Role of Brassinosteroids (BRs) in plants

ABSTRACT:

It is thought that the plant growth and development are organized by five hormone groups: auxins, gibberellins, cytokinins, abscisic acid, and ethylene, however, research proved that Brassinosteroids (BRs) are the sixth group of the plant hormones. They are a group of steroidal substances isolated firstly from the pollen grains of Vape (Brassica napus L.). Some studies refer to the unique capability of Brassinosteroids in increasing the crop yield significantly by protecting the plants against the environmental stresses and gene manipulation. This confirms the value of investigating the Brassinosteroid role in enhancing plant growth and productivity.

Keywords:

Brassinosteroids, BRs, Plants.

Article Citation:

Hayder A. Baqir, Mohammed FH. Al-Hassan and Jamal W. Mahmod
Role of Brassinosteroids (BRs) in plants

Dates:

Received: 07 July 2019       Accepted: 06 Aug 2019       Published: 04 Sep 2019

This article is governed by the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0), which gives permission for unrestricted use, non-commercial, distribution and reproduction in all medium, provided the original work is properly cited.
INTRODUCTION

Brassinosteroids are natural compounds formed in various plant parts. They are precisely found in a pollen grain extract (Grove et al., 1979). Thus, they represent a group of growth hormones (Yokota and Takahashi, 1985). Brassinosteroids are available in plants as molecules associated with sugars or fatty acids (Bajguz, 2007). As a result of the large amounts of brassinosteroid, they have been given figures to distinguish between them (BR1 refers to the brassinolide compound followed by BR2, BR3 and BRn of the same series). Brassinolide, 24-EPibrassinolide, and 28-homo-brassinolide are considered the three vital compounds used frequently in physiological studies (Rao et al., 2002). Chon et al. (2008) reported that brassinolide is a naturally occurring compound widely distributed among many plants and has high biological efficacy in very low concentrations and far more potent than IAA when testing the plumule curvature of the rice plant. The results refer to the stimulating effect of the brassinolide hormone similar to the animal steroid hormones that are produced at low concentrations stimulating the cell division greatly, particularly in the meristematic regions such as root and shoot tips consequently increasing the growth of shoot and root systems (Zandi, 2012). Studies proved that brassinolides play an important role in plant growth and development through their effect and participation in many various growth process (Hussein, 2018) as well as they have several physiological and morphological influences on plants including:

a. Cell division and elongation.

b. Constructing the cell wall components.

c. Stimulating the adventitious roots.

d. Enhancing the seeds' vitality and fertility

e. Seed germination.

f. Branch growth.

g. Flowering and yield increase (Sasse, 2002)

Brassinolides also enhance a varied group of physiological responses including the enzymatic activities and stimulating the construction of DNA, RNA and proteins (Krishna, 2003; Ryu et al., 2007; Bajguz and Hayat, 2009; Mona et al., 2011). Moreover, they help in nitrogen fixation and stress tolerances and in particular, water stress (Anjum et al., 2011; Li et al., 2009; Mahesh et al., 2013), saline stress (Krisha, 2003; Bajguz and Hayat, 2009; Hayat and Ahmad, 2011; Marakli et al., 2014), and high or low temperature stresses (Wang et al., 2012) in addition to many other physiological effects and functions.

Biotic construction of brassinolides

The biotic pathway for synthesizing and constructing brassinolide begins from the campestrol compound, which is derived from cycloartnol, where campestrol first converts into campestanol through steps in which de-etiolated (DET2), is used. Then campestanol converts into castasterone (CS) through one of two paths called early and late C-6 oxidation pathway. The two pathways are merged to form campestanol that later on would convert into Brossinolide (BL). The early and late C-6 oxidation pathways existed together, so they can link to each other in different locations of rice plants; furthermore, the presence of these two pathways linked may further complicate the biotic synthesis and construction of brassinolides and may be useful under various physiological conditions such as different types of stresses. The following is an explanation of the most important physiological effects of brassinolides, which may participate in the effects of other plant growth regulators.

Root growth

Brassinolides have stimulatory and inhibitory effect on the root growth when they are used at high or low concentrations where the root growth inhibition depends upon the brassinolide type and its activity. The high concentrations of brassinolides stimulate ethylene production that may be one of the reasons behind the inhibitory effect on root growth, while the low concentrations of them induce root formation. Hedden and
Thomas (2006) have found that brassinolides stimulated the polar shift of top-to-bottom auxins, which stimulated the root formation and development. Fariduddin et al. (2011) reported that brassinolides affected strongly the root morphology including the elongation percentage and branching nature. Romani et al. (1983) reported that low concentrations of BRs such as EBR-epicastasterone 24 enhanced root elongation in the wild Arabidopsis thaliana by 50%. Mussing et al. (2003) reported that the root elongation of Arabidopsis wild-type plants was promoted up to 50% affected by the low concentrations (0.05 and 0.5 nM) of BRs such as 24-epicastasterone and EBR, while in BR-deficient mutants such as dwfl-6, root promotion was up to 150%.

Based on the physiological and molecular characterization of two Arabidopsis mutants, det2 and birl, BR participated in aux/IAA gene-mediated root development of seeds cultured in main stem media (Kim et al., 2006). Hayat et al. (2007) illustrated the root growth changes as a response in using the concentrations of EBR (0.5, 0.05 and 0.005 ppm) where the root growth was responded to the low concentrations (0.005 and 0.05 ppm), while the higher concentration (0.5 ppm) reduced root length and the number of divisions. Romani et al. (1983) and Mussig et al. (2003) referred to root growth enhancement as a result of low concentrations of EBR, whereas the high concentrations increased the gravity curvature. Mouchel et al. (2006) suggested the relationship between brassinosteroid biosynthesis and auxin signals necessary for the typical root growth either embryonic or postembryonic, thus specific levels of BR are needed for the right expression of many genes by Gene BRX; moreover, the external application of BR increases root growth.

Vegetative growth

The primary study showed that brassinolides (BRs) play an important role in stimulating cell division and elongation as well as enhancing the growth of the young vegetative tissues. The study of Mona et al. (2011) referred that the foliar spray BRs 28 (at 50, 100, and 200 mg.L⁻¹) on wheat plants played an important role in metabolic activities and growth. Results obtained by Nomura et al. (2005) and Bajguz (2007) mentioned that applying brassinosteroide showed remarkable responses in plant growth including stem elongation. Results of Mona et al. (2011) showed that spraying brassinosteroide (BRs) plays an essential role in plant growth and development at the concentrations of 50, 100 and 200 mg.L⁻¹ which increased all growth criteria significantly compared to the control treatment.

These results were consistent with those of Fujii and Saka (2001) on rice plants, Balbaa (2007) and Mona et al. (2011) on Fenugreek plants and Hamid (2008) on wheat plants. Rao et al. (2002) mentioned that applying BRs increased seedling growth that was evident through the seedling height, fresh weight, and dry weight as well as it has a vital role in a wide group of development phenomena in plants including stem cell division and elongation and leaf senility. Braun and Wild (1984) reported that spraying BRs was more beneficial when plants subjected to stress conditions. This effect may be attributed to the positive effect of BRs on stimulating the elongation, photosynthesis pigments, fresh weight, dry weight, and branch growth in the wheat and mustard plants. Results of Sairam (1994) illustrated that spraying brassinosteride stimulated wheat grain yield attributing to the increment of the grain.spike⁻¹ and 1000-grains weight.

Grain yield and its components

Results of Hathout (1996) and Hamid (2008) in wheat and of Kerrit (2005) in maize showed that spraying BR hormones increased the length of both spike and ears, number of spikes, number of gains.spike⁻¹ and grain weight, that was reflected on in the grain yield. The yield stimulation can be attributed to the high concentration of BRs in the leaves, stems, and roots. It was reported that grain yield is resulted from filling them with sucrose and other sugar types that was trans-
located to them from the leaves. Similar effects were obtained by Xu (2007) when maize plants were sprayed by epibrassinolide at the grain filling stage. The positive influence of BRs on wheat may be due to the genes controlling the BR hormones as well as the concentrations used to fill the grains and produce wheat and rice grains. Results obtained by Anwar et al. (2016) referred that spraying 2mgL$^{-1}$ of brassinolide at the tillering stage gave the highest values of the spike number, grain number per spike, 1000 grains weight, grain yield and harvest index with an average as 205.94 m$^{-2}$, 66 grains, 39.89 g, 4.39 t.ha$^{-1}$ and 37.87% respectively compared to the lower concentrations, used in the study (1.5 and 0.5 mg.L$^{-1}$). Results of Ali et al. (2008) showed that spraying homo-brassinolide increased the grain weight and yield in two wheat varieties. Results found by Ramraj et al. (1997) illustrated that spraying homo-brassinolide 28 significantly increased the wheat yield to reach 6.7 t.ha$^{-1}$ compared to the control treatment producing 5.7 t.ha$^{-1}$. Results of Sairam (1994) showed that spraying homo-brassinolide stimulated the wheat grain production that is attributed to the increment in the grain number/spike$^{-1}$ and 1000-grains weight.

**Effect of BRs under the stress condition**

Brassinosteroids (BRs) have an important role in stimulating plant tolerance to the biotic and abiotic stresses including drought, salinity, temperature, etc., as stresses lead to morphological, physiological, biochemical and molecular changes.

**Water stress**

In a study related to wheat plants under the stress condition, it was found that soaking the seeds in or spraying the vegetative parts, by 0.001- 10 ppm of BRs. The plants overcame that condition and their vegetative growth and productivity was enhanced as a result of raising their capability to keep water and of increasing the enzymatic activities, especially the nitrate reductase and glutamin-ammonia ligase. Research results demonstrated 33 positive effects of BRs on reducing the water stress effect where it enhances the cell control on abscisic acid, stomata opening, transpiration as well as it keeps the plant tissue’s water content. BR hormones have the ability to link to other protein types including saccharide proteins inside the endoplasmic reticulum that increase the root cells osmosis for water molecules and prevent their loss due to the stress severity (Marakli and Gozukirmizi, 2016). Many studies proved that BRs increase the enzymatic system efficiency resisting the oxidative stresses (Hayat and Ahmad, 2011) and stimulate cell division and expansion and then enhance the growth of the plants subjected to the water stress (Davies, 2010).

**Saline stress**

Some studies referred that spraying epiBL-$24$ on plants grown in saline media containing NaCl$_2$ in which epiBL-$24$ led to removing their poisonousness and improve the plant tolerance through enhancing the growth and carbon assimilation parameters as well as increasing the levels of the anti-oxidation enzymes and proline. Results of Mona et al. (2011) also reported that the foliar spray of BRs on saline-subjected wheat plants affected significantly the total chlorophyll a and b where the highest effect was obtained by spraying 200 mg.L$^{-1}$. Anuradha and Rao (2003) mentioned that spraying BRs alleviated the inhibitory saline stress on the total chlorophyll that may be a reason behind the growth stimulation.

Vardhini and Rao (1999) and Uperti and GSR (2004) the ability of the BRs, epibrassinolide (EPL) and homo-brassinolide (HpL) to enhance the root nodes in peanut plants. It is known that BRs play a vital role in organizing the ion absorption (Khripach et al., 2000) and they are also used for limiting the accumulation of heavy metals and radioactive elements (Khripach et al., 1996). Bajguz and Hayat (2009) indicated that spraying BRs inhibited the saline effect on seed germination and seedling growth of rice. Results of Braun and Wild (1984) revealed that the effect of BRs was more benefi-
cial under the stress conditions and positively affected in stimulating the stem elongation, photosynthesis pigments, and the fresh and dry weight of the vegetative parts of wheat and mustard plants. Results of Sasse et al. (1995) and Anuradhaahd and Rao (2001) showed that brassinosteroid hormones alleviate the effect of the saline stress on seed germination and seedling growth. Moreover, the studies of Talaat and Shawky (2013), Marakli et al. (2014), Fariduddin et al. (2014) and Divi et al. (2015) confirmed that spraying BRs reduce the saline stress effect on ROS and on nutrient absorption.

Temperature stress

Study results of Wu et al. (2014) showed that the foliar spray of BR hormones reduced the ROS levels and increased activity of the antioxidant enzymes in the high temperature subjected plants. Furthermore, other studies referred that low-temperature stresses such as frost affect the crop growth and productivity (Liu et al., 2009 and 2011). However, applying BRs enhance the seed vigor under the forest condition (Wang and Zeng, 1993). Applying BRs also leads to the root elongation and an increase in the root biomass of rice plants grown under low-temperature conditions (Kim and Sa, 1989; Hirai et al., 1991). These results are consistent with those of Krishna (2003) related to the maize as using the BRs enhanced the growth of seedlings grown under low-temperature (0-3°C). It is known that low temperature stress increases the soluble proteins, proline and sugar in plants (Ashraf and Foolad, 2007; Burbulis et al., 2011).

However, studies revealed that spraying BRs enhanced the protein content and thus increased the plant tolerance to the low temperature as a result of the cell membrane stability (Burbulis et al., 2011; Hu et al., 2010; Fariduddin et al., 2011). Applying BRs also enhanced the anti-oxidant enzymes in the plants subjected to the low-temperature stress (Ahammed et al., 2012). Some studies revealed that treating rice plants by the brassinosteroid epiBL-24 increased their tolerance to the low temperature by stimulating ATP, proline, and the activity of the superoxide dismutase enzyme, that clarifies the BRs role in organizing the osmosis and cell membrane stability. Wheat plants treated by the brassinosteroids became more tolerant to the high temperature due to polypeptides called heat shock proteins, i.e. brassinosteroids under the high temperature stimulate the polypeptide synthesis of the heat shook in the cytoplasm.

CONCLUSION

We can conclude that drought and salinity affect the plant growth, leaf chlorophyll content and crop yield negatively. However, spraying the BRs on the plants enhances the growth and carbon assimilation activity and then increases the grain yield. So we recommend that spraying BRs on plants subjected to stress conditions would be more beneficial than spraying them at the normal conditions.

REFERENCES


Fariduddin Q, Mir BA, Yusuf M and Ahmad A.


Talaat NB and Shawky BT. 2013. 24-Epibrassinolide alleviates salt-induced inhibition of productivity by increasing nutrients and compatible solutes accumulation


Submit your articles online at ecologyresearch.info

Advantages
• Easy online submission
• Complete Peer review
• Affordable Charges
• Quick processing
• Extensive indexing
• You retain your copyright

submit@ecologyresearch.info
www.ecologyresearch.info/Submit.php.