Allium cepa* L.

Sami Mohammed Salih[1*], Ahmed Amrajaa Abdulrraziq[2]

[1,2]Dept. of Biology, Faculty/Education, University/ Omar Al-Mukhtar, Al-Byda, Libya

**Corresponding Author: sami.mohammed@omu.edu.ly*

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Abstract— Onions (*Allium cepa* L.) are the second most important vegetable crop in Libya after tomatoes, due to the large indiscriminate use of chemical fertilizers and pesticides among farmers. So, this study examined the effects of different foliar application treatments on improving the growth parameters of local white onion, represented by: firstly; the foliar application treatment alone of (GA_3, IBA and seaweed extracts of *Padina pavonica*, and secondly; combined treatment between (*P.pavonica* + GA_3 or/and IBA). Generally, The results showed that all foliar application treatments had a significant effect on increase Length of leaves, leaves width, number of leaves /plant, fresh weight of leaves, dry weight of leaves, bulb length, bulb diameter, bulb weight, neck thickness of bulb. In addition, an increase in the content of chlorophyll (a and b) and minerals (p and k). However, combined treatment is most effective for the highest obvious increment in growth parameters, especially *P.pavonica* 10%+ 300ppm GA_3.

Keywords— *Allium cepa* L., Seaweed, Foliar application, GA_3, IBA, *Padina pavonica*.

1. Introduction

Onions (*Allium cepa* L.) are one of the most important vegetable crops in Libya, belonging to the Amaryllidaceae family, indispensable crops in everyday life for their high nutritional value [1,2]. It can be categorized by color (white, red, yellow) and taste (sweet, non-sweet, or pungent) [3], bulbs and skins of onions have a variety of bioactive compounds, such as organosulfur compounds, thiosulfinates, polyphenols, and fructooligosaccharides [4]. Onions possess medicinal properties anti-microbial, anti-cancer, anti-hypertensive, antidepressant, and antiparasitic [5,6,7].

Libya imports huge amounts of up to 75% of agricultural products from various countries, where most of the agricultural land is estimated at about 9% of the total area of the region [8]. In addition, the Overuse of chemical fertilizers by farmers caused lower productivity and soil pollution and the environment [9]. Consequently, the application of employing eco-friendly approaches in the agricultural field, for example, phytohormones and seaweeds, an alternative to chemical fertilizers, to improve crop yield and soil fertility [10,11].

2. Related Work

Gibberellins and indole-3-butyric acid are among the plant hormones, that promote the vegetative, root, and reproductive growth of plants [12,13]. For example, The results of Bhusal and Luitel's study in 2023 suggested soaking onion bulbs with GA3 at 150 ppm to increase the growth and seed yield characteristics [14]. Moreover, Nasef and Yousef, (2021) noted an increase in vegetative growth and the mineral content (N, P and K) by spraying foliar of indole 3 – butyric acid (IBA) at 0.5 mM of *Allium sativum* L [15]. The results of a study conducted at a major Vegetable Research Center in India showed that foliar application of Zn and GA3 resulted in an increase in marketable onion yield [16], It was also found that pre-sowing treatment of garlic cloves with 100 ppm IBA improved the quantity and quality of garlic bulb yield [17]. In contrast, Biostimulants based on seaweed extracts have been observed to be beneficial to plants due to the cell signaling activity of some molecules such as polysaccharides [18,19]. Moreover, contains several active compounds, such as polyphenols, and phytohormones to promote plant growth in agricultural systems [20,21]. revealed a study by Hernandez-Herrera *et al* (2019), the possibility of using Seaweed extracts from *Padina gymnospora* to improve germination rates of *Solanum lycopersicum* L seeds [22]. Also, another study showed that the foliar application of Bio-stimulant Aquasap powder derived from the red seaweed *Kappaphycus alvarezii* can improve the quality of Bellary onion [23].

Therefore, our aims were to Evaluate the effect of foliar application of phytohormones (GA_3, IBA), and seaweed

extracts from *Padina pavonica* Individually, and of the interaction between foliar application of phytohormones and *P.pavonica* in improving the growth parameters of local white onions.

3. Experimental Method/Procedure/Design

3.1. Collection and preparation of seaweed samples:
Brown seaweed Fresh (*Padina pavonica*) was collected from the Al-Hamamah coastline, north of Al-Bayda City / Al-Jabal Al-Akhdar /Libya, and classified in the Department of Biology / Faculty of Education / Omar Al-Mukhtar University. They were washed and rinsed with distilled water in order to eliminate sand and plankton, After that, they were dried at room temperature, ground by an electric grinder, and kept until use.

The aqueous extract of Seaweed was prepared by adding One kilogram of dry powder to a liter of distilled water, boiling for an hour, and filtering through a double-layered muslin cloth to remove debris [24]. The obtained extract concentration was considered as (100%), and from this, 10 and 30% of *P.pavonica* were prepared by adding distilled water, seaweed extracts were stored at a temperature of - 20˚C until use.

3.2. Study experiment design:
The pot experiment was carried out inside a greenhouse, the soil (clay-sandy)samples at the ratio of 2:1 (weight to weight) were collected, air-dried on the ground, Fertilizers were added at the usual range rate for commercial purposes in Libya, mixed, and passed through 2 mm sieve. The experiment contained 33 pots having a diameter of 30 cm and a length of 35 cm. Each pot was filled with 10 kg soil, onion seedlings were obtained from the commercial markets at the age of 30 days, and three seedlings were planted into each pot, the experiment was conducted by randomized complete block design with three replications.

The experiment included the treatments as follows:
- C: Control (without spraying).
- T1: Spraying of GA_3 (200ppm).
- T2: Spraying of GA3(300 ppm),
- T3: Spraying of IBA (200 ppm).
- T4: Spraying of IBA (300 ppm).
- T5: Spraying of *Padina pavonica* extracts (10%).
- T6: Spraying of *Padina pavonica* extracts (30%).
- T7: Spraying of *P.pavonica* extracts (10%) + 300ppm of GA_3.
- T8: Spraying of *P.pavonica* extracts (30%) + 300ppm of GA3.
- T9: Spraying of *P.pavonica* extracts (10%) + 300ppm of IBA.
- T10: Spraying of *P.pavonica* extracts (30%) + 300ppm of IBA.

These levels along with control were applied three times:
The first phase was at the age of 30 days before transplanting seedlings by root soaking for an hour, while phase the second and third foliar sprays were applied in were done at 45 and 60 days.

3.3.Parameters morphological:
Data was collected on plant growth at 70 days of age, represented by: Length of leaves(cm), leaves width(cm), Number of leaves /plant, fresh weight of leaves(g), dry weight of leaves(g), Bulb length(cm), Bulb diameter(cm), Bulb weight(g), and Neck thickness of bulb(cm).

3.4.Biochemical parameters:
1- Chlorophyll a and b contents in leaves were determined using the method described by [25], and the chlorophyll values were obtained according to the following equations:
- chlorophyll a = (absorption at 663.2 × 12.21) − (absorption at 646.8 × 2.81)
- chlorophyll b = (absorption at 646.8 × 20.13) − (absorption at 663.2 × 5.03).

2- Potassium contents were analyzed by flame photometer, while Phosphorus was evaluated by an atomic absorption spectrophotometer, in fresh leaves by the method outlined by [26].

3.5. Statistical Analysis:
The study experiences were designed according to the complete random design (CRD). Statistical analysis was performed using Minitab 17 program and ANOVA variance analysis tables. The averages were compared using Tukey's test at $P < 0.05$.

4. Results and Discussion

4.1. Effect foliar application of (GA_3, and IBA) on growth parameters:
The data presented in Tables (1, 2, and 3) show the results of the individual effect of the foliar application of GA3 and IBA to onion growth parameters, after 70 days of agriculture compared with the control. The results showed Treatment ($GA_3$300ppm) was found significantly superior as compared to other phytohormones treatments, where recorded increased length of leaves and width by (29.67, 60.56%), number of leaves/plant, (12.57%), fresh and dry weight (41.60, 40.92%), bulb length (24.34%), bulb diameter (36.71%), bulb weight (17.90%), neck thickness of bulb (50.00%), the content of chlorophyll a, and b (18.05, 21.87%), the content of minerals p and K (12.90, 19.86%), over control respectively. Followed by foliar treatment with IBA300 ppm, which achieved good results on onion growth parameters. where recorded increased length of leaves and width by (22.11, 54.92%), number of leaves/plant, (7.36%), fresh and dry weight (36.90, 6.48%), bulb length (24.58%), bulb diameter (17.87%), bulb weight (17.85%), neck thickness of bulb (43.47%), the content of chlorophyll a, and b (12.50, 25.00%), the content of minerals P and K (9.67, 21.25%), over control respectively. These findings are in agreement with the findings of several investigators [27,28,29], who opined that the Foliar application of phytohormones (GA_3 and IBA), Improves the vegetative and physiological traits of onion. The increase might be ascribed to the role of GA3 in cell division and elongation, in the meristemic region, by increasing the levels of auxin [30]. Moreover, IBA promotes root length by affecting the synthesis of enzymes that stimulate cell enlargement [31]. On the other hand, the root system is

instrumental in plant growth due to its role in water and nutrient absorption, therefore, maintaining active root growth causes vegetative growth characteristics development [32].

4.2. Effect foliar application of *Padina pavonica* extract on growth parameters:

Also, data presented in Tables (1, 2, and 3) show the results of the effect of the foliar application of *P.pavonica* extract on onion growth parameters. The results showed that there were significant differences in the foliar application of *P.pavonica* extracts Treatment, compared with the control. Treatment lower concentration10% of *P.pavonica* extract was effective, although it did not differ much from the control, where the highest obvious increment was in the length of leaves and width by (12.94, 26.71%), fresh weight of leaves (26.28%), neck thickness of bulb (23.91%), content of chlorophyll b (15.62%), and content of K (11.14%), over control. At a treatment concentration of 30% of *P.pavonica* extract, there was a slight increase in the length of leaves and width by (07.94, 19.71%), fresh weight of leaves (18.83%), neck thickness of bulb (15.21%) and the content of chlorophyll b (06.25%) and K content (08.71%), over control. The significant increase in growth resulting from the effect of spraying seaweed extract was due to the content of important micronutrients, vitamins, and plant hormones, as cytokinins, which play an active role in stimulating growth and increasing plant height [33,34]. On the other hand, the benefits of seaweed extracts are mainly related to their ability to stimulate plant development rather than their ability to provide nutrients, which would ultimately lead to increased growth and productivity of plants [35]. Similar findings were reported by [36], who confirmed that onion seeds soaked with a lower concentration of seaweed extracts had higher germination rates. The negative effect of high concentrations of seaweed extracts could be explained due to high levels of phytohormones like Auxins, gibberellins and cytokinin, resulting in abnormalities of chromosome [37,38], or may be due to the higher phenolic content, which causes an increase in the formation of reactive oxygen species [39].

4.3. Effect of combined treatment (*Padina pavonica* extract + GA_3, or/and IBA) on growth parameters:

Data regarding the treatment (*Padina pavonica* extract + GA3 300 ppm, and *P.pavonica* extract+ IBA300ppm), in Tables (1,2 and 3) indicated that there were highly significant differences, compared with the control, and foliar application of all treatments. Combined treatment (*P.pavonica* extract 10% + GA3 300 ppm) showed the highest registered increments of the length of leaves and width, number of leaves /plant, fresh and dry weight of leaves, bulb length, bulb diameter, bulb weight, Neck thickness of bulb, reached by (51.99, 90.14%), (23.46%),(71.97, 48.99%), (57.99%), (52.33%), (77.41), (82.60%) over control, respectively Fig. (1,2). Also caused an increment in the content of chlorophyll (a and b), and minerals (P and k), which reached (27.77, 40.62%) and (29.03, 42.16%) over control, respectively Fig.(3). Followed by foliar treatment with *P.pavonica* extract+ IBA300ppm, where recorded increased length of leaves and width by (40.18, 69.01%), number of leaves/plant, (23.00%), fresh and dry weight (63.58, 47.40%), bulb length (57.99%), bulb diameter (52.33%), bulb weight (77.41%), neck thickness of bulb (82.60%), the content of chlorophyll a and b (23.61, 34.37%), the content of minerals P and K (12.90, 55.05%), over control respectively. Our results are consistent with many studies that showed combined application treatments successfully increased the productivity of onion crops. For example, the foliar application of yeast extract + boron was the most effective treatment in giving the maximum vegetative growth of onion plants including plant height and neck diameter [40]. Moreover, found the interaction between 60 kg K20/fed and 1.5 gl-1 of algae extract gave the highest significant pigment contents as compared with the application individual of potassium fertilizer and foliar spray with algae extract [41]. Also, [42] observed that the spraying interaction between the fenugreek and licorice root extract, gave the highest value of bulb diameter, bulb weight, and total yield, as compared with the treatments spraying of an individual. In addition to the action of growth-stimulating phytohormones, the reason may also be the good content of seaweed *Padina pavonica* of macronutrients such as nitrogen, phosphate, potassium, and micronutrients like Fe, Cu, Zn, and Mg, which would increase soil fertility [43].

Table.1. Effect of foliar application treatments on vegetative growth of onion after 70 days of agriculture.

Treatment	Length of leaves		leaves width		Number of leaves /plant		fresh weight of leaves		dry weight of leaves	
	(cm)	%	(cm)	%	N	%	(g)	%	(g)	%
C	46.43 k	100	0.71 i	100	6.52 i	100	42.11 i	100	6.94 g	100
T1	53.80 g	115.87	1.06 e	149.29	6.91 f	105.98	50.15 g	119.09	7.02 f	101.15
T2	60.21 e	129.67	1.14 c	160.56	7.34 d	112.57	59.63 d	141.60	9.78 c	140.92
T3	49.85 j	107.36	1.00 f	140.84	6.80 g	104.29	50.00 h	118.73	7.16 e	103.17
T4	56.70 f	122.11	1.10 d	154.92	7.00 e	107.36	57.65 e	136.90	7.39 d	106.48
T5	52.44 h	112.94	0.90 g	126.71	6.61 h	101.38	53.18 f	126.28	7.35 d	105.90
T6	65.31 b	107.94	0.85 h	119.71	6.55 i	100.46	50.04 h	118.83	6.94 fg	100
T7	50.12 i	151.99	1.35 a	190.14	8.05 a	123.46	72.42 a	171.97	10.34 a	148.99
T8	70.57 a	140.66	1.33 a	187.32	7.84 b	120.24	68.98 b	163.80	10.10 b	145.53
T9	65.09 c	140.18	1.20 b	169.01	8.02 a	123.00	69.00 b	163.58	10.23 a	147.40
T10	62.25 d	134.07	1.20 b	169.01	7.76 c	119.01	66.45 c	157.80	10.05 b	144.81

Table.2. Effects of foliar application treatments on Bulb quality of onion after 70 days of agriculture.

Treatment	Bulb length		Bulb diameter		Bulb weight		Neck thickness of bulb	
	(cm)	%	(cm)	%	(g)	%	(cm)	%
C	4.19 f	100	4. 93 j	100	84.90 g	100	0.46 h	100
T1	4.50 d	107.39	6.00 e	121.70	95.46 e	112.43	0.58 f	126.08
T2	5.21 c	124.34	6.74 d	136.71	100.10 d	117.90	0.69 d	150.00
T3	4.45 d	106.20	5.33 g	108.11	90.32 f	106.38	0.52 g	113.04
T4	5.22 c	124.58	5.91 f	119.87	100.00 d	117.85	0.66 e	143.47
T5	4.44 d	105.96	5.20 h	105.47	93.02 e	109.56	0.57 f	123.91
T6	4.34 e	103.57	5.13 i	104.05	92.00 f	108.36	0.53 g	115.21
T7	6.62 a	157.99	7.51 b	152.33	151.00 a	177.41	0.84 a	182.60
T8	6.14 b	146.53	7.15 a	145.03	137.10 b	161.48	0.72 bc	156.52
T9	6.55 a	156.32	7.20 b	146.04	136.07 b	160.27	0.73 b	158.69
T10	6.11 b	145.82	7.05 c	143.00	129.03 c	151.97	0.70 cd	152.17

Table.3. Effect of foliar application treatments on the content of chlorophyll a and b, minerals p and k concentration in leaves of onion.

Treatment	Chl. a		Chl. b		p		K	
	Mg/g	%	Mg/g	%	Mg/g	%	Mg/g	%
C	0.72 f	100	0.032 h	100	0.72 f	100	0.032 h	100
T1	0.79 d	109.72	0.036 fg	112.50	0.79 d	109.72	0.036 fg	112.50
T2	0.85 c	118.05	0.039 de	121.87	0.85 c	118.05	0.039 de	121.87
T3	0.79 d	109.72	0.035 fgh	109.37	0.79 d	109.72	0.035 fgh	109.37
T4	0.81 d	112.50	0.040 cd	125.00	0.81 d	112.50	0.040 cd	125.00
T5	0.79 d	109.72	0.037 ef	115.62	0.79 d	109.72	0.037 ef	115.62
T6	0.75 e	104.16	0.034 gh	106.25	0.75 e	104.16	0.034 gh	106.25
T7	0.92 a	127.77	0.045 a	140.62	0.92 a	127.77	0.045 a	140.62
T8	0.88 b	122.22	0.042 bc	131.25	0.88 b	122.22	0.042 bc	131.25
T9	0.89 b	123.61	0.043 ab	134.37	0.89 b	123.61	0.043 ab	134.37
T10	0.85 c	118.05	0.040 cd	125.00	0.85 c	118.05	0.040 cd	125.00

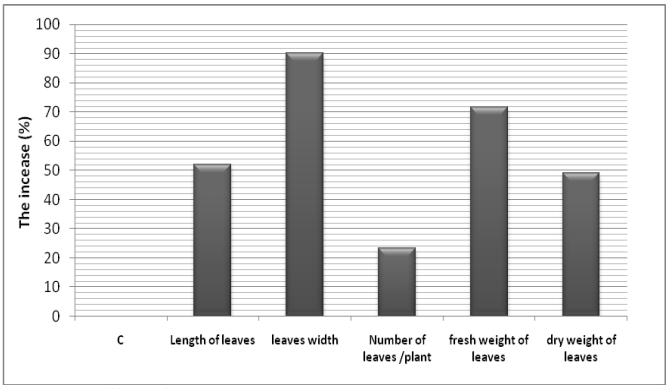

Figure 1. Effect of (*Padina pavonica* extract + GA) on vegetative growth of onion after 70 days of agriculture.

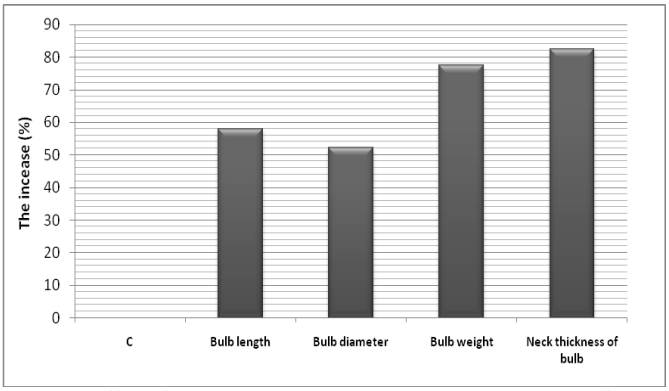

Figure 2. Effect of (*Padina pavonica* extract + GA) on Bulb quality of onion after 70 days of agriculture.

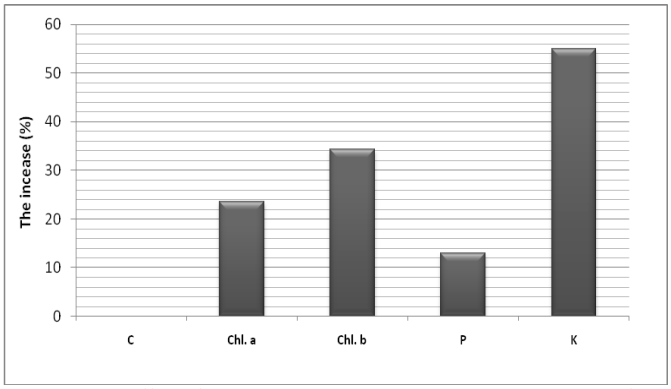

Figure 3. Effect of (*Padina pavonica* extract + GA) on the content of chlorophyll a and b, minerals p and k concentration in leaves of onion.

5. Conclusion

The results in this work indicated the positive effect of all foliar application treatments on increased morpho-physiological parameters of (*Allium cepa* L.), except *Padina pavonica* extract 30%. Also showed that the combined treatment of *P.pavonica* 10 % + $GA_3$300ppm was superior in recording the best indicators studied. Followed by (*P.pavonica* extract10% + IBA300ppm). The study recommends the need to use combined treatments to reduce the damage to soil and plants, caused by chemical fertilizers as they represent a safe means of improving crop production, and benefit from the use of seaweed as they are easy to prepare and inexpensive.

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Data Availability
Data are available upon request from the corresponding author.

Conflict of Interest
The authors declare that there is no conflict of interest.

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Authors' Contributions
- The idea for the article was suggested by Mr. Sami Salih.
- The literature search was performed by Mr. Sami M. Salih & Ahmed A. Abdulrraziq.
- The practical experiment was conducted by Mr. Sami M. Salih.
- Data analysis was performed by Mr. Ahmed A. Abdulrraziq.
- Revising the work was performed by Mr. Sami M. Salih.
- Both authors read and approved the final manuscript.

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AUTHORS PROFILE

Sami Mohammed Salih earned his B. biology., M. plant., from the university Omar Al-mukhtar in 2002, and 2010, respectively. He is currently working as Professor in the Department of Biology, since 2012. He has published 50 research papers in reputed international journals including (Journal of Advances in Microbiology, International Journal of Plant Science and Horticulture and Indian Journal of plant physiology). He has 11 years of teaching experience and 9 years of research experience.

Ahmed Amrajaa Abdulrraziq earned his B. biology., M. plant., from the university Omar Al-mukhtar in 2002, and 2011, respectively. He is currently working as Professor in the Department of Biology, since 2012. He has published 50 research papers in reputed international journals including (Journal of Advances in Microbiology, International Journal of Plant Science and Horticulture and Indian Journal of plant physiology). He has 11 years of teaching experience and 9 years of research experience.

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