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**Research Article**

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# *Molecular and enzymatic response to drought stress in wheat (Triticum aestivum L.)*

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**ABSTRACT**

*The activity of catalase, peroxidase and polyphenol oxidase during seedling stage under drought stress in four Egyptian wheat cultivars was studied. Giza 168 and Sakha 93 are drought tolerant, whereas Gemmiza 9 and Sakha 95 are sensitive to drought. For drought stress experiment, two-week seedling was subjected gradually to osmotic stress at three different polyethylene glycol concentrations; 6.9, 13.75 and 27.5 g/l PEG 6000. A 700 bp band was scored only in the drought tolerant wheat cultivars (Giza 168 and Sakha 93) and absent in the drought sensitive cultivars (Gemmiza 9 and Sakha 95). Enzymatic activity of catalaze, peroxidase and polyphenol oxidase was assayed at 4 time points (0 control, 24 hrs, 3days, and 7 days) to evaluate their activity in the four germplasms under drought stress. The activity of the three genes was gradually increased by time and by increasing the PEG concentration. In conclusion, LEA gene is correlated to drought stress. Moreover, catalase, peroxidase and polyphenol oxidase activity in wheat seedlings of cultivars under study increased by increasing PEG concentration and the time.*

***Keywords:*** *catalase, peroxidase, polyphenol oxidase, drought, polyethylene glycol, wheat.*
***Conflict of interest:*** *The authors declare that they have no conflict of interest.*

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## INTRODUCTION

Wheat (*Triticum aestivum* L.) belongs to *Poaceae* family. It occupies the world first rank for human stable food. Ninety-five percent of wheats grown today are of the hexaploid type and the other 5% is durum (*Triticum turgidum*

L., var. *durum*) tetraploid wheat [1-7]. The wheat genome is 17000 Mb [2, 8-11]. Expression of plant genes changes under drought stress [3, 12-18].

Drought is abiotic stress that affects vital biological processes and limits crop production, delay or lack of crop establishment, plant weakening or loss, susceptibility to pest or disease attack and changes in physiological and biochemical responses [4, 19-24]. Reactive oxygen species (ROS) accumulate under drought stress in plants [5, 25-27]. Adaptation to drought stress leads to generation of oxidative stress, high $H_2O_2$ levels and poor antioxidant enzyme response that generate enhanced membrane damage during [5, 6, 28-30]. Drought stress affected the total protein content, relative water content and photosynthetic pigments of 36 Iranian wheat landraces [7, 31-33].
High-expression levels of total glutathione S-transferase and glutathione peroxidase during grain filling in flag leaves of wheat subjected to drought stress, indicating that the gene products of these genes may play important roles in monocarpic senescence of wheat [8, 34-38]. The expression of 15 genes was up-regulated under heat, drought and combined stress condition in durum wheat by cDNA-AFLP [9, 39, 40]. Glutamine synthetase can be applied for the characterization of wheat cultivars in terms of drought stress tolerance as an indicator of drought stress [10, 41-44].
Molecular markers measure the genetic differences of the genome and may help as markers of different traits like drought tolerance [11, 45-47]. It was successively used in identifying drought tolerant cultivars in *Triticeae* [12,13, 48-51]. Identification of genes participating in drought tolerance reactions can help in understanding the biochemical and physiological basis of stress tolerance in wheat [14, 52-54]. Ali-Benali et al. [15, 55-58] stated that LEA proteins are encoded by multigenic families. Wheat seedlings contain group 3 LEA genes [16, 17, 59, 60].
LEA gene as a molecular marker was used to distinguish between the drought sensitive wheat cultivars from the drought tolerant ones. The expression of catalase, peroxidase and polyphenol oxidase genes in the four wheat cultivars was monitored under different water regimes using polyethylene glycol at three different concentrations (6.9, 13.75 and 27.5 g/l PEG 6000) at four time points (Zero point as control, 24 hours, 3 days and 7 days).

**Materials and methods**

Four wheat cultivars were kindly supplied by Wheat Research Center at Agricultural Research Center, Giza, Egypt and subjected to drought treatment at Biochemistry Department, Faculty of Science, King Abdulaziz University. Giza 168 and Sakha 93 wheat cultivars are drought tolerant, whereas Gemmiza 9 and Sakha 95 are drought sensitive. For drought stress experiment, seeds of the four wheat cultivars were germinated in small pots filled with organic soil for two weeks and then subjected to osmotic stress using polyethylene glycol (PEG 6000) under three different stress conditions according to Sané et al. [18], using polyethylene glycol at the following concentrations: 6.9, 13.75 and 27.5 g/l PEG 6000 for 4 time points (0 control, 24 hrs, 3days, and 7 days). Root and shoot material were harvested at each time point, frozen in liquid nitrogen, ground into a fine powder, and kept in -80ºC until use.

**DNA extraction**

DNA of the four wheat germplasms under study was extracted from fresh growing leaves of 14-day age seedling using DNeasy Plant Mini Kit (250) from QIAGEN according to the instructions of the supplier.

**LEA gene PCR amplification**

**Primer design:**

The LEA gene (DQ663481) primer was designed by Wang et al. [19] and constructed by Metabion International AG, D-82152 Martinsried, Germany. LEA Gene primer sequence is as follows:

**LEA forward primer:** 50-ATGGCTCGCTGCTCTTACTC-30,

**LEA reverse primer:** 50-TCAGTGAGAGGATCGATTGAAC-30

**PCR condition**

LEA gene was amplified in a volume of 25 µl, containing 50 ng genomic DNA in 2 µl, 2.5 µl 10X PCR buffer, 1.5 µl of 25 mM $MgCl_2$, 1 µl of the forward and reverse primers (250 nM), 2 µl of 0.2 mM dNTPs (from Promega) and 0.3 µl *Taq* DNA polymerase (GoTaq Flexi DNA polymerase from Promega) and 14.7 µl bidistilled sterilized water. Amplification was achieved as described by Temnykh et al. (2000). Briefly, 5 min at 94°C followed by 35 cycles of 1 min 94°C, 1 min 55°C and 2 min at 72°C, with a final extension of 5 min at 72°C. The PCR product was photographed after resolving on 1.5% agarose gel against 1 kb DNA ladder.

**Antioxidant enzymes measurements**

**Preparation of crude extract**

1 g of frozen seedling was homogenized in 20 mM Tris–HCl buffer, pH 7.2 using homogenizer, and then centrifuged at 10,000 rpm for 10 min at 4ºC. The supernatant is the crude extract was then transferred and stored at -20 ºC for further analysis.

**Catalase assay**

Catalase activity was assayed according to Bergmeyer [21].

**Peroxidase assay**

Peroxidase activity was assayed according to the method of Yuan and Jiang [22].

**Polyphenol oxidase assay**

Polyphenol oxidase assay (PPO) activity was assayed with catechol as a substrate according to the method of Jiang et al. [23].

**Statistical analysis**

All data were analyzed using the SPSS (Statistical Program for Sociology Scientists) Statistics Version 17.0 to calculate the mean values and the standard errors (SE). In addition, analysis of variance (ANOVA) was calculated using Duncan's Multiple Range Test [24].

**Results**

**LEA gene**

Figure (1) shows the PCR amplification of the genomic DNA of the studied wheat cultivars using the specific LEA gene primers. A 700 bp band presents only in the drought tolerant wheat cultivars (Giza168 and Sakha93) and absent in the drought sensitive ones (Gemmiza9 and Sakha95).

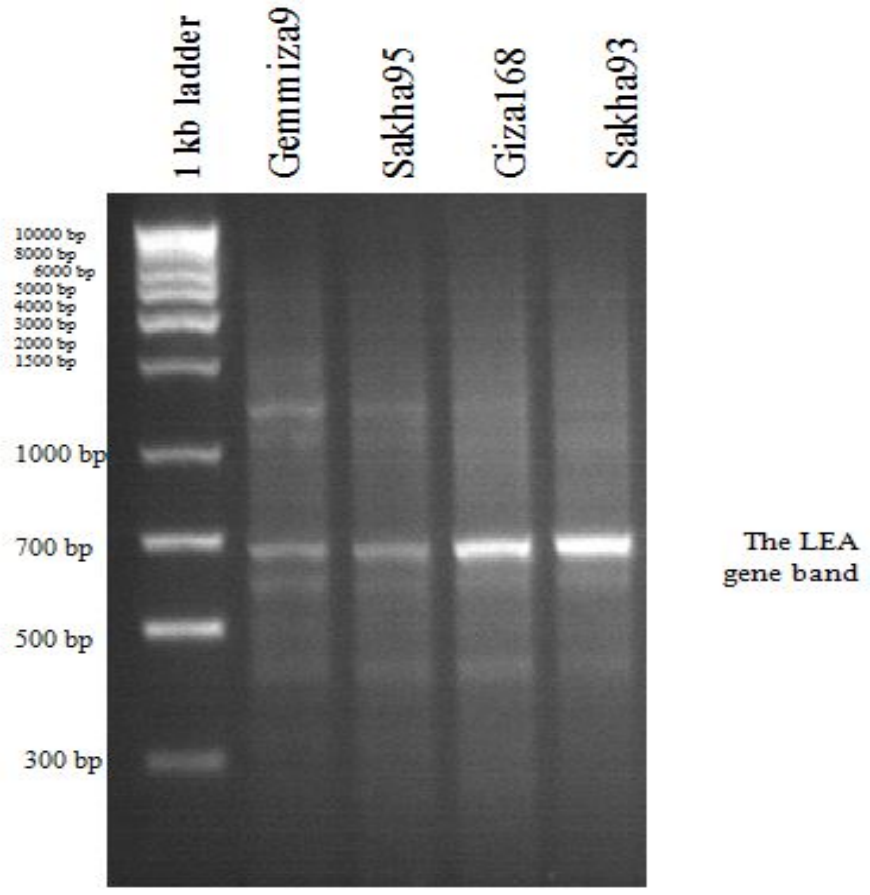


**Figure (1):** The amplified LEA gene in the studied wheat gemplasm.

Previous studies correlated drought tolerance in wheat to the expression of LEA gene that participate in drought adaptation and provide an integrated understanding of the biochemical and physiological basis of stress responses [14,15].

**Catalase activity**

Table (1) and Figure (2) show mean values of catalase activity in the studied wheat cultivars seedlings under drought stress induced by PEG treatment. At the zero time point the activity of catalase in the sensitive wheat germplasms (Gemmiza9 and Sakha95) was higher than that of the tolerant ones (Giza168 and Sakha93). After 24 hours of treating the seedlings with the lowest PEG concentration (6.9 g/l PEG), the activity of catalase was significantly increased in the drought sensitive and the drought tolerant cultivars compared with the activity of the zero-time point. Gemmiza9 showed the lowest catalase activity, whereas Sakha93 showed the highest one. After 3 days, the catalase activity was also significantly increased in all wheat cultivars. The sensitive cultivars showed higher activity than the tolerant ones. In contrast, Sakha93 showed the lowest catalase activity compared to its value after 24 hours. After seven days of PEG treatment using the lowest concentration, the sensitive cultivars showed the highest catalase activity compared with the tolerant ones. Sakha93 showed the lowest catalase activity, whereas Sakha95 showed the highest catalase activity.

**Table (1):** Catalase activity of the studied wheat cultivars under different drought condition induced by three concentrations of PEG for different time periods.

| Catalase U/g/min | Treatments / Statistics | 6.9 g/l PEG | | | | 13.75 g/l PEG | | | 27.5 g/l PEG | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Zero time | 24 h | 3 days | 7 days | 24 h | 3 days | 7 days | 24 h | 3 days | 7 days |
| Gemmiza9 Sensitive | Mean±SE | 86.00± 3.46$^{a}$ | 96.00± 1.15$^{b}$ | 120.00± 1.15$^{a}$ | 165.33± 2.90$^{a}$ | 97.60± 1.45$^{a}$ | 124.00± 2.08$^{a}$ | 174.00± 2.08$^{a}$ | 101.00± 2.08$^{a}$ | 132.33± 1.45$^{a}$ | 181.67± 3.75$^{a}$ |
| Sakha95 Sensitive | Mean±SE | 90.00± 1.15$^{a}$ | 100.00± 0.57$^{b}$ | 120.00± 0.57$^{a}$ | 186.00± 3.46$^{b}$ | 108.00± 1.15$^{b}$ | 130.00± 2.8$^{b}$ | 193.00± 1.73$^{b}$ | 110.00± 1.15$^{b}$ | 135.33± 1.45$^{b}$ | 200.00± 0.57$^{b}$ |
| Giza168 Tolerant | Mean±SE | 74.00± 0.57$^{b}$ | 100.00± 1.73$^{b}$ | 116.00± 0.57$^{b}$ | 153.00± 1.73$^{c}$ | 107.00± 1.15 $^{b}$ | 118.00± 0.57$^{bc}$ | 155.00± 2.88$^{c}$ | 113.00± 0.57$^{b}$ | 129.00± 0.5$^{bc}$ | 167.00± 0.57$^{bc}$ |
| Sakha93 Tolerant | Mean±SE | 73.00± 0.57$^{b}$ | 117.00± 1.15$^{c}$ | 89.00± 0.57$^{c}$ | 118.00± 1.15$^{d}$ | 133.00± 1.73$^{c}$ | 155.00± 2.88$^{c}$ | 138.00± 1.73$^{d}$ | 142.00± 1.15$^{c}$ | 161.00± 0.57$^{c}$ | 175.00± 2.88$^{c}$ |
| LSD 0.05 | | 6.824 | 2.233 | 2.306 | 9.667 | 5.126 | 8.535 | 8.578 | 4.790 | 3.752 | 9.105 |

Means values within a row not sharing a common superscript letter (abcd) were significantly different at $P < 0.05$ by ANOVA. LSD= Least significant difference.

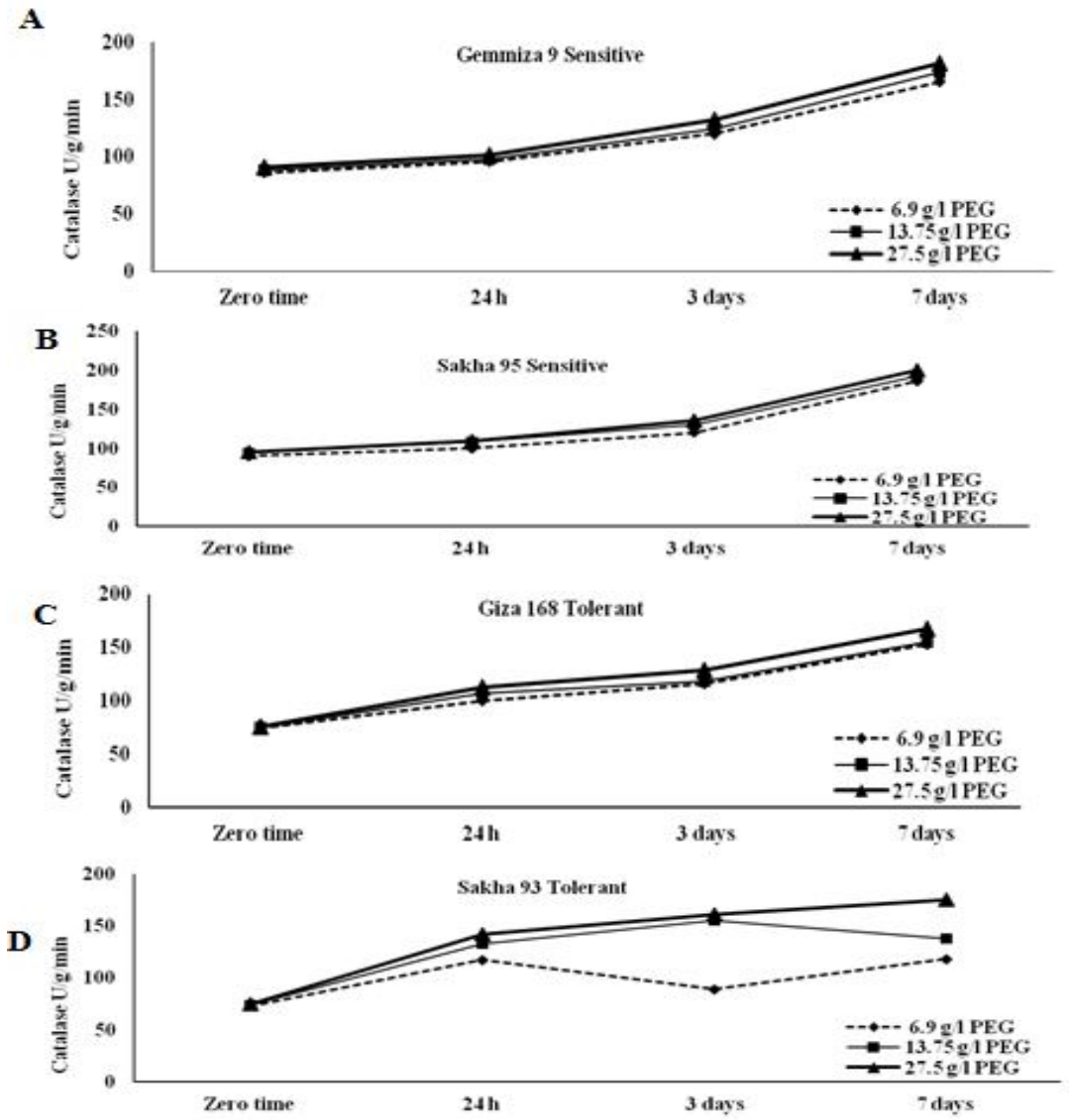


**Figure (2):** Catalase activity of the studied wheat cultivars as a result of drought stress using 3 different PEG concentrations for 7 days. A: Gemmiza9 (Drought sensitive cultivar), B: Sakha95 (Drought sensitive cultivar), C: Giza168 (Drought tolerant cultivar) and D: Sakha93 (Drought tolerant cultivar).

Table (1) and Figure (2) show also that, treating the seedlings with 13.75 g/l PEG concentration for 24 hours significantly increased the activity of catalase in the drought sensitive and the drought tolerant wheat cultivars compared with the activity at the zero-time point. Gemmiza9 showed the lowest catalase activity, whereas Sakha93 showed the highest one. After three days of PEG treatment, the catalase activity was also significantly increased in all wheat cultivars. Giza168 showed the lowest catalase activity, whereas Sakha 93 showed the highest catalase activity. After seven days, the sensitive cultivars showed the highest catalase activity compared with the tolerant ones. Sakha 95 showed the highest catalase activity, whereas Sakha 93 showed the highest catalase activity.

Table (1) and Figure (2) show also that, using the highest PEG concentration (27.5 g/l PEG) after 24 hours, the activity of catalase was significantly increased in the drought sensitive and the drought tolerant cultivars compared with that at the zero-time point. Gemmiza9 showed the lowest catalase activity, whereas Sakha93 showed the highest one. After three days, the catalase activity was also significantly increased in all wheat cultivars as a result of drought stress induced by PEG. Giza168 showed lowest catalase activity, whereas Sakha93 showed the lowest catalase activity. In contrast, Sakha93 showed the lowest catalase activity compared to its value after 24 hours. After seven days of PEG treatment using the highest concentration, the catalase activity showed the highest values compared with other treatments. Sakha95 showed the highest catalase activity, whereas Giza168 showed the lowest activity.

This result agrees with that of Wang [25] who stated that catalase activity was increased in strawberry leaves subjected to drought stress and Huseynova [5] who stated that drought-tolerant wheat cultivars showed a significant increase in catalase, glutathione reductase and ascorbate peroxidase activity as a result of drought stress. It is also worthy to mention that the current result does not support that of Kar and Mishra [26] who noted that the activity of catalase decreased in rice leaves senescence stage as a result of drought stress.

**Peroxidase activity**

Table (2) and Figure (3) show mean values of peroxidase activity as a result of treating the wheat cultivars under study with different PEG concentrations for different time periods. At the zero-time point, the activity of peroxidase in the sensitive wheat germplasms (Gemmiza9 and Sakha95) was lower than that of the tolerant one (Giza168 and Sakha93). After 24 hours, the activity of peroxidase was significantly increased in the drought sensitive and the drought tolerant wheat cultivars compared with the activity at the zero-time point. Gemmiza9 showed the lowest peroxidase activity, whereas Sakha93 showed the highest one. After three days, the peroxidase activity was also significantly increased in all wheat cultivars. Giza168 showed the lowest peroxidase activity, whereas Gemmiza9 showed the highest one. After seven days of PEG treatment using the lowest PEG concentration, Sakha93 showed the highest peroxidase activity, whereas Gemmiza9 showed the lowest one.

**Table (2):** Peroxidase activity of the studied wheat cultivars under different drought condition induced by three concentrations of PEG for different time periods.

| Peroxidase U/g/min | Treatments / Statistics | 6.9 g/l PEG | | | | 13.75 g/l PEG | | | 27.5 g/l PEG | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Zero time | 24 h | 3 days | 7 days | 24 h | 3 days | 7 days | 24 h | 3 days | 7 days |
| Gemmiza9 Sensitive | Mean±SE | 491.00± 1.73$^{a}$ | 530.00± 2.88$^{a}$ | 980.00± 2.88$^{a}$ | 1038.0± 7.50$^{a}$ | 550.00± 4.04$^{a}$ | 1032.0± 4.04$^{a}$ | 1211.0± 3.46$^{a}$ | 671.00± 6.35$^{a}$ | 1100.0± 2.88$^{a}$ | 1392.0± 1.15$^{a}$ |
| Sakha95 Sensitive | Mean±SE | 436.33± 27.09$^{a}$ | 678.00± 4.04$^{b}$ | 855.00± 1.15$^{b}$ | 1392.0± 01.15$^{b}$ | 737.00± 4.04$^{b}$ | 950.00± 5.19$^{a}$ | 1545.7± 2.02$^{b}$ | 757.00± 1.73$^{b}$ | 1050.0± 5.77$^{b}$ | 1785.0± 1.73$^{b}$ |
| Giza168 Tolerant | Mean±SE | 579.00± 4.93$^{b}$ | 638.00± 8.08$^{c}$ | 658.00± 6.92$^{c}$ | 1315.0± 1.73$^{c}$ | 690.00± 5.77$^{c}$ | 922.00± 12.70$^{b}$ | 1654.0± 2.30$^{c}$ | 824.00± 15.01$^{c}$ | 1025.0± 14.43$^{c}$ | 1643.0± 1.73$^{b}$ |
| Sakha93 Tolerant | Mean±SE | 592.00± 2.30$^{c}$ | 768.00± 4.61$^{b}$ | 918.00± 1.15$^{b}$ | 1702.0± 4.04$^{b}$ | 966.00± 2.30$^{d}$ | 1056.0± 3.46$^{c}$ | 1635.0± 2.88$^{d}$ | 1103.3± 7.68$^{d}$ | 1179.0± 5.19$^{c}$ | 1641.0± 3.46$^{c}$ |
| LSD 0.05 | | 46.922 | 21.057 | 13.088 | 15.972 | 14.556 | 24.168 | 10.236 | 33.762 | 31.631 | 7.802 |

Means values within a row not sharing a common superscript letter (abcd) were significantly different at $P < 0.05$ by ANOVA. LSD= Least significant difference.

Table (2) and Figure (3) show also that, after 24 hours of treating the wheat cultivars seedlings with 13.75g/l PEG concentration, the activity of peroxidase was significantly increased in the drought sensitive and the drought tolerant wheat cultivars compared with the activity at the zero-time point. Gemmiza9 showed the lowest peroxidase activity, whereas Sakha93 showed the highest one. After three days, the peroxidase activity was also significantly increased in all wheat cultivars. Giza168 showed the lowest peroxidase activity, whereas Sakha93 showed the highest one. After 7 days of PEG treatment, Gemmiza9 showed the highest peroxidase activity, whereas Sakha95 showed the lowest peroxidase activity.

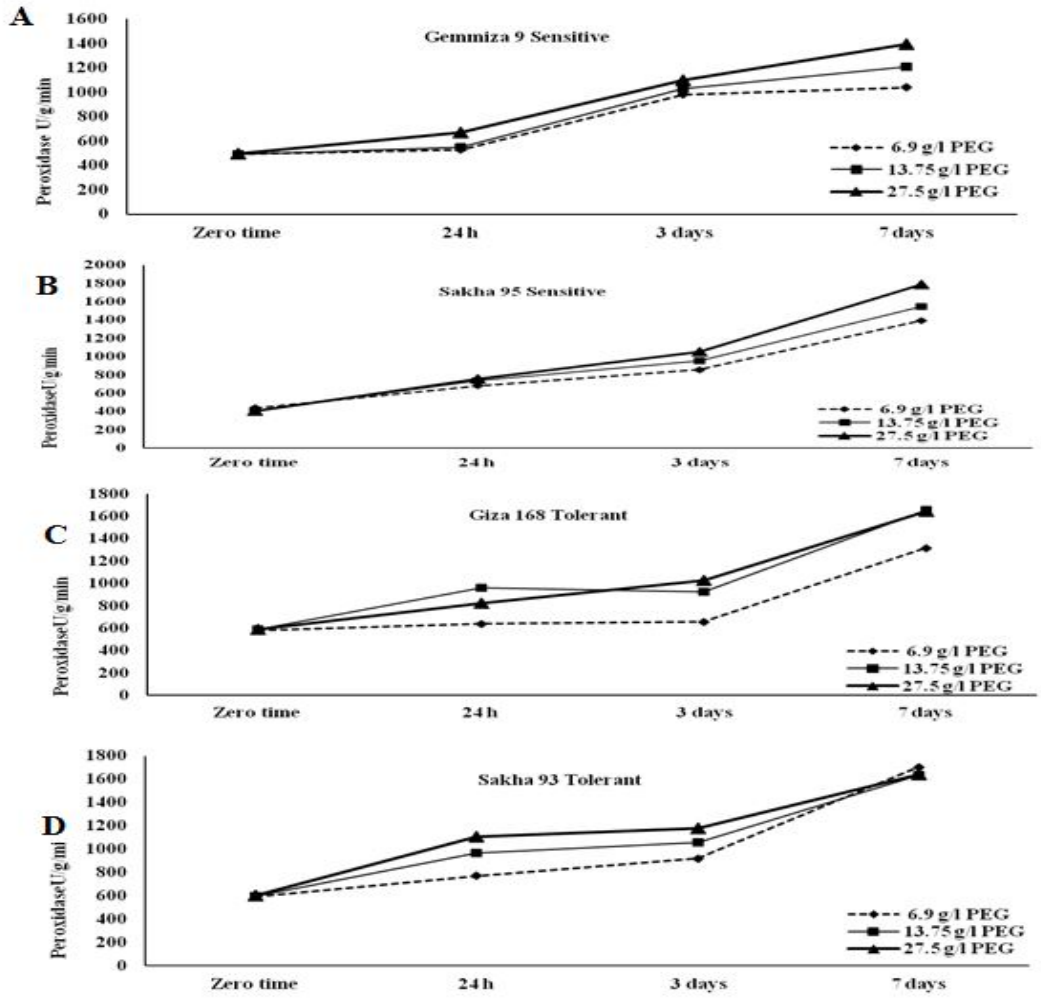


**Figure (3):** Peroxidase activity of the studied wheat cultivars as a result of drought stress using 3 different PEG concentrations for 7 days. A: Gemmiza9 (Drought sensitive cultivar), B: Sakha95 (Drought sensitive cultivar), C: Giza168 (Drought tolerant cultivar) and D: Sakha93 (Drought tolerant cultivar).

Table (2) and Figure (3) show also that, after 24 hours of treating the wheat cultivars seedlings with 27.5 g/l PEG concentration, the activity of peroxidase was significantly increased in the drought sensitive and the drought tolerant wheat cultivars compared with the activity at the zero-time point. Gemmiza9 showed the lowest peroxidase activity, whereas Sakha93 showed the highest one. After three days, the peroxidase activity was also significantly increased in all wheat cultivars. Giza 168 showed the lowest peroxidase activity, whereas Sakha93 showed the highest one. After seven days of PEG treatment, Sakha95 showed the highest peroxidase activity, whereas Gemmiza9 showed the lowest peroxidase activity.

The current result is supported by that of Kar and Mishra [26], Wang [25] and Huseynova [5]. On the other hand, Csiszár et al. [27] stated that peroxidase activity decreased under osmotic stress in the tolerant wheat cultivars than that of the sensitive cultivars.

**Polyphenol oxidase activity**

Table (3) and Figure (4) show the mean values of polyphenol oxidase activity under drought stress condition resulted from treating the wheat cultivars under study with PEG. At the zero-time point, the activity of polyphenol oxidase in Giza168 seedlings was the lowest value, whereas Sakha 93 was the highest one. After 24 hours of treatment with the lowest PEG concentration (6.9 g/l PEG), the activity of polyphenol oxidase was significantly increased in the drought sensitive and the drought tolerant wheat cultivars compared with the activity at the zero-time point. Gemmiza9 showed the lowest polyphenol oxidase activity, whereas Sakha93 showed the highest one. After three days of PEG treatment, the polyphenol oxidase activity was also significantly increased in all wheat cultivars. Gemmiza9 showed the lowest polyphenol oxidase activity, whereas Sakha93 showed the highest one.

After seven days of PEG treatment using the lowest PEG concentration, Giza168 showed the highest polyphenol oxidase activity, whereas Gemmiza9 and Sakha95 showed the lowest ones.

**Table (3):** Polyphenol oxidase activity of the studied wheat cultivars under different drought condition induced by three concentrations of PEG for different time periods.

| Polyphenol oxidase U/g/min | Treatments / Statistics | 6.9 g/l PEG | | | | 13.75 g/l PEG | | | 27.5 g/l PEG | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Zero time | 24 h | 3 days | 7 days | 24 h | 3 days | 7 days | 24 h | 3 days | 7 days |
| Gemmiza9 Sensitive | Mean±SE | 19.40± 0.11 [a] | 21.25± 0.01[a] | 27.10± 0.05 [a] | 40.40± 0.23 [a] | 21.70± 0.05[a] | 35.00± 0.57[a] | 48.00± 0.57[a] | 40.60± 6.30[a] | 39.50± 0.28[a] | 75.00± 1.15[a] |
| Sakha95 Sensitive | Mean±SE | 18.20± 0.05 [b] | 27.100± 0.05 [b] | 33.60± 0.11[b] | 40.00± 0.57 [b] | 31.25± 0.14[b] | 35.00± 1.15[a] | 45.80± 0.17[a] | 32.50± 0.11[a] | 48.40± 0.11[b] | 62.90± 0.23[b] |
| Giza168 Tolerant | Mean±SE | 12.40± 0.05 [c] | 33.30± 0.05[c] | 45.00± 0.11[c] | 71.00± 0.28[c] | 33.53± 0.17[c] | 48.40± 0.23[b] | 74.20± 0.46[b] | 50.40± 0.23[ab] | 79.60± 0.11[c] | 79.60± 0.34[c] |
| Sakha93 Tolerant | Mean±SE | 21.50± 0.05[d] | 40.00± 0.11[d] | 48.00± 0.23[d] | 58.40± 5.90 [c] | 41.00± 0.17[d] | 50.30± 0.17[b] | 73.75± 0.43[c] | 44.20± 0.11[b] | 73.00± 0.05[d] | 100.00± 0.63[d] |
| LSD 0.05 | | 0.251 | 0.276 | 0.450 | 9.815 | 0.541 | 2.118 | 1.967 | 10.741 | 0.623 | 2.705 |

Means values within a row not sharing a common superscript letter (abcd) were significantly different at $P < 0.05$ by ANOVA. LSD= Least significant difference.

Table (3) and Figure (4) show also the mean values of polyphenol oxidase activity under drought stress condition resulted from treating the wheat cultivars under study with 13.75 g/l concentration of PEG. After 24 hours of PEG treatment, the activity of polyphenol oxidase was significantly increased in the drought sensitive and the drought tolerant wheat cultivars compared with the activity at the zero-time point. Gemmiza9 showed the lowest polyphenol oxidase activity, whereas Sakha93 showed the highest one. After three days of PEG treatment, the polyphenol oxidase activity was also significantly increased in all wheat cultivars. Gemmiza9 showed also the lowest polyphenol oxidase activity, whereas Sakha93 showed the highest one. After seven days of PEG treatment, Giza168 showed the highest polyphenol oxidase activity, whereas Sakha95 showed the lowest one.

Table (3) and Figure (4) show also the mean values of polyphenol oxidase activity under drought stress condition resulted from treating the wheat cultivars under study with 27.5 g/l concentration of PEG. After 24 hours of PEG treatment, the activity of polyphenol oxidase was significantly increased in the drought tolerant cultivars than the drought sensitive ones and both of them was higher than that of the zero-time point. Sakha95 showed the lowest polyphenol oxidase activity, whereas Giza168 showed the highest one. After three days of PEG treatment, the polyphenol oxidase activity was also significantly increased in all wheat cultivars. Gemmiza9 showed also the lowest polyphenol oxidase activity, whereas Sakha93 showed the highest one. After seven days of PEG treatment, Sakha93 showed the highest polyphenol oxidase activity, whereas Sakha95 showed the lowest one.

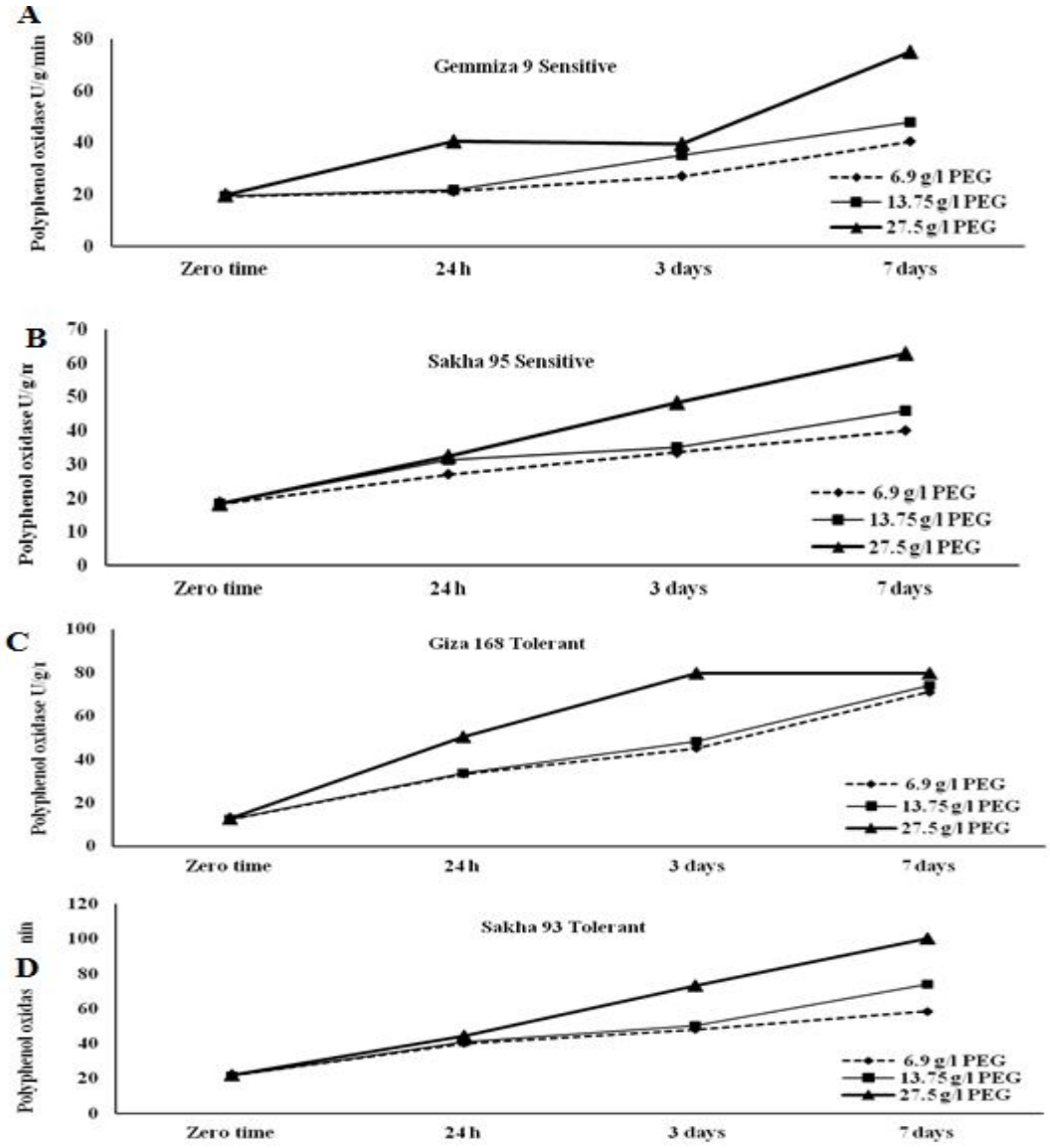


**Figure (4):** Polyphenol oxidase activity of the studied wheat cultivars as a result of drought stress using 3 different PEG concentrations for 7 days. A: Gemmiza 9 (Drought sensitive cultivar), B: Sakha95 (Drought sensitive cultivar), C: Giza 168 (Drought tolerant cultivar) and D: Sakha 93 (Drought tolerant cultivar).

The activity of polyphenol oxidase in all wheat cultivars under study was also increased as a result of increasing the concentration of PEG and also by increasing the time of treatment. The polyphenol oxidase activity was increased 3-5 folds more than that of the control value (zero point). This result is supported by that of Kar and Mishra [26] who noted that the activity of polyphenol oxidase increased in rice leaves senescence stage as a result of drought stress.

The enzymatic activity of the current study is in agreement with the theory that, plants produce a variety of antioxidants that counteract the generation of ROS in response to drought stress [28]. These include nonenzymatic antioxidants such as tocopherols, carotenoids, ascorbic acid, glutathione, and phenolics, as well as enzymatic antioxidants such as superoxide dismu-tase, catalase, and enzymes of the ascorbate/glutathione cycle [29] and various responses and adaptations are evolved that enable plants sustain growth and development under water-limited condition (Ashraf et al., 2011).

**Conclusion**

In conclusion, LEA gene is correlated to drought stress. Moreover, the activity of catalase, peroxidase and polyphenol oxidase in wheat seedlings of cultivars under study increased by increasing PEG concentration and the time.

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