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IMPACT OF FOLIAR SPRAY WITH *SACCHAROMYCES CEREVISIAE* EXTRACT IN DIFFERENT FORMS AND CONCENTRATIONS ON GROWTH, PRODUCTIVITY AND QUALITY OF LETTUCE PLANTS

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ABSTRACT: This investigation was adopted during the two consecutive winter seasons of 2019/2020 and 2020/2021, to examine the impact of foliar spray with bread yeast in different forms and concentrations on the development, production yield and quality of lettuce cv. Dark Green (*Lactuca sativa* L.). This experiment was consisted of twelve treatments which were the combinations between four yeast forms (untreated yeast cells, yeast extract, yeast cells treated with nitric acid 50% and yeast cells treated with urea at three concentrations (1, 2 and 3, w/v).The results showed that, foliar spraying with yeast cells treated with urea at the highest concentration 3% recorded the largest values of the height of plant, leaf area per plant, total fresh and dry weights/plant, total chlorophyll, yield and its components, N, K and dry matter percentages in lettuce leaves in both seasons, with no significant differences between foliar spray with yeast cells treated with urea or with nitric acid treatments regarding number of leaves/plant, P (%) and nitrate content. In general, foliar spraying with yeast cells treated with urea at 3% increased yield and its component but at the same time increased nitrate content in leaves and decreased the quality of lettuce plants. Accordingly, it may be prudent to avoid using a high concentration of yeast cells treated with urea, in order to preserve the quality of lettuce plants, and instead of that it can be used a medium concentration to get the best quality and reasonable yield.

Key words: Lettuce, yeast, urea, nitric acid, yield components.

INTRODUCTION

Head lettuce (*Lactuca sativa* L.) is a significant leafy vegetable crops growing in Egypt and many countries around the world. Lettuce is consumed as salad and in fast foods and leaves have a considerable number of antioxidants compounds like caffeic acid, quercetin, minerals, vitamins (A, C, E and K) and phytochemicals. Lettuce leaves have a little of lactucarium that considered a moderate sedative (**Masarirambi *et al.*, 2012** and **Khalil *et al.*, 2016**). It also contains nutritional fiber, carbs, protein, and a small amount of fat, all of which are beneficial to human health.

The foliar application of natural biostimulants is beneficial, and has stimulated the growth and quality of a large number of crops, where it contains many microbes and elements that have a good effect on plant growth and development. It is also an environmentally friendly technology that reduces the use of fertilizers and pesticides, and increases productivity (**Paradikovic *et al.*, 2011** and **Shahrajabian *et al.*, 2021**).

Bread yeast (*Saccharomyces cerevisiae*) is widely distributed in the natural environments, it is a type of biostimulants that can be used as a soil fertilizer or as a foliar spray on vegetable shoots (**El-Ghamriny *et al.*, 1999**). It is belonging the eukaryotic unicellular micro fungi, family Saccharomycetaceae. It is multiplying vegetatively by budding, and sexually by the formation of ascospores (**Barnett, 2000**). They play an important role in food chains, and carbon, nitrogen and sulphur cycles. It contains also high levels of nutrients and growth stimulants as auxins, gibberellins, and cytokinin hormone, that enhance cell replication, also, the production of protein, nucleic acid, and chlorophyll (**Amer, 2004, Wanas, 2006** and **Xiao, 2014**).

In addition, bread yeast is considered a rich source of sugars, vitamins and the essential amino acids (**Bevilacqua, *et al.*, 2008, Sarhan and Abdullah, 2010** and **Nassef and El-Aref, 2016**). **Yeo *et al.*, (2000)** found that yeast extract contains of trehalose-6-phosphate syntheses which is a biosynthesis enzyme. Moreover, **Xi *et al.*, (2019)** reported that, yeast extract, is an environmentally friend and has benefits exceed plant development promoters. Also, it is a cheap product and can be produced in large amounts easily. During the fission of the yeast, urease enzyme catalyzes the hydrolysis of urea to $2NH_3$ and CO_2, therefore increases the intracellular level of NH_3. The increase in intracellular concentration of NH_3 is likely to inhabit uracil transport and/or the salvage pathway of uridine monophosphate (UMP) synthesis, depletion of intracellular uracil resulted in cell lysis (**Nishino *et al.*, 2017**).

Several studies showed that, foliar spray with yeast improved growth and productivity of many different crops (**Abou El Nasr *et al.*, 2001** on squash**, Fawzy, 2007** on lettuce, **Mahmoud *et al.*, 2013** on pea**, El Sagan, 2015** on cucumber**, Shafeek *et al.*, 2015** on turnip and **Ali, 2017** on garlic). Also, **Ibrahim (2020)** found that, foliar spraying of yeast at a concentration of 5 g/L produced the best results in terms of lettuce growth, leaf mineral content and head weight and **Abd El Galil *et al.* (2021)** reported that, using urea and dry yeast levels increased vegetative growth characters and yield of lettuce. In addition, **Fawzy, 2010** on lettuce and **El-Bassiony *et al.*, 2014** on Kohlrabi reported that, the highest values of dry weight of leaves were present with foliar spray of yeast. Also, foliar application of active yeast increased chlorophyll in leaf tissues (**El-Desouki and Greadly, 2006 on pea; Abou El-Yazied and Mady, 2011** on tomato). Moreover, **Kanimarani (2020)** noticed that the level of (3ml/l) yeast extract revealed a marked elevation in leaf chlorophyll content.

Therefore, the purpose of this study was to evaluate the effect of spraying various forms and levels of yeast on vegetative growth, yield and quality of lettuce plants under sandy soil condition.

MATERIALS AND METHODS

This study was adopted during the two consecutive winter seasons of 2019/2020 and 2020/2021 at El-Khattara Experimental Farm, Faculty of Agriculture, Zagazig University, Sharkia Governorate, Egypt to assess the impact of foliar spray with yeast in different forms and concentrations on growth, productivity, and quality of lettuce plants (cv. Dark Green), planted in sandy soil using drip irrigation system. The trial soil was sandy in texture and some chemical characters were: pH were 8.01 and 7.56, organic matters were 0.89% and 0.91%, total N were 0.033% and 0.039%, available N were 12.11 and 12.43 ppm, available P were 16.90 and 16.48 ppm and available K were 50.18 and 63.02 ppm in the 1st and 2nd seasons, respectively.

Preparation of yeast extract

The indigenous yeast (*Saccharomyces cerevisiae*) was provided by Microbiology Lab., Agricultural Microbiology Department, Faculty of Agriculture, Zagazig University, Egypt. Yeast and Mold (YM) medium used to cultivate the pure culture biomass of yeast. It was grown at 28±2 °C with continuous shaking at 150 rpm, the cultures were grown for a period of 3 days. After incubation the yeast cells suspension treated with Nitric acid (50%) and pellet of urea fertilizer 10% (46.5 N) to disruption the cell wall of yeast cells and releasing their contents (**Nishino *et al.*, 2017**). Then the extract was filtered by Whatman No.1 filter paper and the culture filtrates were kept in refrigerator at 5°C. Yeast forms were added as a foliar application to the plants after 30, 45 and 60 days from transplanting.

Experimental design

This experiment was consisted of twelve treatments which were the combinations between four yeast forms [untreated yeast cells, yeast extract, yeast cells treated with nitric acid 50% and yeast cells treated with urea at three concentrations (1, 2 and 3% W/V)] of each. These treatments were randomly allocated in a split plot system with triplicate, yeast forms were distributed in random method in the main plots while concentrations were arranged in random methods in the sub plots of this experiment.

The recommended amount of botanical compost was added (20 m³/fed.) during soil preparation before transplanting, furthermore, lettuce plants in all experimental units received the required doses of mineral N, P and K fertilizers which used under sandy soil conditions during soil preparation and through the season of growth after transplanting in equal doses. Ammonium sulfate (20.5%N), calcium superphosphate (15.5 % P_2O_5) and potassium sulphate (48% K_2O) were employed as sources of mineral N, P and K, respectively. Transplants of lettuce cv. Dark Green were transplanted on 7 December in both seasons of the study. The site of the experimental unit was 12.6 m². It included 3 lines of 6 m length and 0.7 m width. Lettuce transplants were planted at 25 cm a part on both sides of the drippers. The other normal agriculture treatments for cultivating lettuce plants were practiced as commonly.

Data recorded

1- Plant growth measurements

At 75 days from cultivation a random sample of 5 plants were collected from each experimental unit for measuring plant height, number of leaves per plant, fresh weight of different plant organs and total fresh weight. per plant, also leaf area per plant (cm^2) and dry weight of all studied different organs of lettuce plant and total dry weight per plant were determined (leaves were dehydrated at 70˚C until fixed weight. then recorded). Leaf chlorophyll content: Disc samples from the fourth outer leaf were randomly picked from each plot at the same time to determine total chlorophyll in both seasons, by chlorophyll meter (SPAD502, Osaka, Japan) that evaluate SPAD value following **Castelli *et al.* (1996).**

2- Yield and its structure

Head diameter (cm): At harvest period, five plants were taken from each treatment in all replicates, the diameter of each head was measured in centimeters, and the average was taken.

Head weight (kg): During the harvest period, five plants were taken from each treatment in all replicates, then they were weighed using the electric balance and the average was calculated.

Total yield (ton/ feddan): The yield of each experimental unit was weighed, and then the feddan yield was calculated as follows: Total yield (ton/feddan) = feddan area × the yield of the experimental unit ÷ the area of the experimental unit.

3- N, P and K %: After 75 days of planting, lettuce leaves were dried at 70°C and a known weight was digested with concentrated $H_2SO_4/HClO_4$, then nitrogen, phosphorous and potassium (%) in the dry matter of lettuce leaves were measured according to **Evenhuis and Waard (1980); AOAC (1995)** as follows:

Nitrogen concentration (%): Using the Microkjeldahl device and the Kjeldahl modified method, the total percentage of nitrogen in lettuce leaf sample was estimated by calorimeter device at a wave of 420 nm.

Phosphorus concentration (%): Using a Spectrophotometer, the amount of phosphorus in leaves samples was determined using colorimetric methods by calorimeter at a wave of 660 nm.

Potassium concentration (%): Using the Flame photometer equipment, the total percentage of potassium in leaves was calculated using the flame method.

4- Nitrate content: A dry sample of plant (0.1 mg) was weighed, placed in a centrifuge tube, with the addition of 10 ml of distilled water, and the suspension was placed in the incubator at a temperature of 45˚C, then the suspension was centrifuged for 15 minutes, then the extract was decanted in a clean glass tube and kept for nitrate determination. Then 0.2 ml of the extract was taken into a standard 50 ml flask and 0.8 ml of a solution of salicylic acid dissolved in 5% concentrated citric acid was added, after that 19 mM NaOH was added to the wall of the flask, and then the absorbance was measured on a calorimeter at a wavelength of 410 nm (**Evenhuis and Waard, 1980).**

5- Dry matter (%): Fresh leaves (100 g) were weighed and dried at 105˚C, and weighed to calculate the dry matter percentage.

Statistical analysis

All results were statistically analyzed by the statistics 9 program and means separation were done by least significant value (L.S.D.) at 0.05 level of probability following **Snedecor and Cochran (1980).**

RESULTS

Vegetative development

Impact of yeast forms and concentrations

Results of both seasons in Table 1 indicated that foliar spray with yeast cells treated with urea significantly increased plant height and leaf area per plant in contrast with the other treatments under study during the 2 seasons. Moreover, the highest values in count of leaves per plant were acquired by foliar spray with yeast cells treated with nitric acid or with urea lacking the significant differences among them, in most cases. In addition, using yeast at the highest concentration (3%) significantly increased vegetative growth parameters of lettuce plant in contrast with the rest treatments under the investigation in both seasons. The increases in lettuce leaf area per plant were about 6.52 and 7.34 % for 3% concentration treatment compared to 1% concentration in the first and second seasons, respectively.

Impact of the interaction

Concerning the interaction treatments between the different forms and concentrations of yeast on lettuce growth, the best treatment in this regard was foliar spray with yeast cells treated with urea at the maximum concentration (3%) contrasted to the other interaction treatments under evaluation in the 2 consecutive seasons (Table 2).

Table 1. Impact of foliar spray with yeast as different forms and concentrations on vegetative growth of lettuce plants

Treatments	Plant height (cm)		Number of leaves / plants		Leaf area / plant (cm^2)	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Effect of yeast forms						
Yeast cells untreated	39.25	40.50	34.91	36.33	2053.5	2045.3
Yeast extract	39.58	39.83	37.91	37.59	2158.9	2117.1
Yeast cells treated with nitric acid	41.16	41.16	39.08	41.25	2191.9	2240.2
Yeast cells treated with urea	42.00	42.08	39.58	42.25	2390.6	2407.1
LSD at 0.05 level	0.39	0.91	0.99	1.24	33.29	41.62
Effect of yeast forms concentration						
1%	39.75	40.06	36.43	36.93	2121.0	2126.8
2%	40.56	40.43	38.37	40.00	2216.0	2197.5
3%	41.18	42.18	38.81	41.12	2259.2	2282.9
LSD at 0.05 level	0.62	0.68	0.74	0.93	24.98	31.22

Table 2. Impact of the interaction between foliar spray with yeast as various forms and levels on vegetative growth of lettuce plants

Treatments		Plant height (cm)		Number of leaves / plants		Leaf area / plant (cm^2)	
Yeast forms	Concentrations	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Yeast cells untreated	1 %	39.00	39.25	32.75	34.00	2011.3	2000.3
	2%	39.00	40.50	35.50	37.25	2067.6	2043.0
	3%	39.75	41.75	36.50	37.75	2081.7	2092.5
Yeast extract	1 %	38.75	40.00	37.25	33.50	2080.0	2066.7
	2%	39.75	37.75	38.00	39.02	2197.9	2125.2
	3%	40.25	41.75	38.50	40.25	2198.7	2159.3
Yeast cells treated with nitric acid	1 %	39.50	40.25	37.75	39.25	2116.7	2200.3
	2%	41.75	40.75	39.50	41.75	2201.1	2211.6
	3%	42.25	42.50	40.00	42.75	2258.0	2308.6
Yeast cells treated with urea	1 %	41.75	40.75	38.00	41.00	2276.0	2240.0
	2%	41.75	42.75	40.50	42.00	2397.4	2410.2
	3%	42.50	42.75	40.25	43.75	2498.4	2571.1
LSD at 0.05 level		1.24	1.37	1.49	1.87	49.96	62.45

Fresh weight and total chlorophyll

Effect of yeast forms and concentrations

The results in Table 3 showed that, fresh weight of roots, stem and leaves per plant as well as total plant fresh weight and total chlorophyll content significantly increased by using yeast cells treated with urea fertilizer as foliar application to lettuce plants contrasted to the other ones under study in both seasons.

Regard the different concentrations of yeast forms, different plant organs of lettuce plant as fresh weight and total chlorophyll significantly increased with 3% concentration compared to others which tested in the first and second seasons. The elevation in total fresh weight of lettuce per plant were near 12.69 and 12.64 % for 3% concentration treatment compared to 1% concentration in the first and second seasons, respectively.

Table 3. Impact of foliar spray with yeast as different forms and concentrations on fresh weight of various plant parts and total chlorophyll in leaves of lettuce plants

Treatments	Fresh weight of roots / plant (g)		Fresh weight of stem / plant (g)		Fresh weight of leaves / plant (g)		Total fresh weight /plant (g)		Total chlorophyll (SPAD)	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Effect of yeast forms										
Yeast cells untreated	47.91	48.80	81.57	81.79	430.73	395.75	560.22	526.34	31.37	30.85
Yeast extract	46.96	55.31	94.58	99.23	457.92	455.85	599.47	610.40	33.78	32.16
Yeast cells treated with nitric acid	58.40	67.90	110.15	118.85	472.62	535.68	641.17	722.43	34.46	35.40
Yeast cells treated with urea	63.66	75.21	117.47	121.63	506.25	545.98	687.38	742.83	34.55	37.40
LSD at 0.05 level	2.46	1.06	1.79	2.76	13.65	16.98	23.30	15.98	0.59	0.38
Effect of yeast forms concentration										
1%	50.45	55.85	91.61	93.80	442.10	457.54	584.16	607.19	31.78	32.86
2%	53.25	61.11	101.14	105.67	469.32	493.57	623.71	660.36	33.56	33.28
3%	59.01	68.46	110.09	116.65	489.21	498.84	658.31	683.95	35.28	35.71
LSD at 0.05 level	1.84	0.79	1.34	2.07	10.24	12.74	17.48	11.99	0.44	0.28

Effect of the interaction

In most cases, using yeast cells solution treated with urea at the concentration of 3% significantly increased fresh weight of roots, stem, leaves per plant, total fresh weight and total chlorophyll content compared to the rest interaction treatments in the two seasons (Table 4). The increases in lettuce total chlorophyll content were about 21.18 and 25.85 % for interaction between yeast cells solution treated with urea at 3% concentration treatment compared to yeast cells at 1% concentration in the first and second seasons, respectively.

Dry weight

Effect of yeast forms and concentrations

The results reported in Table 5 demonstrated that, sprayed lettuce plants by yeast cells solution treated with urea resulted in significantly increased regard dry weight of roots, stem, leaves per plant and total plant dry weight compared to the other forms under study in the two seasons. The elevation in lettuce total dry weight were near 36.88 and 37.00 % for yeast cells solution treated with urea form treatment compared to yeast cells form alone in the first and second seasons, respectively. The best concentration among studied treatments in increase dry weight of various plant parts of lettuce plant was that 3 % concentration with significant differences between this concentration and the lowest two ones under study in both seasons. In general, increasing concentration of any form of yeast gradually increased lettuce dry weight in the two consecutive seasons.

Impact of the interaction

Results in Table 6 indicated that, the largest values in this connection were acquired by the treatment of yeast cells solution treated with urea form when interacted with 3 % concentration with significant differences among this treatment and the rest interaction treatments under study.

Yield and its components

Effect of yeast forms and concentrations

The results tabulated in Table 7 revealed that, using yeast cells solution treated with urea as foliar application significantly increased lettuce head diameter, head weight and total yield per feddan in comparison with the other forms of yeast which tested under study in both seasons, with no significant differences between yeast cells solution treated with nitric acid or urea treatments with respect of head diameter in the first season only.

The lowest values in this concern were achieved with yeast cells form in both seasons. Increasing concentrations of yeast forms which studied gradually significant increased lettuce yield components in the two seasons. The largest values in lettuce head diameter, head weight and total yield were recorded with plants sprayed with maximum concentration (3%) compared to the other two ones under study.

The increases in lettuce yield per feddan were about 5.72 and 6.56 % for 3% concentration treatment contrasted to 1% concentration in the first and second seasons, respectively. The elevation in total product of lettuce plants because of spraying lettuce plant with yeast cells treated with urea are correlated to the elevate in plant development and head weight of lettuce plant and this in turn increased total yield.

Table 4. Impact of the interaction between foliar spray with yeast as different forms and concentrations on fresh weight of various plant parts and total chlorophyll in leaves of lettuce plants

Treatments		Fresh weight of roots / plant (g)		Fresh weight of stem / plant (g)		Fresh weight of leaves / plant (g)		Total fresh weight /plant (g)		Total chlorophyll (SPAD)	
Yeast forms	Concent.	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Yeast cells untreated	1 %	45.25	43.20	73.37	62.00	402.30	380.30	520.92	485.50	30.45	30.95
	2%	45.00	44.00	83.65	78.30	440.05	399.95	570.30	522.25	31.80	29.25
	3%	46.60	59.20	87.70	105.07	449.85	407.00	589.45	571.27	31.88	32.35
Yeast extract	1 %	47.40	49.00	79.35	90.85	441.50	416.60	568.25	556.45	31.60	31.55
	2%	48.50	57.75	95.40	96.50	452.45	475.70	592.85	629.95	33.05	31.15
	3%	51.95	59.20	109.00	110.35	479.80	475.25	637.30	644.80	36.70	33.80
Yeast cells treated with nitric acid	1 %	51.90	64.90	100.65	105.00	442.85	511.50	595.45	681.40	32.30	32.70
	2%	55.55	66.95	106.80	126.40	473.05	544.45	635.40	737.80	35.45	35.75
	3%	57.20	71.85	123.00	125.15	501.95	551.10	692.65	748.10	35.65	37.75
Yeast cells treated with urea	1 %	65.85	66.30	113.05	117.35	481.75	521.75	652.00	705.40	32.80	36.25
	2%	67.70	75.75	118.70	121.50	511.75	554.20	696.30	751.45	33.95	37.00
	3%	67.95	83.60	120.65	126.05	525.25	562.00	713.85	771.65	36.90	38.95
LSD at 0.05 level		3.69	1.59	2.69	4.14	20.48	25.48	34.97	23.98	0.89	0.57

Table 5. Impact of foliar spray with yeast as different forms and concentrations on dry weight of different plant organs of lettuce plants

Treatments	Dry weight of roots/ plant (g)		Dry weight of stem/ plant (g)		Dry weight of leaves / plant (g)		Total dry weight / plant (g)	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Effect of yeast forms								
Yeast cells untreated	6.98	6.66	5.66	6.46	27.51	29.02	40.16	42.16
Yeast extract	7.28	8.03	6.45	7.13	29.45	29.50	43.18	44.66
Yeast cells treated with nitric acid	8.95	9.18	8.01	8.01	31.70	32.51	48.20	49.70
Yeast cells treated with urea	9.36	10.85	8.21	8.41	37.39	38.49	54.97	57.76
LSD at 0.05 level	0.41	0.46	0.44	0.36	1.03	0.73	0.80	1.77
Effect of yeast forms concentration								
1%	7.00	7.41	6.55	6.22	28.00	28.59	41.55	42.22
2%	8.38	8.33	6.95	8.09	32.13	33.13	47.12	49.57
3%	9.05	10.30	7.76	8.20	34.40	35.42	51.21	53.92
LSD at 0.05 level	0.31	0.34	0.33	0.27	0.77	0.54	0.60	1.33

Table 6. Impact of the interaction among foliar spray with yeast as different forms and concentrations on dry weight of different plant organs of lettuce plants

Treatments		Dry weight of roots / plant (g)		Dry weight of stem / plant (g)		Dry weight of leaves / plant (g)		Total dry weight / plant (g)	
Yeast forms	Concentr.	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Yeast cells untreated	1 %	6.00	6.40	5.05	5.10	23.10	25.20	34.15	36.70
	2%	7.70	6.60	5.35	7.30	28.50	30.05	41.55	43.95
	3%	7.25	7.00	6.60	7.00	30.95	31.83	44.80	45.83
Yeast extract	1 %	7.00	6.50	6.25	5.99	27.80	26.10	41.05	38.59
	2%	7.70	7.60	6.25	7.55	28.70	31.35	42.65	46.50
	3%	7.15	10.00	6.85	7.85	31.85	31.05	45.85	48.90
Yeast cells treated with nitric acid	1 %	7.00	7.00	7.40	6.45	28.70	29.09	43.10	42.54
	2%	9.00	9.15	8.25	8.63	31.95	32.55	47.80	50.33
	3%	10.85	11.40	8.40	8.95	34.45	35.90	53.70	56.25
Yeast cells treated with urea	1 %	8.00	9.75	7.50	7.35	32.40	33.98	47.90	51.08
	2%	9.15	10.00	7.95	8.90	39.40	38.60	56.50	57.50
	3%	10.95	12.80	9.20	9.00	40.37	42.90	60.52	64.70
LSD at 0.05 level		0.62	0.69	0.67	0.54	1.54	1.09	1.21	2.66

Table 7. Impact of foliar spray with yeast as different forms and concentrations on yield and its components of lettuce plants

Treatments	Head diameter (cm)		Head weight (kg)		Total yield (ton/feddan)	
	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Effect of yeast forms						
Yeast cells untreated	44.33	45.50	0.689	0.694	30.049	30.236
Yeast extract	45.83	46.83	0.726	0.734	31.577	31.797
Yeast cells treated with nitric acid	50.33	53.66	0.735	0.771	32.040	33.391
Yeast cells treated with urea	50.83	56.50	0.794	0.806	34.399	34.931
LSD at 0.05 level	0.99	1.33	0.033	0.024	0.343	0.418
Effect of yeast forms concentration						
1%	45.75	47.75	0.717	0.729	31.181	31.488
2%	47.25	50.25	0.734	0.752	31.904	32.724
3%	50.50	53.87	0.756	0.772	32.963	33.554
LSD at 0.05 level	0.74	0.99	0.025	0.018	0.257	0.313

Impact of the interaction

Results in Table 8 showed that, using yeast cells solution treated with urea at the concentration of 3% significantly increased head diameter, head weight and total product of lettuce plants contrasted to the rest interaction treatments under study in the two seasons. However, the lowest values in this regard were noticed when lettuce plants sprayed with yeast cells at 1 % concentration in both tested seasons.

Table 8. Impact of the interaction among foliar spray with yeast as different forms and concentrations on yield and its structure of lettuce

Treatments		Head diameter (cm)		Head weight (kg)		Total yield (ton/feddan)	
Yeast forms	Concentrations	Season 1	Season 2	Season 1	Season 2	Season 1	Season 2
Yeast cells untreated	1 %	41.50	42.50	0.658	0.674	28.752	29.256
	2%	42.00	46.00	0.697	0.703	30.368	30.632
	3%	49.50	48.00	0.714	0.705	31.026	30.820
Yeast extract	1 %	43.00	45.00	0.724	0.721	31.256	31.084
	2%	46.00	44.00	0.724	0.751	31.456	32.744
	3%	48.50	51.50	0.730	0.731	32.020	31.564
Yeast cells treated with nitric acid	1 %	49.50	50.00	0.722	0.749	31.468	32.056
	2%	50.00	54.50	0.731	0.761	31.764	33.084
	3%	51.50	56.50	0.752	0.803	32.888	35.032
Yeast cells treated with urea	1 %	49.00	53.50	0.767	0.774	33.248	33.556
	2%	51.00	56.50	0.787	0.794	34.028	34.436
	3%	52.50	59.50	0.830	0.850	35.920	36.800
LSD at 0.05 level		1.49	1.99	0.050	0.037	0.515	0.627

Minerals, dry matter (%) and nitrate content

Effect of yeast forms and concentrations

As shown in Table 9 it was noticed that, using a form of yeast cells solution treated with urea as foliar spray markedly increased N, K and dry matter percentages in lettuce leaves compared to the other forms under study. At the same time, P (%) and nitrate content significantly increased when lettuce plants sprayed with yeast cells solution treated with nitric acid or urea treatments compared to the other treatments under study. The largest values in N, P, K and dry matter percentages as well as nitrate content were observed when lettuce plants sprayed with maximum concentration (3%) as compared with the other concentrations under study.

Table 9. Impact of foliar spray with yeast as different forms and concentrations on N, P, K, dry matter and nitrate content in leaves of lettuce plants

Treatments	Mineral content			Dry matter (%)	Nitrate content (mg/kg DM)
	N (%)	P (%)	K (%)		
Effect of yeast forms					
Yeast cells untreated	1.25	0.169	1.39	5.20	207.36
Yeast extract	1.37	0.187	1.50	5.23	210.52
Yeast cells treated with nitric acid	1.45	0.204	1.47	5.46	220.67
Yeast cells treated with urea	1.48	0.208	1.71	5.71	215.64
LSD at 0.05 level	0.03	0.006	0.07	0.04	5.99
Effect of yeast forms concentration					
1%	1.35	0.177	1.45	5.15	205.04
2%	1.40	0.194	1.43	5.31	214.72
3%	1.41	0.205	1.67	5.75	220.89
LSD at 0.05 level	0.02	0.004	0.05	0.03	4.49

Impact of the interaction

The data in Table 10 revealed that, sprayed lettuce plants by yeast cells solution treated with nitric acid or urea each at 3 % significantly increased P and K percentages as well as nitrate content in leaves compared to the other interaction treatments under study. In addition, foliar spray with yeast cells solution treated with urea at the concentration of 3% significantly increased dry matter percentage.

Table 10. Impact of the interaction among foliar spray with yeast as different forms and concentrations on N, P, K, dry matter and nitrate content in leaves of lettuce

Treatments		N (%)	P (%)	K (%)	Dry matter (%)	Nitrate content (mg/kg DM)
Yeast forms	Concentrations					
Yeast cells untreated	1 %	1.15	0.155	1.29	5.05	199.45
	2%	1.30	0.169	1.33	5.05	204.27
	3%	1.30	0.184	1.56	5.50	218.35
Yeast extract	1 %	1.39	0.170	1.54	5.15	216.98
	2%	1.33	0.197	1.41	5.25	209.56
	3%	1.39	0.195	1.55	5.30	205.01
Yeast cells treated with nitric acid	1 %	1.45	0.190	1.30	5.15	206.71
	2%	1.41	0.202	1.33	5.35	221.06
	3%	1.49	0.220	1.79	5.90	234.25
Yeast cells treated with urea	1 %	1.41	0.196	1.70	5.25	197.03
	2%	1.56	0.209	1.66	5.60	223.97
	3%	1.49	0.221	1.78	6.30	225.93
LSD at 0.05 level		0.05	0.009	0.11	0.07	8.99

DISCUSSION

The increase in growth and yield may be because of the role of the bread yeast and its content of proteins, enzymes, amino acids and vitamins, especially vitamin B, and it enriched with the sources of phyto-hormones especially, cytokinins, auxins , gibberellins and minerals that act to enhance the plant cell replication and its development (**Glick, 1995, Bevilacqua, *et al*., 2008, Sarhan and Abdullah, 2010,** and **Nassef and El-Aref, 2016) .**Also, **Taha *et al*. (2016)** reported that, yeast extract enhances vegetative growth through influencing metabolism, biological activity and photosynthetic pigments.

Regarding the effect of yeast cells treated with urea, it may be due to the disruption of the cell wall of yeast cells and releasing their contents like enzymes, phyto-hormones and minerals that act to enhance the growth of the plant. Many investigators found that spraying active yeast increased growth and yield of lettuce (**Fawzy, 2007, Farrag *et al*., 2016** on lettuce and **Alsaady *et al*., 2020** on cabbage). In this context, **Kanimarani (2020)** reported that, the best results of longest leaf, plant height and head diameter of lettuce were acquired from the interaction treatment of 2.5 ml/20 L Asahi star with 3ml/l yeast foliar spray. Also, **Ibrahim (2020)** found that, foliar spraying of yeast at a concentration of 5 g/L produced the best results in terms of lettuce growth, leaf minerals content and head weight. Concerning dry weight, the largest values of leaves were present with foliar spray of yeast (**Fawzy, 2010** on lettuce and **El-Bassiony *et al*., 2014** on Kohlrabi).

The simulative impact of yeast extract on chlorophyll content may be attributed to that yeast acts as natural source of cytokinins that stimulates cell division and development as well as the production of nucleic acid and chlorophyll (**Amer, 2004** and **Wanas, 2006).** Also, **Kanimarani (2020)** noticed that the level of 3 ml/ L yeast extract revealed significant elevation in leaf chlorophyll content of lettuce plants. Also, **Ibrahim (2020)** reported that, the foliar spraying of yeast at the level 5 g/L had the highest results in chlorophyll content.

In this context, **Abdel-Salam (2018)** studied foliar application with nano-urea and vesicular arbuscular mycorrhiza (VAM) on lettuce and noticed that all development parameters of plant height, count of leaves, fresh and dry weight of plant elevated by N or VAM alone or combined. Furthermore, **Abd El Galil *et al*., (2021)** found that, foliar spray with urea and dry yeast levels increased vegetative growth characters, pigments content, chemical contents, yield and its components compared to the control treatment.

Conclusion

In general, greater lettuce plant productivity was noticed when yeast cells solution treated with urea

form was used. Foliar application of yeast at 3% concentration improved markedly plant development, product structure and chemical constituents of lettuce. Furthermore, yeast cells solution treated with urea at 3 % concentration as foliar spray had significant effects on above mentioned parameters of lettuce plants, but in the same time increased nitrate content in leaves, this led to effect on quality of lettuce plants.

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RESEARCH ARTICLE

Impact of foliar spray with *Saccharomyces cerevisiae* extract in different forms and concentrations on growth, productivity and quality of lettuce plants

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