43 Egypt. J. Agron. Vol. 47, No. 3, pp: 513 - 533 (2025)

Egyptian Journal of Agronomy
http://agro.journals.ekb.eg/

Yeast extract leads to improvement of physiological and biochemical parameters and reduction of late planting stress in wheat

Marvat S. Sadak[1], **Elham A. Badr**[2], **Magda H. Mohamed**[2], **Gehan Sh. Bakhoum**[2] and **Medhat M. Tawfik**[2]

[1]*Botany Department, National Research Centre, Dokki, Giza, 33 El Bohouthst., Dokki, Giza, Egypt*
[2]*Field Crops Res. Dept., National Research Centre, 33 El Bohouthst., Dokki, Giza, Egypt*

RECENTLY, there is a great demand for bio-fertilizer usage, to reduce the detrimental effects of late sowing and enhance crop cultivation. Thus, the current research aims to improve wheat plant (Gemiza-11 and Sids-13 cultivars) growth, some physiological parameters, grain yield and quality by the use of yeast extract as foliar treatment. Therefore, throughout the course of two consecutive winter seasons, the effects of foliar treating yeast extract (1%, 2% and 3%) at two different sowing times (15th of November and December) on growth, certain biochemical characteristics and yield attributes were assessed. The obtained results demonstrate the superiority of Gemiza-11 cultivar over Sids-13 cultivar in terms of growth, yield quantity, and quality. Furthermore, compared to plants sown on15th November, the late sowing date Foliar treatment with yeast extract greatly enhanced growth characteristics, photosynthetic pigments, indole acetic acid, some osmoprotectants, yield, and its constituents in wheat plants. Finally, the above findings implied that exogenous yeast extract enhanced photosynthetic pigments, indole acetic acid (IAA), and the studied osmolytes and phenolics which further promoted growth and productivity of the two tested wheat cultivars under late sowing date. Therefore, the stimulative effect of yeast extract may be suggested as an effective strategy for strengthening the late sowing (15th December) stress tolerance of wheat plants.

Key words: Antioxidant activity, Foliar treatment, Late sowing, Osmoprotectants, Wheat, Yeast extract.

1. Introduction

By the end of this century, it is predicted that the average globaltemperature would rise by 1.5-4°C (IPCC. 2021). Globally, increased temperatures significantly impacted agricultural production in many regions especially arid and semiarid regions like South Africa (Bakhoum *et al.*, 2016 and Ramadan *et al*., 2025).

Wheat (*Triticum aestivum* L.) is considered the most important grain-producing cereal and the first crop among cereals consumed by humans (FAO, 2018). Wheat is used as a food crop in urban and rural societies and as a major source of straw for animal feed (El-Said and Mahdy, 2016 and Soliman, 2025). According to the Food and Agriculture Organization of the United Nations (FAO, 2020), wheat is cultivated on an area of 1.343 million hectares season with an annual production of8.800 million tons, with an average yield of6.55 t/ha (Ahmed *et al.,* 2020 and Ragaey *et al.*, 2022). Winter wheat cultivars have unique cold requirements, which depending on a number of variables, including the date of planting, general weather conditions and plant´s cold requirements, blooming may or may not take place.

Late sown wheat cropis subjected to elevated temperature stress resulting in yield decrease and contributing to the yield gap (Pecio and Wielgo, 1999 and Ibrahim & El-Waraky 2023). With recent variations in agricultural climate as well as the unpredictable rainfall pattern, there would be anurgent demand for wheat cultivars to be examined with different sowing schedules and planting densities for yield optimization (Grigorieva *et al.*,

*Corresponding author email: mervat_sh24@yahoo.com
Received: 25/11/2024; Accepted: 28/07/2025
DOI: 10.21608/agro.2025.326609.1528

2023). As a result, evaluating wheat cultivarsfor optimal planting period and seed rate for irrigated and rainfed areas is critical for establishing a proper cropping pattern in wheat-growing regions. The date of planting is determined by the environmental requirements of the wheat crop (Khalaf and Shahaz, 2016). Furthermore, the apparent role of agronomic processes such as the use of promising cultivars, the use of foliar stimulants, such as yeast extracts has a very important impact on plant growth and chemical composition, in addition to its yield and attributes (du Jardin, 2015).

Recently, there is a great demand for bio-fertilizer usage which are safe, in order to reduce the detrimental effects of late sowing or heat stress on different plants and enhance crop cultivation (Kasim *et al*., 2020, and Badr et al., 2025). Given that, yeast extract contains considerable levels of amino acids, carbohydrates, reducing sugars, enzymes, mineral elements, and vitamins (such as B1, B2, B3). Bread yeast (*Saccharomyces cerevisiae*) functions as a natural biological fertilizer which enhances growth and productivity of various plants (Dawood *et al*. 2013 and Sadak & Dawood 2022). Additionally, yeast is a naturally occurring supply of cytokinins and tryptophan, which are building block for indole acetic acid (IAA) biosynthesis (Mostafa and Abou Raya, 2003). Therefore, active dry yeast promotes cell differentiation and proliferation, controls morphogenesis of shoot and root, and modulates chloroplast maturation (Ezz El-Din and Hendawy, 2010).

Foliar treatment of yeast extract are ideal for correcting nutrient deficiencies and it is an excellent additive for increasing growth and crop yield quantity and quality (Bulgari *et al*., 2019). Its use is practiced as an alternative to chemical fertilizers that are safe for humans, animals and the environment (Omran, 2000). Most studies have shown that plant root growth can be directly or indirectly enhanced by rhizospheric yeast (Xin *et al*., 2009). Foliar treatment with yeast extract are good for fixing nutrient deficiencies in agricultural soil and it is an excellent additive for increasing growth and crop yield quantity and quality (Xi *et al.*, 2019). Its use is practiced as an alternative to chemical fertilizers that are safe for humans, animals and environmentally (Omran, 2000). Many researchers have shown that plant root growth can be directly or indirectly enhanced by rhizospheric yeast (Xi *et al*., 2019). In addition, Mohamed *et al*., (2015) stated that foliar spraying of yeast extract has been to improve growth of some plants. It is important to note that treatments with yeast extract enhanced wheat plant development in both normal and stressful field conditions (Haider *et al.,* 2021; Hamed *et al.,* 2022).

Thus, this study aimed to understand how exogenous yeast extract impacts wheat growth under late sowing stress focusing on its potential to mitigate growth inhibition, photosynthetic pigments and IAA inhibition maintain osmoprotectant balance and promote yield components. Also, compare the response of two cultivars Gemiza-11 and Sids -13 with different degrees of tolerance.

2. Material and Methods

2.1. Experiment location: Two field trials were sown in the winters of 2019/2020 and 2020/2021 to study the effect of three concentrations of baker's yeast extract, including 1, 2, and 3% on wheat plant under late sowing effect. In the National Research Center's experimental farm in the Nubaria district of Egypt (30_86'67" N 31_16'67" E, with a mean altitude of 21 m above sea level). The zone of the soil Farm is assumed to be arid or semi-arid. At night, temperatures ranged from 8.83ºC to 15.56ºC at a mean of 12.20ºC and from 7.47ºC to 17.44ºC with an average of 12.46ºC, while daytime temperatures ranged from 16.34ºC to 28.03ºC at a mean of 22.19°C and from 19.27ºC to 29.84ºC 35.74 to 57.42%, at a mean of 46.58%, and from 32.3 to 53.30% at meanof 42.8% while daytime relative humidity about from 85.97 to 91.62% at a mean of 88.80% and from 83.65to 90.79% at a mean of 87.22% in successive winters must be withheld in 2019–2020 and 2020–2021, respectively. The experimental site's meteorological information for the two growth seasons is shown in Figure 1.

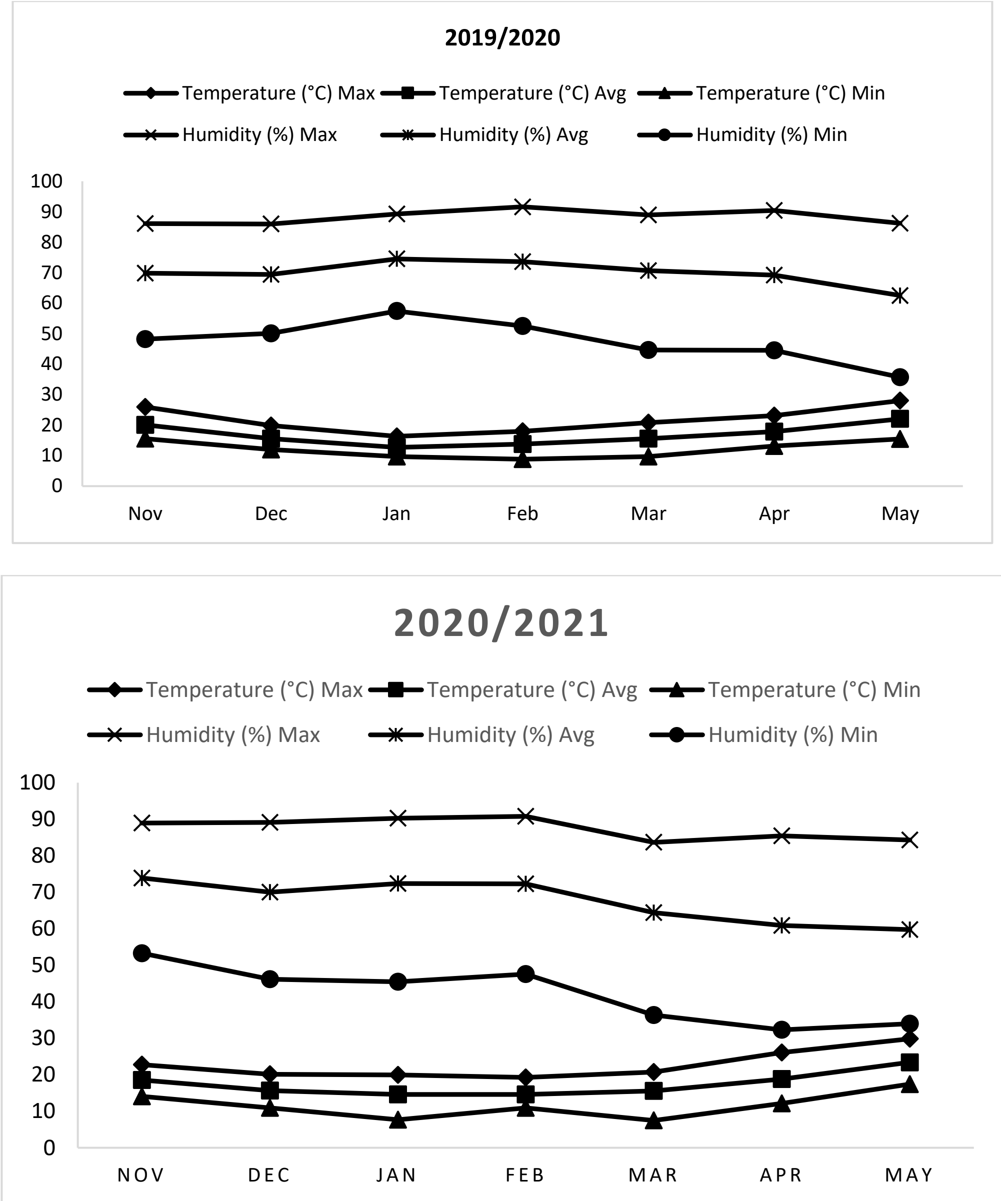

Fig. 1. The data of maximum, minimum, average temperature, and relative humidity, were gained from the weather station installed at the experimental station of the National Research Centre, Nubaria region, Egypt.

The mechanical and chemical analyses of experimental soil were analyzed according to Chapman & Pratt, (1961) as presented in Table (1) and Table (2).

Table 1. Mechanical and chemical analysis of the experimental sandy soil.

Season	Constant Depth (cm)	Sand %	Silt%	Clay%
2019/2020	00 – 30	85.3	10.5	4.2
	30 – 60	81.2	13.6	5.2
2020/2021	00 – 30	81.3	13.4	5.3
	30 – 60	74.6	17.6	7.8

Table 2. Soil chemical analyses of the experimental site.

Seasons	Constant Depth (cm)	pH	Electrical conductivity (ds/m)	Saturation Percentage	Anions (milliequivalents/ liter)				Cations (milliequivalents/ liter)				$CaCo_3$ %	Organic Matter %
					CO_3^- -	CO_3-	Cl	SO_4^- -	Ca^{++}	Mg^{++}	Na^+	K^+		
2019/	00 – 30	7.74	1.17	32	--	0.50	8.40	1.11	1.80	0.90	7.1	0.20	1.00	0.40
2020	30 – 60	7.79	1.79	27	--	0.60	8.00	1.40	2.10	1.50	6.2	0.20	6.00	0.07
2020/	00– 30	7.75	1.59	23	--	0.32	12.70	1.98	4.00	1.80	9.0	0.20	1.90	0.38
2021	30 – 60	7.77	1.81	25	--	0.45	15.40	2.15	5.60	2.00	10.2	0.20	1.30	0.32

2.2. Experimental procedure

Two cultivars of wheat (*Triticum aestivum,* L.) namely Gemiza-11 andSids-13 were sown at two sowing date15thNovember (normal sowing date) and 15thDecember (late sowing date) in two successive winter seasons (2019/2020 and 2020/2022). Grains of two wheat cultivars were obtained from the Agricultural Research Center, Ministry of Agriculture, Giza, Egypt. Granular ammonium sulfate 20.5% N at a rate of 40 kg N ha^{-1}, and single superphosphate (15% P_2O_5) at a rate of 60 kg P_2O_5 ha^{-1} were added. The N and P fertilizers were mixed thoroughly into the soil immediately before sowing. Sprinkler irrigation was used. The recommendations of the Ministry of Agriculture, Egypt, were carried out under field conditions. The plants were foliar sprayed with four concentrations of yeast extract (control, 1%, 2%, and 3%) at 35 and 50 days after sowing using a hand-operated compressed air sprayer. Yeast extract was obtained from the bakery. The commercial bakery yeast (*Saccharomyces cerevisiae*) was used as biological amendments; three different treatments were made by adding 10, 20, and 30 g in one liter of warm water, with two table spoons of sugar to activate the yeast, and allowing it to sit for 24 hours (at 28-35̊C) and consequently filtered via a piece of cloth (Morsi et al., 2008).

2.3. Experimentaldesign*:* Experimental design: The trial was designed using a completely randomized block design with a split split-plot structure with three replicates in both seasons. The main plots were devoted to two wheat cultivars and the sub plots were occupied by the two sowing dates whereas, the sub-sub plots were assigned to the four yeast extract YE treatments. Wheat grains of the two cultivars were planted in rows 3.5 meters long, with 20 cm between each row, the total area of the plot was 10.5 m^2 (3.5 m in length and 3.0 m in width) using traditional agricultural methods.

2.4. Measurements

Samples of five guarded plants were randomly taken from the three middle rows for each sub plot to determining growth parameters including shoot length (cm), leaf number/tiller, fresh and dry weight(g).At harvest, one square meter of each sub-subplot was harvested to determine the following yield characters namely: shoot dry weight (g), spike weight /plant (g), spikelet number/spike, biological yield (ton/hectare), grains weight/plant (g),grains yield (ton/hectare), straw yield (ton/hectare) and 1000 grains weight (g).

2.5. Chemical analysis

Chlorophyll *a*, chlorophyll *b* and carotenoids were determined using the Spectrophotometric method described by Lichtenthaler and Buschmann (2001). Total soluble sugars (TSS) were extracted and analyzed according to the method described by Chow and Landhausser (2004). Free amino acids were extracted and assayed according to the method described by Sorrequieta *et al.* (2010). Proline was assayed by Kalsoom *et al.* (2016). Indole acetic acid content was extracted and analyzed using the method described by Larsen *et al.,* (1962). Total carbohydrates was extracted and analyzed according to Albalasmeh *et al.* (2013). Total phenolic content was measured as described by Gonzalez *et al.* (2003). DPPH% was measured according to the method reported by Gyamfi *et al.*, (2002).

2.6. Statistical analysis

The data was subjected to a completely randomized block design statistical analysis. Given that the tendency was similar between both seasons, the homogeneity test utilized Bartlet's equation to integrate the analyses of both seasons. All data were exposed to the analysis of variance according to the MSTAT-C (1988) statistical analysis program version 14. Duncan's multiple range test was measured to compare the means at$P< 0.05$ (Steel & Torrie, 1997).

3. Results

3.1. Changes in growth characters:

For the individual impact of each factor, Table (2) shows the effect of cultivars, sowing date and foliar application with different levels of yeast extract on different morphological parameters of wheat plants grown in sandy soil, Data clearly show significant differences between Gemiza-11 and Sids-13 regarding to shoot length (cm), number of leaves/tiller, shoot fresh and dry weight (g). Growth of Gemiza-11cultivar was superior by 18.39%, 25.17%, 10.86% and 12.00% over Sids -13 in the above mentioned parameters respectively.

While, the effect of sowing date of wheat plants on morphological parameters (Table 2), clearly stated that, late sowing (15th December) significantly reduced shoot length (12.7% decrease), leaves number/tiller (10.5% decrease), shoot fresh weight (9.5% decrease) and dry weight (with 12.0% decrease) in comparison to first planting date.
Regarding the effect of yeast extract treatment with different concentrations, data presented in the same Table 2 showed that different YE concentrations increased significantly shoot length (cm), leaves number/tiller, shoot fresh and dry weight (g)asover untreated control plants. Furthermore, foliar application with 2% yeast extract was the most effective concentration (it increased shoot length by 27.2%, leaves number/tiller by 21.04%, shoot fresh weight by 34.7% and dry weight by 34.7% increase) followed by (3%) as compared to other y used treatments and control (Table 2).

Analysis of variance for the third interaction effect among cultivars, sowing dates and bio-fertilizer treatment (yeast extract) on growth characters of wheat plants were presented in Table 3. Different treatment of yeast extract increased shoot length (cm), number of leaves/tiller, shoot fresh and dry weight (g)of the two cultivars of wheat plants in both planting dates of both Gemiza -11 or Sids-13. Furthermore, the best effective treatment under both planting times was 2% yeast extract on either Gemiza-11cultivaror Sids-13. Under both normal and late sowing dates of Gemiza-11, foliar treatment of 2% YE, the percentages of increases in shoot length were 31.73%, 22.58%, number of leaves per tiller, 17.64% and 26.6%, shoot fresh weight, 12.14% and 13.31% and shoot dry weight, 24.58% and 21.57%. While the percentages of increases in Sids-13 in shoot length were 24.14%, 29.84%, number of leaves per tiller, 23.09% and 17.98%, shoot fresh weight, 52.94% and 63.85% and shoot dry weight, 45.35% and 54.67%.

Table 2. Impact of cultivars (Gemiza-11 and Sids-13), sowing dates (Normal date and late sowing date) and foliar application of yeast extract (0, 1%, 2% and 3%) on growth attributes in wheat (combined analysis of two seasons).

Treatments	Shoot length (cm)	number of leave/tiller	shoot fresh wt (g)	Shoot dry wt (g)
Impact of cultivars (combined average of the two sowing dates)				
Gemiza-11	38.29a	5.96a	3.50a	1.25a
Sids-13	31.25b	4.46b	3.12b	1.10b
Sowing dates (combined average of the two cultivars)				
Normal sowing	37.13a	5.50a	3.47a	1.25a
Late sowing	32.42b	4.92b	3.14b	1.10b
Foliar application of yeast extract (YE)				
Control	30.08c	4.67c	2.71c	0.95c
1% YE	35.17b	5.17b	3.30b	1.19b
2% YE	38.25a	5.67a	3.65a	1.28a
3% YE	35.58b	5.33ab	3.57ab	1.28a

Table 3. Impact of interaction among cultivars (Gemiza-11 and Sids-13), sowing dates (Normal date and late sowing date) and foliar application of yeast extract (0, 1%, 2% and 3%) on growth attributes in wheat (compound analysis of two seasons).

Cultivars	Time of sowing	Yeast extract (YE)	Shoot length (cm)	Leave no/tiller	Shoot fresh wt (g)	Shoot dry wt (g)
Gemiza-11	Normal sowing	Control	34.67e±2.55	5.67b±0.65	3.26d±0.35	1.18c±0.06
		1% YE	42.00b±3.05	6.33a±0.35	3.72ab±0.14	1.41a±0.05
		2% YE	45.67a±1.15	6.67a±0.51	3.99a±0.62	1.47a±0.03
		3% YE	43.33b±1.65	6.33a±0.15	3.92a±0.15	1.43a±0.03
	Late sowing	Control	31.00f±2.65	5.00bc±0.32	3.08de±0.08	1.02e±0.04
		1% YE	36.33d±1.54	5.67b±0.21	3.28d±0.09	1.11d±0.01
		2% YE	38.00c±3.05	6.33a±0.42	3.49c±0.00	1.24b±0.08
		3% YE	35.33de±2.35	5.67b±0.00	3.23d±0.04	1.13d±0.04
Sids-13	Normal sowing	Control	29.00g±1.32	4.33cd±0.32	2.38d±0.16	0.86f±0.03
		1% YE	33.00ef±1.52	4.67c±0.08	3.18de±0.01	1.14d±0.07
		2% YE	36.00d±2.06	5.33bc±0.36	3.64b±0.10	1.25bc±0.02
		3% YE	33.33ef±2.04	4.67c±0.15	3.68b±0.07	1.24bc±0.00
	Late sowing	Control	25.67h±2.62	3.67d±0.06	2.13f±0.12	0.75g±0.04
		1% YE	29.33fg±2.54	4.00d±0.32	3.00e±0.34	1.09e±0.03
		2% YE	33.33ef±3.62	4.33cd±0.21	3.49c±0.05	1.16d±0.04
		3% YE	30.33f±3.51	4.67c±0.36	3.45c±0.17	1.30b±0.03

3.2. Changes in yield and its components:

For each factor´s individual impact, Table (4) and Fig 1 (a, b, c and d) indicated that wheat cultivar Gemmiza-11 surpassed Sids-13 in yield traits expressed as shoot length cm (7.32%), spike length cm (1.37%),), shoot dry weight g (18.81%), spike weight/plant g (12.85%), spikelet no/spike (11.26%), grains weight /plant g (8.61%), biological yield (ton/ha, 7.23%), grains yield (ton/ha, 10.67%) straw yield (ton/ha, 4.89%) and 1000 grains weight (14.82%). Late sown plants showed significant decreases in the above mentioned yield and its components, the percentages of decreases were, as shoot length cm (10.35%), spike length cm (19.55%),), shoot dry weight g (25.22%), spike weight/plant g (16.94%), spikelet no/spike (13.78%), grains weight /plant g (17.25%), biological yield (ton/ha, 18.27%), grains yield (ton/ha, 18.46%) straw yield (ton/ha, 18.15%) and 1000 grains weight (13.22%). However, treating wheat plants with different levels of yeast extract increased significantly shoot length (13.25%), spike length (17.97%), shoot dry weight (36.97%), spike weight/plant (69.60%), spikelet no/spike (51.83%), grains weight /plant (7.42%), biological yield (35.77%), grains yield (35.79%) straw yield (37.75%) and 1000 grains weight (29.81%). The highest mean values are recorded in plants treated with foliar application of yeast (2%) followed by 3%.

Table 4. Impact of cultivars (Gemiza-11 and Sids-13), sowing dates (Normal date and late sowing date) and foliar application of yeast extract (0, 1%, 2%and 3%) on yield and its attributes in wheat (compound analysis of two seasons).

Treatment	Shoot length (cm)	spike length (cm)	Shoot dry weight (g/plant)	spike weight (g/plant)	spikelet no/spike	grains weight (g/plant)
Cultivars of wheat (combined average of the two dates of sowing)						
Gemiza-11	62.67a	10.92a	2.18a	1.79a	15.54a	2.44a
Sids-13	58.08b	10.77a	1.77	1.56b	13.79b	2.23b
Sowing dates (Combined averabge of the two cultivars)						
Normal sowing	63.67a	12.02a	2.26a	1.83a	15.75a	2.55a
Late sowing	57.08b	9.67b	1.69b	1.52b	13.58b	2.11b
Foliar application of yeast extract (YE)						
Control	55.92c	9.96c	1.65d	1.25c	10.92b	2.29c
1% YE	61.17b	11.00b	1.92c	1.66b	15.92ab	2.20c
2% YE	63.33a	11.75a	2.26a	2.12a	16.58a	2.46a
3% YE	61.08b	10.67a	2.08b	1.67b	15.25ab	2.39b

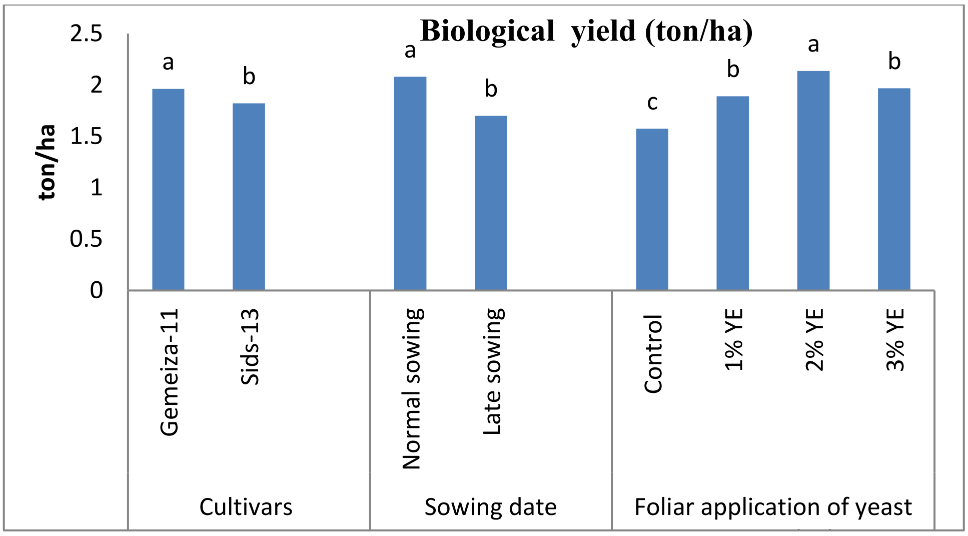

Fig. 1(a). Impact of cultivars (Gemiza-11 and Sids-13), sowing dates (Normal date and late sowing date) and foliar application of yeast extract (0, 1%, 2% and 3%) on yield and its attributes in wheat (compound analysis of two seasons).

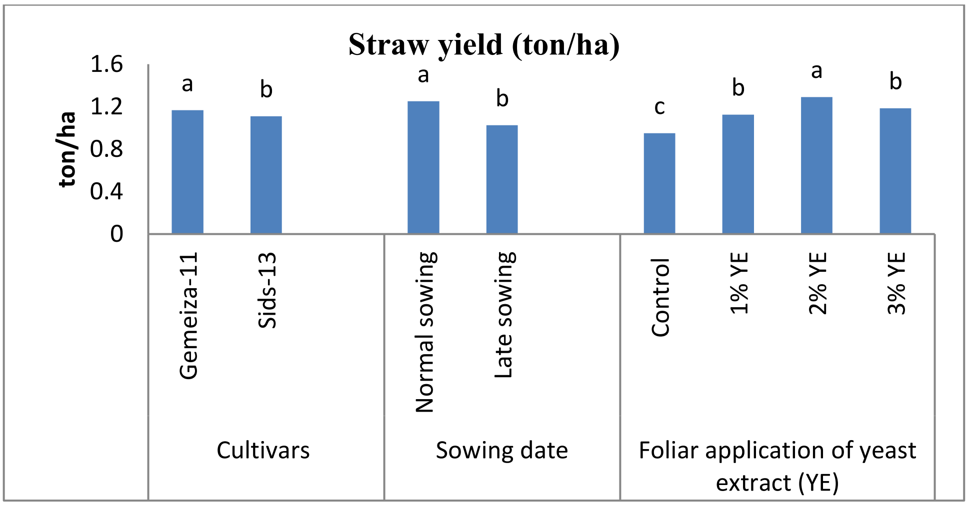

Fig. 1(b). Impact of cultivars (Gemiza-11 and Sids-13), sowing dates (Normal date and late sowing date) and foliar application of yeast extract (0, 1%, 2% and 3%) on yield and its attributes in wheat (compound analysis of two seasons).

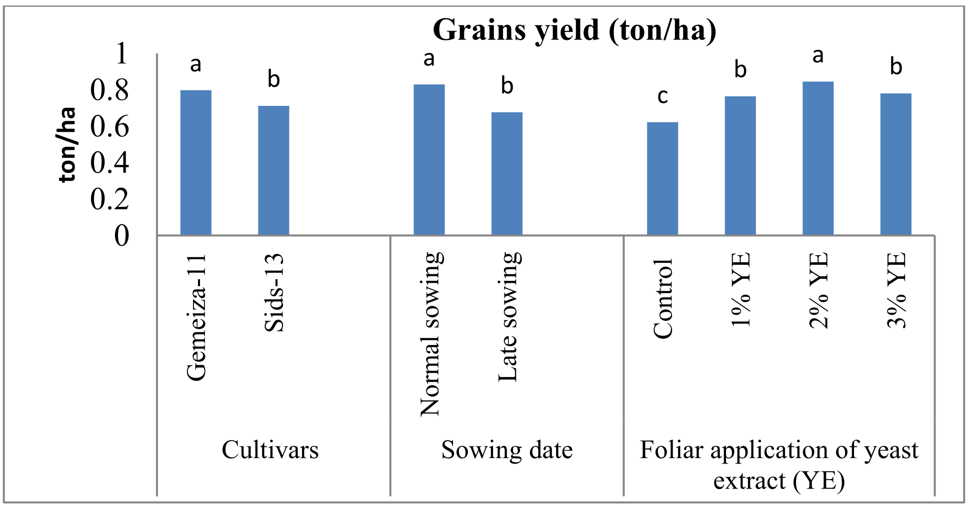

Fig. 1(c). Impact of cultivars (Gemiza-11 and Sids-13), sowing dates (Normal date and late sowing date) and foliar application of yeast extract (0, 1%, 2% and 3%) on yield and its attributes in wheat (compound analysis of two seasons).

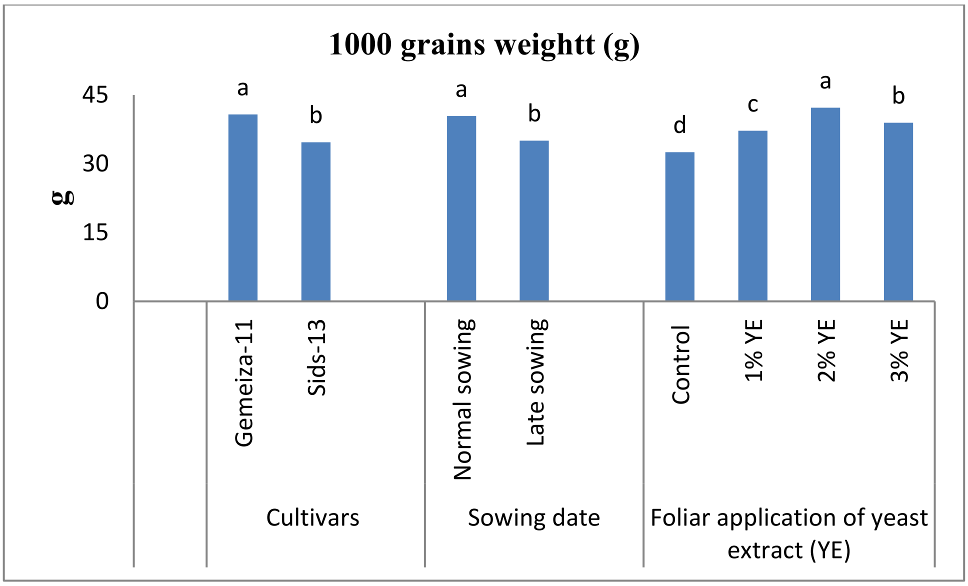

Fig. 1(d). Impact of cultivars (Gemiza-11 and Sids-13), sowing dates (Normal date and late sowing date) and foliar application of yeast extract (0, 1%, 2% and 3%) on yield and its attributes in wheat (compound analysis of two seasons).

Furthermore, results in Tables 5 and Fig 2(a, b, c and d) indicate the impact of interaction effect of cultivars, date of sowing and different concentrations of yeast extract on yield and its components (shoot length (cm), spike length (cm), shoot dry weight (g), spike weight/plant (g), spikelet no/spike, grains weight /plant (g), biological yield (ton/ha), grains yield (ton/ha) straw yield (ton/ha) and 1000 grains weight (g) as well as carbohydrate and protein content of the yielded grains) of wheat plants. Data revealed that, Gemiza-11 showed higher yield and its components in both date of planting and yeast extract treatments Furthermore, data clearly show that treating wheat plants with different concentrations of yeast extract could alleviate the reduced effect of late sowing as compared with untreated controls. The most effective treatment was 2% yeast extract (Table 5).

Table 5. Impact of interaction of cultivars (Gemiza-11 and Sids-13), sowing dates (Normal date and late sowing date) and foliar application of yeast extract (0, 1%, 2% and 3%) on yield and its attributes in wheat (compound analysis of two seasons).

Treatment			Shoot length (cm)	Spike length (cm)	shoot dry weight (g)	spike weight (plant/g)	spikelet no/spike	biological yield (ton/fed)	grains weight (g/plant)
Gemiza -11	Normal sowing	Control	61.3d±0.33	11.5c±0.88	2.16e±0.06	1.29g±0.08	13.00e±0.47	4.57d±0.07	2.21e±0.06
		1% AYE	66.7bc±1.20	12.7b±0.88	2.36c±0.06	1.64d±0.09	16.67c±0.57	5.43bc±0.06	2.50d±0.04
		2% AYE	71.3a±0.57	13.7a±0.66	2.69a±0.03	2.41a±0.08	19.67a±0.06	5.88a±0.05	3.23a±0.00
		3% AYE	68.0b±0.66	11.7c±0.66	2.46b±0.00	1.60d±0.11	17.33b±0.84	5.64b±0.04	3.08b±0.06
	Late sowing	Control	51.7i±1.33	8.0f±0.33	1.57h±0.06	1.13h±0.04	10.67f±0.68	3.58fg±0.06	2.10f±0.04
		1% AYE	58.3e±0.66	9.3e±0.33	1.85g±0.04	1.20g±0.12	15.00d±0.72	4.01f±0.07	2.40d±0.03
		2% AYE	63.7c±0.66	10.0d±0.33	2.26d±0.03	1.67d±0.040	18.33ab±0.03	4.72d±0.06	2.70c±0.05
		3% AYE	60.3de±0.88	9.3e±0.66	2.12e±0.05	1.55e±0.00	16.67c±0.54	4.02e±0.00	2.61cd±0.04
Sids-13	Normal sowing	Control	56.0f±0.84	10.7d±0.33	1.70g±0.00	1.34ef±0.08	10.67f±0.85	4.02±0.06	1.75g±0.06
		1% AYE	61.0d±1.15	11.3c±0.66	2.06f±0.06	1.98c±0.06	15.67d±0.68	5.08c±0.07	1.96g±0.07
		2% AYE	63.0c±1.15	12.7b±0.88	2.34c±0.04	2.25b±0.04	18.33a±0.75	5.51bc±0.00	2.49d±0.06
		3% AYE	62.0cd±1.15	12.0c±0.66	2.28d±0.06	2.11bc±0.03	17.00b±0.68	5.04c±0.06	2.20e±0.04
	Late sowing	control	54.7h±1.25	9.7e±0.33	1.16k±0.05	1.22f±0.01	9.67g±0.84	3.38g±0.08	1.69g±0.00
		1% AYE	58.7e±1.62	10.7d±0.33	1.41j±0.00	1.82cd±0.06	13.33e±0.62	4.02e±0.01	1.97fg±0.07
		2% AYE	55.3g±0.88	10.7d±0.88	1.73g±0.06	2.16bc±0.06	14.67de±0.00	4.99c±0.06	2.15e±0.00
		3% AYE	54.0h±0.66	9.7e±0.66	1.46i±0.03	1.40f±0.00	12.33e±0.75	4.77d±0.04	1.86g±0.006

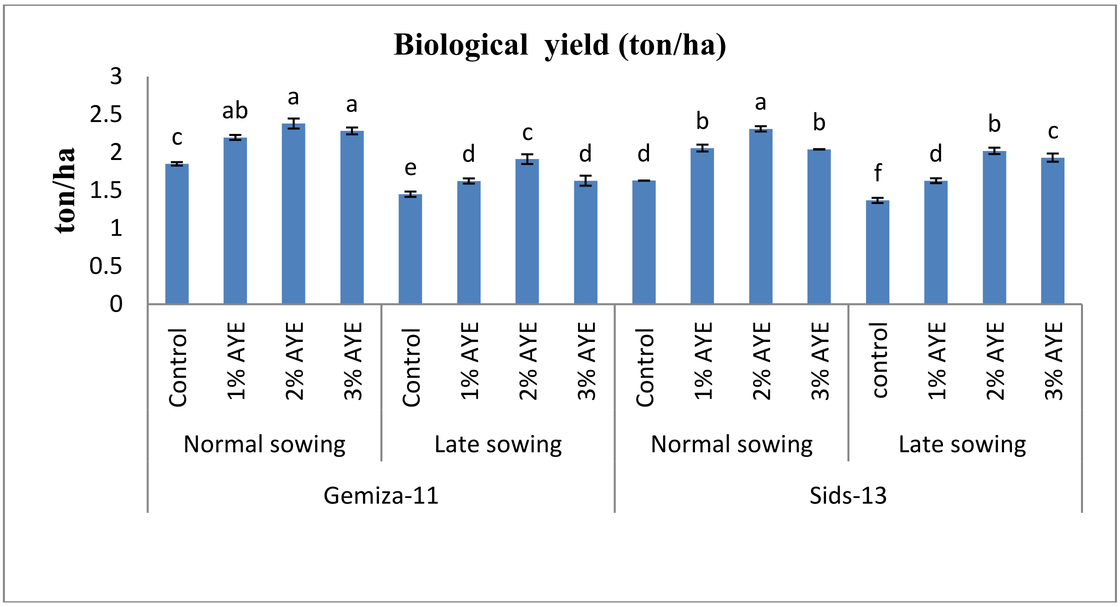

Fig. 2(a). impact of interaction of cultivars (Gemiza-11 and Sids-13), sowing dates (normal date and late sowing date) and foliar application of yeast extract (0, 1%, 2% and 3%) on yield and its attributes in wheat (compound analysis of two seasons).

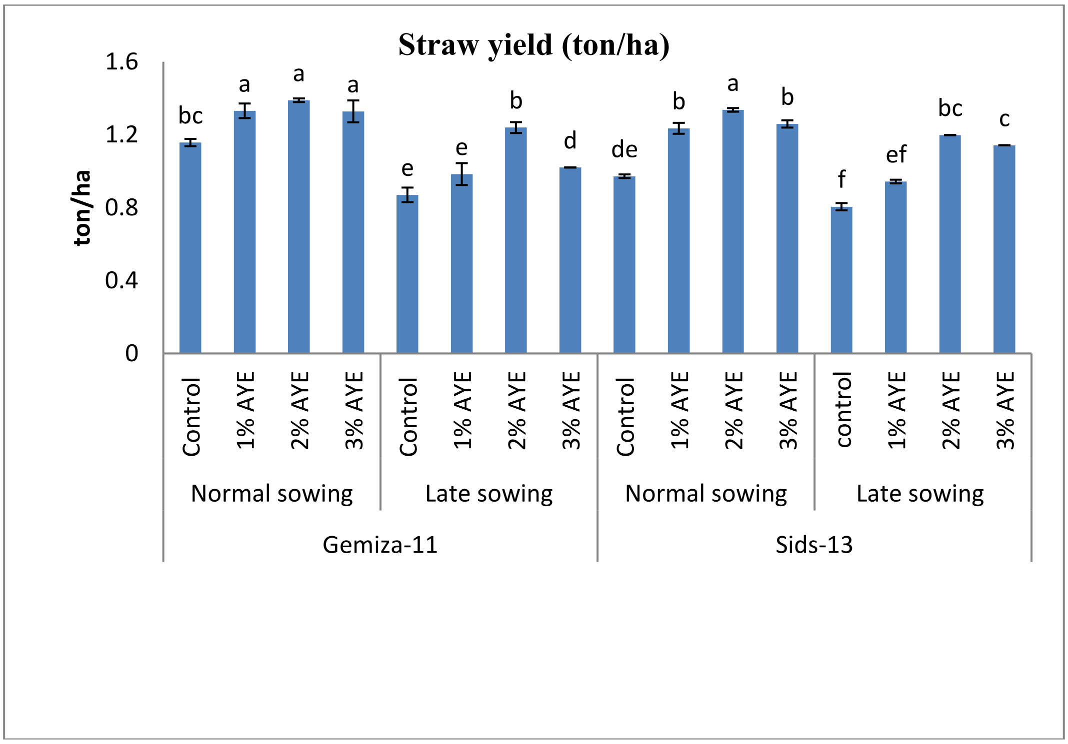

Fig. 2(b). impact of interaction of cultivars (Gemiza-11 and Sids-13), sowing dates (Normal date and late sowing date) and foliar application of yeast extract (0, 1%, 2% and 3%) on yield and its attributes in wheat (compound analysis of two seasons).

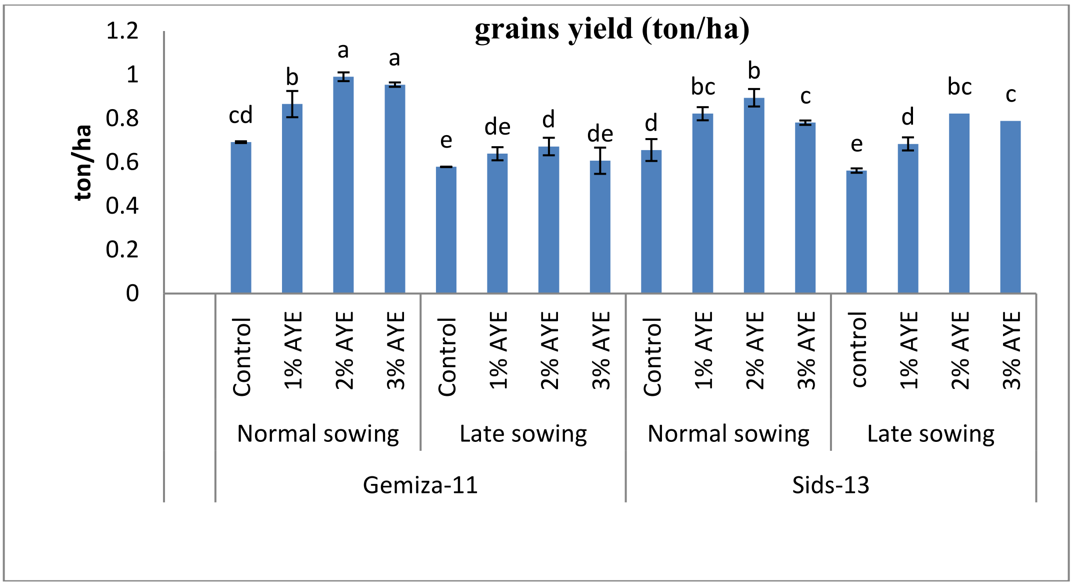

Fig. 2(c). impact of interaction of cultivars (Gemiza-11 and Sids-13), sowing dates (Normal date and late sowing date) and foliar application of yeast extract (0, 1%, 2% and 3%) on yield and its attributes in wheat (compound analysis of two seasons).

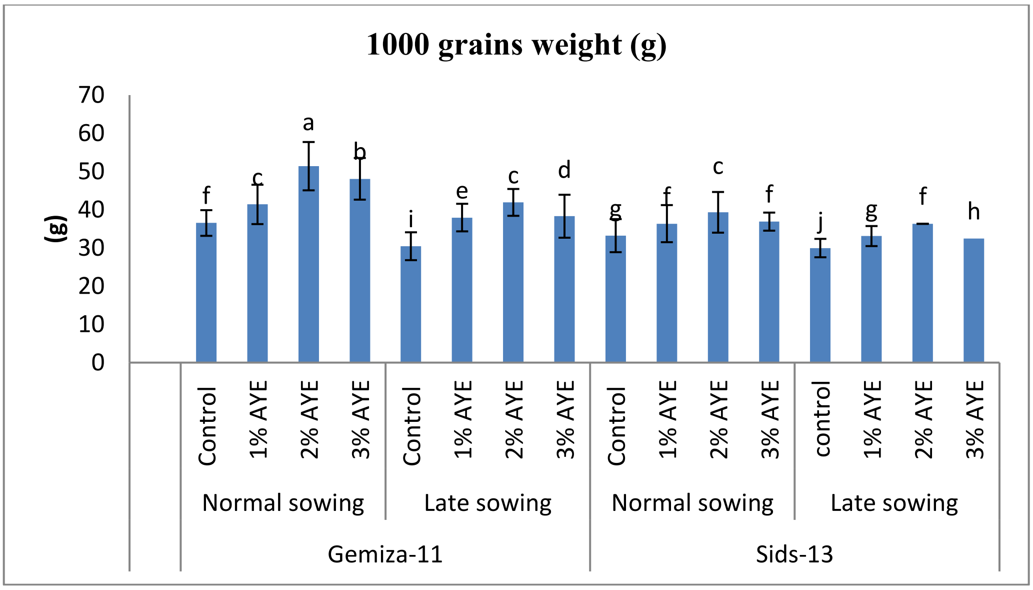

Fig 2 d :LSD at 5%: 0.75

Fig. 2 (d). impact of interaction of cultivars (Gemiza-11 and Sids-13), sowing dates (Normal date and late sowing date) and foliar application of yeast extract (0, 1%, 2% and 3%) on yield and its attributes in wheat (compound analysis of two seasons)

3.3. Changes in photosynthetic pigment and endogenous indole acetic acid:

For the individual impact of each factor, data in Table (6) indicate that chlorophyll a, chlorophyll b, carotenoids, total pigment and indole acetic acid (IAA) contents were significantly ($P < 0.05$) different between the two wheat cultivars (Gemiza-11 and Sids-13). However, Gemiza-11 significantly surpassed Sids-13 cultivars in different photosynthetic pigments constituents and endogenous IAA level. Late sowing date (15th December) significantly decreased in Chlorophyll a, chlorophyll b, carotenoids and total pigments as well as IAA level comparing to control. While, foliar treatment of yeast extract with different levels (1%, 2% and 3%) caused significant increases in the above mentioned studied parameters of wheat leaves as compared with untreated control (Table 6).

Table 6. Impact of cultivars (Gemiza-11 and Sids-13), sowing dates (Normal date and late sowing date) and foliar application of yeast extract (0, 1%, 2% and 3%) on photosynthetic pigment (mg/100 g fresh wt) and IAA (µg/g fresh wt) contentin wheat.

Treatment	Chlo a	Chlo b	Carotenoids	Total pigment	IAA (µg/g FW)
	(mg/100 g FW)				
Cultivars of wheat					
Gemeiza-11	1.25a	0.737a	0.346a	2.35a	45.42a
Sids-13	1.10b	0.559b	0.291b	1.77b	31.34b
Sowing dates					
Normal sowing	1.25a	0.720a	0.362a	2.25a	67.11a
Late sowing	1.10b	0.576b	0.275b	1.88b	89.39b
Foliar application of yeast extract					
Control	0.95c	0.604c	0.291c	1.84c	65.81d
1% YE	1.19b	0.657b	0.318b	2.08b	76.20c
2% YE	1.28a	0.680a	0.346a	2.24a	86.79a
3% YE	1.28a	0.652b	0.319b	2.10b	84.19b

On the other hand, the third order interactions applied of wheat plant as cultivars x sowing dates x foliar yeast extract, presented in Table 7. The obtained data illustrated the influence of foliar application of 2% yeast extract on chlorophyll a, chlorophyll b, carotenoids and total pigments as well as IAA in wheat leaves under two sowing dates and two cultivars. All yeast extract could not only, improve different photosynthetic pigment contents and IAA in normal sowed wheat cultivars, but also, alleviate the effect of late sowing date in the two tested cultivars (Table 7). However maximum values of photosynthetic pigments constituents and endogenous IAA contents were obtained in Gemiza-11 cultivar using foliar sprayed with 2% yeast extract in plants sowed at 15st of November.

Table 7. Impact of interaction of cultivars (Gemiza-11 and Sids-13), sowing dates (Normal date and late sowing date) and foliar application of yeast extract (0, 1%, 2% and 3%) on Photosynthetic pigment and IAA content in wheat.

Treatment			Chlo a	Chlo b	carotenoids	Total pigment	IAA (µg /g FW)
				(mg/100 g FW)			
Gemeiza-11	Early sowing	Control	1.18bc±0.03	0.829b±0.02	0.363c±0.03	2.40c±0.35	24.40m±0.25
		1% YE	1.41a±0.10	0.842a±0.05	0.437b±0.03	2.67b±0.12	33.40i±0.33
		2% YE	1.47a±0.03	0.869a±0.06	0.475a±0.00	2.84a±0.12	43.34e±0.35
		3% YE	1.43a±0.04	0.857a±0.05	0.475a±0.00	2.63b±0.33	38.91g±0.88
	Late sowing	Control	1.02c±0.06	0.596d±0.02	0.252i±0.03	1.77f±0.44	19.73n±0.16
		1% YE	1.11c±0.01	0.619cd±0.02	0.265h±0.01	2.09d±0.06	27.24l±0.35
		2% YE	1.24b±0.03	0.641c±0.04	0.288fg±0.03	2.62b±0.16	32.79j±0.35
		3% YE	1.1bc±0.01	0.640c±0.02	0.261h±0.02	2.16d±0.06	30.89k±0.36
Sids-13	Early sowing	Control	0.86d±0.00	0.515f±0.04	0.286±0.02	1.67±0.00	39.54f±0.16
		1% YE	1.14bc±0.04	0.638c±0.03	0.294f±0.00	1.91±0.03	49.65c±0.00
		2% YE	1.25b±0.03	0.641c±0.04	0.317d±0.03	2.02b±0.06	62.22a±0.66
		3% YE	1.24b±0.02	0.567de±0.06	0.300e±0.04	1.85e±0.00	57.88b±0.88
	Late sowing	Control	0.75e±0.03	0.474g±0.02	0.265h±0.03	1.50h±0.01	28.33k±0.51
		1% YE	1.09c±0.02	0.528f±0.00	0.277g±0.02	1.64g±0.03	35.48h±1.36
		2% YE	1.16bc±0.02	0.567de±0.02	0.302e±0.03	1.83e±0.12	46.73d±1.25
		3% YE	1.30ab±0.01	0.545e±0.03	0.289fg±0.01	1.76f±0.14	43.55e±1.36

3.4. Changes in osmoprotectants, phenols and antioxidant activity (DPPH%):

As for the individual effect of each factor, data presented in table (8) showed the significant differences between the two tested cultivars Gimeza-11 and Sids-13 in the contents of total soluble sugars (TSS), free amino acids (FAA) and proline contents, phenols and antioxidant activities expressed as DPPH%. Furthermore, Gemiza-11 gave higher contents of osmoprotectants expressed in TSS, FAA and proline contents over Sids-13 cultivars. Moreover, sowing wheat plants at 15thDecember significantly increased the above mentioned osmolytes as compared with the plants planted at the normal time 15th November. On the other hand, bio-fertilizer treatment with different concentrations (1%, 2% and 3% yeast extract) significantly enhanced all the studied osmolytes (TSS, FAA and proline contents). However, 2% yeast extract was the most effective treatment compared with the other treatments. Regarding to the third order interaction, wheat cultivars x sowing dates x foliar yeast extract,

Table 8. Impact of cultivars (Gemiza-11 and Sids-13), sowing dates (Normal date and late sowing date) and foliar application of yeast extract (with 1%YE, 2% YE and 3%YE) on some osmoprotectants (TSS, FAA and proline) in wheat plant.

Treatment	TSS	Free AA	Proline	Phenols	DPPH%
		(mg/100 g DW)			
Cultivars of wheat					
Gemeiza-11	6054.79a	409.48b	60.00a	74.66b	47.29b
Sids-13	3908.40b	427.32a	57.27b	81.84a	61.09a
Sowing dates					
Normal sowing	4881.90b	400.57b	50.52b	67.11b	54.31a
Late sowing	5081.29a	436.23a	66.75a	89.39a	54.08b
Foliar application of yeast					
Control	4785.39d	395.73d	45.32d	65.81d	50.71d
1% AYE	4932.08c	416.86c	57.51c	76.20c	53.66c
2% AYE	5135.50a	437.49a	68.94a	86.79a	56.68a
3% AYE	5073.42b	423.53b	62.77b	84.19b	55.71b

Regarding the interaction effects, Table (9) showed that, different osmolytes content were increased significantly in wheat plants sown in late date more than those plants sown in normal date. Furthermore, TSS content was recorded in highest level in plants treated with 2% of yeast extract in cultivar Gemiza-11. While, the maximum FAA content was obtained by late date and sprayed with 2% of yeast extract with cultivar Sides 13. On the other hand, the highest values of prolinecontent were obtained in Gemiza-11 wheatcultivar sprayed with 2% of yeast extract sowing at 15st of December.

Table 9. Impact of interaction of cultivars (Gemiza-11 and Sids-13), sowing dates (Normal date and late sowing date) and foliar application of yeast extract (with 1%YE, 2% YE and 3%YE) on some physiological aspects in wheat.

Treatment			TSS	Free amino acid	proline	Phenols	DPPH%
				(mg/100 g DW)			
Gemiza-11	Normal sowing	Control	5668f±50.3	359i±10.64	39.1i±1.35	56.7m±3.21	43.2n±0.65
		1%AYE	5970e±63.5	381h±9.65	50.8g±1.05	63.9l±3.05	44.7m±0.45
		2%AYE	6259c±61.5	406f±8.54	61.8d±2.31	74.4i±2.05	45.8k±1.02
		3%AYE	6047d±60.2	389g±6.35	49.2h±2.05	67.9k±2.15	45.2l±0.98
	Late sowing	Control	6060d±58.8	409e±8.45	58.2e±1.35	70.2j±2.35	46.7j±0.84
		1%AYE	6112cd±54.6	427c±7.35	71.6c±0.86	80.8h±1.62	49.1i±0.62
		2%AYE	6180a±63.5	456a±5.63	76.1a±0.74	94.7d±1.54	52.6h±0.74
		3%AYE	6140b±45.6	447b±4.65	73.4b±1.03	88.5e±1.06	51.2i±0.65
Sids-13	Normal sowing	Control	3514k±43.5	389g±10.63	35.7j±1.05	52.7±0.95	58.8e±1.00
		1%AYE	3643j±41.6	417e±9.52	49.7h±0.95	62.9l±0.86	63.1c±0.00
		2%AYE	3898j±25.3	432c±8.65	62.2d±0.84	105.6a±0.95	67.6a±0.87
		3%AYE	4054h±43.	428d±7.68	55.8f±0.62	85.8f±0.98	66.1b±0.95
	Late sowing	Control	3897i±36.5	424d±8.36	48.4h±1.06	83.7g±0.00	54.2j±0.75
		1%AYE	4002i±32.5	440b±4.35	58.0e±1.00	97.1c±1.00	57.8f±0.36
		2%AYE	4205g±33.5	454a±3.62	75.7a±0.00	100.6b±1.03	60.8d±0.51
		3%AYE	4052h±34.5	428d±8.25	72.7b±0.86	94.5d±1.16	60.4d±0.25

3.5. Changes in some nutrients of the harvested grains:

As for the individual effect of each factor, data presented in Fig 3 showed that, Gemiza-11 has more nutrients such as total carbohydrates, proteins, phenols and antioxidant activity as DPPH% over Sids-13 cultivars. Moreover, early sowing date significantly increased total carbohydrates, proteins, phenols and DPPH% compared to late planting plants sowed at 15th December (Late sowing). On the other hand, bio-fertilizer treatment with different concentrations of yeast extract significantly enhanced all the studied nutrients contents of the yielded wheat grains. However, 2% caused the highest increases in the nutrients contents of the yielded grains compared with all other treatments.

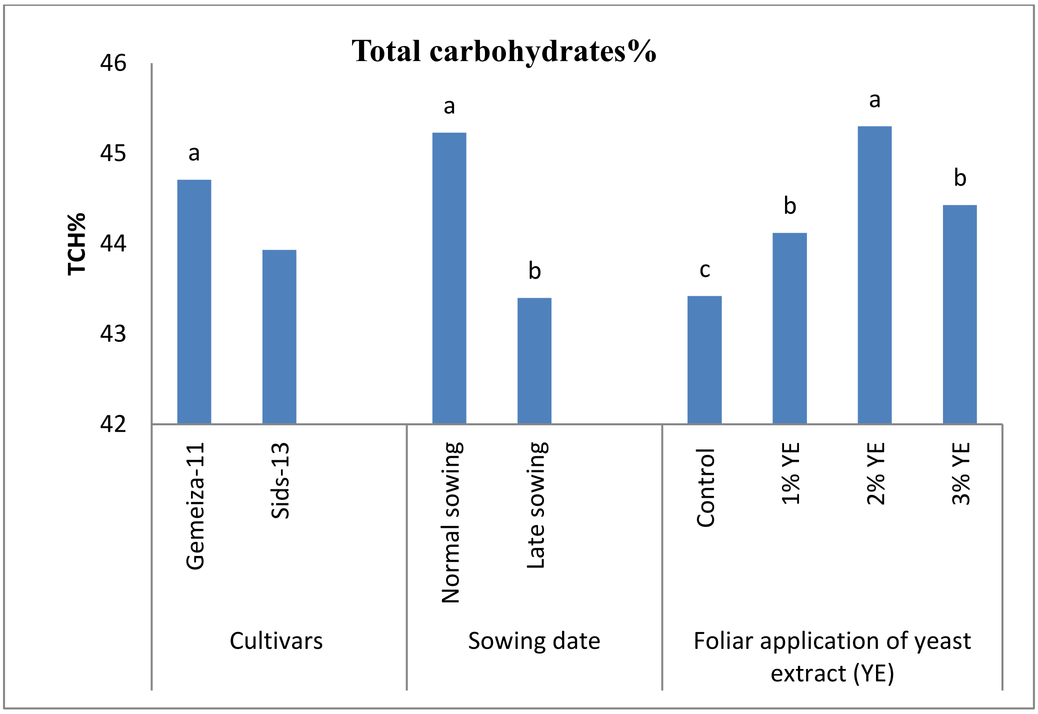

Fig. 3(a). Impact of cultivars (Gemiza-11 and Sids-13), sowing dates (Normal date and late sowing date) and foliar application of yeast extract (0, 1%, 2% and 3%) on nutrient contents (carbohydrate% , proteins, phenols mg/100 g DW and DPPH%) content in the yielded grains of wheat.

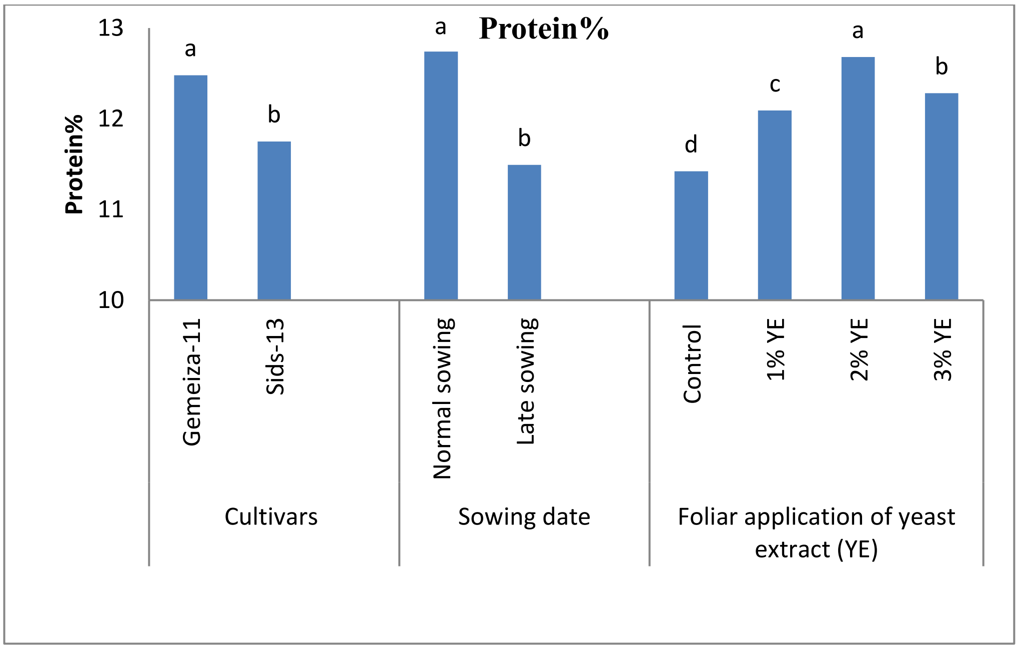

Fig. 3(b). Impact of cultivars (Gemiza-11 and Sids-13), sowing dates (Normal date and late sowing date) and foliar application of yeast extract (0, 1%, 2% and 3%) on nutrient contents (carbohydrate %, proteins, phenols mg/100 g DW and DPPH%) content in the yielded grains of wheat.

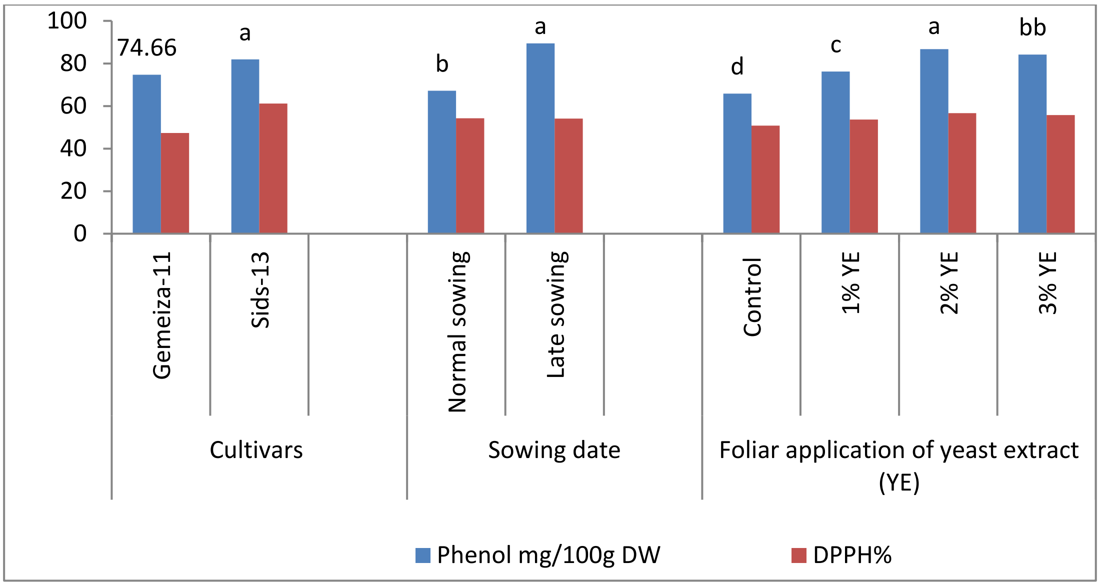

Fig. 3(c). Impact of cultivars (Gemiza-11 and Sids-13), sowing dates (Normal date and late sowing date) and foliar application of yeast extract (0, 1%, 2% and 3%) on nutrient contents (carbohydrate %, proteins, phenols mg/100 g DW and DPPH%) content in the yielded grains of wheat.

As for the third order interaction, wheat cultivars x sowing dates x foliar yeast extract, Data in Fig (4) illustrated that, maximum values of total carbohydrates%, proteins, phenols content and DPPH% was obtained by normal sowing date 15st November. And foliar application with 2% of yeast extracts of Gemiza-11 cultivar. While the highest phenols contents and antioxidant activity were recorded in the normal sowing date and treated with 2% yeast extract of the yielded grains of Sids-13.

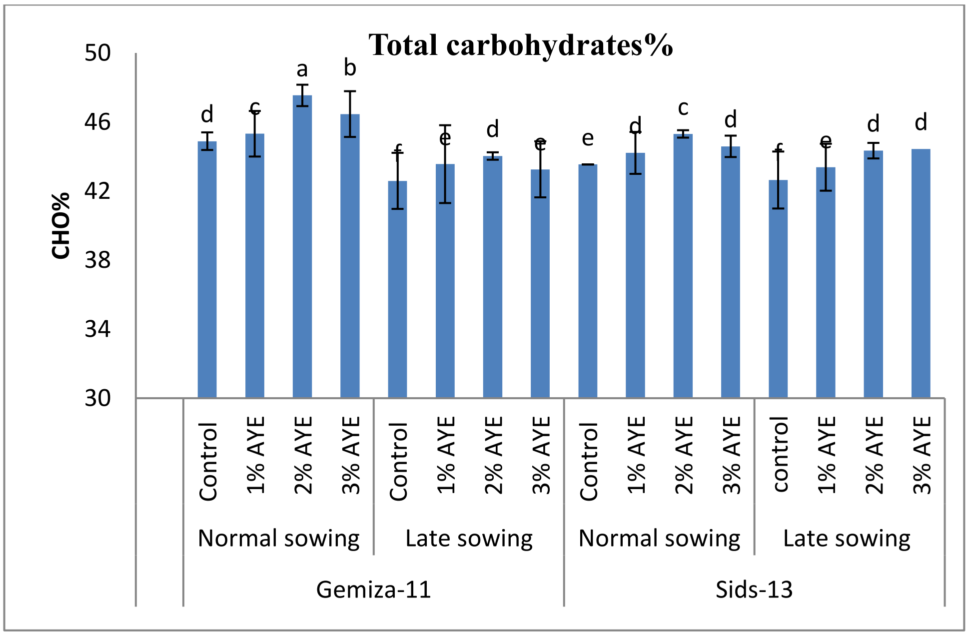

Fig. 4(a). impact of interaction of cultivars (Gemiza-11 and Sids-13), sowing dates (Normal date and late sowing date) and foliar application of yeast extract (0, 1%, 2% and 3%) on yield and its attributes in wheat.

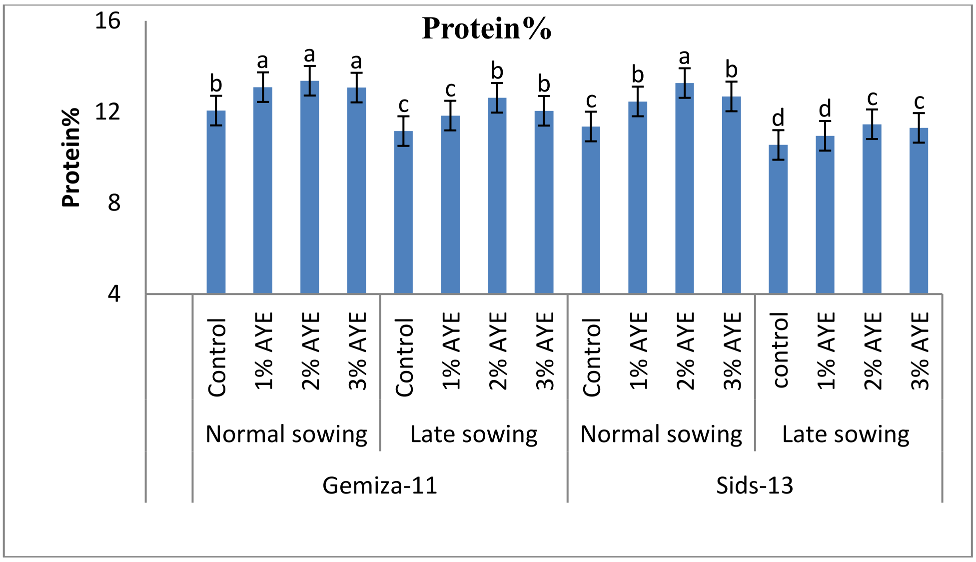

Fig. 4 (b). impact of interaction of cultivars (Gemiza-11 and Sids-13), sowing dates (Normal date and late sowing date) and foliar application of yeast extract (0, 1%, 2% and 3%) on yield and its attributes in wheat.

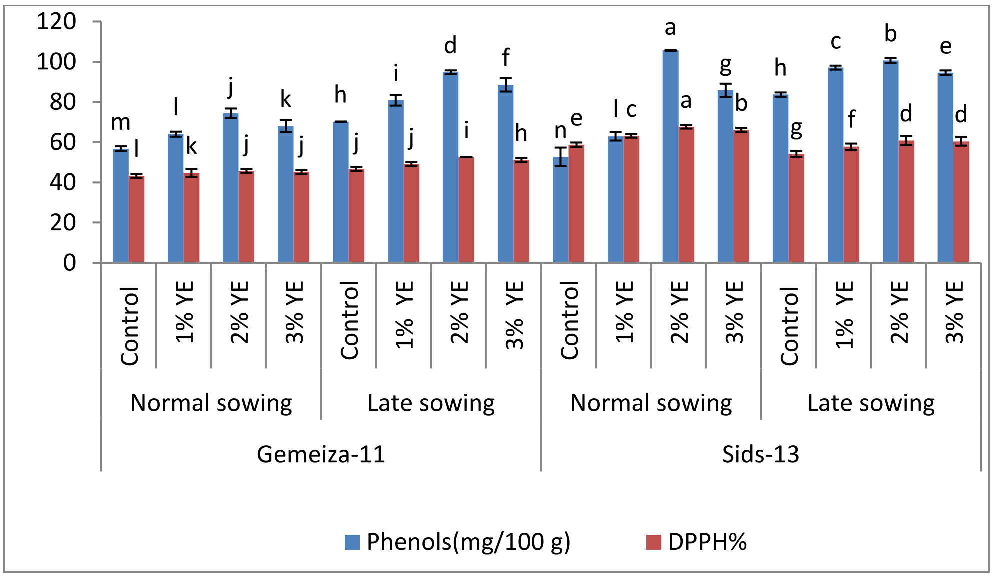

Fig. 4(c). impact of interaction of cultivars (Gemiza-11 and Sids-13), sowing dates (Normal date and late sowing date) and foliar application of yeast extract (0, 1%, 2% and 3%) on yield and its attributes in wheat.

4. Discussion

The analysis of variance of the variations in growth and yield between the two tested cultivars Gemiza-11 and Sids-13, revealed substantial variations between the two tested cultivars. Our results of the impact of cultivars on growth, biochemical aspects and yield of wheat plant are in accordance with those obtained by Bakhoum *et al*., (2019and 2022) on soybean and *Viciafaba* plants. El Habbasha *et al*., (2015) and Asal *et al*., (2015) found that, the genotypes of wheat significantly differed from each other in the studied characters. Elham *et al*. (2016), Mansour *et al*. (2017) and Bakhoum *et al.,* (2022b) reported that these variations are associated with cultivars genetic back-ground. The superiority of Gimeza-11 cultivar may be due to the increased level of photosynthetic pigments as in Table 6(chlorophyll *a*, chlorophyll *b*, carotenoids), these increments resulted due to improved rate of quenching of chlorophyll fluorescence, that significantly increased plant output and this steady state was higher than the other cultivar (Sids-13). Furthermore, the variations between cultivars may be predicted due to the differences in growth habit of these cultivars, the vast diversity in genetic constituent and the environmental conditions of researched cultivars on sandy soils. However, the superiority of Gemaza-11 in growth and yield attributes (Table 2 and 4) may be due to higher rate of translocation of nitrogenous compounds from source to sink comparing Sides-13cultivar (Fergany *et al* 2014).Moreover, it could be concluded that the superiority (Gemiza-11 over Sides -13 cultivar in some characters may be due to the increase in the efficiency to photosynthetic or uptake of more water and minerals from soil (Tawfik *et al.,* 2018). This was reflected on increasing the production of more large grains. The same results on the yield attributes (Table 4 &5), the observed differences in the behavior of variations in the examined features on yield could be attributed to the differential expressivity of specific genes. Sayed *et al*., (2021) in their study found that Gemiza 11 cultivar gave the highest grain yield, 1000 grain weight, straw yield over fourteen Egyptian tested cultivars. These results are consistent with those obtained by Atia and Ragab (2013), who observed that wheat cultivars significantly differed in their straw and grain yield.

Regarding to wheat productivity all over the world, wheat yield might decreased up to6% by every 1˚C higher than the suitable crop temperature (Lipec *et al.,* 2013). Furthermore, there is a greater risk to global wheat productivity and food security due to the increase in the duration, frequency, and severity of the heat stress period during the wheat grain filling stage. Therefore, improving winter wheat´s heat tolerance will be crucial for ensuring food security.

Wheat development is primarily influenced by light and temperature, which makes wheat sensitive to climate change. Temperature change which is concurrent with the late sowing date, particularly throughout the tillering and elongation stage, caused the vegetative parts to slow down their growth and plants’ ability to flower. Results in Table (2) recorded that, late sowing date significant reduced growth attributes of wheat plant comparing with plants sowed at normal date. Many researchers have identified the negative impact of late planting on growth and productivity of wheat (Tahir *et al.* 2009, Al-Hassan. *et al*., 2016 and Al-Ubori, Al-Lami 2023, and Al-Asseel and Madb, 2019). These decreases could be attributed to the substantially higher temperatures that prevailed during the key stages of growth in late sowing plants (Sadak & Orabi, 2015). The decreased growth parameters obtained in late sowing wheat plants might be due to the plant was driven to flower and mature early resulted from late sowing´s reduced growth time, which also, reduced plant height (Al-Asseel and Madb, 2019).

The higher yield obtained in normal date sowing wheat plants (Table 4) resulted due to higher effective tillers, spike length and grains /spike as well as 1000- grains weight. While, the lower yield recorded in the late planted plants might be due to less time taken to maturity (Table 4). According to Sattar *et al*., (2017), high temperatures during reproductive phase alter water relations, reduce photosynthetic rate, and transpiration rate, stomatal conductance and antioxidantive defence system. According to El-Sayed *et al.,* (2018) the recommended sowing date resulted in the maximum grain yield compared to late sowing and improved wheat germination per unit area, plant height, number of spikelets spike^{-1}, number of kernels spike^{-1}, and 1000-kernel.

Thismaybeattributedtobetterweatherconditionsdurin gthegrowingseason,whichfacilitatedgermination,esp eciallythelackofsunshinehours,lower temperature andlightintensity,whichmadethegrowingperiodsuita bleforvegetativegrowthofwheatplants (El Hag, 2012), these results were in agreement with El-Nakhlawy *et al*., (2015) and Mumtaz *et al*. (2015)they stated that delay in sowing suppressed the yield caused by reducing the yield contributing characters .In our study, we found planting at 15thNovember surpassed 15th December in most of characters. Hence, Haroun*et al.,* (2012) confirmed these obtained data, also, El-Nakhlawy *et al*., (2015) and Mumtaz *et al*. (2015) recorded same results, that delay in sowing suppressed the yield caused by reduction in the yield contributing traits; number of productive tillers, grains spike^{-1} and grain yield plant.

It is possible that late sowing accumulated heat units were not enough to finish the phonological stages of wheat growth which had a negative impact on plant´s growth and output. Late sown wheat produced poor grains quality (decreased total carbohydrates content) because of exposure to high temperature stress during different developmental stages of growth (Table 10). These outcomes could be explained by the decrease in grain weight or a decrease in starch accumulation. Additionally, these reductions could be the result of shorter grain filling times and smaller endosperm cells (Wir*et al.*, 1984) decreasing the activity of soluble starch synthesis (Hawker and Jenner, 1993), or impaired starting of α–type starch granules (Bhullar and Jenner, 1985) that might be correlated to the decreased duration of grain filling. These findings are consistent with those obtained by Sadak & Orabi, (2015) and El-Shafey et al., (2016) when compared to those sown on time (Table 10). Those findings can be related to a decrease in grain weight. High temperature stress causes great metabolic variations that are reflected by disturbed of endogenous hormones such as IAA. These decreases in auxin expressed as IAA in response to late sowing (high temperature) were also obtained by Sadak*et al.*, (2015) on wheat plant. The increased temperature inhibitory effect on flowering is mediated via its impact on decreasing endogenous IAA content (Su *et al.*, 2000). Furthermore, high temperature stress (at Late sowing date) increased significantly total soluble sugars (TSS), free amino acids, proline and phenolics contents as well as antioxidant activity (DPPH %) of wheat plants. These increases might be among of the earliest metabolic responses triggered in transduction pathways that link the perception of many environmental stresses to the elicitation of physiological responses at cellular levels (El-Awadi, *et al.*, 2016 and Sadak, 2016).

On the other hand, foliar application of bio-regulators as yeast extract with different concentrations is one of the recent agricultural methods to improve growth, yield quantity and quality characteristics of different crops (Sadak *et al.,* 2015; Sadak and Ramadan 2021). The obtained results reported that various concentrations improved significantly all the studied growth and yield attributes of wheat plants either at normal and late sowing dates. These results are similar to those obtained earlier by Sadak and Dawood, (2023)on wheat. El-Hawary *et al.,* (2019). Sadak (2016) on pea plant and Dawood *et al.,* (2013) on soybean plant. These beneficial effects on wheat growth may be attributable to yeast extract's abundance of growth factors, including thiamine, riboflavin, niacin, pyridoxine and vitamins B1, B2, B3, and B12), cytokines, sugars, macro and micronutrients, short peptides of two to three amino acids, and long chain protein hydrolysates, as well as free amino acids and short peptides of two to three amino acids (Elhabasha *et al.*, 2015). Additionally, the advantages brought about by the addition of yeast suspension in improving shoot characteristics may be attributable to the yeast's direct or indirect effects through its capacity to alter the environment of roots or because of the yeast´s development following analysis into various groups of amino acids and vitamins. (El-Shafey *et al.,* 2016). According to El-Shafey *et al.,* (2016) the physiological functions of vitamins and amino acids in yeast extract can speed up metabolic processes and endogenous hormone levels, both of which promote growth. Also, due to their hormone-like action and signaling effects, yeast extract act as prophylactic agents against stressful conditions and can also, improve stomatal control and gene expression for stem growth (Svennerstam *et al.,* 2008). Furthermore, foliar spraying of yeast extract improves plant growth parameter, so, the application of readily uptake amino acids allows the plants to save energy and increase their development or reconstruction, especially during critical times of plant development (Popko *et al*., 2018). These findings were confirmed with the results of Salwa& Osama (2014) who reported that adding yeast to a crop increased both the yield and grain quality of the wheat.

Regarding to Photosynthetic pigment (Table 6 & 7), the obtained results showed that, yeast extract with 1%, 2% and 3% levels caused marked significant increases in photosynthetic pigments and endogenous IAA in both wheat cultivars, These results could be due to the foliar treatments' stimulating effects on enzymes involved in the photosynthetic process and their reduction of electrolyte leakage, which increased uptake of minerals like magnesium and iron as well as other nutrients needed forchlorophyll biosynthesis. (El-Guibali, 2016; Hafez and Gharib2016).The accumulation of the studied osmoprotectants TSS, FAA and proline in addition to phenolic contents and DPPH%, this could be due to building up osmoprotectants made from the proteins, carbohydrates, and amino acids found in yeast extract, the employed yeast extract may help with osmotic adjustment (Darwesh2016).This finding is supported by research by Dawood *et al*. (2013) on soybeans, which found that the most effective yeast concentration was 6%; and by Sadak and Dawood (2023), which discovered that the most effective yeast concentration was 4%. These concentration differences are caused by the different plant species and responses of the various varieties.

Finally, the obtained data of the interaction between cultivars, time of sowing and yeast extract treatments Table (3, 5, 9) showed the alleviating effect of yeast extract on late sowing reduced effect on the two used cultivars. The highest values of growth and productivity under late sowing (15th December) were obtained by Gemeiza -11 and applying yeast extracts (2%) foliar treatment.

5. Conclusion

This research demonstrated that exogenous application of yeast extract ameliorates late sowing stress in two cultivars of wheat, as evidenced by enhancing vegetative growth parameters, photosynthetic pigments, IAA, total soluble sugars, proline and proline, as well as phenolics and DPPH% in addition to, grains yield/plant, and carbohydrates content. It is worthy to mention that the promotive effect of yeast extract at 2% in increasing wheat tolerance and decreasing harmful effect of high temperature on wheat growth, grain yield quality and quantity. F.

Future perspectives

Foliar treatment of yeast extract significantly reduced the adverse impact of heat stress on both used cultivars of wheat plants. Gimeza-11 cultivar of wheat showed overall higher growth, photosynthetic and other biochemical parameters as well as yield aspects with foliar treatment of yeast extract under heat stress than Sids-13. Hence, ann exogenously applied yeast extract is an effective strategy to increase plant physiological and biochemical activities thus increase plant productivity. The best concentration was 2% yeast extract will be recommended to enhance the growth, and yield of plants and minimize the heat stress impact.

Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reportedin this paper.
The authors declare no competing interests.

Declaration of use of AI Technologies: The authors declare that no AT was used in any part in this paper.

Authors´ Contributions

Marvat Shamoon Sadak, Elham Abd EL Moneim Badr, Magda, H. Mohamed, and Gehan Shaker Bakhoum;
All authors contribute equally.

Data Availability Statement: Not applicable

Funding
Not applicable

References

Ahmed, M. I., Meleha, A. F., Hassan, M. A., El-Bialy, M., El-Mansoury A. M., (2020)Effect of planting dates and planting methods on water relations of wheat *International Journal of Agronomy* Article ID 8864143, 11 pages

Ahmed, M.A., Bakhoum,G. Sh., EL-Housini, E. A., BadrE. A. (2016). Alleviation of water Stress on Wheat by Benzyl adenine International *Journal of Pharm Tech Research,* 9(12): 109-119.

AL-Asseel, A. S. Madb, M., D. S. (2019). Response of bread wheat (*Triticum aestivum* L.) cultivars for sowing dates. *Tikrit Journal for Agricultural Sciences* 51 (0) 15 -20.

Al-Hassan M., Hamza, F., Abbas J. K. (2016).Pattern and branching ability of bread wheat cultivars with the effect of planting date and its relationship to thermal aggregation. *Iraqi Journal of Agricultural Sciences*. 47, (1): 223-.237.

Al-Ubori R., Al-Lami O. A. J. (2023). Effect of planting date and spraying with the physiological stimulant (Appetizer) on the growth and yield of wheat (*Triticum aestivum.*L). Fifth International Conference for Agricultural and Environment Sciences IOP Conf. Series: Earth and Environmental Science 1158, (2023) 062021 IOP Publishing doi:10.1088/1755-1315/1158/6/062021

Albalasmeh A. A., Berhe, A. A., Ghezzehei, T. A., T. A. (2013).A new method for rapid determination of carbohydrate and total carbon concentrations using UV spectrophotometry, *Carbohydrate Polymers*. 97(2), 253-261.https://doi.org/10.1016/j.carbpol.2013.04.072.

Asal, M. W., Badr, E. A., Ibrahim, O. M., Ghalab E. G. (2015). Can humic acid replace part of the applied mineral fertilizers? A study on two wheat cultivars grown under calcareous soil conditions. *Inter. J. of Chem Tech Res.* .8 (9): 20-26.

Atia, R. H., Ragab Kh.E. (2013). Response of some wheat varieties to nitrogen fertilization. *J. Soil Sci. and Agric. Eng., Mansoura Univ*.,4: 309 – 319.

Badr, E. A., Afifi, M. H. M. and EL-Dewiny C. A. (2016). Effect of biofertilization and nnitrogen level on yield, chemical constituents and nitrogenuse efficiency on two wheat cultivars grown under calcareous soil conditions. *Intern. J. of Chem Tech Research.*vol.9.No.09 pp132-141.

Badr, E. A., Bakhoum, G. Sh., Amin G., and Sadak. M. S. (2025). Enhancing barley growth and yield under drought stress through exogenous folic acid application. *Egypt. J. Agron*. 47 (1): 157 – 165.DOI: 10.21608/AGRO.2025.310178.1485.

Bakhoum, G.Sh., Kabesh M.O., El-Kramany, M. F. Alice, T. Thalooth and Tawfik M. M**.** (2016).Utilization of Bio-Fertilizers in Field Crop Production 17-Effect of organic manuring, mineral and bio fertilizers on forage yield and nutritive value of Egyptian clover (berseem) grown in new reclaimed sandy soil *Int. J. Chem Tech Res.,* 9 (3), pp. 34-41.

Bakhoum, G. Sh., Tawfik, M.M., Kabesh, M O. Sadak, M. S. (2023). Potential role of algae extract as a natural stimulating for wheat production under reduced nitrogen fertilizer rates and water deficit.*Biocatalysis and Agricultural* 51. 102794. https://doi.org/10.1016/j.bcab.2023.102794

Bulgari R., Franzoni, G., Ferrante, A. (2019). Biostimulants Application in Horticultural Crops under Abiotic Stress Conditions.*Agronomy*, 9: 306-335.doi:10.3390/agronomy9060306

Chapman, H.D. and Pratt,P.F. (1961).Methods of Analysis for Soils, Plants and Water. Univ. of California, Berkeley, CA, USA

Chow, P.S., Landhausser, S. M. (2004). A method for routine measurements of total sugar and starch contentin woody plant tissues. *Tree Physiology* 24, 1129- 1136 https://academic.oup.com/treephys/article-pdf/24/10/1129/4641775/24-11129.pdf.

Darwesh R.S.S. (2016) Phoenix dactylifera cv. Medjol plantlets as affected by yeast extract and NPK fertilizers. *Ann Agric Environ Sci* 1:7–14.

Dawood MG, S R. El-Lethy and M S. Sadak., (2013). Role of Methanol and Yeast in Improving Growth, Yield, Nutritive Value and Antioxidants of Soybean.*World Applied Sciences Journal* 26 (1): 06-14.

Dawood M. G., Sadak ,M. S., Abdallah, M. M. S., Bakry,. ADarwis., O. M.. (2019.) Influence of biofertilizers on growth and some biochemical aspects of flax cultivars grown under sandy soil conditions *Bull. of the National Res. Centre* 43:81.

Du Jardin, P. (2015). Plant biostimulants: Definition, concept, main categories and regulation. *Scientia Horticulturae*, 196: 3–14.

El Habbasha, S.F., Badr, E. A., Abdel LatefE. (2015).Effect of Zinc foliar application on growth characteristics and Grain Yield of some Wheat varieties under Zn deficient sandy soil condition. Inter. J. of Chem. Tech. Res..8(6): 452-458.

El Hag, Dalia, A. A. (2012). Effect of sowing date and nitrogen level on yield and quality of bread and durum wheat.Ph D. Thesis, Kafrelsheikh Univ., Egypt.

El Karamany M.F., Sadak, M. S.,Bakhoum, G. Sh., Omer A. A., Bakry, . A. (2022) Pyridoxine improving effect on yield, chemical and nutritional value of Egyptian clover plant.*Asian J. Plant* Sci., 21 (4): 654-666.

El-Awadi, M E, Ibrahim,S. K., Sadak, M. S., Abd Elhamid,E. M., Gamal El-Din, K. (2016) Impact of cysteine or proline on growth, some biochemical attributes and yield of faba bean, *Intern. J. of Pharm Tech Research*,. 9(6):100-106.

El-Guibali, A.H. (2016).Effect of organic and mineral fertilization on wheat yield andquality.*J of Soil Sci. and Agric*., 7(11): 829-836. DOI:10.21608/jssae.2016.40498.

El Habbasha, S.F., Badr, E. A., Elkramany, M. F., Ibrahim O. M. (2014).Grouping of some Egyptian wheat genotypes with cluster analysis. *Global Journal of Advanced Research.*1 (2):.93-100.

El-Hawary, M.M., Gad K. I. and Ismail. A. O. A. (2019).Physiological response of some wheat varieties to foliar application with yeast, potassium and ascorbic acid under salt affected soil conditions*Bioscience Research*, 16(2): 1009-1027.

El-Said M. A. A.,MahdyA.Y. (2016).Response of two wheat cultivars to foliar application with amino acids under low levels of nitrogen *fertilization Middle East J. Agric. Res*., 5(4): 462-472.

El-Sarag-E., Ismaeil, E.,Ryad, I. M. (2013) Evaluation of some bread wheat cultivarsproductivity as affected by sowing dates and water stress in semiaridregion.*Asian J. Crop Sci.* 5, 167-178.

EL-Sayed, S., Mohamed,., E. , El Hag, D., Mohamed, A. (2018). Sowing dates effect on yield and grain quality of some wheat cultivars.*J. of Plant Production*, 9(2), 203-213.

El-Shafey, A.; El-FekyS. and Abo-Hamad S. (2016).Effect of sowing time and foliarapplication of yeast extract on growth and productivity of different cultivars of faba bean (*Vicia faba*L.). Egypt J. Bot., 56(1): 35-48.

Emam, A., Mohamed,A., Abd EL-Mageed, M., Niedbała, G., Samah,A. S., Ahmed,S., F.Kapiel, F., Piekutowska, M., MahmoudS. A. (2022). Genetic characterization and agronomic evaluation of drought tolerance in ten Egyptian wheat (*Triticum aestivum* L.) Cultivars *Agronomy*, *12*(5) 1217. https://doi.org/10.3390/agronomy12051217

Ezz El-Din AA, Hendawy S. F. (2010) Effect of dry yeast and tea compost on growthand oil content of *Boragoofficinalis* plant.*Res J AgricBiolSci* 6(4):424–430.

FAO (2018). FAOSTAT. Available at:. http://www.fao.org/faostat/en/#data/QC

FAO (2020). Food and Agriculture Organization of the United Nations, FAOSTAT,FAO Statistics Division 2019, March 2020.

Fergany, M.A., El-Habbal ; M.S., and El-Temsah M. E. (2014). Sowing dates effect on some grain biochemical and technological characteristics of certain wheat cultivars. *Asian J. of Crop Sci*., 6 (1):83-88.

Gonzalez, M.B., Guzman, R., Rudkyk, E., Romano, M., Molina, A. A. (2003) Spectrophotometric determination of phenolic compounds in propolis. Lat. *Am. J. Pharm.* 22(3), 243-8.http://www.latamjpharm.org/trabajos

Grigorieva, E.; Livenets, A.; Stelmakh, E. (2023) Adaptation of Agriculture to Climate Change: A Scoping Review. *Climate* 2023, 11, 202. https://doi.org/10.3390/cli11100202

Gyamfi MA, Yonamine, M. Aniya Y. (2002) Free radical scavenging action ofmedicinal herbs from GhanaThonningia sanguine on experimentally inducedliver injuries. *Gen Pharmacol* 32:661–667.

Hafez, E.M., GharibH. S. (2016).Effect of exogenous application of ascorbic acidon physiological and biochemical characteristics of wheat under water stress.*Inter. J. of Plant Production*, 10(4): 579-596.

Haider I, Raza, M. A. S., Iqbal, R., Ahmad, S., Aslam, M. U., Israr, M., Riaz, U., Sarfraz, M., Abbas, ., Abbasi, S. H., Abbas, Z., AamerM. (2021) Alleviating the drought stress in wheat (*Triticum aestivum* L.) by foliar application of amino acidand yeast. *Pak J Agric Res* 34(1):239–246.https://doi.org/10.17582/journal.pjar/2021/34.1.239.246

Hamed S.M., El-Gaml, . M., EissaS. T. (2022) Integrated biofertilization using yeast withcyanobacteria on growth and productivity of wheat. *Beni-Suef Univ J Basic Appl Sci* 11:112. https://doi.org/ 10.1186/s43088-022-00288-y

Hamood M.Y., El-ArefKh, A. O.Ahmed, H. A., Abd El Monem, A. M. A. (2021). Effectof sowing dates and foliar spraying by some antioxidant on yield and itscomponents for two bread wheat cultivars in new valley governorate, Egypt. *Archives of Agricultre Sciences Journal* 4(1): 329-347.

HarounS., A. Abbas, M. A., Boshaba, M., El-Mantawy R. F. (2012). Effect of planting date on phenology, productivity and flour quality of some wheat cultivars. J. of plant production 3(4), 615-626.

Hawker JS, C.F. Jenner (1993). High temperature affects the activity of enzymes in thecommitted pathway of starch synthesis in developing wheat endosperm. Aust. J. Plant Physiol., 20: 197-209.

Ibrahim A. A., El-Waraky F. A. 2023. Effect of Spraying Phosphoric acid and Ascorbic Acid on Cotton Productivity under Delayed Sowing Date, *Egypt. J. Agron.* 45 (1):, 81-97. DOI: 10.21608/AGRO.20 23.182398.1352

IPCC. Summary for Policy makers. In Climate Change (2021).The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report ofthe Intergovernmental Panel on Climate Change; Masson-Delmotte, V., Zhai,P., Pirani, A., Connors, S.L., Péan, C., Berger, S., Caud, N., Chen, Y., Goldfarb, L., Gomis, M.I., et al., Eds.; Cambridge University Press: Cambridge, UK, 2021; p. 41. [Google Scholar]

Kasim W. A.#, Hafez, T. M., Saad-Allah K. M., 2020. Yeast Extract and Lithovit Mineral Fertilizer Ameliorate the Harmful Effects of Drought Stress in Wheat. *Egypt. J. Bot.* **Vol. 60**, No.3, pp. 889-903.

DOI: 10.21608/ego.2020. 36166.1526.

Kalsoom, U., Bennett, I. G., Boyce M. C. (2016). "A Review of extraction and analysis: methods for studying osmoregulants in plants "Kalsoom, et al., Chromatogr, J., Sep. Tech. 7,1. DOI: 10.4172/2157-7064.1000315.

Khalaf and shahaz, (2016). Effect of seed rates on growth and yield traits and itscomponents for some varieties of wheat. vol. 56, College of Agriculture University of Baghdad, Baghdad, Iraq, , Higher diploma.

Larsen P, Harbo, A., Klungron, S., Ashein T. A. (1962) On the biosynthesis of some indole compounds in Acetobacter Xylinum. *PhysiologiaPlantarum*. 15: 552-565.

Lichtenthaler HK, Buschmann C. (2001). Chlorophylls and carotenoids: measurementand characterization by UV-VIS spectroscopy. In: Wrolstad RE, Acree TE, An H, Decker EA, Penner MH.

Lipec, J., Doussan, A. Nosalewicz, K. Kondracka, K. (2013). Effect of drought and heat stresses on plant growth and yield: a review. Int. *Agrophys.* 27,463–477.doi: 10.2478/intag-2013-0017.

Mansour, E.; Merwad; A. M. A., Yasin; M. A. T., Abdul-Hamid; M. I. E.,. El-Sobky E.E.A and Oraby H. F. (2017). Nitrogen use efficiency in spring wheat: genotypic variation and grain yield response under sandy soil conditions. Journal of Agricultural Science, 1-17.

Mohamed, A. N.; Mohamed E. U. and Samah A. N. (2015). Influence of foliar spraywith yeast extract on vegetative growth yield of fresh herb, anatomicalstructure, and composition of volatile oil and seed yield components of Basilplant (*Ocimum basilicum*L.). *Intern. J. of Adv. Res*., 3(10): 978-993.

Morsi, M. K.; El-Magoli; B., Saleh; N. T., El-Hadidy, E. M., Barakat H. A. (2008). Study of antioxidants and anticancer activity licorice *Glycyrrhizaglabra* extracts. *Egypt. J. Nutr. And Feeds,* 2(33): 177-203.

Mostafa EAM, Abou Raya M. S. (2003). Effect of soil application of active dry yeast on growth, yield and fruit quality of Grand Nain banana cv. *Arab Univ J Agric Sci* 12(2):693–704.

MSTAT-C (1988).A Microcomputer program for the design, arrangement, and analysis of agronomic research. Michigan State Univ. East Lansing, East Lansing

Mumtaz, M. Z; Aslam; M. Nasrullah; H. M., Akhtar, M.,. Ali .(2015). Effect of various sowing dates on growth, yield and yield components of different wheat genotypes. *J. Agric. & Environ. Sci*., 15 (11): 2230-2234.

Omran, Y.A., (2000).Studies on histophysiological effect of hydrogen cyanamide (Dormex) and yeast application on bud fertility, vegetative growth and yield of "Roumi Red"' grape cultivar. Ph. D. Thesis, Fac of AgricAssiutUnivEgypt.

Pecio A., Wielgo B. Buck (1999) wheat yielding and structure of plant and canopy dependent of sowing time.Fragm.Agron. (Poland) 1999 [Google Scholar]

Popko, M., Michalak,I.,Wilk, R., Ma. Gramza, Chojnacka K. and Górecki H. (2018). Effect of the New Plant Growth Biostimulants Based on Amino Acids on Yield and Grain Quality of Winter Wheat. Molecules, 23, 470.

Ragaey, M.M.; Sadak, M.S.; Dawood, M.F.A.; Mousa, N.H.S.; Hanafy, R.S.; Latef, A.A.H.A. 2022. Role of Signaling Molecules Sodium Nitroprusside and Arginine in Alleviating Salt-Induced Oxidative Stress in Wheat. Plants, 11, 1786. https://doi.org/10.339 0/plants11141786

Ramadan, B.S.H, Hassanin, M.A., Mahmoud, E.A. Alafandy K.T. and Mohamed. M.S.Z. 2025. Effect of Sowing Date and Plant Density on Productivity of Some Sugar Beet Varieties Under North Sinai Conditions, Egypt. J. Agron. Vol. 47, No. 3, pp: 373 – 380. DOI: 10.21608/agro.2025.377726.1673

Sadak M.S., Dawood, M. G. (2022). Biofertilizerrole in alleviating the deleterious effects of salinity on wheat growth and productivity.GesundePflanzen,https://doi.org/10.1007 /s10343-022-00783-3

Sadak, M. S (2016): Physiological role of yeast extract and nicotinamide on *Pisums ativum* L. plants under heat stress. Inter J. of Pharm Tech. Res. 9 (9):170-178.

Sadak, M. S, Orabi., S. A. (2015). Improving thermo tolerance of wheat plant by foliar application of citric acid or oxalic acid. Inter. J. of Chem. Tech. Res. 8 (1): 111-123.

Sadak, M. S., Ramadan A. A (2021). Impact of melatonin and tryptophan on waterstresstolerancein white lupine (*Lupinus termis*L.). Physiol Mol Biol Plants 27(3):469–481 https://doi.org/10.1007/s12298-021-00958-8.

Salwa, A.R. A. Hammad, A. M. Osama, A. M. Ali(2014). Physiological and biochemical studies on drought tolerance of wheat plants by application of amino acids and yeast extract. Annals of Agricultural Science (2014) 59(1), 133–145.

Sattar, M. A., Cheema, T., Abbas, A., Sher, M,.A. Iaz, M., Wahed M.,, Hussain M. (2017). Physiological response of late sown wheat to exogenous application of silicon, Cereal Research Communications 45(2) pp 202-213. DOI:10.1556/0806.45.2017.005

Shaalan, A. M, Attia, M.A., Hassaan M.A. (2019). Response of some wheat cultivars to sowing dates and biofertilizers under North West Coast of Egypt .*Egypt. J.Agron*. Vol. 41, No. 3, pp. 313-324DOI: 10.21608/agro.2019.19247.1192 .

Snedecor G.W., Cochran, W. G. (1982).“Statistical Methods” 7th ed. Iowa StateUniv.press Iowa, USA.

Soliman D. A. 2025. Efficacy Foliar Spraying of NPK Nano Fertilizer on Yield Attributes of Wheat. Egypt. J. Agron. Vol. 47, No. 1, pp: 187 – 195.DOI:10.21608/AGRO.2025.331469.1546

Sorrequieta, A.G., Ferraro, S. B., Boggio, E., Valle, M., 2010. Free amino acid production during tomato fruit ripening:a focus on L-glutamate. Amino Acids. 38, 1523-1532. DOI 10.1007/s00726-009-0373-1.

Steel, R.G..Torrie, D., J. H (1997). Principles and procedures of statistics, A biometrical approach, 3rd Edition, McGraw-Hill Book Company, New York, 400-428. USA. https://doi.org/10.1002/bimj.19620040313

Su W. R., Chen,W. S., Koshioka M., Mander, L. N., Hung, LS., Chen, W. H., Fu, Y. M., Huang K. L. (2000) Changes in gibberellins levels in the flowering shoot of Phalaenopsis hybrid under high temperature conditions when flower development is blocked. *PlantPhysiol. &Bioch*., 39(1), 45-50.

Svennerstam, H., Ganeteg, U., Näsholm T. (2008). Root uptake of cationic amino acids by Arabidopsis depends on functional expression of amino acid permease 5. *New Phytologist Foundation.* 180: 620-630.

Sayed. A. Mohamed M., Said T., Elrawy M. A. (2021). Evaluation of local bread wheat cultivars for grain yield and its attributes at different sowing dates under Assiut conditions. *Egypt. J. Agron*.43(2):189- 206.

Tawfik M.M., Bakhoum,G. Sh., Kabesh, M. O., Thalooth A. T. (2018). Comparative study on some Faba bean cultivars under water limitationconditions and different sowing dates *Middle East J. Agric. Res*., 7(4): 1431-1443.

Weir A. H., Bragg, P. L., Porter J. R.., Rayner J. H. A. (1984) winter wheat crop simulation model without water or nutrient limitations. J. *Agric. Sci*., 102: 371-382.

Xin, G., Glawe, D., Doty S.L. (2009) Characterization of three endophytic, indole-3-acetic acid-producing yeasts occurring in *Populus* trees. Mycol. Res., 113: 973-980.

Xi, Q.; Lai, W., Cui Y., Wu H., Zhao, T. (2019). Effect of yeast extract on seedlinggrowth promotion and soil improvement in afforestation in a semiarid chestnutsoil area. *Forests*, 10, 76.[CrossRef].