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IMPACT OF SOME BIO-STIMULANTS ON PERFORMANCE OF *ZINNIA ELEGANS* SEEDLINGS

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ABSTRACT: The purpose of this study was to investigate the impacts of *Spirulina platensis* algae extract (seaweed) and *Saccharomyces cerevisiae* yeast extract as bio-stimulants on the growth, flowering, and chemical composition of the *Zinnia elegans* plants during 2021 and 2022 seasons. When the seedlings reached about 10 cm in length, they were transplanted into individual pots filled with a mixture of clay and sand (1:1, v/v). Seedlings were sprayed with algae extract at 0.5 and 1% and yeast extract at 3 and 6 g/l however, control plants were sprayed with distilled water. The obtained results indicated that algae extract at 1% treatment increased all vegetative parameters including plant height, stem diameter, number of branches/plant, number of leaves/plant, root length, leaf area, shoot and root fresh and dry weights, flowering parameters including number of inflorescences/plant, inflorescence F.W. and D.W. in both seasons and inflorescence diameter in the second season only. The chemical composition was also positively affected by the same treatment and gave the highest values for photosynthetic pigments, total amino acids, crude protein, macronutrient elements (N, P and K%), total sugar content and total indoles followed by plants sprayed with yeast extract at 6 g/l for all the mentioned parameters during both seasons. It was concluded that algae extract at 1% or yeast extract at 6 g/l can be used as bio-stimulants to boost the growth of the *Zinnia elegans* plant.

Keywords: bio-stimulants, *Zinnia elegans,* seaweed, *Spirulina platensis, Saccharomyces cerevisiae*, yeast extract, algae extract.

INTRODUCTION

Zinnia (*Zinnia elegans* Jacq.) belongs to the family Asteraceae, and is a summer flowering annual plant native to Mexico. The plants are upright and bushy, with 8 cm long, ovate to lance-shaped, lightly hairy leaves. In the summer, broad-petaled purple flower heads with an average diameter of 4.5 cm look like daisies. It expands fairly quickly, reaching a height and width of between 60 and 75 cm. Flowers blooming in a rainbow of colors which can be white, yellow, orange, red, purple, or lilac and sometimes have contrasting eyes, are single, long-stemmed daisy-like flowers (Park *et al.*, 2013). Zinnia plants are used in an annual or mixed border, and for cutting. Smaller cultivars are suitable for edging and for window boxes or containers (Stimart and Boyle, 2007 and Riaz, 2008). Zinnia has attracted the interest of researchers due to its biological actions such as antibacterial, antifungal, antioxidant, and hepatoprotective activities (Gomaa *et al*., 2019). Many species that have been investigated for their chemical constituents and biological

properties are found to be medicinally useful.

Plant bio-stimulants (PB) are defined as substances containing microorganisms which, when applied to plants or the rhizosphere, function to stimulate natural processes to improve nutrient uptake, nutrient efficiency, tolerance to abiotic stress and crop quality improvement (Brown and Saa, 2015). Du Jardin (2015) defined PB as very heterogeneous materials, and in his study proposed eight classes of substances that could act as bio-stimulants: humic substances, complex organic materials (from agro-industrial and municipal waste, sewage sludge extracts, composts, and fertilizers), useful chemical elements (Al, Co, Na, Se, and Si), inorganic salts including phosphite, seaweed extracts (brown, red, and green macroalgae). Bio-stimulants enhance plant productivity because they interact with plant signaling processes, reducing negative plant responses to stress (Brown and Saa, 2015). Bio-stimulants have significant effects on a variety of metabolic processes; promote plant growth and development by increasing photosynthesis, endogenous hormones, ion uptake, nucleic acid and protein synthesis (Abbas, 2013).

Microorganisms extracts that might be derived from bacteria, yeasts, or fungi are widely employed in the production of bio-stimulants. These preparations may involve both living and or non-living microorganisms, in addition to their metabolites. Microorganism-based preparations as bio-stimulants have been described by (Colla *et al.*, 2015; Matyjaszczyk, 2015).

Spirulina is a photosynthetic multicellular blue-green microalga. Microalgae extract mainly consists of mineral-rich natural bioactive substances, gibberellins, auxins, cytokinins, abscisic acid, proteins, carbohydrates and vitamins (Bello *et al*., 2021). Foliar spraying with algae-based bio-stimulants is a promising in recent agricultural technique due to its environmental friendliness and the possibility of obtaining better crop production (Yong *et al*., 2021). Godlewska *et al.* (2019) and El Sharif *et al*. (2020) indicated that foliar spraying of *S. platensis* algae extracts to sugar beet significantly increased photosynthetic pigments, fresh and dry weight/plant, and extractable sugars (%). An extract of *Spirulina platensis* algae regulates and enhances the crop's physiological processes. It acts an important role in plant physiology through different pathways, improving crop growth, yields, quality, nutrient uptake, and tolerance to abiotic stresses (Abd El-Aleem *et al*., 2017; Rouphael and Colla, 2018; Ronga *et al*., 2019 and Rouphael and Colla, 2020).

Yeast is a natural, safe bio-stimulant that plays an important role in plant growth. It is considered a natural source of cytokinins and B vitamins (Brown and Saa, 2015 and Mannino *et al*., 2020), organic compounds (protein, carbohydrates, nucleic acid, lipids, and most nutrient elements) as well as growth substances such as thiamine, riboflavin, pyridoxine, folic acid, and vitamin B12 (Wang *et al*., 2019). It stimulates nucleic acid synthesis, chlorophyll formation, cell division and enlargement, and has protective functions against various stressors (Shehata *et al*., 2012). In addition, yeast also promotes plant growth by raising the pH of the soil (Sterkenburg *et al*., 2015) and converting insoluble forms of phosphorus into soluble forms, thereby facilitating plant uptake of nutrients and minerals, thereby Phosphorus content of plants was improved (Dineshkumar *et al*., 2020).

The purpose of the study was to investigate the effects of *Spirulina platensis* algae extract (seaweed) and *Saccharomyces cerevisiae* (yeast extract) as bio-stimulants on the growth, flowering, and chemical composition of the *Zinnia elegans* plant.

MATERIALS AND METHODS

The pot experiment was carried out at the nursery of the Horticulture Research Institute (HRI), Agricultural Research Centre

(ARC), Giza, Egypt, during two seasons of 2021 and 2022, and however, the chemical analysis was performed in the Ornamental Plants and Woody Trees Dept., National Research Centre (NRC), Egypt.

Seeds of *Zinnia elegans* were obtained from the Horticulture Research Institute and sown in plastic trays on 15th February in both seasons. After 40 days in both seasons, when the seedlings reached about 10 cm in length and had 6–8 leaves, they were transplanted individually in 16 cm plastic pots filled with a mixture of clay and sand (1:1, v/v). Physical and chemical analysis of the soil media is described by Jackson (1973) and mentioned in Table (a). After two weeks from transplanting, the seedlings were sprayed with *Spirulina platensis* algae extract at two rates (0.5 and 1%) and yeast extract at two rates (3 and 6 g/l) in addition to control plants which were sprayed with distilled water every three weeks. The common cultural practices were followed, including hand picking of weeds and monthly plant fertilization with commercial Kristalon (NPK 19-19-19) at the rate of 2 g/pot.

Spirulina platensis algae extract was obtained from Algal Biotechnology Unit, NRC, Egypt. Chemical analysis of algae extract was mentioned in Table (b), was referenced by El-Sayed *et al*. (2014), El-Chaghaby *et al*. (2019) and Sdiq (2020).

Yeast extract was prepared by allowing yeast cells (pure dry yeast) to be grown and multiplied efficiently during conducive aerobic and nutritional conditions that allowed to produce beneficial bio-constituent (carbohydrates, proteins, amino acids, fatty acids, hormones, etc.) specific yeast weight (3 and 6 g) in addition to equal weight of sugar were added into one liter of distilled water for each weight and kept in a dark, warm place for 30 minutes. After that, yeast cells were disrupted to release their content by two cycles of freezing and thawing (Carter *et al.*, 1983). The chemical analysis of yeast extract mentioned in Table (c) was referenced by El-Yazied and Mady (2012).

After 4 months after transplanting the experiment was terminated to record the following data:

Vegetative growth parameters:

Plant height (cm), stem diameter (cm), number of branches/plant, number of leaves/plant, root length (cm), leaf area (cm^2), shoot fresh weight (g/plant), root fresh weight (g/plant), shoot dry weight (g/plant) and root dry weight (g/plant).

Inflorescences parameters:

Number of inflorescences/plant, inflorescence diameter (cm), inflorescence F.W. (g) and inflorescence D.W. (g).

Chemical analysis:

Photosynthetic pigments including chlorophyll a, b and carotenoid (mg/g F.W.) were determined according to Saric *et al.* (1967). Total amino acids (g/100 g F.W.) were measured by spectrophotometer at 570 nm, using glycine as a standard as described by Moore and Stein (1954). Crude protein (%) was determined as nitrogen content and converted to protein % by multiplying N % by 6.25 according to Mariotti *et al*. (2008). Macronutrients including nitrogen (N %) were assessed by the modified Kjeldahl method as determined by Cottenie *et al.* (1982). Phosphorus (P %) was determined according to Pierzynski (2000), and potassium (K %) was determined in the digested solution described by Chapman and Pratt (1961). Total sugar content (mg/g F.W.) was determined according to the methods described by Dubois *et al*. (1956). Total indoles content (mg/100 g F.W.) was determined according to Larsen *et al*. (1962).

Experiment layout and statistical analysis:

The experiment was arranged in a completely randomized design with 5 treatments with 5 replicates for each season. The collected data were analyzed using ANOVA, and the means of the treatments were compared for significance using Duncan's new multiple range test (DMRT) at a 5% level of probability (Duncan, 1955).

Table a. Physical and chemical properties of the soil.

Soil type	Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)
Sandy loam	61.44	9.36	12	17.20

E.C. (1:1) (dS/m)	pH	O.M. (%)	Anion (meq/l)			Cation (meq/l)			
			HCO_3^-	Cl^-	So_4^-	Ca^{++}	Mg^{++}	Na^{++}	K^+
0.48	8.1	1.36	6.88	3.25	2.47	6.00	1.82	2.79	0.78

Table b. Chemical analysis of the *Spirulina platensis* algae extract.

Amino Acid (%)		Minerals	
Aspartic acid	4.52	**N**	8.00%
Glutamic acid	4.30	**P**	0.65%
Glutamine	6.38	**K**	1.60%
Glycine	2.87	**Ca**	0.40%
Histidine	4.08	**S**	0.08%
Arginine	4.60	**Mg**	25 ppm
Threonine	4.05	**B**	12 ppm
Alanine	4.54	**Zn**	80 ppm
Proline	7.14	**Fe**	2000 ppm
Tyrosine	0.70	**Mn**	70 ppm
Tryptophan	3.90	**Cu**	100 ppm
Methionine	5.53	**Others**	
Cystine	4.55	**Total antioxidant capacity**	3720.67 mg AAE/100g
Valine	6.58	**Total phenols**	2238.64 mg GAE/kg
Isoleucine	5.65	**Total flavonoids**	142.23mg QE/kg
Leucine	6.42	**Protein**	53.30%
Phenyl alanine	5.04	**Fat**	12.83%
lysine	19.05	**Ash**	10.30%
		Moisture	2.03%

Table c. Chemical analysis of the *Saccharomyces cerevisiae* yeast extract.

Amino acid (%)		Vitamins (mg/100 g D.W.)		Minerals	
Alanine	1.69	Vit. B1	23.33	N	6.88%
Arginine	1.49	Vit. B2	21.04	P	0.66%
Aspartic acid	2.32	Vit. B6	20.67	K	0.95%
Cystine	0.63	Vit. B12	19.17	Mg	0.19%
Glutamic acid	3.76	Thiamine	23.21	Ca	0.17%
Glycine	1.45	Riboflavin	27.29	S	0.48%
Histidine	0.71	Inositol	20.43	Fe	107 ppm
Isoleucine	0.85	Biotin	20.04	Zn	77 ppm
Leucine	1.91	Nicotinic acid	73.92	Cu	5 ppm
Lysine	1.13	Pantothenic acid	38.43	Mn	13 ppm
Phenylalanine	1.18	P aminobenzoic acid	29.49	**Growth regulators (ppm)**	
Proline	1.29	Folic acid	26.22	Adenine	31
Serine	1.98	Pyridoxine	22.09	Betaines	56
Threonine	1.54	**Others (%)**			
Tryptophan	0.25	Crude protein	43.00		
Tyrosine	0.99	Crude fat	2.20		
Valine	1.40	Carbohydrates	33.21		
Methionine	0.40	Crude fiber	7.20		
		Ash	3.80		

All the statistical analyses were performed by using CoStat (CoHort software, Monterey, CA, USA) V6.4 (2005). Standard Error (±SE) was calculated.

RESULTS

Vegetative growth traits:

The study showed that the bio-stimulant (algae and yeast) had a positive effect on the growth of *Zinnia elegans* plants. The mentioned data in Tables (1 and 2) showed that all the bio-stimulant treatments increased the values for all the measured morphological parameters, where, the highest values for plant height (65.50±2.78 and 68.67±1.65 cm), stem diameter (0.64±0.02 and 0.66±0.03 cm), number of branches/plant (6.00±0.00 and 6.67±0.58), number of leaves/plant (58.67±2.52 and 62.00±2.65), root length (16.33±0.81 and 17.33±0.72 cm), leaf area (27.53± 0.60 and 28.79±0.67 cm^2), shoot fresh weight (25.36±0.55 and 27.65±0.70 g/plant), root fresh weight (2.35±0.05 and 2.69±0.05 g/plant), shoot dry weight (7.48±0.09 and 7.81±0.08 g/plant) and root dry weight (1.40±0.05 and 1.62±0.07 g/plant), respectively, in the first and second seasons were obtained from plants sprayed with algae at rate of 1% followed by plants sprayed with yeast extract at rate of 6 g/l giving values for each of plant height (61.50±2.18 and 63.67±1.97 cm), stem diameter (0.60±0.03 and 0.61±0.03 cm), number of branches/plant (5.33±0.57 and 5.67±0.57), number of leaves/plant (50.00±1.73 and 52.67±2.31), root length (15.23±0.55 and 16.67±0.64 cm), leaf area (25.26±0.60 and 25.88±0.94 cm^2), shoot fresh weight (19.98±0.76 and 20.22±0.73 g/plant), root fresh weight (2.24±0.06 and 2.29±0.05 g/plant), shoot dry weight (5.66±0.06 and 5.58±0.08 g/plant) and root dry weight (1.31±0.06 and 1.36±0.07 g/plant), respectively, in the first and second season.

Flowering traits:

Treatment with bio-stimulants also had a positive effect on the inflorescences traits of zinnia plants as cleared in Table (3), as the plants that were treated with algae extract at 1% treatment showed a significant increase in number of inflorescences/plant giving 5.33±0.57 and 6.00±1.00, inflorescence fresh weight giving 1.55±0.05 and 1.64±0.06 g and inflorescence dry weight giving 0.45±0.04 and 0.46±0.03 g, respectively, in the first and second seasons and inflorescence diameter giving 5.96±0.08 cm in the second season, followed by plants treated with yeast at 6 g/l giving 4.00±1.00 and 5.67±0.58 for number of inflorescences/plant, 1.51±0.05 and 1.54±0.04 g for inflorescence fresh weight and 0.42±0.05 and 0.42±0.04 g for

Table 1. Effect of algae or yeast extracts on plant height, stem diameter, number of branches, number of leaves and root length of *Zinnia elegans* plant.

Treatments	Plant height (cm)	Stem diameter (cm)	No. of branches/plant	No. of leaves/ plant	Root length (cm)
			First season		
Control	50.67± 2.33^{d}	0.49±0.03^{c}	4.00±1.00^{c}	38.67±1.53^{d}	13.20±0.35^{c}
Algae 0.5%	56.33±2.39^{c}	0.52±0.03^{bc}	4.67±0.58^{bc}	40.33±2.31^{d}	14.50±0.46^{b}
Algae 1%	65.50±2.78^{a}	0.64±0.02^{a}	6.00±0.00^{a}	58.67±2.52^{a}	16.33±0.81^{a}
Yeast 3 g/l	58.80±2.43^{bc}	0.54±0.03^{b}	4.67± 0.58^{bc}	45.67± 1.52^{c}	14.67±0.65^{b}
Yeast 6 g/l	61.50±2.18^{ab}	0.60±0.03^{a}	5.33±0.57^{ab}	50.00±1.73^{b}	15.23±0.55^{b}
			Second season		
Control	51.60±1.35^{e}	0.50±0.04^{c}	3.67±0.57^{c}	41.33±1.51^{d}	13.83±0.66^{d}
Algae 0.5%	55.33±1.48^{d}	0.52±0.04^{c}	5.00±1.00^{b}	44.00±2.65^{d}	15.20±0.44^{c}
Algae 1%	68.67±1.65^{a}	0.66±0.03^{a}	6.67±0.58^{a}	62.00±2.65^{a}	17.33±0.72^{a}
Yeast 3 g/l	59.50±1.95^{c}	0.55±0.04^{bc}	5.33±0.57^{b}	48.67±1.52^{c}	16.00±0.62^{ab}
Yeast 6 g/l	63.67±1.97^{b}	0.61±0.03^{ab}	5.67±0.57^{ab}	52.67±2.31^{b}	16.67±0.64^{ab}

Mean values (± SE) by the same letter in the same column do not significantly differ based on DMRT at 5% level.

Table 2. Effect of algae or yeast extracts on leaf area, shoot and root fresh and dry weights of *Zinnia elegans* plant.

Treatments	Leaf area (cm^2)	Shoot F.W. (g/plant)	Root F.W. (g/plant)	Shoot D.W. (g/plant)	Root D.W. (g/plant)
			First season		
Control	16.29±0.62^{d}	14.05±0.81^{d}	1.24±0.06^{e}	3.65±0.08^{e}	0.70±0.03^{d}
Algae 0.5%	20.55±0.68^{c}	16.24±0.55^{c}	1.74±0.06^{d}	4.32±0.07^{d}	1.00±0.06^{c}
Algae 1%	27.53±0.60^{a}	25.36±0.55^{a}	2.35±0.05^{a}	7.48±0.09^{a}	1.40±0.05^{a}
Yeast 3 g/l	24.74±0.53^{b}	16.66±0.63^{c}	1.94±0.05^{c}	4.52±0.08^{c}	1.28±0.04^{b}
Yeast 6 g/l	25.26±0.60^{b}	19.98±0.76^{b}	2.24±0.06^{b}	5.66±0.06^{b}	1.31±0.06^{b}
			Second season		
Control	17.1±0.66^{e}	13.78±0.71^{e}	1.17±0.05^{e}	3.46±0.07^{e}	0.69±0.06^{e}
Algae 0.5%	21.37±0.98^{d}	15.46±0.42^{d}	1.52±0.07^{d}	4.11±0.08^{d}	0.89±0.05^{d}
Algae 1%	28.79±0.67^{a}	27.65±0.70^{a}	2.69±0.05^{a}	7.81±0.08^{a}	1.62±0.07^{a}
Yeast 3 g/l	23.14± 0.41^{c}	16.97±0.91^{c}	2.12±0.06^{c}	4.59±0.10^{c}	1.25±0.06^{c}
Yeast 6 g/l	25.88±0.94^{b}	20.22±0.73^{b}	2.29±0.05^{b}	5.58±0.08^{b}	1.36±0.07^{b}

Mean values (± SE) followed by the same letter in the same column do not significantly differ based on DMRT at 5% level.

Table 3. Effect of algae or yeast extracts on no. of inflorescences/ plant, inflorescence diameter and inflorescence fresh and dry weights of *Zinnia elegans* plant.

Treatments	No. of Inflorescences/ plant	Inflorescence diameter (cm)	Inflorescence F.W. (g)	Inflorescence D.W. (g)
		First season		
Control	2.00±0.00^{c}	3.28±0.07^{e}	1.27±0.06^{c}	0.31±0.06^{b}
Algae 0.5%	3.67±0.58^{b}	4.34±0.07^{d}	1.40±0.05^{b}	0.36±0.05^{ab}
Algae 1%	5.33±0.57^{a}	5.85±0.09^{b}	1.55±0.05^{a}	0.45±0.04^{a}
Yeast 3 g/l	3.67±0.57^{b}	4.77±0.08^{c}	1.46±0.05^{ab}	0.38±0.06^{ab}
Yeast 6 g/l	4.00±1.00^{b}	6.38±0.08^{a}	1.51±0.05^{a}	0.42±0.05^{a}
		Second season		
Control	1.67±0.58^{c}	3.17±0.09^{e}	1.23±0.05^{d}	0.32±0.03^{c}
Algae 0.5%	3.67±0.58^{b}	4.48±0.07^{d}	1.39±0.06^{c}	0.37±0.03^{bc}
Algae 1%	6.00±1.00^{a}	5.96±0.08^{a}	1.64±0.06^{a}	0.46±0.03^{a}
Yeast 3 g/l	4.00±0.00^{b}	4.66±0.08^{c}	1.45b±0.07^{c}	0.39±0.05^{b}
Yeast 6 g/l	5.67±0.58^{a}	5.52±0.10^{b}	1.54±0.04^{b}	0.42±0.04^{ab}

Mean values (± SE) followed by the same letter in the same column do not significantly differ based on DMRT at 5% level.

inflorescence dry weight, respectively, in the first and second seasons. Regarding the inflorescence diameter, the highest value was obtained in the first season from plants treated with yeast extract at 6 g/l followed by algae treatment at 1% giving 6.38±0.08 and 5.85±0.09 cm, respectively. On opposite in the second season, the highest value was obtained from plants treated with algae at 1% followed by yeast extract at 6 g/l treatment giving 5.96±0.08 and 5.52±0.10 cm, respectively.

Chemical analysis:

The results presented in Figs. (1-3) showed the positive effect of bio-stimulant treatments on the chemical content of zinnia leaves. In this regard, treatment with algae at a concentration of 1% led to an increment in the content of photosynthetic pigments (Fig., 1) including chlorophyll a by 100 and 95.32%, chlorophyll b 110.71 and 81.81% and carotenoids by 102.56 and 102.38%, respectively, in the first and second season. Treatment with yeast extract also had a stimulating effect on the photosynthetic pigments content of zinnia leaves following the effect of algae. It was noticed that the plants were sprayed with yeast extract at rate 6 g/l produced an increment in chlorophyll a by 91.67 and 85.71%, chlorophyll b 92.86 and 72.73% and carotenoids 89.74 and 90.48%, respectively, in the first and second season.

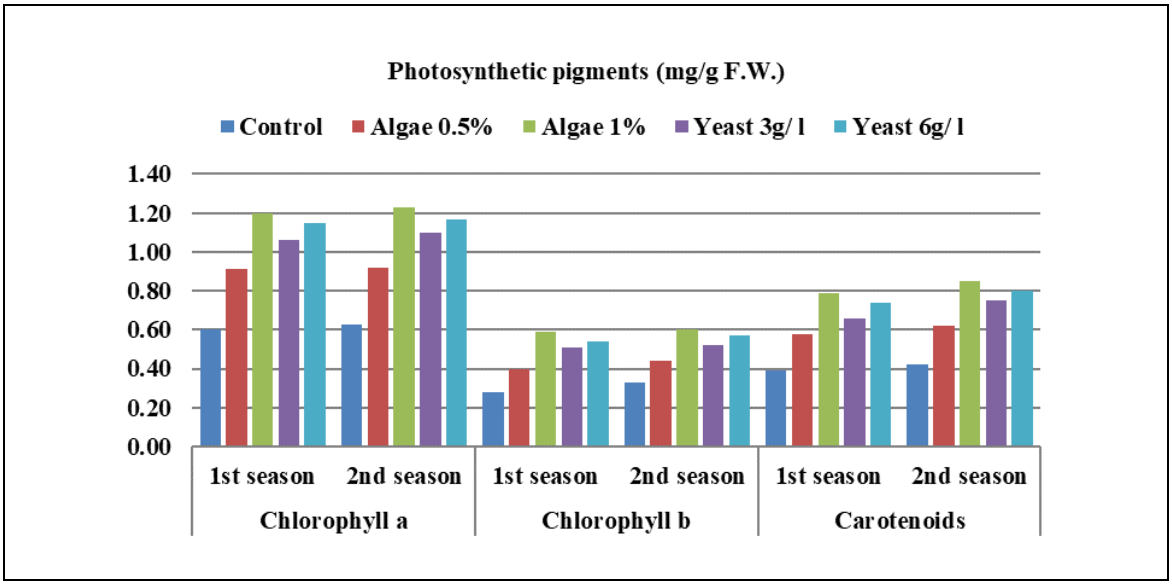

Fig. 1. Effect of algae or yeast extracts on photosynthetic pigments in leaves of *Zinnia elegans* seedlings.

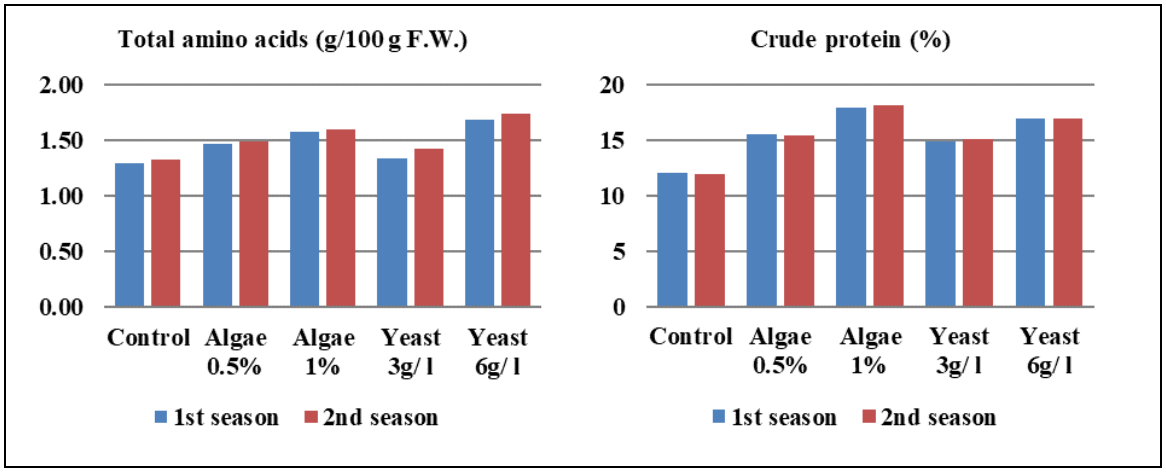

Fig. 2. Effect of algae or yeast extracts on total amino acids (g/100 g F.W.) and crude protein (%) in leaves of *Zinnia elegans* seedlings.

The data showed in Fig. (2) indicated that the total amino acids content positively affected by yeast extract treatment at rate 6 g/l producing the highest increment percentage (30.23 and 31.82%) followed by plants treated with algae at rate 1% giving (21.71 and 21.21%), respectively, in the first and second season. On the other hand, the crude protein % giving the highest increment (49.00 and 52.61%) in the plants which sprayed with algae at rate 1% followed by yeast extract treatment at rate 6 g/l giving 41.17 and 42.09%, respectively, in the first and second season (Fig., 2).

The data presented in Fig. (3) illustrated that macronutrient (N, P and K %), total sugars and total indoles content in *Zinnia elegans* leaves were improved by treatment with algae at a rate of 1% producing an increment (48.96, 82.61 and 50.75%, respectively, in the first season and 52.63, 114.29 and 52.05% respectively, in the second season) for macronutrient and (62.11 and 84.67%, respectively, in the first season

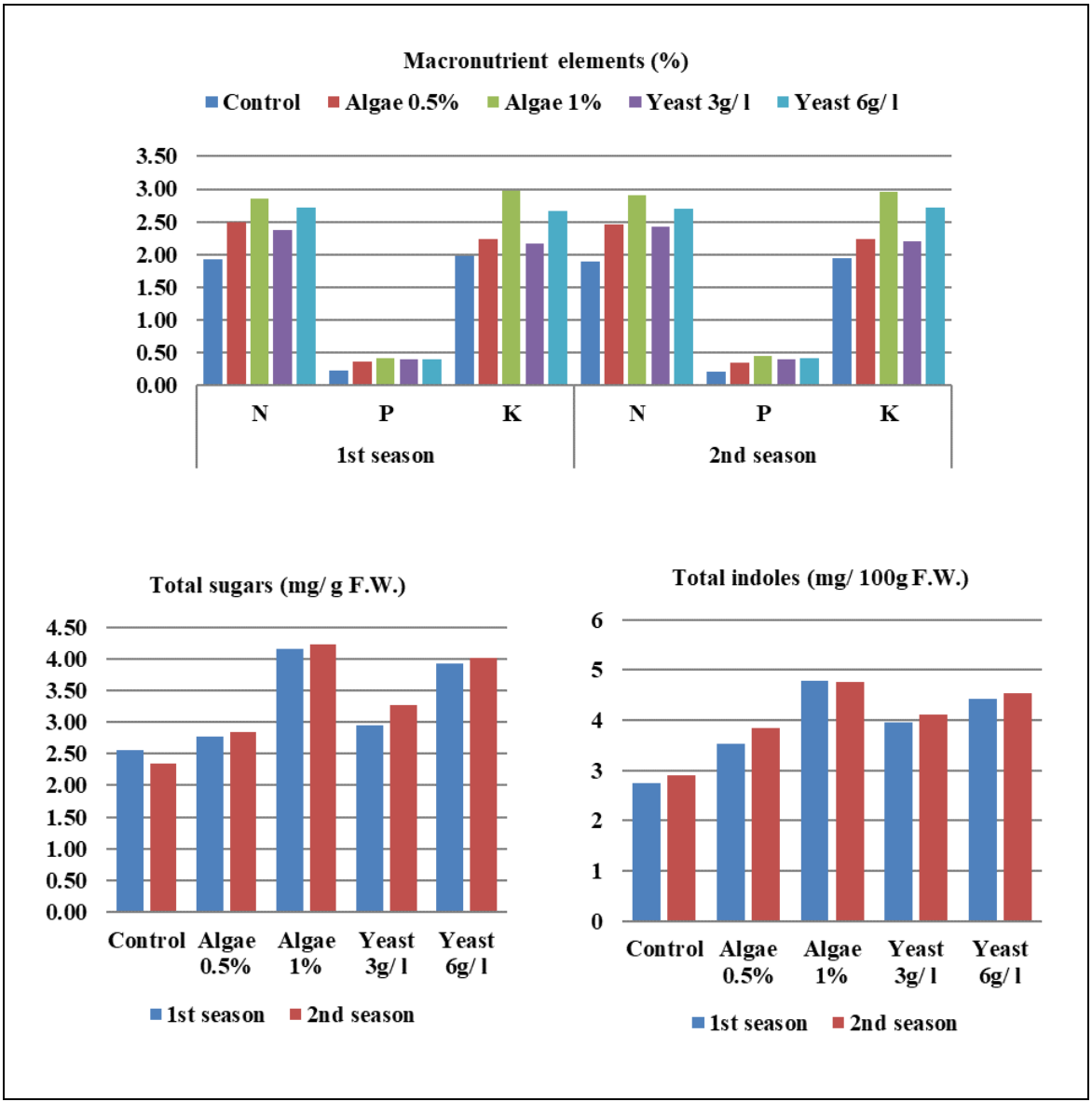

Fig. 3. Effect of algae or yeast extracts on macronutrient elements, total sugars and total indoles in leaves of *Zinnia elegans* seedlings.

and 80.34 and 63.23%, respectively, in the second season) for total sugars and total indoles content.

The following effect was showed in plants received yeast extract at rate 6 g/l produced an increment percentage (41.15, 73.91 and 35.03%, respectively, in the first season and 42.11, 95.24 and 40.21% respectively, in the second season) for macronutrient elements and (53.13 and 61.31%, respectively, in the first season and 71.79 and 55.67%, respectively, in the second season) for total sugars and total indoles content.

DISCUSSION

The obtained results, which were previously presented, showed that bio-stimulants had an effective positive role in the growth and flowering of plants. A large number of researchers have clarified the positive role of *S. platensis* algae on the vegetative growth and flowering characteristics of many plants such as

Hamouda *et al*. (2022) on *Triticumae stivum*, Saadaoui *et al*. (2019) on *Phoenix dactylifera*, Plaza *et al*. (2018) on *Petunia X hybrid*, Tarraf *et al*. (2015) on *Trigonella foenum-graecum* and Nawar and Ibraheim (2014) on *Pisum sativum*.

The enhancement effect of algae extract on the plant growth characteristics may be attributed to the auxin content of the algae extract which has an effective role in cell division and enlargement. This leads to increase the shoot growth, leaves number, and plant dry weight (Parađiković *et al*., 2019). *Spirulina platensis* is a rich source of potassium and contains considerable amounts of Ca, Cu, Fe, Mg, Mn, P and Zn (Marrez *et al*., 2014), which have a great role in cell division and enlargement and induce the photosynthesis and this in turn reflected on a great shoot growth (Singh *et al*., 2011). It also contains macronutrients (N, P and K) which are very essential for growth and development of the plant (Battacharyya, 2015 and Plaza, 2018). These results may explain the great importance of algae extract on supplementing the plants with their requirements from organic and mineral nutrients.

The increased chlorophyll content in the leaves, which increased the photosynthetic activity of the treated plants, may be attributed to metabolism and biological activity and their stimulatory effects on effects on photosynthetic pigments and enzyme activities, thereby promoting the vegetative development of *Vicia faba* (ElSherbeny *et al*., 2007 and Mady, 2009).

Also, this study proved the positive role of yeast extract application. This can be attributed to its content of nutrients, proteins, carbohydrates, vitamins B, thiamine and cytokinins which stimulate the plant to produce dry matter (Youssef, 2022). It is also a natural source of cytokinins, which promote cell proliferation and differentiation, while controlling shoot and root morphogenesis, chloroplast maturation, protein and nucleic acid synthesis (Hammad and Ali, 2014), or may be due to yeast extract being high in tryptophan, which is a precursor to IAA. This substance promotes cell division and elongation (Abdel Latef *et al*., 2019). Furthermore, this increase may be due to differential roles of amino acids in the protein structure of several plant enzymes required for vegetative development (Shafeek *et al*., 2012). The importance of different concentrations of yeast extract on N, P and K % accumulation in leaves may be due to its diversity of amino acids and vitamins.

Spraying algae extract improves the photosynthetic pigment contents (Chojnacka and Kim, 2015). It may play a role through its content of cytokinins in delaying the leaves' ageing by reducing the chlorophyll degradation (Abdelaal *et al*., 2019) and its stimulated influence in nutrients held by plants (Abdel-Mawgoud *et al*., 2010).The same trend was obtained by Nawar and Ibraheim (2014) on *Pisumsativum*, Saadaoui *et al.* (2019) on *Phoenix doctylifera*, Abd El-Aleem *et al*. (2021) on *Petroselinum crispum*, Hamouda *et al*. (2022) on *Triticum aestivum* and Makhlouf and Helmy (2022) on sugar beet. This increase in chlorophyll content seemed to be a result of reduction in chlorophyll degradation, which might be caused in part by betaines in the seaweed extract (Chen *et al*., 2017). Also, Khan *et al*. (2009) reported that algae extract contains cytokines which induce the physiological activities and increase total chlorophyll in plants. This will positively reflect in the activity of photosynthesis and the synthesized materials which will positively reflect on shoots characteristics.

It is noticed from the former studies that there are some plants gave similar results to obtained in this study when treated with yeast extract such as *Vicia faba* plant (Mady, 2009), *Citrus aurantifolia* (Mustafa *et al*., 2019), potato (Manea *et al*., 2019), *Ocimum basilicum* (Mohamed *et al*., 2022), *Gladiolus grandiflorus* (Sarhan *et al*., 2022). The improvement effect of the foliar application of yeast extract may be attributed to its bio-regulator role in plants, affecting the balance

of photosynthesis and photorespiration (Olaiya, 2010) and delaying the leaf senescence by reducing the degradation of chlorophyll, improving protein and RNA synthesis (Youssef *et al*., 2022).

The positive effect of algae extract treatment on protein content in plants was reported by Becker (2013) and Hamouda *et al*. (2022) on *Triticumae stivum*. The effect of yeast extract was reported also by Parađiković *et al*. (2019) on some horticultural plant species. In this aspect, many studies showed that the enhancement effect of algae extract on macronutrient elements content (Tarraf *et al*., 2015), total sugars content (Hamouda *et al*., 2022).The similar results for the effect of yeast extract on macronutrient elements were obtained by many authors on (Mady, 2009; Mustafa *et al*., 2019; Manea *et al*., 2019; Sarhan *et al*., 2022 and Youssef *et al*., 2022).

In addition, Yeast extract is a natural source of many growth components acting as protectants and most nutrients (Na, Ca, Fe, K, P, S, Mg, Zn, and Si), cytokinins, and several organic compounds (Francesca *et al*., 2020). Furthermore, the beneficial effect of yeast extract on promoting vegetative growth may explain why the nutrient concentration in leaves is increased (Al-Juthery, 2020). Yeast extract stimulates the production of endogenous hormones leading to the accumulation of secondary metabolites such as all soluble sugars, phenols, flavonoids and glycosides (Abraham *et al*., 2011). Yeast extract plays an important role in increasing the release of carbon dioxide through the fermentation process, leading to an increase in photosynthetic pigments and successful activation of the photosynthetic processes. Therefore, it may be because it promotes cell division and cell elongation, resulting in increased leaf area (Abdallah *et al*., 2016), as carbohydrate biosynthesis is accelerated (Nassar *et al*., 2016). Dawood *et al*. (2019) have previously published similar reports on flax plants (Al-Juthery, 2020), wheat plants (Khudair and Hajam, 2021), Chinese carnations, and (Taha *et al*., 2021) white lupine plants.

CONCLUSIONS

From the present study we can concluded that algae extract at rate 1% had the best effect on vegetative growth (plant height, stem diameter, number of branches/plant, number of leaves/plant, root length, leaf area and shoot and roots fresh and dry weights), flowering traits (number of inflorescences/plant, inflorescence diameter, inflorescence fresh and dry weights) and chemical compositions (photosynthetic pigments, total amino acids, crude protein, macronutrient elements (N, P and K), total sugars and total indoles), followed by yeast extract on the same traits during two growth season as compared with untreated plants..

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تأثير بعض المنشطات الحيوية على أداء شتلات الزينيا ايليجانس

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المنشطات الحيوية هي المواد الطبيعية والكائنات الحية الدقيقة المختلفة التي تستخدم لتحفيز نمو النبات. كان الهدف من الدراسة هو معرفة تأثير مستخلصات طحلب *Spirulina platensis* ومستخلص الخميرة *Saccharomyces cerevisiae* كمحفزات حيوية على النمو والتزهير والتركيب الكيميائي للزينيا. تم الحصول على بذورالزينيا من معهد بحوث البساتين و زراعتها في الحديقة البحثية الخاصة بالمعهد في صواني بلاستيكية. عندما وصل نمو الشتلات إلى حوالي ١٠ سم، تم نقلها في اصص بمزيج من الطين والرمل (١:١، حجم/حجم). خلال عامي ٢٠٢١ و ٢٠٢٢ تم رش شتلات الزينيا بتركيزات (٠,٥ و ١٪) من مستخلص الطحالب و (٣ و ٦ جم / لتر) من الخميرة بالإضافة إلى الكنترول (رش النباتات بالماء المقطر). أظهرت النتائج أن النباتات التي تم رشها بمستخلص الطحالب بنسبة ١٪ أدت إلى زيادة جميع الصفات النباتية بما في ذلك ارتفاع النبات، قطر الساق، عدد الأفرع/نبات، عدد الأوراق/نبات، طول الجذر، مساحة الورقة، أوزان الساق والجذورالطازجة والجافة والقياسات الزهرية (عدد النورات/النبات) والوزن الطازج والجاف للنورات في كلا الموسمين وقطر النورة في الموسم الثاني فقط، كما تأثرت المكونات الكيميائية إيجابياً بنفس المعاملة وأعطت أعلى قيم للصبغات الضوئية والاحماض الامينية الكلية والبروتين الخام كذلك العناصر الكبري (النيتروجين والفسفور والبوتاسيوم %)، محتوى السكريات الكلية وايضا الإندولات الكلية تُبعت بالمعاملة ٦ جم لكل لتر بالنسبة لنفس القياسات السابقة في كلا الموسمين. يمكن ان نستنتج من هذه التجربة أن مستخلص الطحالب بتركيز ١٪ أو الخميرة عند ٦ جم/لتر يمكن أن يستخدم كمحفزات حيوية لتعزيز نمو نبات الزينيا.