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Response of White Mustard (*Sinapis alba* L.) Plant to Foliar Spraying by Some Antioxidants and Yeast under Sinai Conditions

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ABSTRACT

The research was carried out at Baluza Research Station, Desert Research Center, North Sinai, during two successive seasons 2020/2021 and 2021/2022 to study the effect of spraying with different levels of yeast and some of the antioxidants and their interaction on vegetative growth, seed yield, fixed oil yield, and active substances in white mustard seeds under the Sinai land conditions. The experimental design was a split-plot design that included 12 treatments, Yeast extract (0,4and 8 g/L) in the main plots, and different sources of antioxidants (control, salicylic acid, 200ppm, and ascorbic acid, 300ppm and salicylic +ascorbic acids) in the sub-main plots. Results showed that spraying with yeast extract levels, led to an increase in all vegetative growth, oil production and active ingredients of the white mustard plant. Concerning antioxidants effect, find that when spraying with the antioxidants Ascorbic acid and Salicylic acid alone significantly increase in the growth characteristics of white mustard plants, while when spraying Ascorbic acid + Salicylic acid led to a significant increase in all growth characteristics. The effect of the interaction between yeast extract and antioxidants was effective on all growth characteristics, as the treatment of 8 g/l Yeast + Ascorbic acid + Salicylic acid recorded the highest significant increase in all growth characteristics of a white mustard plant. In addition, when analyzing the fixed oil, the erucic acid, is the main component of white mustard oil giving 40.27% while oleic acid was the second major component recorded at 17.63%.

Keywords: White mustard, yeast, salicylic acid, ascorbic acid.

1. Introduction

White mustard or yellow mustard (*Sinapis alba* L.) is an annual plant that belongs to the family Brassicaceae. It originates from the Mediterranean and Crimea but was introduced elsewhere in Northwestern Europe, Japan, India, China, Russia, North and South America, and North Africa. It is found worldwide as a cultivated plant species and a weed, currently cultivated in many temperate regions of the world (Katepa-Mupondwa *et al*., 2005 and Elzebroek, 2008).

White mustard is grown for its seeds, used as a condiment, green fodder crop, or manure. Seeds yield contain 15-30 % of golden-yellow mild-tasting oil. It is considered one of the important medicinal plants. In medicine, white mustard seeds manufacture medical plasters to treat rheumatism, back pain, joints, muscles, and diseases of the respiratory system and lungs. The seeds or their oil is taken internally and externally to prevent cancer cell growth, stimulate blood circulation, remove cold, and relieve pain in the feet. It also increases the secretions of digestive juices. It promotes bowel movement as a gargle for treating mouth, tonsils, and larynx infections, preventing atherosclerosis, and lowering blood pressure. It is also used as an emetic in treating simple poisoning cases (Libster, 2001). Young seedling leaves, rich in vitamins A, C and E are eaten as fresh and tasty salad leaves and have a medicinal value in purifying blood (Rahman *et al*., 2018).

In the field of food industries: white mustard seeds are used in the mustard industry, where they are added to meat, fish, and various foods as a flavor gain and preservative. Oil Mustard is used as an illuminant and lubricant (Alam and Rahman, 2013) for biodiesel production (Ciubota-Rosie *et*

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al., 2013; Sáez-Bastante *et al*., 2016; Kostić *et al*., 2018). White mustard seeds are considered a protein-rich spice, where their protein content reaches 26.4% (Tainter and Grenis, 2001). Therefore, oil mustard is used mainly as cooking oil, especially in Asia (Weiss, 2002).

White Mustard contains a glucoside sinalbin and an enzyme myrosin, which produces upon hydrolysis, acrinyl isothiocyanate, which gives mustard a pungent tasting. Mustard oil is almost odorless and only slightly volatile with steam and causes blisters on the skin. Erucic acid is cardiotoxic in animals and, therefore, potentially in humans. This fatty acid is considered a raw material in manufacturing and used as a low-cost fuel, which maximizes the use of technology and various industrial processes. Therefore, researchers have made many efforts to produce varieties of mustard, free of erucic acid, suitable for human use, and to develop types with a maximum erucic acid content for industrial applications. (Sparks, 2004; Weiss, 2002; Balke and Diosady, 2000). White mustard seeds contain fixed oil (15-30%), volatile oil (0.08-0.1%), protein materials, cellulose, water, and water-soluble materials. It also contains 6% of omega-3, 15% of omega-6, and about 12% saturated fats. Its well-balanced amino acid profile makes the seed an attractive source of food-grade proteins (Hamed, 2011).

Dry yeast (*Saccharomyces cerevisiae*) is a safe, natural bio-stimulant that encourages plant growth. It is a natural source of cytokinin hormone that works on cell division and elongation and a source of vitamin B and amino acids. All leads to increases in the vegetative growth that leads to the quality of the flowering and fruit process (Matter and El Sayed, 2015; Hamed, 2018). Therefore, in recent years, the world has tended to expand the use of yeast on some medicinal and aromatic plants.

Salicylic acid stimulates plants to tolerate different environmental stresses (salty, heat, and drought) (Hanafy *et al*., 2022). It also plays a vital role in regulating some physiological processes in the plant, such as growth and the absorption and transportation of nutrients inside the plant (Simaei *et al*., 2012). It also accelerates the formation of total chlorophylls and carotene pigments, accelerates the photosynthesis process, and increases the activity of some essential enzymes. It has a role in the thermoregulation process in some plants.

Ascorbic acid (Vitamin C) has a regulatory role in enhancing productivity in many plants. Ascorbic acid acts as a cofactor for several enzymes and regulates plants' hormonal and many physiological processes. It is considered one of the cofactors of enzymatic activity, allowing plants to withstand different types of environmental stress (Barth and Mario, 2006).

The agricultural expansion in the new lands faces problems related to the lack of information for many medicinal plants, including white mustard plants

The aim of this study was to determine the effect of spraying with different levels of yeast extract and some of antioxidants and their interaction on vegetative growth, seed yield, fixed oil yield, and its active components in white mustard seeds under the Sinai land conditions.

2. Materials and Methods

The research was carried out at Baluza Research Station, Desert Research Center, North Sinai, the area located on 30^0 3' 0" N, 32^0 36' 0" E. during two successive seasons 2020/2021 and 2021/2022 to study the effect of yeast extract, salicylic acid, and ascorbic acid and their interaction treatments on plant growth, seed yield, active ingredients, fixed oil production and active constituents of white mustard plants.

White mustard plant seeds were sown on October 15^{th} for the two seasons. The distance between plants was 30 cm while the distance between rows was 50 cm. After germination, the plants were thinned at one plant per hill (28000 plants/feddan). The mechanical and chemical properties of the used soil are shown in Table (1) according to (Page *et al*., 1984). The experimental field was drip irrigated, and the used water's chemical analysis is shown in Table (2). All agricultural practices of growing white mustard plants were done.

Table 1: Physical and chemical properties of the experimental soil in at Baluza Research Station, Desert Research Center, North Sinai governorates.

Particle size distribution (%)			Texture class	EC dSm^{-1}	pH
Sand	Silt	Clay			
88.17	6.31	5.52	Sand	1.37	8.20

Soluble ions (meq/l)								Available nutrients (ppm)		
Cations				Anions						
Ca^{+2}	Mg^{+2}	Na^{+1}	K^{+1}	CO^{-3}	HCO^{-3}	SO^{-4}	Cl^{-1}	N	P	K
1.8	2.4	1.56	0.09	-	3.5	0.84	1.51	60	3.65	144

Table 2: Chemical analysis of irrigation water.

Samples	pH	E.C. (ppm)	S.A.R	Soluble cations (mm/l)				Soluble anions (mm/l)			
				Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3^{--}	HCO_3^{-}	$SO_4^{=}$	Cl^{-}
1 st. season	7.45	1456	3.80	2.90	3.20	8.60	0.60	0.10	5.60	2.10	7.50
2nd. season	7.10	1512	3.52	3.25	3.05	9.50	0.40	0.50	3.81	3.69	8.20

The treatments were conducted as follows:

1. Control
2. Salicylic acid at 200ppm
3. Ascorbic acid at 300 ppm
4. Salicylic acid + Ascorbic acid
5. 4 g/l Yeast
6. 4 g/l Yeast + Salicylic acid
7. 4 g/l Yeast + Ascorbic acid
8. 4 g/l Yeast + Salicylic acid + Ascorbic acid
9. 8 g/l Yeast
10. 8 g/l Yeast + Salicylic acid
11. 8 g/l Yeast + Ascorbic acid
12. 8 g/l Yeast + Salicylic acid + Ascorbic acid

The experimental design was a split plot that included 12 treatments, yeast extract in the main plots, and different sources of antioxidants in the sub-main plots. The active dry yeast *Saccharomyces cerevisia*e was dissolved in water followed by adding sugar at a ratio of 1:1 and kept overnight for activation and reproduction of yeast (El-Tohamy *et al*., 2008), the analysis of active dry yeast is shown in Table (3). The different antioxidants sources included (salicylic acid, at 200 ppm, and ascorbic acid, at 300ppm), after 45 days from sowing, the plants were sprayed three times in both seasons, at 30 days intervals. Harvesting was done on 15th May when 50% of the fruits had converted to the appropriate stage for harvesting.

2.1. Statistical analysis

The experimental design was split plot design. All values represent the mean of three replicates .data were exposed to ANOVA and examined by Duncan's multiple range tests at probability using the COSTAT 6.3 program Statistic version[9] (Analytical software, 1985). Means monitored by the similar letter did not significant vary at ≤ 0.05 fitting to Duncan's multiple range tests according to Gomez and Gomez, (1984).

Table 3: Chemical analysis of yeast extract

Protein	Carbohydrates	Nucleic acids	Minerals	Lipids
47%	33%	8%	8%	4%

The composition of minerals (mg/g)

Na	Ca	Fe	Mg	K	P	S	Zn	Si
0.12	0.75	0.02	1.65	21.00	13.50	3.90	0.17	0.03
Cu	**Se**	**Mn**	**Cr**	**Ni**	**Va**	**Mo**	**Sn**	**Li**
8.00	0.10	0.02	2.20	3.00	0.04	0.40	3.00	0.17

The composition of vitamins (mg/g)

Thiamine	Riboflavin	Niacin	Pyridoxine HCL	Pantothenate	Biotin	Cholin	Folic acid	Vitamin B12
6 – 100	35 – 50	300 – 500	28	70	1.3	4000	5 – 13	0.001

The following measurements were recorded:

1- Plant height (cm)
2- Number of branches/plant
3- Fresh weight/plant (g)
4- Dry weight/plant (g)
5- Seed weight per plant(g)
6- Seed weight per feddan (kg) which is calculated by multiplying the weight of seeds for each plant by the number of plants per feddan (28000 plants).
7- Fixed oil percentage was determined by the soxhlet method used for the estimation of fixed oil as stated by the A.O.A.C. (1970).
8- Fixed oil yield per plant (g) this was calculated as follows: (Fixed oil percentage × Seeds weight/plant (g))/100.
9- Fixed oil per feddan (kg) which is calculated by multiplying the fixed oil yield per plant by the number of plants per feddan (28000 plants).
10- Fixed oil chemical constituents were analyzed by G.L.C. according to Ichihara (2010).
11- Protein (%) in seeds was determined according to the methods described by Horneck and Miller (1998) and calculated as follows: (Nitrogen % × 6.25).
12- Total chlorophylls the Minolta chlorophylls meter (model SPAD 502) determined total chlorophylls according to A.O.A.C. (1990).

3. Results

3.1. Effect of yeast extract

The results obtained in this study showed that spraying plants with 8g/L of yeast extract significantly increased all measurements parameters including plant height (cm), number of branches/plant, fresh weight/plant (g), dry weight/plant (g), and fixed oil (%) of white mustard plants which recorded in the first season 74.75cm,13.00,435.83g, 147.00 g, and 25.65 % respectively. while it given 128.92 cm, 15.50, 442.92g, 149.92g, and 25.67% in the second season, respectively. this treatment also significantly enhanced white mustard productivity as seed weight/plant (g), seed weight/feddan (kg), fixed oil/plant (ml), and fixed oil/feddan (L) which recorded in the first season 29.84g, 835.43 kg, 7.65 ml, and 214.31 L, respectively. while it gave 32.77g, 917.58 kg, 8.41 ml, and 235.54 L in the second season, respectively, was compared with 4g/L which increased all above mentioned parameters as compared with control (Table, 3).

Likewise, the data in Table, 3 the difference in yeast extract levels led to a significant increase in protein and total chlorophylls in white mustard plants, which were recorded in the first season at 23.11 % and 50.08 respectively, compared to the control treatment. While it was given 24.14 % and 50.57 in the second season, respectively. Effects of the treatments on white mustard plants, growth, and yield were more obvious at the higher concentration of yeast (8 g/l).

Table 3: Effect of yeast extract treatments on characters of *Sinapis alba* plant during 2020/2021 and 2021/2022 seasons under North Sinai conditions.

Treatments	Plant height (cm)		Number of branches/plant		Fresh weight/plant (g)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	54.50C	62.75C	8.00C	9.50C	267.42C	271.58C
4 g/l Yeast	70.58B	114.75B	12.00B	14.08B	414.00B	419.83B
8 g/l Yeast	74.75A	128.92A	13.00A	15.50A	435.83A	442.92A
	Dry weight/plant (g)		**Seed weight/plant (g)**		**Seed weight/feddan (kg)**	
Control	89.83C	94.67C	22.19C	19.54C	621.41C	547.12C
4 g/l Yeast	139.83B	142.92B	28.02B	30.97B	784.51B	867.14B
8 g/l Yeast	147.00A	149.92A	29.84A	32.77A	835.43A	917.58A
	Fixed oil (%)		**Fixed oil/plant (ml)**		**Fixed oil/feddan (L)**	
Control	23.59C	23.68C	5.23C	4.63C	146.57C	129.56C
4 g/l Yeast	25.34B	25.46B	7.10B	7.88B	198.81B	220.78B
8 g/l Yeast	25.65A	25.67A	7.65A	8.41A	214.31A	235.54A
	Protein (%)		**Total chlorophylls (SPAD)**			
Control	21.10C	21.31C	44.91C	44.35C		
4 g/l Yeast	22.89B	23.77B	48.80B	48.93B		
8 g/l Yeast	23.11A	24.14A	50.08A	50.57A		

Averages that share the same alphabet do not differ from each other significantly according to Duncan's test at the 5% level.

3.2. Effect of some antioxidants

Cleared from Table, 4 that the effect of spraying with antioxidants (ascorbic acid at 300 ppm + salicylic acid at 200ppm) led to a significant increase in plant height (cm), which was recorded at 77.56 cm and 143.44 cm, the number of branches/plant was 13.78 and 16.11 fresh weight/ plant (g) which recorded 435.56 g and 443.44 g and dry weight/plant (g) which gave 147.78 g and 152.67g in the first and second seasons, respectively. Although there was a significant difference between salicylic acid alone and ascorbic acid alone compared to control.

Also, the treatment (ascorbic acid + salicylic acid) gave the highest values of seed weight/plant (g) 30.41g and 31.75 g. seed weight/ feddan (kg) was 851.45 kg and 888.94 kg during the first and second seasons, respectively, compared to the control and other treatments.

On the other hand, the data in Table, 4 gave similar increase in the fixed oil (%), fixed oil/plant (ml), and fixed oil/feddan (L) which significant superiority for (ascorbic acid + salicylic acid) treatment, which recorded 25.80% and 7.85 g, 219.68 kg during the first season, respectively, while it gave 25.96%, 8.24 ml, and 230.78 L during the second season, respectively. There were also a significant increase in this concern in plants treated with salicylic acid alone and ascorbic acid alone as well as compared to control.

As for protein and total chlorophylls, it is clear from Table, 4 that the best treatment was recorded when spraying with antioxidants (ascorbic acid + salicylic acid), followed by the treatment of ascorbic acid alone compared to the control and the rest of the treatments.

Table 4: Effect of antioxidants treatments on characters of *Sinapis alba* plant during 2020/2021 and 2021/2022 seasons under North Sinai conditions

Treatments	Plant height (cm)		Number of branches/plant		Fresh weight/plant (g)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	56.67D	74.89D	10.00C	11.88C	309.44D	314.44D
Salicylic acid	63.00C	83.56C	11.33B	13.44B	349.78C	355.00C
Ascorbic acid	69.22B	106.67B	8.89D	10.67D	394.89B	399.56B
Ascorbic acid + Salicylic acid	77.56A	143.44A	13.78A	16.11A	435.56A	443.44A
	Dry weight/plant (g)		Seed weight / plant (g)		Seed weight/ feddan (kg)	
Control	104.00D	108.11D	23.67D	22.99D	662.67D	643.66D
Salicylic acid	117.67C	120.22C	25.21C	27.00C	705.91C	756.09C
Ascorbic acid	132.78B	135.67B	27.44B	29.30B	768.44B	820.43B
Ascorbic acid + Salicylic acid	147.78A	152.67A	30.41A	31.75A	851.45A	888.94A
	Fixed oil (%)		Fixed oil/plant (ml)		Fixed oil/feddan (L)	
Control	24.07D	24.15D	5.70D	5.55D	159.53D	155.46D
Salicylic acid	24.63C	24.69C	6.21C	6.67C	173.86C	186.66C
Ascorbic acid	24.94B	24.94B	7.84B	7.31B	191.62B	204.61B
Ascorbic acid + Salicylic acid	25.80A	25.96A	7.85A	8.24A	219.68A	230.87A

Treatments	Protein (%)		Total chlorophylls (SPAD)	
Control	21.40 D	21.94D	45.37D	45.51D
Salicylic acid	22.32C	23.12C	47.20C	47.11C
Ascorbic acid	22.57B	23.35B	48.51B	48.09B
Ascorbic acid + Salicylic acid	23.17A	23.86A	50.63A	51.09A

Averages that share the same alphabet do not differ from each other significantly according to Duncan's test at the 5% level.

3.3. Effect of interaction between Yeast extract and some antioxidants

Data in Table (5) tended to clarify the effect of interaction between spraying with yeast and antioxidants on plant height of white mustard, the results showed a significant increase in both seasons, and the best treatment was when spraying with yeast at the rate of 8 g/l with spraying combined with Ascorbic acid + Salicylic acid, which gave the best values for plant height reaching 91.67 cm and 195.00 cm during the first and second seasons, respectively.

Regarding the number of branches, the data in Table 5 shows the effect of interaction between yeast and spraying with antioxidants on number of branches of mustard plant, where a significant increase resulting from different treatments was observed. This increase was significant during the first and second seasons, respectively, as it recorded 17.33 and 20.33 for treatment 8 g/l Yeast + Ascorbic acid + Salicylic acid compared to other treatments and controls, which recorded the lowest number of branches for mustard plants, which reached 6.67 and 7.33.

On the other hand, the interaction effect between yeast and antioxidants recorded the best results for increasing fresh and dry weight, as the highest values were recorded at 501.67 gm and 171.00 gm during the first season, respectively, while they recorded 513.33 gm and 174.33 gm during the second season, respectively, as a result of spraying 8 g/ l Yeast + Ascorbic acid + Salicylic acid, while the following treatment Yeast at 4 g/l + Ascorbic acid + Salicylic acid recorded 485.00 and 164.00 gm in the first season, respectively, and 491.00 gm and 167.00 in the second season, respectively, compared to the control and other treatments (Table, 5).

Table 5: Effect of interaction between Yeast extract and some antioxidants on plant height (cm), number of branches/plant, fresh and dry weights per plant (g), and feddan (g) of *Sinapis alba* plant during 2020/2021 and 2021/2022 seasons under North Sinai conditions

Treatments	Plant height (cm)		Number of branches/plant	
	1st season	2nd season	1st season	2nd season
Control	50.00 I	53.33 I	6.67 H	7.33 J
Salicylic acid	54.00 H	59.00 I	7.67 G	9.00 I
Ascorbic acid	55.67 GH	66.67 H	8.33 G	10.67 H
Ascorbic acid + Salicylic acid	58.33 FG	72.00 H	9.33 F	11.00 GH
4 g/l Yeast	60.00 F	86.67 FG	10.00 F	12.67 EF
4 g/l Yeast + Salicylic acid	64.67 E	92.67 EF	11.00 E	13.00 EF
4 g/l Yeast + Ascorbic acid	75.00 C	118.33 D	12.33 D	14.33 CD
4 g/l Yeast + Ascorbic acid + Salicylic acid	82.67 B	163.33 B	14.67 B	17.00 B
8 g/l Yeast	60.00 F	84.67 G	10.00 F	12.00 FG
8 g/l Yeast + Salicylic acid	70.33 D	99.00 E	11.33 E	13.67 DE
8 g/l Yeast + Ascorbic acid	77.00 C	135.00 C	13.33 C	15.33 C
8 g/l Yeast + Ascorbic acid + Salicylic acid	91.67 A	195.00 A	17.33 A	20.33 A
	Fresh weight/plant (g)		**Dry weight/plant (g)**	
Control	210.00 L	215.00 L	70.67 L	75.00 L
Salicylic acid	348.33 H	352.67 H	84.00 K	87.00 K
Ascorbic acid	288.00 J	290.00 J	96.33 J	100.00 J
Ascorbic acid + Salicylic acid	320.00 I	326.00 I	108.33 I	116.67 I
4 g/l Yeast	348.33 H	352.67 H	117.33 H	121.67 H
4 g/l Yeast + Salicylic acid	387.67 F	394.67 F	131.33 F	133.67 F
4 g/l Yeast + Ascorbic acid	435.00 D	441.00 D	146.67 D	149.33 D
4 g/l Yeast + Ascorbic acid + Salicylic acid	485.00 B	491.00 B	164.00 B	167.00 B
8 g/l Yeast	370.00 G	375.67 G	124.00 G	127.67 G
8 g/l Yeast + Salicylic acid	410.00 E	415.00 E	137.67 E	140.00 E
8 g/l Yeast + Ascorbic acid	461.67 C	467.67 C	155.33 C	157.67 C
8 g/l Yeast + Ascorbic acid + Salicylic acid	501.67 A	513.33 A	171.00 A	174.33 A

Averages that share the same alphabet do not differ from each other significantly according to Duncan's test at the 5% level.

Consequences Table, 6 resulting from the interaction of yeast and antioxidants recorded an increase in the weight of seeds/plant (g) and per feddan (kg), whereas the results in the first season showed a significant increase in the weight of seed/plant (g) and feddan (kg) estimated at 35.43 g and 991.95 kg, respectively. Also, the significant increase in the second season was estimated at 38.00 gm and 1064.10 kg, respectively, when treated with 8 g/l Yeast + Ascorbic acid + Salicylic acid in comparison with other treatments.

Moreover, the weight of seed/plant (g) recorded the lowest values of 18.36 g and 17.53 g from the control treatment during the first and second seasons, respectively, while the lowest value was recorded in the weight of seeds / feddan (kg), which reached 514.17 kg and 490.90 kg, during the first and second seasons, respectively.

Regarding, the effect of the interaction between yeast and antioxidants on the fixed oil of white mustard plant led to an increase in both seasons. Table, 7.

On the other hand, data in Table, 7 indicated that the highest values were recorded by the treatment of 8 g/l Yeast + Ascorbic acid + Salicylic acid, which recorded 26.91% and 26.98% during both seasons, respectively, while the control treatment recorded the lowest values for fixed oil, which gave 23.24% and 23.36% during both seasons, respectively.

Table 6: Effect of interaction treatments between Yeast extract and some antioxidants on seed weight/plant (g) and feddan (kg) of *Sinapis alba* plant during 2020/2021 and 2021/2022 seasons under North Sinai conditions

Treatments	Seed weight/plant (g) 1st season	Seed weight/plant (g) 2nd season	Seed weight/feddan (kg) 1st season	Seed weight/feddan (kg) 2nd season
Control	18.36^{K}	17.53^{L}	514.17^{K}	490.90^{L}
Salicylic acid	20.89^{J}	18.97^{K}	585.01^{J}	531.10^{K}
Ascorbic acid	20.89^{J}	18.97^{K}	585.01^{J}	531.10^{K}
Ascorbic acid + Salicylic acid	24.16^{I}	20.41^{J}	676.48^{I}	571.50^{J}
4 g/l Yeast	25.37^{H}	21.25^{I}	709.99^{H}	595.00^{I}
4 g/l Yeast + Salicylic acid	26.99^{F}	30.00^{F}	755.81^{F}	840.10^{F}
4 g/l Yeast + Ascorbic acid	28.60^{D}	32.95^{D}	800.80^{D}	922.70^{D}
4 g/l Yeast + Ascorbic acid + Salicylic acid	30.44^{B}	35.99^{B}	852.41^{B}	1007.70^{B}
8 g/l Yeast	26.04^{G}	24.93^{H}	729.03^{G}	698.00^{H}
8 g/l Yeast + Salicylic acid	27.75^{E}	32.04^{E}	776.91^{E}	897.10^{E}
8 g/l Yeast + Ascorbic acid	29.57^{C}	34.54^{C}	828.05^{C}	967.10^{C}
8 g/l Yeast + Ascorbic acid + Salicylic acid	35.43^{A}	38.00^{A}	991.95^{A}	1064.10^{A}

Averages that share the same alphabet do not differ from each other significantly according to Duncan's test at the 5% level.

Table 7: Effect of interaction between yeast extract and some antioxidants on fixed oil (%), fixed oil per plant (g), and feddan (g) of *Sinapis alba* plant during 2020/2021 and 2021/2022 seasons under North Sinai conditions

Treatments	Fixed oil (%) 1st season	Fixed oil (%) 2nd season	Fixed oil/plant (ml) 1st season	Fixed oil/plant (ml) 2nd season	fixed oil/feddan (L) 1st season	fixed oil/feddan (L) 2nd season
Control	23.24^{J}	23.36^{L}	4.270^{L}	4.093^{L}	119.50^{L}	114.70^{L}
Salicylic acid	23.50^{I}	23.45^{K}	4.910^{K}	4.450^{K}	137.48^{K}	124.56^{K}
Ascorbic acid	23.75^{H}	23.75^{J}	5.740^{J}	4.847^{J}	160.67^{J}	135.73^{J}
Ascorbic acid + Salicylic acid	23.85^{H}	24.13^{I}	6.047^{I}	5.130^{I}	169.33^{I}	143.59^{I}
4 g/l Yeast	24.24^{G}	24.35^{H}	6.313^{H}	6.070^{H}	176.74^{H}	169.95^{H}
4 g/l Yeast + Salicylic acid	25.05^{E}	25.26^{F}	6.763^{F}	7.577^{F}	189.34^{F}	212.21^{F}
4 g/l Yeast + Ascorbic acid	25.42^{D}	25.48^{D}	7.273^{D}	8.397^{D}	203.70^{D}	235.14^{D}
4 g/l Yeast + Ascorbic acid + Salicylic acid	26.64^{B}	26.77^{B}	8.110^{B}	9.633^{B}	227.09^{B}	269.73^{B}
8 g/l Yeast	24.73^{F}	24.74^{G}	6.580^{G}	6.557^{G}	184.22^{G}	183.57^{G}
8 g/l Yeast + Salicylic acid	25.33^{D}	25.36^{E}	7.030^{E}	8.127^{E}	196.77^{E}	227.54^{E}
8 g/l Yeast + Ascorbic acid	25.63^{C}	25.58^{C}	7.583^{C}	8.833^{C}	212.26^{C}	247.39^{C}
8 g/l Yeast + Ascorbic acid + Salicylic acid	26.91^{A}	26.98^{A}	9.530^{A}	10.253^{A}	266.90 ^{A}	287.13^{A}

Averages that share the same alphabet do not differ from each other significantly according to Duncan's test at the 5% level.

Data in Table 7 showed an increase in the fixed oil/plant (ml) and per feddan (L) of white mustard plants as a result of the interaction between spraying yeast extract and antioxidants, where the increase was significant in both seasons. The best treatment was that spraying with 8 g/l yeast + ascorbic acid + salicylic acid, followed by 4 g/l yeast + ascorbic acid + salicylic acid

Treatment 8 g/l yeast + ascorbic acid + salicylic acid recorded the highest values for fixed oil/plant, which gave 9.53 ml and 10.25 ml during the first and second season, respectively, while the same treatment gave similar increase in fixed oil/feddan, which gave values 266.90 L and 287.13 L during the first and second seasons, respectively.

3.4. Fixed oil chemical constituents and Fatty acids determination

The fatty acids composition for methylated samples of white mustard seeds oils was determined according to Ichihara, (2010) by GLC, the obtained data are recorded in Figures (1, and 2).

Data in Figure (1) showed that, the total unsaturated fatty acids in white mustard seed oils, recorded the highest percentage, while the total saturated fatty acid decreased in both control and 8 g/l Yeast + Ascorbic acid + Salicylic acid.

Acids present in the fixed oil of white mustard were divided into two parts. The first part included saturated fatty acids, which are two acids palmitic acid and stearic acid, while the second part included unsaturated fatty acids, which are five acids, oleic acid, linoleic acid, linolenic acid, alpha-linolenic acid and erucic acid.

The total unsaturated fatty increased in the control treatment, which recorded 82.60%, while the total saturated fatty acids percentage decreased to 6.45%.

Whereas, Figure, 1 found the reverse in the treatment of 8 g/l Yeast + Ascorbic acid + Salicylic acid, the total unsaturated fatty acids recorded 82.22%, but the total saturated fatty acids which scoreded 6.47%.

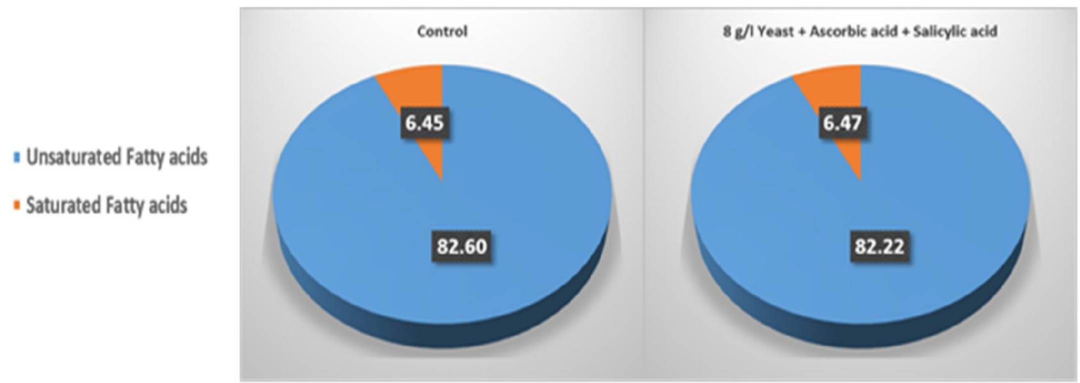

Fig. 1: Saturated and unsaturated fatty acids on fixed oil of *Sinapis alba* plant during 2021/2022 seasons

It is clear from Figure (2) that the analysis of the fixed oil of white mustard plant resulted in the presence of 7 fatty acids: palmitic acid, stearic acid, oleic acid, linoleic acid, linolenic acid, alpha-linolenic acid and erucic acid.

Data in Figure (2) showed that, erucic acid represented the highest value in the fixed oil in both control and 8 g/l yeast + ascorbic acid + salicylic acid treatments, while Stearic acid represented the lowest percentage in the fixed oil components of the mustard plant for the same treatments previously mentioned.

In addition, erucic acid, the main component of white mustard oil, recorded 40.82% in the control treatment, while it recorded 40.27% when treating plants with 8 g/l yeast + ascorbic acid + salicylic acid. While oleic acid was the second major component in the fixed oil of the white mustard plant, it scored 17.59% and 17.63% in both the control and 8 g/l yeast + ascorbic acid + salicylic acid treatments, respectively.

Moreover, cleared from figure 2 that palmitic acid increased in untreated plants (control) it gave 4.65%, while it decreased to 4.63% when spraying plants 8 g/l yeast + ascorbic acid + salicylic acid

In addition, stearic acid decreased in the control treatment, recording 1.80%, while it increased by 8 g/l yeast + ascorbic acid + salicylic acid, which recorded 1.84%.

On the other hand, the results in figure 2 showed an increase in oleic acid when spraying 8 g/l yeast + ascorbic acid + salicylic acid plants, which gave 17.63% compared to the control plants, which recorded 17.59%.

Moreover, both linoleic acid and linolenic acid increased when plants were sprayed with yeast extract at a rate of 8 g/l with ascorbic acid + salicylic acid, which recorded 8.25% and 9.69%, respectively, compared to the untreated plants (control), which recorded 8.21% and 9.11%, respectively.

Alpha-linolenic acid, which is commercially known as (omega-3 acid), recorded an increase in the untreated plants (control) 6.87%, while it recorded 6.38% in the treated plants with 8 g/l yeast + ascorbic acid + salicylic acid

Furthermore, erucic acid recorded an increase in control plants that reached 40.82%, while it decreased in plants that were sprayed with yeast extract at a rate of 8 g/l and ascorbic acid + salicylic acid.

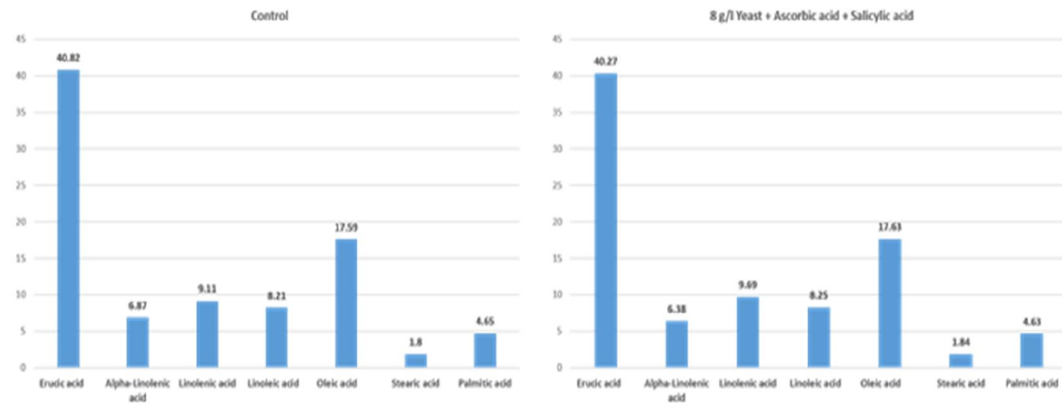

Fig. 2: Chemical constituents on fixed oil of *Sinapis alba* plant during 2021/2022 seasons

Noted in Table 8 that the data tended to clarify the effect of the interaction between spraying with yeast extract and antioxidants on the white mustard plant.

The results showed a significant increase in protein percentage during the first and second seasons. The highest percentage of protein produced when spraying plants with 8 g/l yeast + ascorbic acid + salicylic acid, which recorded 23.92% in the first season and 24.90 in the second season compared to control and the rest of the treatments.

Table 8: Effect of interaction between yeast extract and some antioxidants on protein and total chlorophylls of *Sinapis alba* plant during 2020/2021 and 2021/2022 seasons under North Sinai conditions

Treatments	Protein %		Total chlorophylls (SPAD)	
	1st season	2nd season	1st season	2nd season
Control	19.42^{L}	19.66^{K}	43.07^{J}	42.73^{K}
Salicylic acid	21.42^{K}	21.61^{J}	45.30^{I}	44.47^{J}
Ascorbic acid	21.54^{J}	21.86^{I}	45.47^{I}	44.63^{J}
Ascorbic acid + Salicylic acid	22.02^{I}	22.11^{H}	45.80^{HI}	45.57^{I}
4 g/l Yeast	22.29^{H}	22.65^{G}	46.20^{H}	46.33^{H}
4 g/l Yeast + Salicylic acid	22.69^{F}	23.81^{E}	47.80^{F}	48.07^{F}
4 g/l Yeast + Ascorbic acid	23.00^{D}	24.02^{CD}	49.57^{D}	49.30^{D}
4 g/l Yeast + Ascorbic acid + Salicylic acid	23.56^{B}	24.58^{B}	51.63^{B}	52.03^{B}
8 g/l Yeast	22.48^{G}	23.51^{F}	46.83^{G}	47.47^{G}
8 g/l Yeast + Salicylic acid	22.86^{E}	23.94^{DE}	48.50^{E}	48.80^{E}
8 g/l Yeast + Ascorbic acid	23.17^{C}	24.19^{C}	50.50^{C}	50.33^{C}
8 g/l Yeast + Ascorbic acid + Salicylic acid	23.92^{A}	24.90^{A}	54.47^{A}	55.67^{A}

Averages that share the same alphabet do not differ from each other significantly according to Duncan's test at the 5% level.

Results shown in Table, 7 the interaction effect between yeast extract and antioxidants, where an increase in total chlorophylls was observed in all treatments compared to control. Also, an increase in total chlorophylls was observed, this increase was significant in the both season.

The treatment of 8 g/l yeast + ascorbic acid + salicylic acid recorded the highest values of total chlorophylls, which recorded 54.47 and 55.67 (SPAD) during the first and second seasons, respectively, compared to the control, which recorded the lowest values of total chlorophylls 43.07 and 42.73(SPAD) during the two seasons, respectively.

4. Discussion

The positive effects of yeast extract, salicylic acid, and ascorbic acid on plants impacted growth and productivity, as will be discussed .

Dry yeast (*Saccharomyces cerevisiae*) encouraged plant growth. It was a natural source of the hormone cytokinin that worked on cell division and elongation and a source of vitamin B and amino acids. It increased the size of the resulting fruits and the formation of the plant into a sizeable vegetative group, leading to increased growth branching, and the quality of the flowering and fruit process. Subsequently yield of seeds. These results are in agreement with Amer (2004) on common bean plant; Ezz El-Din and Hendawy, (2010) on *Borago officinalis* plsant and Matter and El Sayed, (2015) on Caraway plants.

The effect of ascorbic acid on the production of *Sinapis alba* L. was due to Ascorbic acid contributing to the process of plant cell division and growth. It also has an influential role in the photosynthesis process and maintains the effectiveness of a large number of plant enzymes important in the process of growth and photosynthesis and maintains chloroplast as one of the antioxidant factors that all work in increasing the number of Leaves and their area, which leads to the absorption of the largest amount of nutrients and thus is reflected on the strength and growth recipes and increase all the different parts of the plant. These results are in agreement with Conklin, and Barth, (2004); Hamayun *et al*. (2010) on soybean ; Smirnorf, and Wheeler, (2000); Faize *et al*., (2011).

Salicylic acid accelerates the formation of chlorophylls and carotene pigments, which accelerate photosynthesis and increase the activity of some important enzymes. Moreover, helps cells to absorption and transportation of nutrients inside the plant and stimulated plants to tolerate different environmental stresses (salty, heat and drought) Simaei *et al*., (2012) on soybean plants.

Furthermore, regulates and reduces the effect of aging leaves and works to increase the levels of plant hormones such as auxins and cytokinins, where the increase in the growth characteristics of the plant is due to the growth-promoting effects of this plant hormone.

These consequences are in agreement with El-Tayeb *et al*., (2006) on sunflower; Misra and Saxena, (2009) on lentil plants; Hussain *et al*., (2011) on *Viola odorata* L.; Bastam *et al*., (2013) on pistachio; Kouhifayegh *et al.* (2013) and Khan *et al*., (2014) on *Vigna radiata* L..

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