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EFFECT OF SALICYLIC ACID AND ABSCISIC ACID ON MORPHO-PHYSIOLOGICAL AND ANATOMICAL CHARACTERS OF FABA BEAN PLANTS (*Vicia faba* L.) UNDER DROUGHT STRESS

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ABSTRACT

Two pot experiments were carried out during the two winter seasons of 2013/2014 and 2014/2015 under greenhouse conditions at the Department of Agricultural Botany, Faculty of Agriculture, Kafrelsheikh University, Egypt to investigate the influence of salicylic acid (1 mM) and abscisic acid (0.1 mM) on morpho-physiological characters and anatomical structure as well as yield characters of faba bean plants under drought stress. As a result of stress only, all studied morphological and anatomical characters as well as chlorophyll concentrations and yield components were decreased, whereas, electrolyte leakage was increased under drought stress. However, application of salicylic acid (SA) and abscisic acid (ABA) under drought stress significantly improved or increased all the mentioned characters except electrolyte leakage which was decreased. Application of SA and ABA under drought stress enhanced the anatomical characters of faba bean stem and leaflets, for instance, stem diameter, number of vessels/bundle in stem as well as leaf lamina thickness and average diameter of xylem vessel. Accordingly, the exogenous application of SA and ABA lead to minimize the harmful effect of drought stress and improve the morpho-physiological characters, stem and leaflets anatomy as well as yield components of faba bean plants even under drought stress.

Keywords: *Vicia faba* L., Drought, Salicylic acid (SA), Abscisic acid (ABA), Physiology, Anatomy, Productivity.

Abbreviations: Salicylic acid (SA), Abscisic acid (ABA), peroxidase (POD), catalase (CAT), Superoxide dismutase (SOD), reactive oxygen species (ROS).

INTRODUCTION

Faba bean (*Vicia faba* L. var. faba) belongs to the family Fabaceae and is one of the most important leguminous crops in Mediterranean Sea region. In Egypt, it is a major source of protein for human food and animal feeding and fits well to the low fertility soils of the region. Drought is one of the most environmental stresses threatening the crop production and the major causes of crop loss worldwide, reducing average yields for most major crop plants by more than 50% (Wang *et al*., 2003). It is critical factor during the flowering and grain-filling phases in wheat (Farooq *et al*., 2014). Abdel *et al*. (2006) found that drought reduced number of leaves, leaf area, number of flowers and pods/plant as well as number of seeds per pod in faba bean. Photosynthesis, respiration, translocation and ion uptake were decreased under drought stress. Drought stress lead to morphological, biochemical and anatomical modifications with a decrease in dry weight and leaf area as well as accumulation of organic compounds like proline and glycine betaine. The plant height, chlorophyll content and the growth duration as well as grain yield were decreased under drought stress (Anwar *et al*., 2015). Under drought stress, Elgmaal and Maswada (2013) found significant increase in electrolyte leakage on maize plant. Siddiqui *et al*. (2015) reported that drought stress affected growth parameters such as plant dry weight and leaf area in faba bean.

Salicylic acid (SA) is considered as a hormone-like substance and plays an important role in regulation of physiological process such as photosynthesis, ion uptake and transport, stress tolerance as well as membrane permeability (Noreen *et al*., 2009). Application of salicylic acid at concentration of 50 ppm led to enhancement of the plant growth and development (Azooz and Youssef, 2010), increased resistance to abiotic stresses in many plants and protects the plants from oxidative injury (Moosavi, 2012). Orabi *et al*. (2010) stated that salicylic acid at concentration of 1 mM regulates physiological adaptation and protects the plant from oxidative damage with an increase in antioxidant enzyme activities and a decrease in ROS level and lipid peroxidation. Application of SA protects the plants against abiotic and biotic stress as well as improves the plant growth and development (Hayat *et al*., 2010). In mung bean plants under drought stress, SA treatment led to increase plant height, number of pods and seeds/plant as well as 100 seeds weight (Ali and Mahmoud 2013). Foliar application of 1 mM SA caused an increase in chlorophyll a, b, carotenoids and total pigments of faba bean (Azooz *et al*., 2011). Application with SA at concentration of 0.5 mM significantly decreases the harmful effect of drought stress in wheat seedling (Kang *et al*., 2013), and also decreases electrolyte leakage in maize plants under salinity stress (Gunes *et al*., 2007).

Abscisic acid (ABA) is an important plant hormone that plays a key role in plant signaling system which helps the plant to perform function normally under water stress conditions (Ma *et al*., 2008). ABA play important roles in many physiological processes such as seed dormancy, induces stomatal closure, synthesis of storage proteins and lipids and defense against biotic factors. Under drought stress conditions the rates of ABA and electrolyte leakage were increased, while relative water content was decreased. Application of ABA at concentration of 10 µg l^{-1} led to increase in drought resistance on stressed faba bean plant (Abdel and El-Hamadany, 2010). ABA is produced in the guard cells and induces stomatal closure under drought stress (Lee and Luan, 2012) and significantly enhances the antioxidant enzymes activity in maize under water stress. It was established that the application of ABA increases tolerance to chilling stress by increasing superoxide dismutase and guaiacol peroxidase activities and related gene expression (Guo *et al*., 2012). Exogenously ABA at concentration of 100 µM/L protects maize plants against the drought stress (Zhang *et al*. 2012). Application of ABA and Proline in combination was more effective and improved growth parameters of faba bean (Ali *et al*., 2013). Electrolyte leakages of pretreated citrus leaves with ABA were decreased under freezing stress (Yang *et al*., 2013). The harmful effects of drought stress decreases with ABA treatment on *Pisum sativum* (Latif, 2014). ABA can be used to minimize the harmful effects of drought stress and regulates many processes in plant in addition to adaptation to biotic and abiotic stresses (Lim *et al*., 2015).

Therefore, this investigation was designed to enhance the morpho-physiological, anatomical and yield characters of faba bean plants with foliar spray with 1 mM of SA and 0.1 mM of ABA under drought stress.

MATERIALS AND METHODS

Two pot experiments were conducted during the two successive winter seasons of 2013/2014 and 2014/2015 under greenhouse conditions of Agricultural Botany Department, Faculty of Agriculture, Kafrelsheikh University, Egypt to study the effect of foliar spray with salicylic acid (SA) and Abscisic acid (ABA) on morpho-physiological and yield characters as well as anatomical structure of faba bean plant (*Vicia faba* L.) grown under water deficit stress. Plastic pots used in this investigation were 40 cm in diameter; each pot was filled with 10 kg clay soil. Seeds of faba bean Sakha 1 were obtained from Division legumes, Agricultural Research Station, Sakha, Egypt and sown on 21th October in the first season and 23rd October in the second one. Five seeds were sown in each pot and after 21 days from sowing, the seedlings were thinned to leave three seedlings per pot. Each pot was provided with 2gm calcium superphosphate (15.5% P_2O_5) mixed with the soil before sowing, while ammonium sulphate (20.5% N) at the rate of 1gm was added with the first irrigation and 1gm potassium sulphate (48% K_2O) was added after flowering. Other agricultural practices were done according to the recommended practices for faba bean in the vicinity. The irrigation intervals were 4 days, considered as a control (well watered), 7 days and 15 days. SA at concentration of 1 mM and ABA at concentration of 0.1 mM were sprayed twice at 30 and 40 days from sowing date.

Soil samples were taken for conducting some physical and chemical analysis according to A.O.A.C. (2005) and all data were shown in Table 1.

Table 1. Physical and chemical soil characteristics during both growing seasons.

Soil analysis	**2013/2014 season**	**2014/2015 season**
Physical analysis		
Sand %	17.45	15.80
Silt%	36.55	34.90
Clay %	46.00	49.30
Textural class	Clay	Clay
Chemical analysis		
Organic matter (%)	1.5	1.6
Avialable N (ppm)	33. 5	28.65
Avialable P (ppm)	12.7	11.45
Avialable K (ppm)	291.48	292.23
PH	8.2	8. 1

The experiment was made in a complete randomized design with three replicates. The treatments were seven as follows:

1-Control, plants irrigated every 4 days (well watered) and untreated with SA or ABA.
2-Plants irrigated every 7 days and untreated with SA or ABA.
3-Plants irrigated every 15 days and untreated with SA or ABA.
4-Plants irrigated every 7 days and treated with SA at 1 mM.
5-Plants irrigated every 7 days and treated with ABA at 0.1 mM.
6-Plants irrigated every 15 days and treated with SA at 1 mM.
7- Plants irrigated every 15 days and treated with ABA at 0.1 mM.

Samples were taken for morpho-physiological and anatomical studies at the age of 50 and 75 days from sowing date. Likewise, samples were taken at maturity for yield characters. Data were recorded as follows:

Morpho-physiological and yield characters

1- Plant height (cm).
2- Number of branches / plant.
3- Number of leaves / plant.
4- Leaf area (cm^2/ plant).
5- Number of flowers/plant.
6- Number of pods/plant.
7-Number of seeds/pod.
8-100 seeds weight (g).
9- Seed yield (g/plant)
10- Chlorophyll concentrations

Chlorophyll a and b concentrations as mg/g fresh weight of leaves were extracted. Leaves samples (0.5 g) were homogenized with acetone (90% v/v), filtered and make up to a final volume of 50 mL. Chlorophyll concentrations were calculated spectrophotometerically from the absorbance of extract at 663 and 645 nm according to Lichtenthaler (1987).

11- Electrolyte leakage

Twenty leaf discs ($1cm^2$) of faba bean leaves were taken randomly and placed individually into flasks each contained 25 mL deionized water. Flasks were shaken for 20 h at ambient temperature to facilitate electrolyte leakage from tissues. Initial electrical conductivity measurements were recorded for each vial using an Acromet AR20 electrical conductivity meter (Fisher Scientific, Chicago, IL). Flasks were then immersed in a hot water bath (Fisher Isotemp, Indiana, PA) at 80°C (176°F) for 1 h to induce cell rupture. The vials were again placed on the Innova 2100 platform shaker for 20 h at 21°C (70°F). Final conductivity was measured for each flask. Electrolyte leakage percentage was calculated as follow:

Initial conductivity/final conductivity x 100 according to Szalai *et al*. (1996) and as described by Hafez *et al*. (2014) and Abdelaa *et al*. (2014).

Anatomical studies

For anatomical studies, specimens 1 cm length from selected samples were taken during the second season 2014/2015 from the middle of fifth internode from stem tip and the fifth leaf (leaflet including the midrib 0.5 cm length) of faba bean plant at the age of 50 days from sowing. Samples were killed and fixed for at least 48 h in F.A.A. solution (5 ml glacial acetic acid, 10 ml formalin and 85 ml ethyl alcohol 70%). Samples were washed in 50% ethyl alcohol and dehydrated in a normal butyl alcohol series. The specimens were impeded in paraffin wax (56-58°C). Transverse sections (15 microns) thick were done with rotary microtome model 820, paraffin sections were fixed on the slides with albumin, stained with safranin light green combination and mounted in Canada balsam (Nassar and El-Sahhar, 1998). Slides were examined microscopically and photomicrographed.

Statistical analysis:

The obtained data for each studied character were subjected to appropriate statistical analysis according to O'Mahony (1986).

RESULTS AND DISCUSSION

Morphological characters of vegetative growth

The effects of SA and ABA on plant height, number of branches, number of leaves/plant and leaf area (cm^2) / plant of faba bean plants under drought stress are shown in Figure 1. Drought stress caused significant decreases in plant height, number of branches and leaves/plant as well as leaf area (Figure 1 A, B, C and D) in both seasons. This reduction in growth parameters may be due to the reduction of water flow from the xylem to the different cells, which regulates cell division, elongation and development as well as the decline in chlorophyll content and lipid peroxidation in the cell membrane.

These results are similar to those reported by (Hassan *et al*., 2011; Farooq *et al*., 2014 and Anwar *et al*., 2015). Interestingly enough that the maximum values of plant height, number of branches, number of leaves/plant and leaf area (cm^2) / plant were obtained with application of SA at 1 mM and ABA at 0.1 mM on faba bean plants irrigated every 15 days, while the lowest values of studied characters were recorded on plants which irrigated every 15 days and untreated with SA or ABA in both seasons. The pivotal role of SA on growth characters may be due to enhance activity of antioxidant enzyme which protects the plants from the oxidative damage, reducing ROS levels and lipid peroxidatin as well as ion leakage (Nazar *et al*., 2011). These results were in conformity with the observation of many researchers (Azooz, 2009 in faba bean and Aldesuquy *et. al*., 2013 in wheat). The presented data in Figure 1 (A,B,C and D) indicated the enhancement effect of ABA on plant height, number of branches, number of leaves and leaf area of faba bean plants under drought stress. This effect could be attributed to improve antioxidant enzyme activities such as CAT and increase proline content as well as induces stomatal closure to conserve water in the plant organs. Our results were supported by the obtained results with Guo *et al*. (2012); Yang *et al*. (2013) and Lim *et al*. (2015).

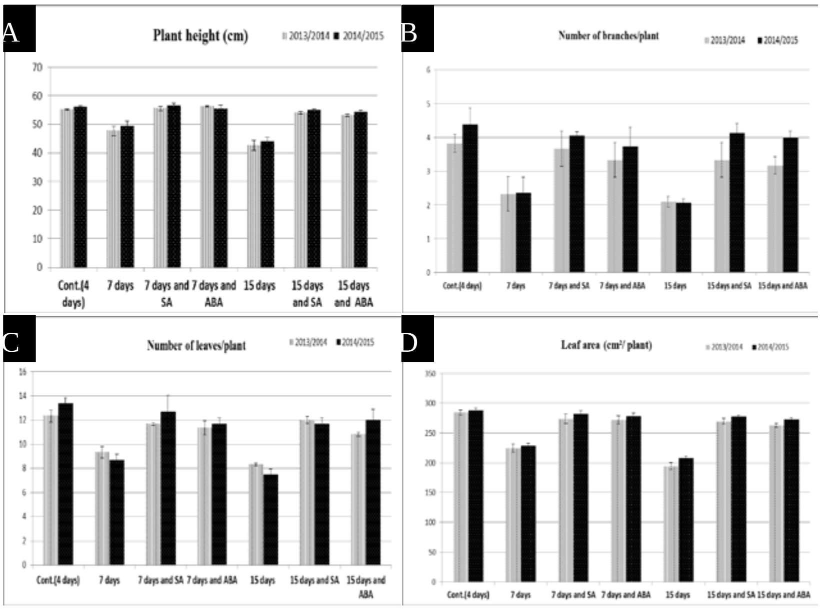

Fig. 1: Plant height, number of branches and leaves and leaf area of faba bean plants affected with salicylic acid and abscisic acid under drought stress during the two seasons 2013/2014 and 2014//2015

Details:- Control (4 days) (plants irrigated every 4 days and untreated with SA or ABA), 7 days (plants irrigated every 7 days and untreated with SA or ABA), 7 days and SA (plants irrigated every 7 days and treated with SA at 1 mM), 7 days and ABA (plants irrigated every 7 days and treated with ABA at 0.1 mM), 15 days (plants irrigated every 15 days and untreated with SA or ABA), 15 days and SA (plants irrigated every 15 days and treated with SA at 1 mM), 15 days and ABA (plants irrigated every 15 days and treated with ABA at 0.1 mM).

Yield characters

Data presented in Figure 2 (A,B,C,D and E) cleared that drought stress significantly decreased number of flowers and pods/plant, number of seeds/pod and 100 seeds weight (g), as well as seed yield (g/plant), whereas application of SA at 1 mM and ABA at 0.1 mM led to increases in these parameters of faba bean plant under drought stress in both seasons. The deleterious effect of drought on flowers number and pods may be due to the reduction of relative water content, total chlorophyll contents and efficiency of photosynthesis as well as translocation and ion uptake were decreased under drought stress. These results are in harmony with those obtained by Anwar *et al*. (2015) on faba bean plants. Al-Suhaibani (2009) mentioned that stressed faba bean plant significantly decreased seed weight (g/plant), 100-seed weight (g) and seeds yield (ton/fed). The useful effect of SA improves the relative water content and photosynthesis as well as increases the growth and seeds production on common bean plants

(Sadeghipour and Aghaei, 2012). In this concern, Hayat *et al*. (2010) reported that Salicylic acid induce flowering process in many plants. It is documented that application of SA led to increase number of pods and seeds/plant as well as 100 seeds weight of mung bean plants (Ali and Mahmoud 2013). Similar results were recorded by Elgmaal and Maswada (2013) on maize plants. Furthermore, the recorded data also showed that ABA at 10 µg l^{-1} significantly increased number of flowers and pods/plant, as well as number of seeds/pod and 100-seeds weight (g) as well as seed yield (g/plant) in the two growing seasons compared with stressed untreated plants (Fig. 2 A, B, C, D and E), however there were no significant deference when compared with the control. These results may be due to the significant role of ABA to induce stomatal closure, preserve water in plant organs and accumulate of amino acid as well as osmotic adjustment and enhance the antioxidant enzymes activity in many plants under drought stress. These results are in consistency with those reported by Lee and Luan (2012).

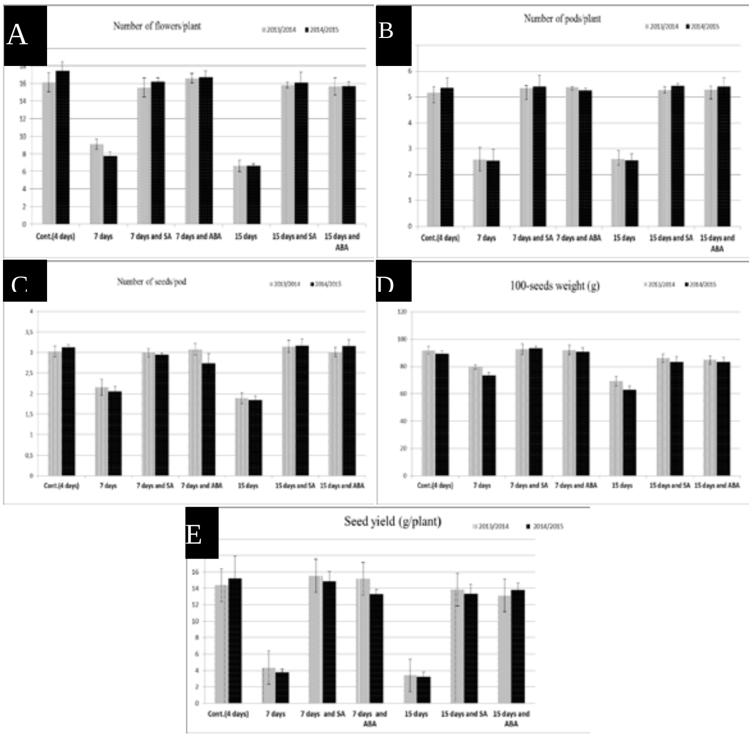

Fig. 2: Number of flowers and pods/plant, number of seeds/pod and 100-seeds weight (g) as well as seed yield (g/plant) of faba bean plants affected with salicylic acid and abscisic acid under drought stress during the two seasons 2013/2014 and 2014//2015.

Chlorophyll a, b concentrations and electrolyte leakage percentage

Referring to the effect of drought stress, data in Figure 3 showed that concentrations of chlorophyll a and b in faba bean plants were significantly decreased in plants which irrigated every 7 and 15 days and untreated with SA or ABA in both seasons (Fig. 3A and B). This effect may be due to the reduction in photo-assimilation rate (Matile *et al*., 1999) and oxidative damage to the chloroplasts as well as decline of the pigment protein complexes, in addition to disorganization of thylakoid membranes, formation of enzymes such as chlorophyllase, which is responsible for degrading chlorophyll (Sidiqii *et al*., 2015). Similar results were confirmed by Dawood *et al*. (2014) and Anwar *et al*. (2015). The presented data also showed significant increases in chlorophyll a and b concentrations in both seasons with treatments of SA and ABA under drought stress compared with control (irrigation every 4 days) and stressed untreated plants (irrigation every 7 and 15 days without SA or ABA treatments). The increases in chlorophyll concentrations were not significantly different between the plant irrigated every 7 and 15 days and treated with SA and ABA. The enhancement of chlorophyll concentrations may be due to the effective role of SA in increment nutrient contents in plant organs as well as improvement some physiological and biochemical processes such as photosynthetic capacity and antioxidant activity as well as increase leaves longevity. These findings correlate with those of Elgmaal and Maswada (2013). On the other hand, Gunes *et al*. (2007) mentioned that application of SA did not affect total chlorophyll concentrations in maize plants under salinity stress. Under water stress application of ABA lead to increase the chlorophyll concentrations in seedlings of bean, tobacco, beets, and corn (Haisel *et al*., 2006), The positive effect of ABA may be due to its role in protecting chlorophyll by decreasing chlorophyll degradation and also improves photosystem II and photochemistry (Haisel *et al*., 2006), as well as induces antioxidant enzymes activity such as catalase, peroxidase and polyphenol oxidase which increases chlorophyll concentrations (Abdelaal *et al*., 2014 and Hafez *et al*., 2014).

It is evident from Figure 3C that electrolyte leakage was increased in stressed untreated faba bean plants compared with control and stressed treated plants with SA and ABA. Under drought stress plants produce reactive oxygen species (ROS), which are injurious to plants due to the oxidative stress of cells. Similar results were obtained by many researchers (Gunes *et al*., 2007) on several plants and Abdelaal *et al*. (2014) on wheat plants under biotic stress. Application of SA led to significant decreases in electrolyte leakage under drought stress (Gunes *et al*. (2007). These results may be due to the pivotal role of SA in improving ion uptake, enhancing the function of cell membrane and reducing the harmful effect of stress. These effects of SA on electrolyte leakage are in accordance with those obtained by Elgmaal and Maswada (2013) and Singh *et al*. (2015) under different stresses. Furthermore, a significant reduction in electrolyte leakage was recorded with ABA treatment under drought stress. In agreement with our findings Yang *et al*. (2013) reported that exogenously ABA lead to reduce the electrolyte leakage in citrus plants under freezing stress, this effect of ABA in reduction of electrolyte leakage may be dye to increase the antioxidant enzyme activities for instance superoxide dismutase (SOD), catalase (CAT), peroxidases (PODs).

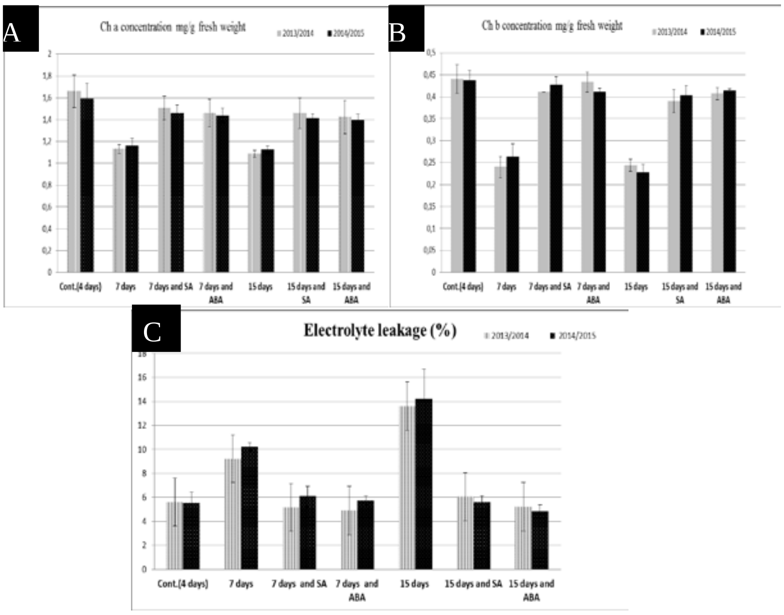

Fig. 3: Chlorophyll a, b concentrations and electrolyte leakage of faba bean plants affected by salicylic acid and abscisic acid under drought stress during the two seasons 2013/2014 and 2014//2015.

Anatomical studies

Stem anatomy

It is realized from Table (2) and Figure 4 (A-F) that the lowest values of stem diameter and cortex thickness of stressed faba bean stem were recorded in the stressed untreated plants (plants irrigated every 7 and 15 days and untreated with SA or ABA) (Fig.4B & C) in comparing with control (Fig.4A) and stressed treated plants (Fig.4D-F), whereas the best values of stem diameter, cortex thickness, vascular tissues thickness and number of xylem vessels/bundle as well as average diameter of vessel were achieved in the stressed treated plants (plants irrigated every 15 days and treated with SA at 1.0 mM or ABA at 10 µg l^{-1}) (Fig .4E & F) compared with control plant and stressed untreated plants (Fig.4A-C). The reduction in anatomical characters under drought stress may be due to the harmful effect of water deficit on cell division and expansion as well as nutrient uptake. These results were supported by Guerfel *et al*. (2009), Makbul *et al*. (2011) and Reda (2007) under salinity stress. The positive role of SA or ABA on the stem diameter and cortex thickness as well as vascular tissues could be attributed to the increments induced in most tissues.

Table 2. Anatomical characters of faba bean stem under drought stress and affected with salicylic acid or abscisic acid during season 2014/2015.

Treatments	Stem diameter (μ)	Cortex thickness (μ)	Vascular tissue thickness (μ)	Number of vessels/ bundle	Average diameter of vessel (μ)
Control (irrigation every 4 days)	927.88	108.56	167.3	14.5	10.8
Plants irrigated every 7 days and untreated with SA or ABA.	795.93	78.01	160.3	16	11. 7
Plants irrigated every 15 days and untreated with SA or ABA.	760.01	52.80	193	17	18.4
Plants irrigated every 7 days and treated with ABA at 10 μg l^{-1}.	937.78	93.90	183.3	21	15
Plants irrigated every 15 days and treated with SA at 1.0 mM.	944.5	97.75	161.8	15	17.9
Plants irrigated every 15 days and treated with ABA at 10 μg l^{-1}.	948	117.69	170.4	16.5	15.6

Leaf Anatomy

Anatomical characters of leaf (leaflet) of faba bean plants grown under drought stress and affected by foliar spraying with SA at 1 mM or ABA at 0.1 mM were monitored and illustrated in Table 3 and Figure 5 (A-F). The obtained results revealed that drought stress decreased thickness of the leaflet lamina and xylem as well as phloem in midvein bundle (Fig. 5A). This effect of drought stress could be attributed to the decrease induced in the palisade and spongy tissues thickness, as well as in the length and width of midvein bundles. These results are in agreement with those obtaind by Boghdady (2009) in mung bean and Petrov *et al.* (2012) in barley plants. Data illustrated in Fig. 5 (D-F) showed the important role of SA and ABA treatments in enhancement most of characters of leaflet in stressed faba

Formatted: Justify Low, Indent: First line: 0.95 cm, Line spacing: single bean plants irrigated every 15 days and treated with SA or ABA (Fig. 5E and F) particularly stem diameter, cortex thickness, vascular tissues thickness and number of xylem vessels/bundle as well as average diameter of vessel.

The pivotal effect of SA and ABA could be attributed to reduce the deleterious effect of drought on the anatomical structure of faba bean. Similar results were recorded by Dawood *et al*. (2014) on faba bean plants with proline application under salinity stress.

Table 3. Anatomical characters of faba bean leaf (leaflet) under drought stress and affected by salicylic acid or abscisic acid during season 2014/2015.

Treatments	Thickness of lamina (μ)	Thickness of phloem (μ)	Thickness of xylem (μ)	No. of xylem rows/ midvein bundle	No. of vessels/ midvein bundle
Control (irrigation every 4 days)	246.08	39.92	68.15	6	18
Plants irrigated every 7 days and untreated with SA or ABA.	216.39	63.57	49.65	7	21
Plants irrigated every 15 days and untreated with SA or ABA.	208.39	54.12	55.03	5	16
Plants irrigated every 7 days and treated with ABA at 10 µg l^{-1}.	256.67	36.87	78.11	5	18
Plants irrigated every 15 days and treated with SA at 1.0 mM.	275.14	26.87	93.01	7	27
Plants irrigated every 15 days and treated with ABA at 10 µg l^{-1}.	250.69	46.01	73.68	8	28

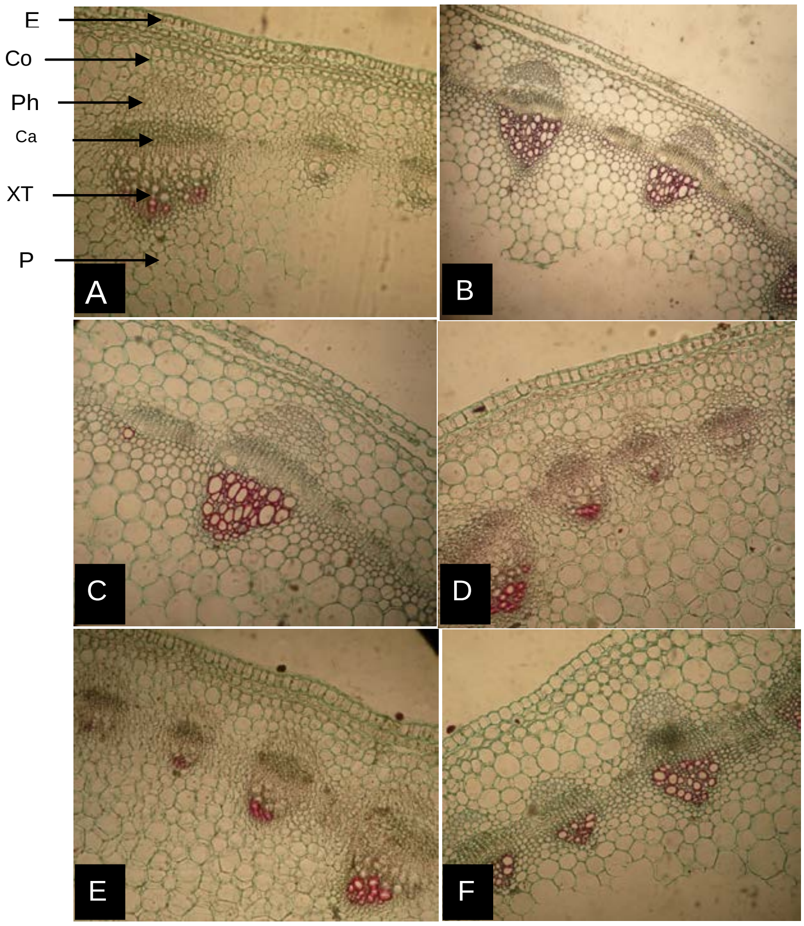

Fig.4: Transverse sections of faba bean stem. A: control (plants irrigated every 4 days), B: plants irrigated every 7 days and untreated with SA or ABA. C: Plants irrigated every 15 days and untreated with SA or ABA. D: Plants irrigated every 7 days and treated with ABA. E: Plants irrigated every 15 days and treated with SA. F: Plants irrigated every 15 days and treated with ABA. (X 100).

Details:- E: Epidermis, Co: cortex, Ph T: Phloem tissue, Ca: cambium, X T: Xylem tissue, P: pith

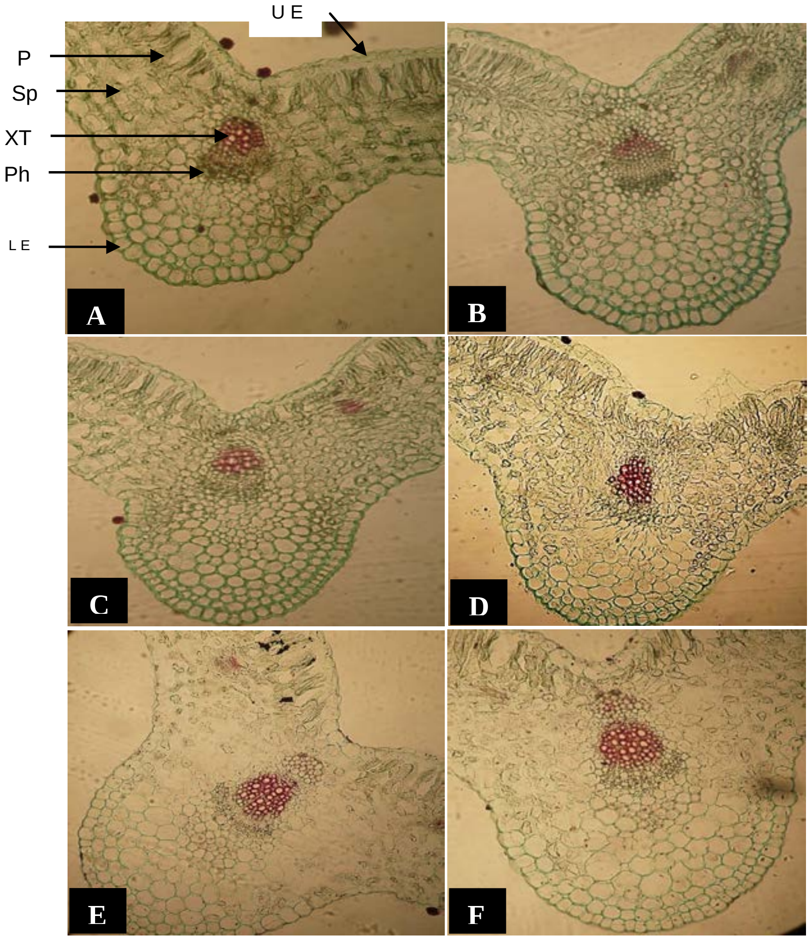

Fig.5: Transverse sections of faba bean leaf (leaflet). A: control (plants irrigated every 4 days), B: plants irrigated every 7 days and untreated with SA or ABA. C: Plants irrigated every 15 days and untreated with SA or ABA. D: Plants irrigated every 7 days and treated with ABA. E: Plants irrigated every 15 days and treated with SA. F: Plants irrigated every 15 days and treated with ABA. (X 100).

Details: U E: Upper epidermis, P_T: Palisade tissue, Sp_T: Spongy tissue, X_T: Xylem tissue, Ph T: Phloem tissue, L E: Lower epidermis.

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تأثير حمض السلسيليك والأبسيسيك على الصفات المورفوفسيولوجية والتشريحية لنبات الفول تحت إجهاد الجفاف

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أجريت تجربتى أصص خلال الموسمين الشتويين 2013/2014 و 2014/2015 بصوب قسم النبات الزراعى- كلية الزراعة- جامعة كفر الشيخ- مصر وذلك لدراسة تأثير حمض السلسيليك والأبسيسيك بتركيزات (1 mM و 0.1 mM) على التركيب المورفوفسيولوجي والتشريحى والمحصول لنبات الفول تحت إجهاد الجفاف. وأشارت النتائج المتحصل عليها إلى نقص طول النبات، عدد الأفرع، عدد الأوراق، المساحة الورقية، وتركيزات كلوروفيل أ ، ب وكذلك نقص عدد الأزهار وعدد القرون/نبات وكذلك عدد البذور/قرن ، وكان النقص عالى المعنوية فى محصول البذور(جرام/نبات) فى كلا الموسمين، وأيضا حدث نقص فى قطر الساق وعدد الأوعية فى الحزمة الوعائية وكذلك سمك نصل الورقة، بينما ازدادت نسبة تسرب الأيونات أو الاكتروليتات تحت إجهاد الجفاف.

أشارت النتائج إلى أن استخدام حمض السلسيليك والأبسيسيك تحت إجهاد الجفاف أدى إلى تحسين وزيادة كل الصفات السابقة فيما عدا تسرب الأيونات قد تناقصت.

أدى استخدام حمض السلسيليك بتركيز 1 mM والأبسيسيك بتركيز 0.1 mM إلى تحسين الصفات التشريحية للساق والوريقة، على سبيل المثال قطر الساق وسمك القشرة وعدد الأوعية فى الحزمة الوعائية وكذلك سمك نسيجى الخشب واللحاء فى الورقة. وطبقا لهذه النتائج فإن استخدام حمض السلسيليك والأبسيسيك يؤدى إلى تقليل التأثير الضار لإجهاد الجفاف ويحسن من الصفات المورفوفسيولوجية والتشريحية وكذلك محصول نبات الفول تحت إجهاد الجفاف.