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Yeast Extract and Lithovit Mineral Fertilizer Ameliorate the Harmful Effects of Drought Stress in Wheat

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THE effects of two levels of drought stress (25% and 50% of FC) and the control (75% FC) on the growth, some physiological processes and some metabolites in wheat (*Triticum aestivum*, cv. Masr 2) at seedling (30 days), vegetative (65 days) and yield (160 days) stages were studied. The ameliorative effects of the foliar spray for the harmful effects of drought by the bio-stimulant yeast extract (10%) or the mineral fertilizer lithovit (3.8%) were also studied. The results showed that both levels of drought stress decreased all of the measured growth criteria and chl a and chl b at both growth stages. The foliar spray with yeast extract or lithovit resulted in the alleviation of these inhibitory effects. Carotenoids increased with drought stress but decreased using both foliar spray treatments. Carbohydrates and total soluble proteins decreased under both drought levels, but using yeast extract or lithovit treatment alleviated these effects. Higher activities of catalase, peroxidase and ascorbic oxidase were recorded under the two stress levels, while yeast extract and lithovit treatments inhibited them. At yield stage, both drought levels resulted in severe reduction in all yield parameters, carbohydrates and total soluble proteins contents in the produced grains. Foliar spray with yeast extract or lithovit improved all the measured parameters of yield and increased the contents of the metabolites in the grains. Although lithovit was slightly more effective than yeast extract, the latter treatment seems preferable as it is a natural product with no apparent residual effects on plants and soil.

Keywards: Antioxidant, Drought stress, Lithovit, Wheat, Yeast, Yield.

Introduction

Wheat is a winter crop which belongs to the Poaceae, one of the most widely cultivated cereal crops in the world, and in Egypt, it is widely cultivated in the Nile Delta region (Cooper, 2015).

Drought is one of the main obstacles to seed germination which is affected by unfavorable moisture conditions due to lack of rainfall and/or irrigation (Bodner et al., 2015). A common adverse effect of water stress on crops is the reduction in their fresh and dry biomass (Jamal et al., 2014). However, water stress may induce an increase in root growth (Jaleel et al., 2008). Generally, when water availability is limited, the root/shoot ratio of plants increases because roots are less sensitive than shoots to growth inhibition by low water potentials (Aslam et al., 2013).

Photosynthesis, together with cell growth, is among the primary processes to be affected by drought which induces a large decline in total chlorophyll content in different crop species (Keyvan, 2010). It diminished the activities of Calvin cycle's enzymes, which are important causes of reduced crop yield (Dias & Brüggemann, 2010). Another important effect, that inhibits the growth and photosynthetic abilities of plants, is the loss of balance between the production of reactive oxygen species (ROS) and the antioxidant defense (Farooq et al., 2009).

To alleviate undesirable effects of ROS, plants have evolved a precise antioxidant defense system including SOD, CAT, POD, APX and GR, in addition to the non-enzymatic components as glutathione, ascorbic acid, flavonoids, carotenoids, phenolics, glycine betaine, non-protein amino acids and α-tocopherols (Lambeth & Neish,

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2014). These antioxidant defense systems control the cascades of uncontrolled oxidation and protect plant cells from oxidative damage by scavenging ROS. There are many reports underlining the close relationship between enhanced antioxidant enzyme activities and increased resistance to environmental stresses in several plant species (Kaushal et al., 2011; Molla et al., 2014).

The deficiency of water leads to severe decline in yield traits of crop plants probably by disrupting leaf gas exchange properties which not only limits the size of the source and sink tissues, but also impairs the phloem loading, assimilate translocation and dry matter portioning (Farooq et al., 2009). The spike length, number of grains per spike and weight of 100 grains were significantly decreased under drought stress in the drought susceptible wheat (Bano et al., 2012). Similarly, when maize plants were exposed to drought stress at seedling stage, substantial reduction was recorded in yield and yield components such as kernel number per row, 100 kernels weight and grain yield/plant (Anjum et al., 2011a**)**.

Yeast, as bio stimulant, is one of the richest sources of high quality protein, especially the essential amino acids, the essential minerals and trace elements such as Ca, Co, Fe, and also its extract is the best source of the B-complex vitamins and bio-constituents especially cytokinins (Hammad & Ali, 2014). The effect of elicitation with yeast extract depends on the dose and time of application, and it is used in agriculture for stimulating the plant defense mechanism (Ibraheim, 2014). The positive effect of yeast extract in alleviation of the deleterious effect of drought stress was observed by Kasim et al. (2017).

Lithovit (manufactured by Zeovita-GmbH, Berlin, Germany) and quantitatively analyzed by Wichmann & Basler (2006), who described it as a natural calcium carbonate foliar fertilizer supplemented with 12 different minerals which delivers fine particles (<10 µm) that can be easily adsorbed directly through the stomata of plant leaves. The positive effects of lithovit on plant growth and chemical constituents were reported by Abou-Shleell (2017). Plant height, leaf chlorophyll, fresh and dry weights of plants increased by lithovit treatments (Ghatas & Mohamed, 2018). The micronutrients supplied with lithovit such as Mn, Cu, Z, among others, influence plant physiology and metabolism and cell wall formation (Morsy et al., 2018).

The target of this study is to assess the deleterious effects of water stress on wheat (*Triticum aestivum* L., cv. Masr 2) at various growth stages, and might offer an effective comparison between the foliar spray of either yeast extract, as a natural growth-stimulants, or the ready-made commercial mixture of mineral nutrients called lithovit, on growth, some metabolic activities and yield of drought-stressed wheat.

Material and Methods

After complete seedling emergence (10 days), pots were divided into three main groups. The first group was irrigated with 75% field capacity (FC) and considered as control, the second group received 50% FC and considered as a moderate water stress, and the third one received 25% of the FC and considered as sever water stress. Each group was subdivided into three sub-groups: the sub-group of the control treatment was irrigated with only water without any treatment to the end of the growth season. The second sub-group received yeast extract with a concentration of 100g/ L as a foliar spray, while the third sub-group received lithovit as a foliar spray using a dose of 38g/ L as recommended by the manufacturer. All pots were irrigated with their corresponding FC every 8 days to the end of the growth season (160 days) and the foliar application of either yeast extract or lithovit was repeated at constant time intervals, every 8 days with the irrigation in the early morning to avoid wind effect till the end of the growth season.

At seedling (30 days) and vegetative (65 days) stages, samples (4 replica for each treatment) were collected, washed carefully and separated into roots and shoots. Some growth criteria (shoot height, root depth, fresh and dry weights of shoot and root and relative water content) were measured. Photosynthetic pigments (Chlorophyll a, chlorophyll b, and carotenoids) were determined according to Metzner et al. (1965). In the 3 stages of growth, the soluble sugars and starch contents were determined using the modified Nelson's method (1944) by Naguib (1963), and total soluble protein contents were estimated using the method described by Bradford (1976).

Three antioxidant enzymes, catalase (CAT, EC1.11.1.6], peroxidase (POD, EC1.11.1.7] and ascorbate oxidase (AO, EC1.10.3.3] were extracted according to Beauchamp & Fridovich (1971). CAT and POD were assayed according to Kato & Shimizu (1987), while AO was assayed according to Oberbacher & Vines (1963). At the end of the season (160 days), the yielded grains were harvested and the following yield parameters were recorded: spike length, number of spikelets/spike, spike weight, number of grains/plant, maturity % (no of mature grain/ no of grains) X 100, and the weight of 100 grains.

Results

Seedling and vegetative stages

Based on the results of a preliminary experiment, the most drought-tolerant wheat cultivar Masr 2 was selected for use in the study. Figures 1, 2 and 3 revealed that at seedling and vegetative stages, the growth criteria including shoot height, root depth, root and shoot fresh and dry weights, relative water content of root and shoot significantly decreased following the decreasing field capacity (50% and 25% FC). Meanwhile, data showed that all growth criteria significantly increased by the applied single doses of yeast (10%) or lithovit (3.8%) treatments, compared to the control (75% FC).

Figure 4 indicated that at seedling and vegetative stages Chl. *a* and Chl. *b* decreased remarkably with the increase in water stress. The largest decrease was attained at 25% FC, where the percentages of decrease of chl. a were 9.8% and 6.6% at seedling and vegetative stages, respectively; while for Chl. *b*, they were 12.4%, at seedling stage and 25.9% at the vegetative one, compared with the control. The application of either yeast extract or lithovit significantly mitigated the decline in both Chl. *a* & Chl. *b* of the water-stressed plant, compared to the corresponding non water stressed-samples, at the two growth stages.

The reducing sugars contents of shoot and root decreased significantly with the decrease of FC, in seedling and vegetative stages (Fig. 5). In shoot, their lowest content was attained at 25% FC with percentage of decrease 14.2% and 6.7% at seedling and vegetative stages, respectively. In root, the least content was attained at 25% FC, where the percentage of decrease was 7.9% and 6.4% at the seedling and vegetative stages, respectively. The application of yeast or lithovit resulted in increases of their values in root and shoot to be near to those of the stressed plants, at the two growth stages. Figure 5 also showed that, during both stages, sucrose content of shoot and root decreased with the decrease in FC, where the lowest shoot content was attained at 25% FC, with decrease percentages 9.4% and 13.8% at seedling and vegetative stages, respectively. Data showed that the foliar spray of yeast or lithovit, increased its content in shoot and root of the stressed plants, compared to the corresponding untreated-stressed samples, at the two growth stages.

At seedling and vegetative stages, Fig. 5 revealed that the starch contents of shoot and root decreased significantly following the decrease in FC. The lowest contents in shoot were recorded at 25% FC with 9.1 and 12.1% decreases in seedling and vegetative stages, respectively, compared to the control. In root, the lowest starch content were recorded at 25% FC, with decrease percentages of 16.5 and 27.7% at seedling and vegetative stages, respectively. Both yeast and lithovit treatments mitigated significantly the decline in starch content of shoot and root subjected to water stress, compared to the corresponding stressed samples.

The total soluble protein (TSP) contents of shoot and root increased slightly with the decrease in FC (Fig. 5) with percentages of 7.4% and 0.03%, respectively with 25% FC at seedling stage, relative to the control. Concerning yeast and lithovit treatments, data revealed that, at seedling stage, they improved TSP contents in shoot and root of the stressed wheat plants, compared to the corresponding untreated stressed samples. The highest TSP content was obtained with lithovit spray at 25% FC, compared to the control. At vegetative stage, TSP content of wheat shoot and root faintly decreased with the increase in FC and their lowest value were recorded in shoot and root at 25% FC, with percentages of 8% and 12.8%, respectively, compared to the control. However, the application of yeast extract or lithovit, retrieved these decreases in the water-stressed plants at this growth stage.

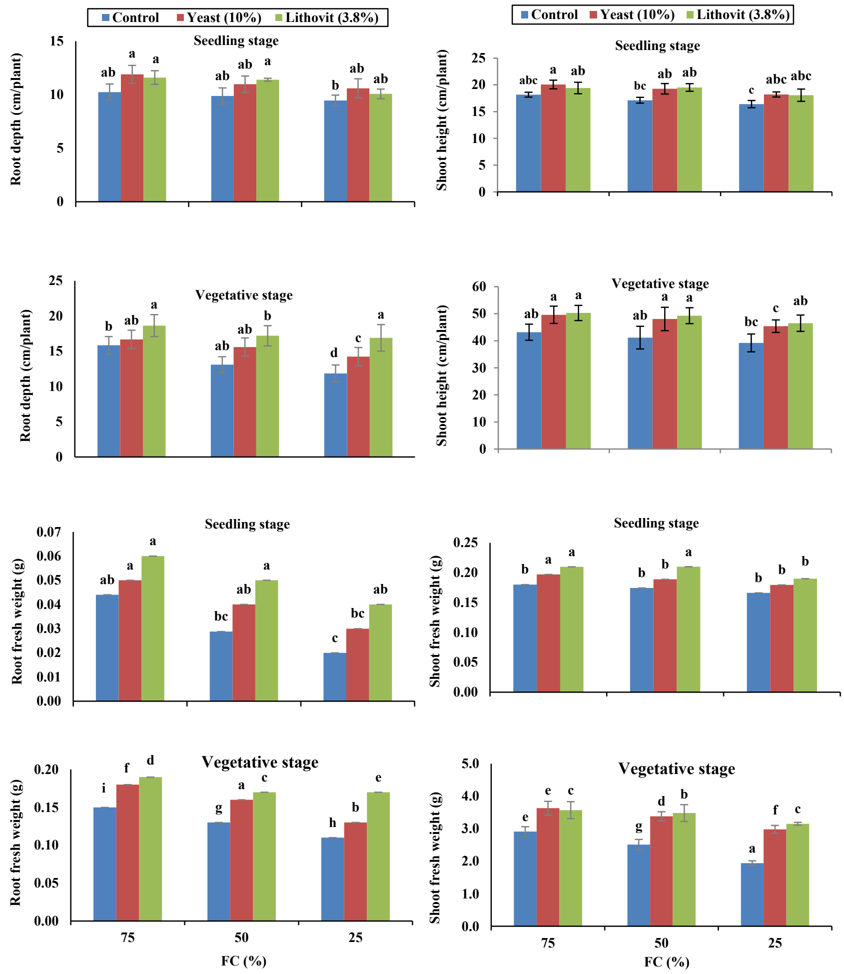

Fig. 1. Effect of water stress (75, 50 or 25 % field capacity, FC) on root depth, shoot height (cm/plant), root and shoot fresh weights (g/organ) of *Triticum aestivum* L. grown in clay-sandy soil (2:1 w/w) treated with yeast extract (10%) and lithovit (3.8%) at seedling (30 days) and vegetative (65 days) stages [Different letters mean that values are significantly different at 0.05 level].

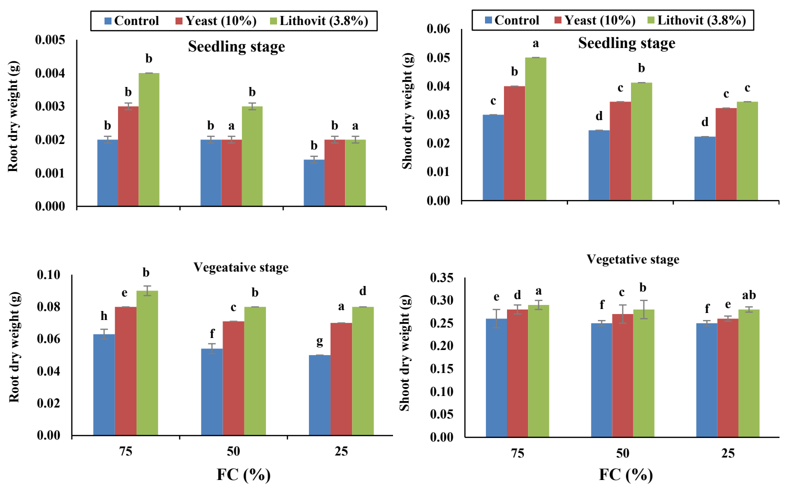

Fig. 2. Effect of water stress (75, 50 or 25 % field capacity, FC) on root and shoot dry weight (g/organ), root of *Triticum aestivum* L. grown in clay-sandy soil (2:1 w/w) treated with yeast extract (10%) and lithovit (3.8%) at seedling (30 days) and vegetative (65 days) stages [Different letters mean that values are significantly different at 0.05 level].

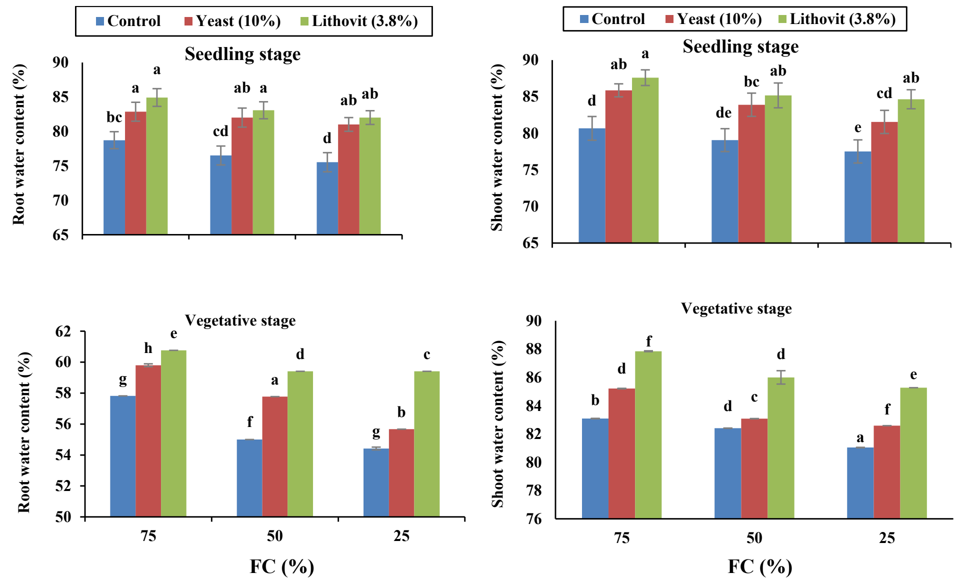

Fig. 3. Effect of water stress (75, 50 or 25% field capacity) on the % root and shoot water contents of *Triticum aestivum* L. grown in clay-sandy soil (2:1 w/w) treated with yeast extract (10%) and lithovit (3.8%) in the seedling (30 days) and vegetative (65 days) stages [Different letters mean that values are significantly different at 0.05 level].

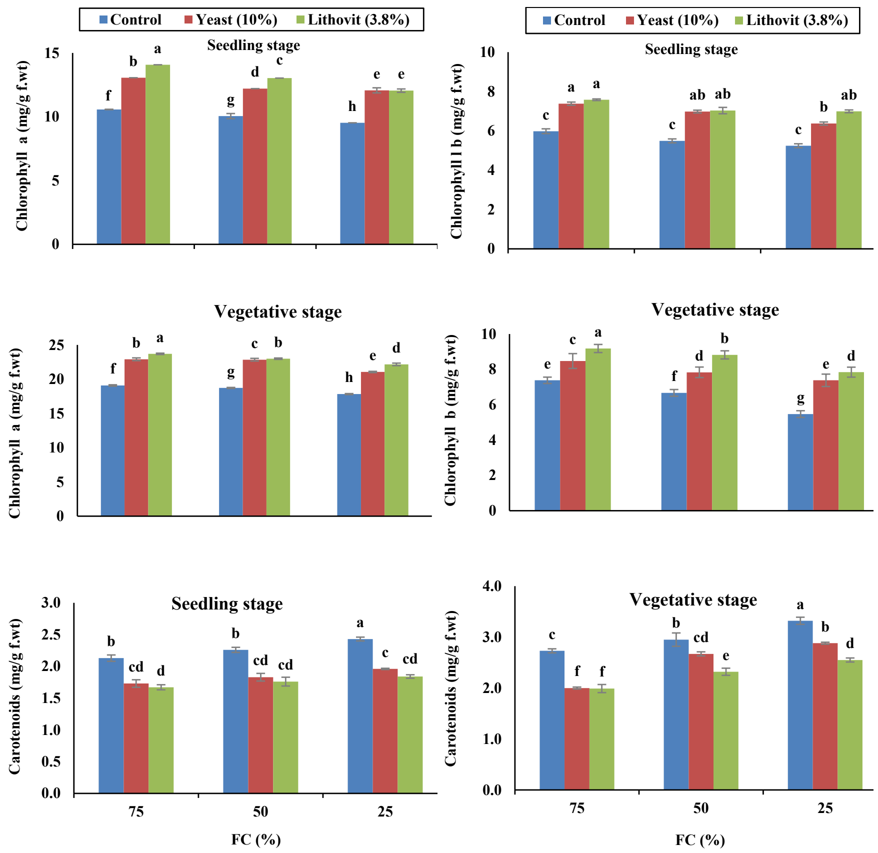

Fig. 4. Effect of water stress (75, 50 or 25 % field capacity FC) on chlorophyll (*a*), chlorophyll (*b*), and carotenoid contents (mg/g f.wt) of *Triticum aestivum* L. grown in clay-sandy soil (2:1 w/w) treated with yeast extract (10%) and lithovit (3.8%) at seedling (30 days) and vegetative (65 days) stages [Different letters mean that values are significantly different at 0.05 level].

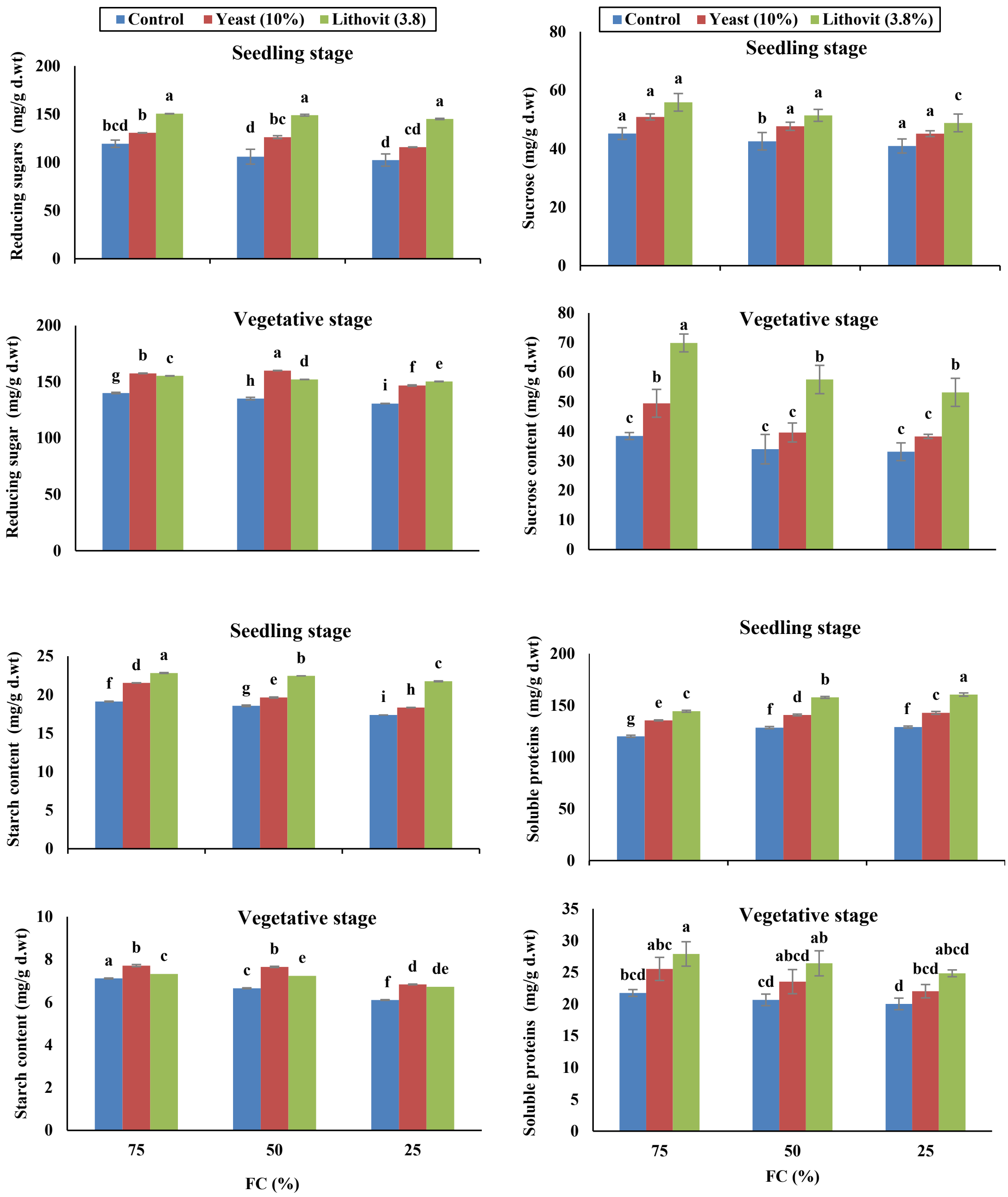

Fig. 5. Effect of water stress (75, 50 or 25% field capacity) on the reducing sugars, sucrose, starch, soluble proteins (mg/g d.wt) in the shoot of *Triticum aestivum* L. grown in clay-sandy soil (2:1 w/w) treated with yeast extract (10%) and lithovit (3.8%) at seedling (30 days) and vegetative (65 days) stages [Different letters mean that values are significantly different at 0.05 level].

Catalase (CAT) activity increased significantly with the increase in water stress (Fig 6). The highest activity was recorded at 25% FC with percentage of 27.3 and 25% increase, at seedling and vegetative stages, respectively, compared to the control. However, the application of yeast extract or lithovit resulted in the alleviation of these increases to be near those of the untreated water-stressed plants. Peroxidase (POX) activity increased with the increase in water stress (Fig. 6) and the highest value was recorded at the 25% FC which caused 22.4% and 21.1% more than the control at seedling and vegetative stages, respectively. Nevertheless, the use of any of yeast extract or lithovit with the water-stressed plants retrieved their enzyme activity, compared to the untreated stressed counterparts, at both growth stages.

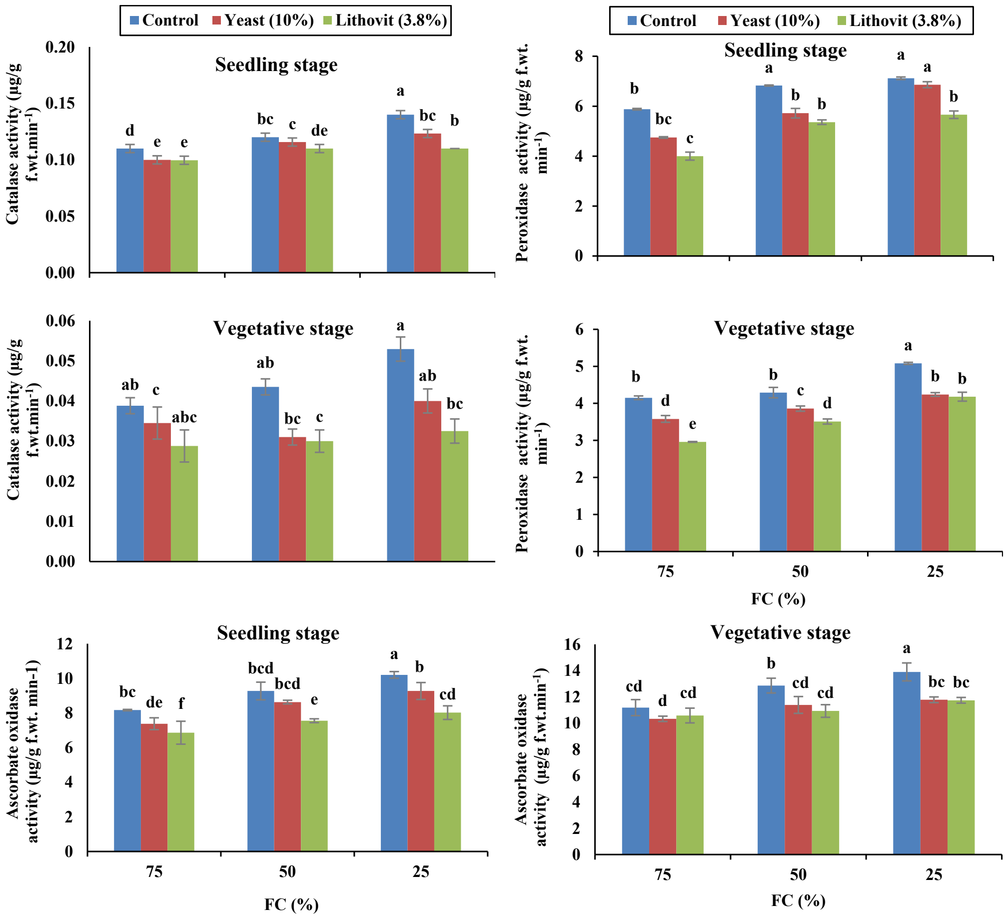

Fig. 6. Effect of water stress (75, 50 or 25 % field capacity, FC) on catalase, peroxidase, and ascorbate peroxidase activity (µg/g f.wt. min^{-1}) of *Triticum aestivum* L. grown in clay-sandy soil (2:1 w/w) treated with yeast extract (10%) and lithovit (3.8%) at seedling (30 days) and vegetative (65 days) stages [Different letters mean that values are significantly different at 0.05 level].

Figure 6 indicated an increase in the activity of ascorbate oxidase (AO) parallel to the increase in water stress at both growth stages. The highest activity was recorded at the highest water stress level (25% FC). This treatment lead to 24.8 % and 24.3% increase in AO activity at seedling and vegetative stages, respectively, relative to the control. On the other hand, AO activity decreased following the foliar spraying with yeast extract or lithovit to the water-stressed wheat plants, compared to the corresponding untreated water-stressed counterparts, at both growth stages.

Yield stage

As shown in Fig. 7 the yield parameters including spike length, number of spikelets/ spike, the weight of the spike, number of grains/ plant, maturity percentage, and the weight of 100 grains significantly decreased with the decrease in irrigation water level (increase of water stress) and the least values were attained at 25% FC. Nevertheless, the use of yeast extract (10%) and lithovit (3.8%) on the water-stressed plants increased all of these parameters, compared to the untreated stressed-plants.

Data in Fig. 8 revealed that sucrose and starch contents decreased in the produced grains in response to drought stress, while the reducing sugar increased. Using the foliar spray of yeast extract or lithovit with water stress ameliorated these harmful effects and increased all of these determinations to be near or more than those of the control plants.

Total soluble proteins in the produced grains decreased considerably following the decrease of FC (Fig. 8). Its lowest content was attained with 25% FC which caused a 10.2% decrease. However, its content in the grains of the stressed plants increased significantly with the treatment with yeast extract (10%) or lithovit (3.8%) with water stress levels, compared to the corresponding water-stressed samples.

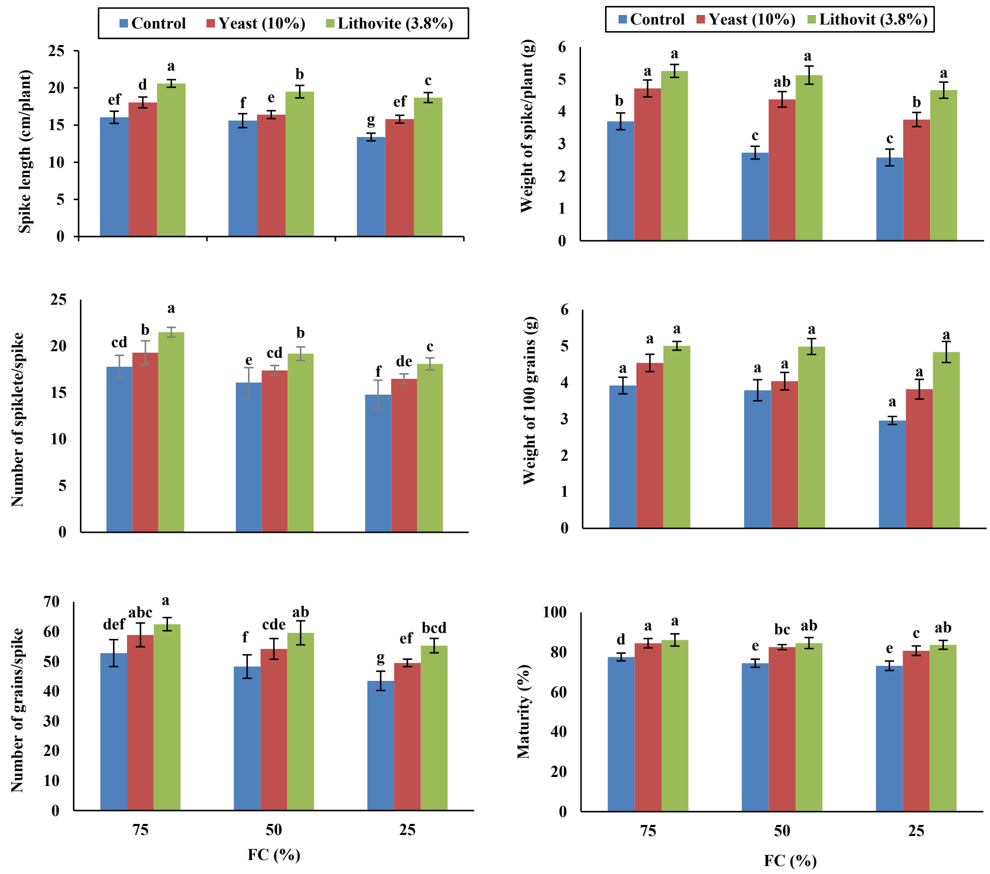

Fig. 7. Effect of water stress (75, 50 or 25 % field capacity, FC) on spike length (cm/spike), weight of spike/plant (g/plant), number of spike/plant, weight of 100 grains, number of grains/ spike and % maturity of *Triticum aestivum* (L.) grown in clay-sandy soil (2:1 w/w) treated with yeast extract (10%) and lithovit (3.8%) at yield (160 days) stage [Different letters mean that values are significantly different at 0.05 level].

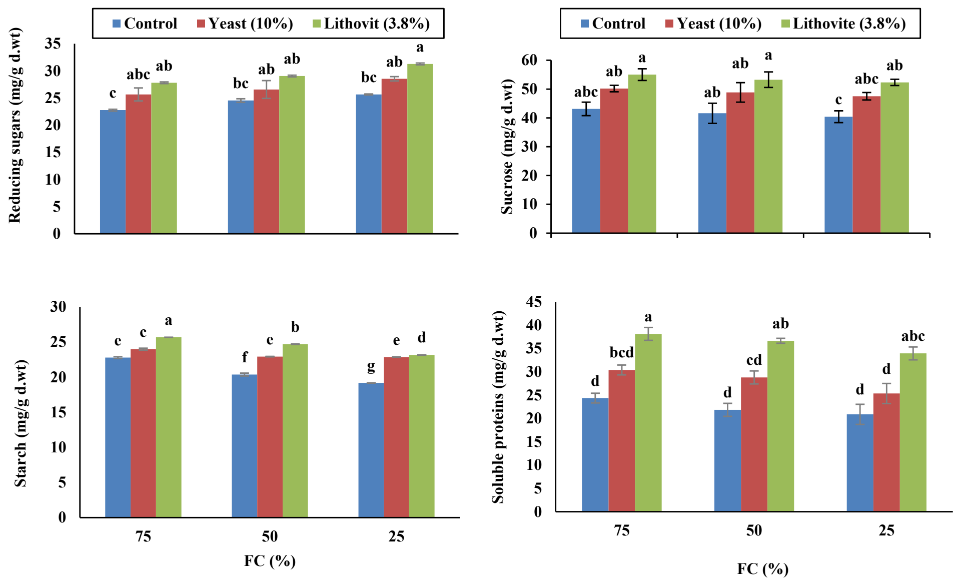

Fig. 8. Effect of water stress (75, 50 or 25 % field capacity) on the reducing sugars, sucrose, starch, and total soluble proteins (mg/g d.wt) in shoot of *Triticum aestivum* L. grown in clay-sandy soil (2:1 w/w) treated with yeast extract (10%) and lithovit (3.8%) at seedling (30 days) and vegetative (65 days) stages [Different letters mean that values are significantly different at 0.05 level].

Discussion

There was a decrease in the growth criteria of wheat (shoot height, root length, shoot and root fresh and dry weights) throughout this study following the exposure to the two levels of drought stress which are in agreement with the results of Singh et al. (2013) and Kumar et al. (2014). These reductions may be referred to the reduction in nutrients availability (Razmjoo et al., 2008) or to the physiological disturbance caused by the increase in osmotic stress which is associated with a decline in cell enlargement, cell turgor, cell volume and eventually cell growth (Shao et al., 2008).

The foliar spray treatment with yeast extract resulted in increasing all the measured growth attributes and this is in accordance with the results of Zaki et al. (2008) and Hammad (2008). This stimulatory effect of yeast extract may be because it is a natural source of many growth enhancing substances as thiamine, riboflavin, niacin, pyridoxine and vitamins B_1, B_2, B_3 and B_{12}, cytokinins (Hammad, 2008; Ibraheim, 2014), and also it has high contents of nutrient elements and growth regulators like auxins, gibberellins and cytokinins which stimulate cell division and enlargement, number of leaves and dry weights of leaves, stems and roots (Ahmed et al., 2011; Hammad & Ali, 2014). Furthermore, Arafa et al. (2013) indicated that the application of yeast extract induced the uptake and accumulation of some essential mineral nutrients in the shoot and root of several plant species via stimulating root system growth, increasing proliferation of root hairs and production of smaller but more ramified secondary roots.

The chemical fertilizer lithovit is a mixture of important nutrients such as Ca, Mg, Al, Si, Cu, Zn, Fe, Mn, Ni and other minerals, which increase the value of agricultural products and minimize environmental problems (Zhu et al., 2008). The foliar application of lithovit resulted in increasing growth parameters of water-stressed wheat plants. This result is in accordance with those of Farouk (2015) and Ghatas & Mohamed (2018). This stimulatory effect of lithovit may be referred to the positive influence of this mineral fertilizer on some seedling morphological features as leaf number, length and width, as well as shoot height (Sabina, 2013). It easily penetrates plant tissues through stomata and improves the biological and physiological processes of wheat plants (Mardalipour et al., 2014). The increased plant growth under the effect lithovit spray may be also due to the increased carbon assimilation, biomass and leaf area of plants due to elevated CO_2 concentrations and assimilation (Maswada & Abd El-Rahman, 2014).

A significant decline in photosynthetic pigments after the exposure of wheat to drought stress was recorded which is similar to that of Anjum et al. (2011b) on maize. This decline may be attributed to the decreased stomatal CO_2 absorbability, decreased rate of photosynthesis, pigment photo-oxidation, chlorophyll degradation, loss of chloroplast membranes (Abass & Mohamed, 2011), or deterioration of thylakoid membranes (Kannan & Kulandaivelu, 2011). There was an evident increase in carotenoids content in the drought-stressed wheat plant. This result is in agreement with that of Mssacci et al. (2008). This increase may be because they are present in the plant cellular membranes as non-enzymatic scavengers to protect the membranes from oxidative damage caused by ROS and its increase help plants to resist drought stress. (Jaleel et al., 2009).

Using yeast extract as spray, there was an increase in the content of total photosynthetic pigments in the leaves of the drought-stressed wheat which is in harmony with the results of Alaei (2011). The recorded increase of pigments may be due to the active role of yeast extract in the biosynthetic pathway of α-aminolevulinic acid, the precursor of chlorophyll biosynthesis (Hammad, 2008). Likewise, lithovit solution resulted in the increase of the photosynthetic pigments of the stressed plants which is in agreement with the results of Abd El-Ghafar et al. (2016) and Abdel Nabi et al. (2017). This increase may be because it is taken up directly through the stomata and is converted into carbon dioxide leading to enhanced photosynthetic efficacy (Carmen et al., 2014). Lithovit contains an amount of micro- and macro-nutrients, like Mg and Fe; where Mg rapidly penetrates the leaves and plays an important role in chlorophyll biosynthesis and in the number of chloroplasts/cell which significantly increases the concentration of photosynthetic pigments (Attia et al., 2016). Moreover, Fe plays an important role in photosynthetic reactions, activates several enzymes and improves the performance of photosystems (Sheykhbaglou et al., 2010).

Drought stress decreased the content of carbohydrate, soluble sugars and starch contents in wheat, which is concomitant with the results of Akinci & Losel (2010) and Ebeed et al. (2019). This alteration may act as a set of metabolic signals in the response to drought stress, where the role of these sugars in this signaling is affected variously by stress intensity, either in their accumulation or decrease in their concentrations (Lisar et al., 2012). However, the resultant reduction in the soluble proteins under drought stress may be because of either the protein degradation into amino acids as a result of increased activity of protease or other catabolic enzymes, or to the fragmentation of proteins due to toxic effects of reactive oxygen species (Mafakheri et al., 2011).

The application of yeast extract and lithovit reversed the effect of stress and increased carbohydrate concentration in the drought-stressed wheat which is in accordance with the results of Abbas (2013). This stimulatory effect of yeast extract may be due to its content of trehalose-6-phosphate synthase which is a key enzyme for trehalose biosynthesis that affects sugar metabolism and osmo-protection against several environmental stresses by balancing the osmotic strength of the cytosol with that of the vacuole and the external environment (Farouk, 2015).

The recorded increase in reducing sugars, sucrose and starch in stressed plants treated with lithovit spray is analogous to the results of Abo-Sedera et al. (2010), which may be due to that lithovit contains Mg, the prosthetic group of chlorophyll molecules and it is essential for the metabolism of carbohydrates, where it facilitates their translocation (Abo-Sedera et al., 2016; Attia et al., 2016). In addition, it contains P, as pyridoxal, is essential for the biosynthesis of chlorophyll and is also involved in the biosynthesis of phosphoglycric acid which plays an important role in CO_2 conversion to sugar; i.e. P decomposes carbohydrates produced in photosynthesis and leads to an increase in sugars. Lithovit also contains Ca which aids in carbohydrate translocation (Attia et al., 2016), and Zn which plays a crucial physiological role in enzymes and proteins involved in photosynthesis (Tsonev & Lidon, 2012). The increase in protein content due to lithovit sprays may be due to that it increased the synthesis of new proteins and/or inhibition of proteolytic activities and RNase activities (Hassan et al., 2011).

The exposure of wheat plants to drought stress caused a pronounced increase in the activities of CAT, POD and AO. These findings agreed with those of Akram et al. (2012) and Abbaspour (2012). This increase helps to face the effects of water stress through scavenging the free radicals and alleviates their damaging effects (Li et al., 2012). A decline in the antioxidant enzymatic activities by yeast extract spray was recorded in the drought stressed wheat which is concomitant with the results of El-Ghinbihi & Hassan (2007). Many of the effects of yeast extract, as a bio stimulant, are based on their ability to influence the hormonal activity of plants (Su et al., 2017) which can alter the plant's hormonal status and have a major influence on its growth and health, and act as a hormonal and nutritional increment factor (Vasconcelos & Chaves, 2019).

Lithovit decreased the activity of CAT, POD and AO, which is in accordance with the results of Ghaderi et al. (2015) and Attia et al. (2017). This effect of lithovit might be due to its Fe content which is involved in mitochondrial respiration, hormone biosynthesis, scavenging of reactive oxygen species and osmo-protection (Marschner, 2012). The suitable amount of Zn in lithovit is a necessary component of various enzyme systems for energy production and growth regulation (Mozafari et al., 2018).

Drought stress resulted in a severe decline in all yield parameters of wheat which is in agreement with the results of Anjum et al. (2011b). These reductions may be attributed to the disturbed nutrient uptake efficiency and photosynthates translocation within the plant (Farooq et al., 2009). The increased antioxidant enzymes and H_2O_2 with drought stress lead to a severe decline in yield traits of crops via disrupting leaf gas exchange, limiting the size of the source and sink tissues, impairing phloem loading, assimilate translocation and dry matter partitioning, stomatal closure and decrease of the intake of CO_2 and photosynthesis rate (Waseem et al., 2011).

The foliar application of yeast extract or lithovit increased all the yield characteristics which are in line with the results of Bakhtiari et al. (2015) and Abd El-Ghafar et al. (2016). The enhancing influence of yeast extract on yield characteristics may be ascribed to its stimulative effect on photosynthesis, and to its high concentration of some promoter hormones such as cytokinin which is involved in cell division, and the formation of proteins, carbohydrates and chlorophyll (Farouk, 2015). Moreover, the presence of vitamin B_{12} and minerals in yeast extract might play a role in the orientation and translocation of metabolites from leaves into reproductive organs (Dromantiene et al., 2009). The stimulatory effect of lithovit may be due to its components of $CaCO_3$ and $MgCO_3$, which can penetrate rapidly into plant tissues through the stomata and play vital roles in biological and physiological processes of wheat plants such as high photosynthetic rates which increased the amount of carbohydrates in the grains, which in turn leads to improved grain quality (Attia et al., 2018; Gangwar & Lodhi, 2018).

Conclusion

This study showed that drought stress reduced wheat growth and development, leading to hampered production and grain filling, and thus smaller and fewer grains. The application of foliar spray of lithovit gave slightly better results than that of the yeast extract in the alleviation of the negative effects of drought stress on wheat. However, the yeast extract treatment at a dose of 10% g/L seems preferable to recommend to wheat growers as it is a natural product with no apparent residual effects on the plants and the soil.

Competing interests: The authors declare that they have no competing interests.

Author contributions: WK, TH and KS all equally participated in the design, experimental set up writing, and editing of the manuscript. WK revised the final version.

Ethical approval: Not applicable.

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مستخلص الخميرة وسماد الليزوفيت المعدنى يحسنوا من الاثار الضارة لإجهاد الجفاف فى نبات القمح

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فى تجربة فى الأصص فى الصوبة الزراعية تمت دراسة تأثير مستويين من الجفاف بالرى بنسبة 25% و 50% وكذلك المعاملة القياسية 75% من القدرة الاستيعابية الحقلية FC على النمو، بعض العمليات الفسيولوجية وبعض مركبات الأيض فى نبات القمح صنف مصر2 فى مرحلة البادرة (30 يوم)، المرحلة الخضرية (65 يوم) ومرحلة المحصول (160 يوم). وقد تمت أيضا دراسة علاج التأثير الضار للجفاف باستخدام الرش الورقى بمستخلص الخميرة كمحفز حيوى بتركيز 10% وسماد الليزوفيت المعدنى (3.8%). وقد أظهرت النتائج أن مستويى الجفاف انقصت معايير النمو المقاسة (ارتفاع الساق، طول الجذر، الوزن الغض والجاف للساق والجذر) وكلوروفيل أ، كلوروفيل ب فى كل من مرحلة البادرات والمرحلة الخضرية.وقد أدى الرش الورقى بمستخلص الخميرة والليزوفيت إلى تحسين هذه الاثار المثبطة. وقد زادت الكاروتينيدات مع معاملات الجفاف ولكنها نقصت مع معاملات الرش بمستخلص الخميرة والليزوفيت. وقد نقصت كمية الكربوهيدرات (السكر المختزل، السكروز، النشا) والبروتينات القابلة للذوبان مع مستويات الجفاف ولكن استخدام معاملات مستخلص الخميرة والليزوفيت أزال هذا التأثير.تم تسجيل نشاط عالى فى كل من انزيم الكاتاليز،البيرأوكسيديز، أسكوربيك أوكسيديز مع مستويى الجفاف بينما الرش بمستخلص الخميرة والليزوفيت ثبط هذه الزيادة. أما فى مرحلة المحصول، فقد نتج عن مستويى الجفاف نقص شديد فى معايير الإنتاجية، السكريات المختزلة، السكروز، النشا، والبروتينات الكلية القابلة للذوبان فى البذور المنتجة.

وعلى الرغم من أن سماد الليزوفيت كان أعلى قليلا من مستخلص الخميرة فى فاعليته فى إستعادة وتحسين النمو وصفات المحصول فى القمح المجهد بالجفاف فإنه يفضل إستخدام مستخلص الخميرة لانه منتج طبيعى لايترك اى اثار ظاهرة على النبات أو التربة.