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# Effect of sowing dates and foliar spraying by some antioxidants on yield and its components for two bread wheat cultivars in New Valley governorate, Egypt

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## Abstract

Two field experiments were conducted in El-Monera village, the New Valley governorate, Egypt, during the two successive winter seasons of 2017-2018 and 2018-2019, to study the effect of three sowing dates *i.e*., (1st November ($D_1$), 15th November ($D_2$) and 1st December ($D_3$)) and foliar spray with antioxidants (Ascorbic acid, citric acid and ascorbic + citric acids at 200 ppm and tap water as control) on two bread wheat cultivars (Sids12 and Misr1) under New Valley governorate conditions. The experimental design was a randomized complete block design (RCBD) in spilt-split plots with three replications. The obtained results pointed to sowing date, antioxidants treatments and wheat cultivars had highly significant effect (prob <0.01) on all studied traits in both seasons. The highest values of total chlorophyll content, flag leaf area, plant height, number of grain /spike, 1000-grain weight and number of spikes /$m^2$ as well as grain and straw yields ton /feddan (feddan = 4200 m² = 0.420 hectares = 1.037 acres) were recorded when wheat was sown at 15th November. On the other hand, the highest percent of protein in grain were recorded at1st December. Ascorbic + citric acids at 200 ppm foliar spray treatment gave the highest values of all studied traits. Also, Misr-1 cultivar was superior to Sids-12 in all traits under study. The first and second order interactions exerted significant effects on all most traits under study. In general, the highest grain and straw yields were obtained from Misr-1 cultivar when was sown at15th November and was sprayed with mix of ascorbic/citric acids at 200 ppm.

*Keywords*: sowing dates, antioxidants, foliar spraying, bread wheat.

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## 1. Introduction

Wheat (*Triticum aestivum* L.) ranks 1st among world's cereal crops as food crop. In Egypt, wheat is the main winter cereal crop and it is widely distributed all over the country. The cultivated area is 3.4 million feddans (equivalent to 1.38 million hectares) were planted with wheat in the 2019/2020 cropping year, slightly more than 1.37 million hectares were planted in the previous year. The country remains the world's largest wheat importer. Wheat imports for the current 2019/2020 marketing year (July/June) are estimated at 12.5 million tons, about the same as the previous year and about 15 percent above the average of the last five years (FAO, 2020). Improvement of Egyptian wheat productivity is the most important way to minimize the gap between production and consumption and can be achieved through the use of modern agricultural practices, promising wheat cultivars, water-saving agricultural practices, expansion of new lands and improved field irrigation efficiency (Abdelmageed *et al.,* 2019). Sowing date has an active role on growth, yield and quality of wheat. Choosing the right sowing dates can maximize the outcomes of the interaction between genotype and environment, thus increasing grain yield and baking quality of wheat (Silva *et al.,* 2014). Sowing of wheat during November gave the highest values for each of the yield and its components, while the late sowing in early or mid-December led to a decrease these values and an increase in the grain content of protein (El-Hag Dalia, 2019; El-Sayed *et al.*, 2018; Farooq *et al.*, 2016; Taha *et al.*, 2017).

Plants grown in new lands, especially sandy lands, are exposed to many stresses, including the poverty of the land in organic matter and nutrients and the lack of its ability to retain water. The expansion of wheat cultivation in such lands requires reducing the stresses to which the plant is exposed through the use of some antioxidants. Application of ascobin with different concentrations induced a stimulatory effect on growth parameters greater than that estimated in the control plants which were accompanied by marked increases in IAA, GA, 3 cytokinin, photosynthetic pigments, total carbohydrates and polysaccharides contents. On the other hand, yield and yield components showed progressive increases with increasing ascobin treatments (Sadak Mervat *et al.*, 2013). Bakry *et al.* (2013) revealed that increasing foliar application levels of ascorbic acid significantly increased grain and straw yields per plant and per faddan (feddan = 4200 m² = 0.420 hectares = 1.037 acres) as well as protein content, protein yield, plant height, spike length, seed index, number of spikelets per spike and water use efficiency. Using both antioxidants glutathione and ascorbic acid especially at 100 ppm of glutathione to improve wheat growth and yield (El-Awadi *et al.*, 2014). Exogenous application of ascorbic acid can enhance foliar growth which may contribute to increase plant biomass and yield (Hussein and Alva, 2014). Seadh and El-Metwally (2015) showed that soaking wheat seeds before sowing or foliar spray by antioxidants *i.e.*, salicylic acid (SA), citric acid (CA) and ascorbic acid (AA) at a rate of 300 ppm of each one exhibited significant increase on wheat growth, yields and its attributes and grains quality compared to control. Foliar application of citric acid, ascorbic acid and ascobin on chickpea lead to overall better performance of the plants and increases the growth and yield as well as its components. Citric acid, ascorbic acid and ascobin showed accumulative yield–promoting effect compared with untreated plant. The most favorable treatments for growth parameters, yield and its components, and photosynthetic pigments content per leaves were foliar spraying with 300 mg/l ascobin followed by 300 mg/l ascorbic acid, 200 mg/l ascobin, 200 mg/l ascorbic acid and 300 mg/l citric acid, in this descending order, respectively (Ahmed *et al.*, 2016). Shah *et al.* (2019) demonstrated that AsA priming significantly boosted different yield characteristics including chlorophyll content, tillers per unit area, number of grains per spike, and 1000-grain weight, contributing higher productivity and biomass of wheat plants. The objective of this work was to study the effect of sowing dates, foliar spray by some antioxidants and their interaction on the yield and its components of two wheat cultivars under New Valley region conditions, Egypt.

## 2. Materials and methods

Two field experiments were conducted in the New Valley governorate (El-Monera village), Egypt, the site was located at 25.66°N, 30.65°E and 70 m level above sea level) in 2017/2018 and 2018/2019 winter growing seasons. The present work aimed to study the effect of three sowing dates *i.e.*, (1$^{st}$ November ($D_1$), 15$^{th}$ November ($D_2$) and 1$^{st}$ December ($D_3$)), different treatments of foliar spray with antioxidants (Ascorbic acid, citric acid and ascorbic + citric acids at 200 ppm and tap water as control) and two bread wheat cultivars (Sids12 and Misr1) in new sandy soil under New Valley governorate conditions. Each experiment was laid out in randomized complete block design (RCBD) in split-split plots with three replications, where the three sowing dates were plotted in main plots , while foliar spray with antioxidants was allocated in the sub-plots , whereas the two bread wheat cultivars were distributed randomly in the sub-sub-plots. The plot area of the experimental unit was 3 m width and 3.5 m long (10.5 $m^2$). Antioxidants foliar spray treatments were sprayed using hand sprayer (2 liter) in three times the first one was applied after 45, 65 and 85 days from sowing at a rate of 0.5 liter/plot (200 liter /feddan) at 200 ppm concentration. In both seasons, wheat was preceded by fallow. The soil of experimental sites was well prepared with two plowing and good leveling was done after addition farmyard manure at a rate of 20 $m^3$/feddan. Phosphorus fertilizer in the form of super-phosphate (15% $P_2O_5$) at a rate of 45 kg $P_2O_5$/feddan, was incorporated in the soil after the leveling. Nitrogen fertilizer (ammonium nitrate 33.5% at a rate of 100 kg N/feddan) was applied in three split portions *i.e.* 20% before the first irrigation, 40% before the second irrigation and 20% applied before the third irrigation. Normal agricultural practices for growing wheat were applied. The mechanical and chemical analyses of the experimental soil are presented in Table (1). Monthly averages of temperature (°C), at New Valley governorate, Egypt during 2017/2018 and 2018/2019 wheat seasons are presented in Table (2).

Table (1): Mechanical and chemical properties of the experimental soil at the experimental site during 2017/2018 and 2018/2019 seasons.

| Characters | 2017/2018 | 2018/2019 |
|---|---|---|
| Mechanical characters | | |
| Sand (%) | 96.71 | 96.79 |
| Silt (%) | 2.38 | 2.25 |
| Clay (%) | 0.91 | 0.96 |
| Soil texture | Sandy | Sandy |
| Chemical analysis | | |
| N (Avalable ppm) | 18.00 | 20.00 |
| P (Avalable ppm) | 3.00 | 3.00 |
| K (Available ppm) | 77.00 | 72.00 |
| Soil pH | 2.30 | 2.40 |
| EC ds/m | 8.26 | 8.26 |

Table (2): Monthly averages of temperature (°C), at New Valley during 2017/2018 and 2018/2019 wheat season.

| Season | 2017/2018 | | | 2018/2019 | | |
|---|---|---|---|---|---|---|
| Month | Maximum (°C) | Minimum (°C) | Mean (°C) | Maximum (°C) | Minimum (°C) | Mean (°C) |
| 11/2017 | 27.4 | 13.0 | 20.2 | 29.0 | 14.6 | 21.8 |
| 12/2017 | 25.7 | 12.2 | 19.1 | 22.9 | 5.0 | 14.0 |
| 01/2018 | 22.1 | 6.6 | 14.4 | 21.2 | 5.8 | 13.5 |
| 02/2018 | 28.6 | 11.7 | 20.2 | 23.8 | 8.7 | 16.3 |
| 03/2018 | 33.9 | 15.2 | 24.6 | 26.8 | 10.9 | 18.9 |
| 04/2018 | 38.6 | 19.2 | 28.9 | 42.0 | 26.0 | 34.0 |

### *2.2 Studied characters*

#### *2.1.1 Growth characters*

Were taken after 100 days from sowing on ten main stems in each plot to determine total chlorophyll (SPAD) which was measured on twenty leaves from each plot were assessed using SPAD-502 Plus (Konica Minolta, INC., Japan). Plant height (cm) was measured. Flag leaf area ($cm^2$) which was measured in $cm^2$ as average of five flag leaves chosen randomly of main stems and calculated according to Stickler and Pauli (1961) and as following formula:

$$\text{Flag leaf area} = \text{maximum width} \times \text{maximum length} \times 0.747$$

#### *2.1.2 Yield and its components*

At harvesting, one square meter was randomly selected from each plot to estimate the following characters *i.e.*, grains number/spike, 1000 grain weight (g) and number of spikes/m$^2$ as well as grain, and straw yields (ton/feddan) which was calculated by harvesting whole the plot in each experiment.

*2.1.3 C-Protein content in grains (%)*

It was estimated by the improved Kyeldahl method according to AOAC (1990), modified by distilling the ammonia into saturated boric solution and titration in standard acid. Crude protein percentage was calculated by multiplying the total nitrogen values in wheat flour by 5.75 as follows:

$$\text{Protein percentage} = \text{grain N } \% \times 5.75$$

*2.2 Statistical analysis*

All obtained data were subjected to statistical analysis according to Gomez and Gomez (1984) and treatment effects were compared using Revised Least Significant Differences ($RLSD_{0.05}$). All statistical analysis was performed using analysis of variance technique by “MSTAT-C” computer software package 1990.

## 3. Results and Discussion

*3.1 Effect of sowing dates*

*3.1.1 Growth characters*

The presented results in Table (3) showed that sowing dates had highly significant effects on all growth characters *i.e.* (total chlorophyll content, flag leaf area and plant height) of two bread wheat cultivars in 2017/2018 and 2018/2019 growing seasons. The recommended sowing date (15$^{th}$ November) gave the higher values compared to the early or the delaying sowing dates for all studied growth characters.in both growing seasons. The highest values of chlorophyll (56.32 and 59.70), flag leaf area (25.43 and 32.40 cm$^2$) and plant height (95.21 and 97.17 cm) were recorded when sowing was done on 15$^{th}$ November (recommended sowing date) in the first and second seasons, respectively. This finding might be due to the suitable environmental conditions that encouraged growth and early development of plants sown on 15 November rather than those sown in 1$^{st}$ November or 1$^{st}$ December and hence creating more chlorophyll, leaf area for plants, especially the flag leaf as well as cells elongation an plants. The similarly results were obtained by Dhyani *et al.* (2013), Al-Tahir (2014), Nadim *et al.* (2016), Wahid *et al.* (2017), Singh *et al.* (2018), El-Hag Dalia (2019), Tahir *et al.* (2019) and EI-Khafagi *et al.* (2020).

*3.1.2 Yield components*

Results as shown in Table (4) pointed that sowing dates showed highly significant effects in all yield components *i.e*. (number of grains /spike, 1000-grain weight and number of spikes /m$^2$) under study in both seasons. Sowing on 15$^{th}$ November (recommended sowing date) outperformed over sowing on 1st November and 1st December where, the highest values of number of grains /spike (57.75 and 61.75), 1000-grain weight (52.57 and 54.63 g) and number of spikes/m$^2$ (408.67 and 405.08) were recorded in the first and second season, respectively. This may be due that originated from more suitable weather conditions during this period, which led to encouragement germination, particularly day shortage, low temperatures and light intensity with suitable growth period of wheat plants vegetative growth. These results are in line with those obtained by Farooq *et al.* (2016), Taha *et al.* (2017), El-Hag Dalia (2019) and Tahir *et al.* (2019).

Table (3): Effect of sowing dates and antioxidants foliar spray on total chlorophyll, flag leaf area and plant height of two wheat cultivars during 2017/2018 and 2018/2019 growing seasons.

| Traits | Total chlorophyll | | Flag leaf area (cm$^2$) | | Plant height (cm) | |
|---|---|---|---|---|---|---|
| Season | 2017/2018 | 2018/2019 | 2017/2018 | 2018/2019 | 2017/2018 | 2018/2019 |
| Sowing dates (D) | | | | | | |
| 1st November ($D_1$) | 53.28 | 55.92 | 19.74 | 23.23 | 86.83 | 91.04 |
| 15th November ($D_2$) | 56.32 | 59.70 | 25.43 | 32.40 | 95.21 | 97.17 |
| 1st December ($D_3$) | 50.05 | 51.65 | 16.14 | 15.55 | 79.63 | 81.17 |
| F test | ** | ** | ** | ** | ** | ** |
| RLSD $_{0.05}$ | 0.16 | 0.35 | 0.31 | 0.41 | 0.26 | 0.32 |
| Antioxidants (A) | | | | | | |
| Control | 52.42 | 54.69 | 17.18 | 21.35 | 84.78 | 87.50 |
| Citric acid | 52.84 | 55.49 | 20.93 | 23.55 | 86.78 | 89.39 |
| Ascorbic acid | 53.47 | 56.02 | 21.62 | 24.68 | 87.83 | 90.50 |
| Citric + ascorbic acids | 54.14 | 56.84 | 22.01 | 25.33 | 89.50 | 91.78 |
| F test | ** | ** | ** | ** | ** | ** |
| RLSD $_{0.05}$ | 0.18 | 0.41 | 0.35 | 0.47 | 0.30 | 0.36 |
| Cultivars (C) | | | | | | |
| Sids-12 | 52.28 | 54.54 | 18.95 | 21.37 | 85.17 | 87.81 |
| Misr-1 | 54.16 | 56.97 | 21.93 | 26.08 | 89.28 | 91.78 |
| F test | ** | ** | ** | ** | ** | ** |

Table (4): Effect of sowing dates and antioxidants foliar spray on number of grains /spike, 1000-grain weight and number of spikes/m$^2$ of two wheat cultivars during 2017/2018 and 2018/2019 growing seasons.

| Traits | Number of grains/spike | | 1000-grain weight (g) | | Number of spikes/m$^2$ | |
|---|---|---|---|---|---|---|
| Season | 2017/2018 | 2018/2019 | 2017/2018 | 2018/2019 | 2017/2018 | 2018/2019 |
| Sowing dates (D) | | | | | | |
| 1st November ($D_1$) | 51.13 | 48.92 | 49.04 | 48.44 | 347.42 | 338.50 |
| 15th November ($D_2$) | 57.75 | 61.75 | 52.57 | 54.63 | 408.67 | 405.08 |
| 1st December ($D_3$) | 41.04 | 42.21 | 43.24 | 42.90 | 287.29 | 302.04 |
| F test | ** | ** | ** | ** | ** | ** |
| RLSD $_{0.05}$ | 0.54 | 1.05 | 0.50 | 0.30 | 5.82 | 3.40 |
| Antioxidants (A) | | | | | | |
| Control | 46.50 | 47.61 | 45.77 | 46.95 | 322.33 | 334.78 |
| Citric acid | 49.61 | 50.33 | 47.65 | 48.20 | 334.78 | 340.89 |
| Ascorbic acid | 50.83 | 52.00 | 49.23 | 49.05 | 359.22 | 353.44 |
| Citric + ascorbic acids | 52.94 | 53.89 | 50.47 | 50.43 | 374.83 | 365.06 |
| F test | ** | ** | ** | ** | ** | ** |
| RLSD $_{0.05}$ | 0.62 | 1.22 | 0.58 | 0.34 | 6.72 | 3.93 |
| Cultivars (C) | | | | | | |
| Sids-12 | 47.75 | 48.72 | 46.81 | 47.09 | 329.944 | 332.583 |
| Misr-1 | 52.19 | 53.19 | 49.76 | 50.22 | 365.639 | 364.500 |
| F test | ** | ** | ** | ** | ** | ** |

*3.1.3 Grain and straw yields and protein content*

Results as shown in Table (5) cleared that grain and straw yields ton/feddan as well as protein content in grain were high significantly affected by sowing dates in both seasons where, the highest grain yields 2.24 and 2.22 ton/feddan (14.93 and 14.80 ardab/feddan) were obtained when sowing was done on 15 November in the first and second seasons, respectively. Sowing on moderate date November gave an increase of 23.76 % compared to early and late sowing date in the first season while, these increases were 21.98 and 23.87 % in the second season. In the same trend also, sowing on 15th November recorded the highest values of straw yield 5.69 and 5.78 ton/fad as compared to early or late sowing date in the first and second season, respectively. This enhancement in grain and straw yields may be due to planting wheat on this sowing date attributed to corresponding environmental conditions in order to maximum wheat growth and development more offer the increase in yield component values such as number of spikes/m$^2$, number of grains/spike and 1000-grain weight. These results are in line with those obtained by El-Sayed *et al.* (2018), Yadav, *et al.* (2018), El-Hag Dalia (2019) and EI-Khafagi *et al.* (2020). On the other hand, the highest protein content in wheat grains 14.62 and 13.77 % were obtained from delay sowing at1st December in the first and second season, respectively. This could be attributed to the fact that late planted crop had lower yields than the recommended or earlier sowing dates, resulting in similar amounts of N translocated to fewer grains. Similar results were recorded by Haroun Samia *et al.* (2012), Munsif *et al.* (2015), El-Sayed *et al.* (2018) and El Sayed *et al.* (2018).

Table (5): Effect of sowing dates and antioxidants foliar spray on grain yield (ton/feddan), straw yield (ton/feddan) and protein content (%) of two wheat cultivars during 2017/2018 and 2018/2019 growing seasons.

| Traits | Grain yield (ton/feddan) | | Straw yield (ton/ feddan) | | Protein content (%) | |
|---|---|---|---|---|---|---|
| Season | 2017/2018 | 2018/2019 | 2017/2018 | 2018/2019 | 2017/2018 | 2018/2019 |
| Sowing dates (D) | | | | | | |
| 1st November ($D_1$) | 1.81 | 1.82 | 4.58 | 4.45 | 9.97 | 11.23 |
| 15th November ($D_2$) | 2.24 | 2.22 | 5.69 | 5.78 | 12.20 | 12.39 |
| 1st December ($D_3$) | 1.81 | 1.69 | 4.11 | 3.77 | 14.62 | 13.77 |
| F test | ** | ** | ** | ** | ** | ** |
| $RLSD_{0.05}$ | 0.03 | 0.04 | 0.16 | 0.08 | 0.20 | 0.35 |
| Antioxidants (A) | | | | | | |
| Control | 1.69 | 1.65 | 4.22 | 4.54 | 11.66 | 11.64 |
| Citric acid | 1.89 | 1.88 | 4.55 | 4.66 | 11.99 | 12.28 |
| Ascorbic acid | 2.05 | 1.92 | 4.92 | 4.76 | 12.62 | 12.59 |
| Citric + ascorbic acids | 2.18 | 2.17 | 5.50 | 4.69 | 12.78 | 13.34 |
| F test | ** | ** | ** | ** | ** | ** |
| $RLSD_{0.05}$ | 0.04 | 0.05 | 0.19 | 0.11 | 0.23 | 0.42 |
| Cultivars (C) | | | | | | |
| Sids-12 | 1.79 | 1.85 | 4.54 | 4.39 | 11.60 | 12.07 |
| Misr-1 | 2.12 | 1.97 | 5.05 | 4.95 | 12.93 | 12.85 |
| F test | ** | ** | ** | ** | ** | ** |

### *3.2 Effect of foliar spray with antioxidants*

#### *3.2.1 Growth characters*

According to the results listed in Table (3), revealed that foliar spray treatments had highly significant effects for all studied growth characters in both 2017/2018 and 2018/2019 seasons. Foliar spray with the mix of citric + ascorbic acids at 200 ppm concentration gave the highest values of chlorophyll content (54.14 and 56.84), flag leaf area (22.01 and 25.33 cm$^2$) and plant height (89.50 and 91.78) in the first and second seasons, respectively. These increases may be due to the role of citric and ascorbic acid in reducing environmental stress on wheat plants and enhancement redox system to efficiently protect plants particularly against potential anomalies caused by ROS and its products. These results are agreement with those obtained by Malik and Ashraf (2012), Sadak Mervat *et al.* (2013), Osman *et al.* (2014), Ahmed *et al.* (2016), Moghadan (2016) and Shah *et al.* (2019).

#### *3.2.2 Yield components*

The given results in Table (4), showed that foliar spray treatments had highly significant effects for all studied of yield components *i.e*. (number of grains/spike, 1000-grain weight and number of spikes/m$^2$) in 2017/18 and 2018/19 seasons. Foliar spray with mix of citric and ascorbic acids resulted in the highest number of grains/spike (53.94 and 53.89), heaviest 1000-grain weight (50.47 and 50.43 g) and the highest number of spikes/m$^2$ (374.83 and 365.06 spike/m$^2$) in the first and second seasons, respectively. This may be due to the stimulation effect of antioxidants on vegetative growth as a result stimulation and increasing photosynthetic activity of such plants which led to more tillers and spikes as well as grains fertility and filling rate. These results are agreement with those obtained by El-Awadi *et al.* (2014), Seadh and El-Metwally (2015), Ahmed *et al.* (2016) and Shah *et al.* (2019).

#### *3.2.3 Grain and straw yields and protein content*

The obtained results in Table (5) revealed that foliar spray treatments had highly significant effects for grain and straw yields and protein content characters in 2017/18 and 2018/19 seasons. The highest grain yield 2.18 and 2.17 ton/feddan (14.53 and 14.47 ardab/feddan) in the two respective seasons were obtained from wheat plants which were sprayed by 200 ppm citric/ascorbic acids while, the highest values of straw yield 5.50 and 4.76 ton/feddan were resulted from plants which were sprayed by 200 ppm citric/ascorbic acids in the first season and by 200 ppm ascorbic acid only in the second season, respectively. In this respect, the highest percent of protein content in grain 12.78 and 13.34 % were obtained from citric/ascorbic acids foliar spray treatment in the first and second season, respectively. This may be due to that the stimulatory effect on antioxidants may be attributed to good foliage growth and formation ample canopy able to make best photosynthesis, hence increase dry matter accumulation and increasing all yield attributes under this study by antioxidants foliar spray especially, citric/ascorbic acids. These results are in the same trend with those reported by El-Awadi *et al.* (2014), Seadh and El-Metwally (2015), Ahmed *et al.* (2016) and Shah *et al.* (2019).

### *3.3 Wheat cultivar performance*

#### *3.3.1 Growth characters*

Results in Table (3) showed that wheat cultivars had highly significant effects for all growth characters *i.e.* (total chlorophyll content, flag leaf area and plant height) in the two growing seasons. Misr-1 cultivar outperforms over Sids-12 cultivar where, it recorded the highest values of chlorophyll content (54.16 and 56.97), flag leaf area (21.93 and 26.08 $cm^2$) and plant height (89.28 and 91.78 cm) in the first and second seasons, respectively. This may be due to differ of genetic makeup and its response to environment conditions. These results are agreement with those obtained by Al-Tahir (2014), Wahid *et al.* (2017), Kandil*et al.* (2017), Hassanein *et al.* (2019), EI-Khafagi *et al.* (2020) and Al-Zahy *et al.* (2020).

#### *3.3.2 Yield components*

Regarding the results in Table (4) showed that the wheat cultivars were highly significant effects for all yield components in the two growing seasons. The two wheat cultivars differed significantly in number of grains/spike, 1000- grain weight and number of spikes/$m^2$ in the two seasons. Misr-1 cultivar was superior to Sids-12 in both seasons where, recorded the highest number of grains /spike (52.19 and 53.19), the highest 1000-grain weights (49.76 and 50.22 g) and the highest numbers of spikes/$m^2$ (365.64 and 364.50 spike/$m^2$) in the two successive seasons, respectively, Table 4. The differences here may be due to the variation in the gene makeup and their response to the environmental conditions. The previous results are in accordance with those obtained by Mekkei and El–Haggan (2014), Mumtaz *et al.* (2015), Wahid *et al.* (2017), El-Sayed *et al.* (2018), Hassanein *et al.* (2019) and Al-Zahy *et al.* (2020).

#### *3.3.3 Grain and straw yields and protein content*

The given results in Table (5), showed that the two tested wheat cultivars gave highly significant effects on grain and straw yields and protein content characters in the two growing seasons. The cultivar Misr-1 was superior to Sids-12 cultivar in grain yield (ton/feddan) by 18.44 and 6.09 % and straw yield by 11.23 and 12.76 % in the first and second seasons, respectively. Where, Misr-1 cultivar recorded the highest grain yields 2.12 and 1.97 ton/feddan (14.13 and 13.13 ardab/feddan) and the highest straw yields 5.05 and 4.95 ton/feddan in the first and second seasons, respectively. As for the protein content of the grains, the Misr-1 variety surpassed sids-12 where, it recorded the highest values 12.93 and 12.85% in the first and second season, respectively. The difference may be due to relative superiority of this cultivar (Misr-1) with relation to plant height, number of grains/spike and number of spikes/m$^2$ compared with the other cultivar, may be attributed to its genetic makeup. These results are in accordance with those obtained by Wahid *et al.* (2017), El-Sayed *et al.* (2018), EI-Khafagi *et al.* (2020) and Rachon *et al.* (2020).

### *3.4 Effect of the interactions*

#### *3.4.1 Growth characters*

All first order interactions among the studied factors showed significant or highly significant effects on chlorophyll content, flag leaf area and plant height in the both growing seasons except for cultivars- antioxidants interaction which had insignificant effect on chlorophyll content in both seasons (Table 6). The highest values of chlorophyll content (57.65 and 61.12), flag leaf area (27.06 and 33.73 cm$^2$) and plant height (98.17 and 99.33 cm) were recorded when wheat planted on 15 November and were sprayed by citric+ascorbic acids at 200 ppm concentration in the first and second seasons, respectively. Also, the highest values of chlorophyll content (57.33 and 61.08), falg leaf area (27.20 and 34.40 cm$^2$) and plant height (97.75 and 99.00 cm) were obtained from Misr-1cultivar when it was planted on 15 November during the two successive seasons, respectively. In the same turned, the interaction between Misr-1 cultivar and foliar spraying with citric+ascorbic acids at 200 ppm gave the highest flag leaf area (23.26 and 27.31 cm$^2$) and tallest plants (91.00 and 93.56 cm) in the first and second growing season, respectively. The second order interaction showed significant or highly significant effects on all growth characters in the both seasons except for chlorophyll content in the second season (Table 7). The highest chlorophyll content 59.37 was obtained from Misr-1 when was sown on 15 November and was sprayed with citric + ascorbic acids at 200 ppm in this line, the highest values of flag leaf area (28.46 and 35.47 cm$^2$) and plant height (101.00 and 102.33 cm) were obtained from Misr-1 when was sowing on 15 November and was sprayed with citric + ascorbic acids at 200 ppm in the first and second season respectively.

#### *3.4.2 Yield components*

The first order interactions among the study factors showed significant effects in yield components (Table 8). Number of grains/spike was affected significantly by sowing dates-antioxidants interaction in the first season only where, the highest number of grains (62.00 grain/spike) was recorded when wheat was planted on 15 November and was sprayed with the mix of citric and ascorbic acids.

Table (6): Effect of the first order interactions between sowing dates and antioxidants foliar spray on total chlorophyll, flag leaf area and plant height of two wheat cultivars during 2017/2018 and 2018/2019 growing seasons.

| Sowing dates (D) | Traits / Antioxidants (A) | Total chlorophyll | | Flag leaf area ($cm^2$) | | Plant height (cm) | |
|---|---|---|---|---|---|---|---|
| | | Season | | Season | | Season | |
| | | 2017/2018 | 2018/2019 | 2017/2018 | 2018/2019 | 2017/2018 | 2018/2019 |
| 1st November ($D_1$) | Control | 52.87 | 55.52 | 14.88 | 18.82 | 84.67 | 89.33 |
| | Citric acid | 53.13 | 55.75 | 20.87 | 23.82 | 86.50 | 90.83 |
| | Ascorbic acid | 53.45 | 56.05 | 21.44 | 25.05 | 87.50 | 91.67 |
| | Citric + ascorbic acids | 53.68 | 56.37 | 21.77 | 25.25 | 88.67 | 92.33 |
| 15th November ($D_2$) | Control | 55.47 | 58.53 | 22.43 | 30.98 | 93.17 | 95.67 |
| | Citric acid (C) | 55.67 | 59.32 | 25.84 | 31.81 | 94.33 | 96.17 |
| | Ascorbic acid (A) | 56.50 | 59.85 | 26.39 | 33.07 | 95.17 | 97.50 |
| | Citric + ascorbic acids | 57.65 | 61.12 | 27.06 | 33.73 | 98.17 | 99.33 |
| 1st December ($D_3$) | Control | 48.93 | 47.53 | 14.24 | 14.26 | 76.50 | 77.50 |
| | Citric acid (C) | 49.72 | 49.90 | 16.08 | 15.02 | 79.50 | 81.17 |
| | Ascorbic acid (A) | 50.47 | 50.60 | 17.04 | 15.92 | 80.83 | 82.33 |
| | Citric + ascorbic acids | 51.08 | 51.63 | 17.21 | 17.00 | 81.67 | 83.67 |
| F test | | ** | * | ** | ** | ** | ** |
| $RLSD_{0.05}$ | | 0.33 | 0.86 | 0.63 | 0.86 | 0.56 | 0.66 |
| Sowing dates (D) | Cultivar | | | | | | |
| 1st November ($D_1$) | Sids-12 | 52.78 | 55.38 | 18.02 | 20.19 | 84.92 | 89.33 |
| | Misr-1 | 53.79 | 56.46 | 21.46 | 26.28 | 88.75 | 92.75 |
| 15th November ($D_2$) | Sids-12 | 55.32 | 58.33 | 23.65 | 30.39 | 92.67 | 95.33 |
| | Misr-1 | 57.33 | 61.08 | 27.20 | 34.40 | 97.75 | 99.00 |
| 1st December ($D_3$) | Sids-12 | 48.74 | 49.92 | 15.16 | 13.54 | 77.92 | 78.75 |
| | Misr-1 | 51.36 | 53.38 | 17.12 | 17.56 | 81.33 | 83.58 |
| F test | | ** | ** | ** | ** | * | * |
| $RLSD_{0.05}$ | | 0.50 | 0.68 | 0.66 | 0.68 | 1.01 | 0.75 |
| Antioxidants (A) | Cultivar | | | | | | |
| Control | Sids-12 | 51.38 | 53.32 | 14.82 | 17.90 | 81.78 | 84.44 |
| | Misr-1 | 53.47 | 56.06 | 19.55 | 24.80 | 87.78 | 90.56 |
| Citric acid (C) | Sids-12 | 51.94 | 54.42 | 19.79 | 21.45 | 84.78 | 87.78 |
| | Misr-1 | 53.73 | 56.56 | 22.07 | 25.65 | 88.78 | 91.00 |
| Ascorbic acid (A) | Sids-12 | 52.74 | 54.93 | 20.42 | 22.79 | 86.11 | 89.00 |
| | Misr-1 | 54.20 | 57.10 | 22.83 | 26.57 | 89.56 | 92.00 |
| Citric + ascorbic acids | Sids-12 | 53.04 | 55.50 | 20.76 | 23.35 | 88.00 | 90.00 |
| | Misr-1 | 55.23 | 58.18 | 23.26 | 27.31 | 91.00 | 93.56 |
| F test | | N.S. | N.S. | ** | ** | ** | ** |
| $RLSD_{0.05}$ | | -- | -- | 0.75 | 0.78 | 1.10 | 0.80 |

Sowing dates-antioxidants interaction had a highly significant effect on 1000-grain weight and number of spikes/$m^2$ in the both seasons where, the heaviest 1000-grain (55.26 and 56.21 g) and the highest numbers of spikes/$m^2$ (449.17 and 435.17 spike) was recorded when wheat was planted on 15th November and was sprayed with the mix of citric and ascorbic acids (at 200 ppm) in the first and second season, respectively. Sowing date-cultivars interaction exhibited a highly significant effect (prob<0.01) on number of grains /spike and number of spikes/$m^2$ where, the highest numbers of grains /spike (60.67 and 65.67 grain) and number of spikes/$m^2$ (432.58 and 433.50 spike/$m^2$) were obtained when Misr-

1cultivar was sown on 15th November during the two successive seasons, respectively. Concerning the interaction between the cultivars and antioxidants, showed a highly significant effect on 1000-grain weight in the second season only where, the highest value51.54 g was recorded when Misr-1 cultivar was sprayed by mix of citric and ascorbic acids while, the interaction between the cultivars and antioxidants showed a highly significant effect on number of spikes/$m^2$ in the first season only from the same treatment.

Table (7): Effect of the second order interaction between sowing dates and antioxidants foliar spray on total chlorophyll, flag leaf area and plant height of two wheat cultivars during 2017/2018 and 2018/2019 growing seasons.

| Sowing dates (D) | Antioxidants (A) | Cultivars | Total chlorophyll | | Flag leaf area ($cm^2$) | | Plant height (cm) | |
|---|---|---|---|---|---|---|---|---|
| | | | 2017/18 | 2018/19 | 2017/18 | 2018/19 | 2017/18 | 2018/19 |
| 1st November ($D_1$) | Control | Sids-12 | 52.40 | 54.97 | 13.29 | 12.58 | 82.33 | 86.67 |
| | | Misr-1 | 53.33 | 56.07 | 16.47 | 25.05 | 87.00 | 92.00 |
| | Citric acid | Sids-12 | 52.53 | 55.27 | 19.18 | 21.93 | 84.33 | 89.33 |
| | | Misr-1 | 53.73 | 56.23 | 22.55 | 25.70 | 88.67 | 92.33 |
| | Ascorbic acid | Sids-12 | 52.97 | 55.53 | 19.57 | 22.99 | 85.67 | 90.33 |
| | | Misr-1 | 53.93 | 56.57 | 23.30 | 27.11 | 89.33 | 93.00 |
| | Citric + ascorbic acids | Sids-12 | 53.20 | 55.77 | 20.05 | 23.24 | 87.33 | 91.00 |
| | | Misr-1 | 54.17 | 56.97 | 23.50 | 27.26 | 90.00 | 93.67 |
| 15th November ($D_2$) | Control | Sids-12 | 54.70 | 57.47 | 18.50 | 28.79 | 90.67 | 94.33 |
| | | Misr-1 | 56.23 | 59.60 | 26.35 | 33.17 | 95.67 | 97.00 |
| | Citric acid (C) | Sids-12 | 54.97 | 58.10 | 25.11 | 29.37 | 92.00 | 94.67 |
| | | Misr-1 | 56.37 | 60.53 | 26.56 | 34.25 | 96.67 | 97.67 |
| | Ascorbic acid (A) | Sids-12 | 55.67 | 58.67 | 25.35 | 31.42 | 92.67 | 96.00 |
| | | Misr-1 | 57.33 | 61.03 | 27.43 | 34.72 | 97.67 | 99.00 |
| | Citric + ascorbic acids | Sids-12 | 55.93 | 59.10 | 25.65 | 31.99 | 95.33 | 96.33 |
| | | Misr-1 | 59.37 | 63.13 | 28.46 | 35.47 | 101.00 | 102.33 |
| 1st December ($D_3$) | Control | Sids-12 | 47.03 | 47.53 | 12.66 | 12.33 | 72.33 | 72.33 |
| | | Misr-1 | 50.83 | 52.50 | 15.82 | 16.19 | 80.67 | 82.67 |
| | Citric acid (C) | Sids-12 | 48.33 | 49.90 | 15.08 | 13.05 | 78.00 | 79.33 |
| | | Misr-1 | 51.10 | 52.90 | 17.08 | 17.00 | 81.00 | 83.00 |
| | Ascorbic acid (A) | Sids-12 | 49.60 | 50.60 | 16.33 | 13.96 | 80.00 | 80.67 |
| | | Misr-1 | 51.33 | 53.70 | 17.75 | 17.88 | 81.67 | 84.00 |
| | Citric + ascorbic acids | Sids-12 | 50.00 | 51.63 | 16.58 | 14.82 | 81.33 | 82.67 |
| | | Misr-1 | 52.17 | 54.43 | 17.84 | 19.19 | 82.00 | 84.67 |
| F test | | | * | N.S. | ** | ** | ** | ** |
| $RLSD_{0.05}$ | | | 1.20 | -- | 1.36 | 1.36 | 2.01 | 1.39 |

Concerning the second order interactions as shown in Table (9) exhibited a highly significant effect on 1000-grain weight and number of spikes/$m^2$ in the both seasons. In general, when Misr-1 cultivar was sown on 15 November and was sprayed with mix of citric and ascorbic acids recorded the heaviest 1000-grain weight (57.77 and 57.48 g) and the highest number of spikes/$m^2$ (485.67 and 472.67) in the first and second seasons, respectively.

Table (8): Effect of the first order interactions between sowing dates and antioxidants foliar spray on number of grains/spike, 1000-grain weight (g) number of spikes/m$^2$ of two wheat cultivars during 2017/2018 and 2018/2019 growing seasons.

| Sowing dates (D) | Traits | Number of grains /spike | | 1000-grain weight | | Number of spikes/m$^2$ | |
|---|---|---|---|---|---|---|---|
| | Antioxidants (A) | Season | | Season | | Season | |
| | | 2017/2018 | 2018/2019 | 2017/2018 | 2018/2019 | 2017/2018 | 2018/2019 |
| 1st November ($D_1$) | Control | 48.50 | 45.50 | 47.77 | 45.64 | 326.50 | 331.50 |
| | Citric acid | 50.50 | 49.17 | 48.34 | 47.97 | 341.33 | 336.33 |
| | Ascorbic acid | 52.17 | 50.00 | 48.85 | 49.28 | 353.00 | 341.33 |
| | Citric + ascorbic acids | 53.33 | 51.00 | 51.21 | 50.88 | 368.83 | 344.83 |
| 15th November ($D_2$) | Control | 52.83 | 57.83 | 49.11 | 53.58 | 371.17 | 380.67 |
| | Citric acid (C) | 57.33 | 60.67 | 52.32 | 54.06 | 383.50 | 389.50 |
| | Ascorbic acid (A) | 58.83 | 62.83 | 53.57 | 54.68 | 430.83 | 415.00 |
| | Citric + ascorbic acids | 62.00 | 65.67 | 55.26 | 56.21 | 449.17 | 435.17 |
| 1st December ($D_3$) | Control | 38.17 | 39.50 | 40.43 | 41.62 | 269.33 | 292.17 |
| | Citric acid (C) | 41.00 | 41.17 | 42.30 | 42.57 | 279.50 | 296.83 |
| | Ascorbic acid (A) | 41.50 | 43.17 | 45.28 | 43.20 | 293.83 | 304.00 |
| | Citric + ascorbic acids | 43.50 | 45.00 | 44.96 | 44.20 | 306.50 | 315.17 |
| F test | | ** | N.S. | ** | ** | ** | ** |
| RLSD $_{0.05}$ | | 1.25 | -- | 1.12 | 0.63 | 12.73 | 7.10 |
| Sowing dates (D) | Cultivar | | | | | | |
| 1st November ($D_1$) | Sids-12 | 49.58 | 47.25 | 47.88 | 46.80 | 334.58 | 330.08 |
| | Misr-1 | 52.67 | 50.58 | 50.21 | 50.08 | 360.25 | 346.92 |
| 15th November ($D_2$) | Sids-12 | 54.83 | 57.83 | 50.78 | 53.21 | 384.75 | 376.67 |
| | Misr-1 | 60.67 | 65.67 | 54.35 | 56.05 | 432.58 | 433.50 |
| 1st December ($D_3$) | Sids-12 | 38.83 | 41.08 | 41.76 | 41.25 | 270.50 | 291.00 |
| | Misr-1 | 43.25 | 43.33 | 44.72 | 44.54 | 304.08 | 313.08 |
| F test | | ** | ** | N.S. | N.S. | ** | ** |
| RLSD $_{0.05}$ | | 0.94 | 1.63 | -- | -- | 7.40 | 6.85 |
| Antioxidants (A) | Cultivar | | | | | | |
| Control | Sids-12 | 44.22 | 45.00 | 44.52 | 44.67 | 303.67 | 323.22 |
| | Misr-1 | 48.78 | 50.22 | 47.02 | 49.23 | 341.00 | 346.33 |
| Citric acid (C) | Sids-12 | 47.33 | 48.56 | 46.19 | 46.57 | 318.22 | 324.78 |
| | Misr-1 | 51.89 | 52.11 | 49.12 | 49.82 | 351.33 | 357.00 |
| Ascorbic acid (A) | Sids-12 | 49.22 | 50.00 | 47.70 | 47.80 | 347.33 | 336.78 |
| | Misr-1 | 52.44 | 54.00 | 50.77 | 50.30 | 371.11 | 370.11 |
| Citric + ascorbic acids | Sids-12 | 50.22 | 51.33 | 48.81 | 49.31 | 350.56 | 345.56 |
| | Misr-1 | 55.67 | 56.44 | 52.14 | 51.54 | 399.11 | 384.56 |
| F test | | N.S. | N.S. | N.S. | ** | ** | N.S. |
| RLSD $_{0.05}$ | | -- | -- | -- | 0.67 | 8.94 | -- |

### *3.4.3 Grain and straw yields and protein content*

The exhibited results in Table (10) revealed that all the first order interactions between studied factors had significant effects on grain and straw yields/feddan in the two seasons. In this tendency, sowing dates-antioxidants interaction recorded the highest grain yield 2.56 and 2.47 ton/feddan and the highest straw yield 6.33 and 5.93 ton/feddan when wheat was sown on 15$^{th}$ November and was sprayed by citric/ascorbic acids (200 ppm) in the first and second seasons, respectively. Sowing dates-cultivars interaction gave the highest grain yield 2.37 and 3.36 ton/feddan and the highest straw yield 6.12 and 6.27 ton/feddan when Misr-1 cultivar was sown on 15$^{th}$ November in the two successive seasons. Also, the interaction between Misr-1 cultivar with citric/ascorbic acids (200 ppm) foliar spray treatment gave the highest grain yields 2.39 and 2.20 ton/feddan in the first and second growing seasons, respectively while, the highest straw yield 5.61 and 5.17 ton/feddan were obtained from Misr-1 cultivar when was sprayed with citric/ascorbic acids (200 ppm) in the first season and ascorbic acid only in the second season, respectively.

Table (9): Effect of the second order interaction between sowing dates and antioxidants foliar spray on number of grains/spike, 1000-grain weight and number of spikes/m$^2$ of two wheat cultivars during 2017/2018 and 2018/2019 growing seasons.

| Sowing dates (D) | Antioxidants (A) | Cultivars | Number of grains/spike | | 1000-grain weight | | Number of spikes/m$^2$ | |
|---|---|---|---|---|---|---|---|---|
| | | | 2017/18 | 2018/2019 | 2017/2018 | 2018/2019 | 2017/2018 | 2018/2019 |
| 1$^{st}$ November (D$_1$) | Control | Sids-12 | 47.67 | 44.67 | 46.56 | 42.39 | 314.33 | 324.67 |
| | | Misr-1 | 49.33 | 46.33 | 48.98 | 48.90 | 338.67 | 338.33 |
| | Citric acid | Sids-12 | 48.33 | 47.33 | 47.47 | 46.38 | 339.67 | 328.33 |
| | | Misr-1 | 52.67 | 51.00 | 49.20 | 49.56 | 343.00 | 344.33 |
| | Ascorbic acid | Sids-12 | 51.00 | 48.33 | 48.10 | 48.34 | 345.00 | 332.00 |
| | | Misr-1 | 53.33 | 51.67 | 49.61 | 50.21 | 361.00 | 350.67 |
| | Citric + ascorbic acids | Sids-12 | 51.33 | 48.67 | 49.37 | 50.10 | 339.33 | 335.33 |
| | | Misr-1 | 55.33 | 53.33 | 53.04 | 51.65 | 398.33 | 354.33 |
| 15$^{th}$ November (D$_2$) | Control | Sids-12 | 50.00 | 53.67 | 48.40 | 52.03 | 354.00 | 363.33 |
| | | Misr-1 | 55.67 | 62.00 | 49.82 | 55.14 | 388.33 | 398.00 |
| | Citric acid (C) | Sids-12 | 54.67 | 58.00 | 50.63 | 52.57 | 361.67 | 367.33 |
| | | Misr-1 | 60.00 | 63.33 | 54.01 | 55.55 | 405.33 | 411.67 |
| | Ascorbic acid (A) | Sids-12 | 56.67 | 59.33 | 51.33 | 53.32 | 410.67 | 378.33 |
| | | Misr-1 | 61.00 | 66.33 | 55.81 | 56.04 | 451.00 | 451.67 |
| | Citric + ascorbic acids | Sids-12 | 58.00 | 60.33 | 52.76 | 54.94 | 412.67 | 397.67 |
| | | Misr-1 | 66.00 | 71.00 | 57.77 | 57.48 | 485.67 | 472.67 |
| 1$^{st}$ December (D$_3$) | Control | Sids-12 | 35.00 | 36.67 | 38.61 | 39.59 | 242.67 | 281.67 |
| | | Misr-1 | 41.33 | 42.33 | 42.25 | 43.64 | 296.00 | 302.67 |
| | Citric acid (C) | Sids-12 | 39.00 | 40.33 | 40.47 | 40.77 | 253.33 | 278.67 |
| | | Misr-1 | 43.00 | 42.00 | 44.13 | 44.36 | 305.67 | 315.00 |
| | Ascorbic acid (A) | Sids-12 | 40.00 | 42.33 | 43.66 | 41.74 | 286.33 | 300.00 |
| | | Misr-1 | 43.00 | 44.00 | 46.90 | 44.65 | 301.33 | 308.00 |
| | Citric + ascorbic acids | Sids-12 | 41.33 | 45.00 | 44.30 | 42.89 | 299.67 | 303.67 |
| | | Misr-1 | 45.67 | 45.00 | 45.61 | 45.51 | 313.33 | 326.67 |
| F test | | | N.S. | N.S. | ** | ** | ** | ** |
| R.L.S.D$_{0.05}$ | | | -- | -- | 1.68 | 1.32 | 14.79 | 16.41 |

Concerning protein percentage was affected significantly by the interaction between sowing dates and antioxidants foliar spray in the first season only where, the highest percent 14.85 and 14.93% were recorded in the late sowing with ascorbic acid and citric/ascorbic acids (200 ppm) foliar spray, respectively. Sowing dates-cultivars interaction had a highly significant effect on grain protein content in the both seasons where, it recorded the highest protein percentage 15.04 and 14.53 % when Misr-1 cultivar sowing was done on 1$^{st}$ December in the two successive seasons. On the other hand, the interaction effect between antioxidants foliar spray and wheat cultivars was insignificant in both seasons.

Table (10): Effect of the first order interactions between sowing dates and antioxidants foliar spray on grain yield (ton/feddan), straw yield (ton/feddan) and protein content (%) of two wheat cultivars during 2017/2018 and 2018/2019 growing seasons.

| Sowing dates (D) | Traits / Antioxidants (A) | Grain yield (ton/feddan) | | Straw yield (ton/feddan) | | Protein content (%) | |
|---|---|---|---|---|---|---|---|
| | | Season | | Season | | Season | |
| | | 2017/2018 | 2018/2019 | 2017/2018 | 2018/2019 | 2017/2018 | 2018/2019 |
| 1st November ($D_1$) | Control | 1.59 | 1.62 | 3.95 | 4.04 | 8.94 | 10.42 |
| | Citric acid | 1.71 | 1.77 | 4.47 | 4.57 | 9.92 | 11.14 |
| | Ascorbic acid | 1.91 | 1.81 | 4.53 | 4.69 | 10.41 | 11.51 |
| | Citric + ascorbic acids | 2.05 | 2.09 | 5.38 | 4.52 | 10.62 | 11.85 |
| 15th November ($D_2$) | Control | 1.90 | 2.02 | 5.22 | 5.61 | 11.71 | 11.74 |
| | Citric acid (C) | 2.17 | 2.14 | 5.66 | 5.78 | 11.71 | 12.11 |
| | Ascorbic acid (A) | 2.33 | 2.26 | 5.56 | 5.80 | 12.59 | 12.29 |
| | Citric + ascorbic acids | 2.56 | 2.47 | 6.33 | 5.93 | 12.81 | 13.41 |
| 1st December ($D_3$) | Control | 1.59 | 1.33 | 3.48 | 3.98 | 14.35 | 12.77 |
| | Citric acid (C) | 1.80 | 1.74 | 3.51 | 3.64 | 14.35 | 13.60 |
| | Ascorbic acid (A) | 1.91 | 1.70 | 4.67 | 3.81 | 14.85 | 13.96 |
| | Citric + ascorbic acids | 1.94 | 1.97 | 4.78 | 3.64 | 14.93 | 14.76 |
| F test | | ** | ** | ** | ** | * | N.S. |
| RLSD $_{0.05}$ | | 0.07 | 0.10 | 0.36 | 0.18 | 0.47 | -- |
| Sowing dates (D) | Cultivar | | | | | | |
| 1st November ($D_1$) | Sids-12 | 1.58 | 1.81 | 4.63 | 4.29 | 8.88 | 11.10 |
| | Misr-1 | 2.05 | 1.83 | 4.53 | 4.62 | 11.06 | 11.36 |
| 15th November ($D_2$) | Sids-12 | 2.10 | 2.08 | 5.26 | 5.29 | 11.71 | 12.10 |
| | Misr-1 | 2.37 | 2.36 | 6.12 | 6.27 | 12.70 | 12.67 |
| 1st December ($D_3$) | Sids-12 | 1.69 | 1.64 | 3.73 | 3.58 | 14.20 | 13.02 |
| | Misr-1 | 1.93 | 1.73 | 4.49 | 3.95 | 15.04 | 14.53 |
| F test | | ** | ** | ** | ** | ** | ** |
| RLSD $_{0.05}$ | | 0.04 | 0.05 | 0.22 | 0.16 | 0.31 | 0.43 |
| Antioxidants (A) | Cultivar | | | | | | |
| Control | Sids-12 | 1.58 | 1.58 | 4.01 | 4.50 | 10.81 | 11.39 |
| | Misr-1 | 1.81 | 1.73 | 4.42 | 4.58 | 12.52 | 11.90 |
| Citric acid (C) | Sids-12 | 1.75 | 1.76 | 4.28 | 4.38 | 11.32 | 11.82 |
| | Misr-1 | 2.03 | 2.01 | 4.81 | 4.94 | 12.66 | 12.75 |
| Ascorbic acid (A) | Sids-12 | 1.86 | 1.90 | 4.49 | 4.36 | 12.13 | 12.13 |
| | Misr-1 | 2.24 | 1.95 | 5.35 | 5.17 | 13.10 | 13.04 |
| Citric + ascorbic acids | Sids-12 | 1.97 | 2.15 | 5.38 | 4.30 | 12.13 | 12.95 |
| | Misr-1 | 2.39 | 2.20 | 5.61 | 5.09 | 13.44 | 13.73 |
| F test | | ** | ** | * | ** | N.S. | N.S. |
| RLSD $_{0.05}$ | | 0.05 | 0.07 | 0.30 | 0.19 | -- | -- |

Table (11): Effect of the second order interaction between sowing dates and antioxidants foliar spray on grain yield (ton/feddan), straw yield (ton/feddan) and protein content (%) of two wheat cultivars during 2017/2018 and 2018/2019 growing seasons.

| Sowing dates (D) | Antioxidants (A) | Cultivars | Grain yield (ton/feddan) | | Straw yield (ton/feddan) | | Protein content (%) | |
|---|---|---|---|---|---|---|---|---|
| | | | 2017/18 | 2018/2019 | 2017/2018 | 2018/2019 | 2017/2018 | 2018/2019 |
| 1st November ($D_1$) | Control | Sids-12 | 1.51 | 1.56 | 4.25 | 4.39 | 7.25 | 10.40 |
| | | Misr-1 | 1.66 | 1.68 | 3.65 | 3.69 | 10.62 | 10.44 |
| | Citric acid | Sids-12 | 1.56 | 1.80 | 4.37 | 4.23 | 8.78 | 10.88 |
| | | Misr-1 | 1.86 | 1.73 | 4.57 | 4.90 | 11.06 | 11.40 |
| | Ascorbic acid | Sids-12 | 1.60 | 1.84 | 4.40 | 4.34 | 9.75 | 11.29 |
| | | Misr-1 | 2.22 | 1.78 | 4.66 | 5.04 | 11.06 | 11.73 |
| | Citric + ascorbic acids | Sids-12 | 1.65 | 2.04 | 5.52 | 4.19 | 9.75 | 11.83 |
| | | Misr-1 | 2.45 | 2.13 | 5.23 | 4.84 | 11.49 | 11.87 |
| 15th November ($D_2$) | Control | Sids-12 | 1.76 | 1.86 | 4.39 | 5.30 | 11.49 | 11.16 |
| | | Misr-1 | 2.04 | 2.17 | 6.05 | 5.91 | 11.93 | 12.31 |
| | Citric acid (C) | Sids-12 | 2.06 | 1.98 | 5.20 | 5.29 | 11.49 | 11.81 |
| | | Misr-1 | 2.28 | 2.31 | 6.12 | 6.28 | 11.93 | 12.41 |
| | Ascorbic acid (A) | Sids-12 | 2.17 | 2.17 | 5.18 | 5.193 | 11.93 | 11.78 |
| | | Misr-1 | 2.48 | 2.35 | 5.93 | 6.40 | 13.25 | 12.79 |
| | Citric + ascorbic acids | Sids-12 | 2.42 | 2.33 | 6.26 | 5.38 | 11.93 | 13.64 |
| | | Misr-1 | 2.69 | 2.61 | 6.39 | 6.48 | 13.69 | 13.17 |
| 1st December ($D_3$) | Control | Sids-12 | 1.46 | 1.31 | 3.39 | 3.82 | 13.69 | 12.61 |
| | | Misr-1 | 1.72 | 1.34 | 3.57 | 4.14 | 15.00 | 12.94 |
| | Citric acid (C) | Sids-12 | 1.65 | 1.49 | 3.27 | 3.62 | 13.69 | 12.75 |
| | | Misr-1 | 1.94 | 2.00 | 3.75 | 3.65 | 15.00 | 14.44 |
| | Ascorbic acid (A) | Sids-12 | 1.79 | 1.69 | 3.89 | 3.55 | 14.71 | 13.34 |
| | | Misr-1 | 2.02 | 1.71 | 5.45 | 4.07 | 15.00 | 14.58 |
| | Citric + ascorbic acids | Sids-12 | 1.85 | 2.06 | 4.36 | 3.32 | 14.71 | 13.37 |
| | | Misr-1 | 2.03 | 1.88 | 5.21 | 3.96 | 15.15 | 16.15 |
| F test | | | ** | ** | ** | ** | ** | ** |
| R.L.S.D $_{0.05}$ | | | 0.09 | 0.11 | 0.48 | 0.36 | 0.67 | 0.95 |

The second order interaction as shown in Table (11) revealed a highly significant effect on grain and straw yields/fad as well as protein percentage in the both seasons where, the highest grain yields 2.69 and 2.61 ton/feddan and straw yield 6.39 and 6.48 ton/feddan were obtained from Misr-1 when was sown on 15$^{th}$ November and was sprayed with citric/ascorbic acids at 200 ppm in the first and second growing season, respectively. On the other hand, the highest percent of protein in grain was 15.15 and 16.15% Misr-1 when was sown on 1$^{st}$ December and was sprayed with citric/ascorbic acids at 200 ppm in the first and second growing seasons, respectively.

## References


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