Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; SP2: 199-203

Nikita Nehal
Department of Crop Physiology, NDUA&T, Faizabad, Uttar Pradesh, India

Ah Khan
Department of Crop Physiology, NDUA&T, Faizabad, Uttar Pradesh, India

Nitish Sharma
Department of Crop Physiology, NDUA&T, Faizabad, Uttar Pradesh, India

Sanjay Kumar Tripathi
Department of Crop Physiology, CSAUA&T, Kanpur, Uttar Pradesh, India

Mayanker Singh
Department of Crop Physiology, NDUA&T, Faizabad, Uttar Pradesh, India

Correspondence
Nikita Nehal
Department of Crop Physiology, NDUA&T, Faizabad, Uttar Pradesh, India

National Conference on Conservation Agriculture
(ITM University, Gwalior on 22-23 February, 2018)

Role of GA_3, SA and ABA on growth and yield of Indian mustard [*Brassica juncea* (L.) Czern. & Coss.] under rainfed condition

Nikita Nehal, Ah Khan, Nitish Sharma, Sanjay Kumar Tripathi and Mayanker Singh

Abstract
The present investigation entitled "Role of GA_3, SA and ABA on growth and yield of Indian mustard [*Brassica juncea* (L.) Czern. & Coss.] under rainfed condition" was conducted during *Rabi* season, 2013-14 at the Student Instructional Farm (SIF) of Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (U.P.), India. The treatments were comprised of foliar spray of three plant growth regulators (PGRs) of different concentrations *viz*., GA_3 (50 ppm, 100 ppm), Salicylic acid (0.5 mM, 0.7 mM) and ABA (10^{-5} M) along with untreated control (distilled water spray) & spraying was done at 30 DAS. Experiment was setup in randomized block design with twelve treatments and three replications on Narendra rai (NDR-8501) under normal and rainfed conditions. PGRs were applied on the foliage of plant at 30 DAS. Drought was imposed for 30 days by curtailing irrigation at 30 DAS and normal condition plots were irrigated at 30 DAS. Normal and rainfed conditions plots were irrigated at 60 DAS. On the basis of results obtained foliar application of plant growth regulators improved all the growth (dry matter partitioning and relative water content) and yield and yield attributing characters under normal and rainfed conditions. But the effect of SA @ 0.7 mM was more pronounced and mitigate the adverse effect of rainfed condition on mustard.

Keywords: mustard, GA_3, SA, ABA, growth and grain yield

Introduction
Oilseed crops play an important role in agricultural economy of India. Rapeseed-mustard is the third important oilseed crop in the world after soybean (*Glycine max*) and palm oil (*Elaeis guineensis* Jacq.). Brassica (rapeseed-mustard) is the second most important edible oil seed crop in India after groundnut and accounts for nearly 30 per cent of the total oilseeds production and 13 per cent of the country's gross cropped area. When compared to other edible oils, the rapeseed-mustard oil has the lowest amount of harmful saturated fatty acid. It also contains adequate amount of the two essential fatty acids (*i.e.* linoleic and linolenic) which are not present in many of the other edible oils.

Mustard is cultivated in mostly under temperate climates. It is also grown in certain tropical and subtropical regions as a cold weather crop. Indian mustard is reported to be grown under temperate annual precipitation of 500 to 4200 mm, annual temperature 6 to 27^0C, and at pH of 4.3 to 8.3. Rapeseed-mustard follows C_3 pathway for carbon assimilation. Therefore, it has efficient photosynthetic response at 15-20^0C temperature. At this temperature the plant achieve maximum CO_2 exchange range which declines thereafter. *Rai* is mostly grown as a rainfed crop, moderately tolerant to soil acidity, preferring a pH from 5.5 to 6.8 thrives in areas with hot days and cool night and can fairly sustain drought. Mustard requires well drained sandy loam soil. Rapeseed-mustard has a low water requirement (240-400mm) which fits well in the rainfed cropping systems. Nearly 20% are under these crops is in rainfed.

Drought is a major environmental cue impairing many physiological and metabolic processes in plants, which may lead to suppressing plant growth and development, reducing crop productivity and promote plant death. Across plant species drought imposes various physiological and biochemical limitations and adverse effects (Chaves *et al*., 2004 and Wang *et al*., 2003) [10, 37]. Drought stress also induces accumulation of compatible solutes such as glycerol, sugars, betaines and proline, a phenomenon that also varies among plant genotypes.

Proline, for example, is one of the most common osmolytes accumulating in plants in response to a variety of environmental stresses (Bates *et al*., 1973; and Nikoleava, 2010) [5]. Accumulation of free proline is likely a part of general adaption of plants to drought stress, as it promotes water retention in plants thereby alleviating negative effects of water deficit (Ashraf and Foolad 2007; and Szabados and Savoure 2010) [33, 2]. Thus, the concentration of free proline in plants has been suggested as a metabolic measure of drought tolerance (Farooq and Bano, 2006) [14].

PGRs are organic compound other than nutrients that modify plant physiological process. PGRs are called bio-stimulants / bio-inhibitors act inside the plant cell to stimulate / inhibit specific enzymes / enzyme system & help to regulate plant metabolism. They normally activate at low concentration. PGRs are extremely important agent and play an important role from germination upto senescence of the plant. Plant growth regulators (PGRs) can play an important role in increasing its yield by making the plants photosynthetically more effective (Sinha and Ghildyal, 1973) [31]**.** Use of growth regulators increased the rate of photosynthesis by increasing the chlorophyll content per unit area and the size of the mesophyll cells of leaves (Dulizhao and Ooterhuis 2000) [11].

Gibberellins (GAs) constitute a group of tetracyclic diterpenes that best known for their influence on leaf expansion, stem elongation, flower, fruit development and plant morphology (Yamaguchi, 2008; Chauhan *et al*., 2010) [29, 9]. Several studies on different plant species have shown that the exogenous application of GA_3 can enhance the productivity of crops affecting the vital physiological process (Rahman *et al*., 2004; Bora and Sarma, 2006) [28, 7]. GA_3 increases shoot length by increasing its rate of elongation in majority of plants, including *Brassica campestris* (Pressman and Shaked, 1991). Root length was also observed to increase by GA_3 treatment in *Lupinus albus* (Sidiras and Karsioti, 1996) [30]. GA_3 increased dry matter and leaf-area index in mustard plant (Khan, 1996), and photosynthetic rate in leaves of bean (Khan *et al*., 2002). Gibberellic acid (GA) accumulates rapidly when plants are exposed to both biotic (McConn *et al*., 1997) [24] and abiotic stresses (Lehmann *et al*., 1995). Drought showed that the GA content of the leaves induced a 4-fold increase in the gibberellin level 1 week after the onset of water stress, followed by a gradual decrease over the following 3 weeks until the trees were watered again.

Salicylic acid is ortho- hydroxyl benzoic acid and is a secondary metabolite acting as analogous of growth regulating substances. It helps in protection of nucleic acids and prevention of protein degradation. Salicylic acid is a signaling molecule, naturally occurs in plants and plays a major role in regulating plant growth and development. Salicylic acid is mediated in photosynthesis (Cag *et al*., 2009) [8], transpiration, stomatal regulation, nutrient uptake and transport (Gunes *et al*., 2005) [15], flowering, inhibition of fruit ripening (Srivastava and Dwivedi, 2000) [32]. Salicylic acid is a PGR that is part of a signaling pathway induced by several biotic and abiotic stresses (Ashraf *et al*., 2010; and Ashraf *et al*., 2011) [3, 4]. Exogenous application of SA has been shown to induce plant stress tolerance.

ABA has been associated as a stress hormone in vascular plants. ABA has been detected in every major organ of plant from the root cap to the apical bud and synthesized in almost all cells that contain chloroplast and amyloplasts. The plant hormone ABA is produced under water deficit conditions and plays a major role in response and tolerance to dehydration (Shinozaki and Yamaguchi Shinozaki, 1999) [29]. ABA under drought is produced in dehydrated roots, transported to the xylem and regulates stomatal opening and leaf growth in the shoots (Zhang *et al*., 1987; Zhang and Davies, 1990) [39, 40]. Stomata respond to the concentration of ABA in the guard cell apoplast (Hornberg and Weiler, 1984; Anderson *et al*. 1994) [1, 17].

Materials and Methods

The present investigation was conducted at Instructional Farm of Narendra Deva University of Agriculture and Technology Kumarganj, Faizabad (U.P.), India during *rabi* season of 2013-2014. The soil of the experimental plot was sandy loam having pH 7.8, organic carbon 0.32%, nitrogen 136.50 kg ha^{-1}, phosphorous 14.50 kg ha^{-1} and potassium 248.50 kg ha^{-1}. The experiment constituted of 12 treatment combinations were laid out in randomized block design (RBD) with three replications. Solution of GA_3 50 ppm, $GA_3$100 ppm, Salicylic acid 0.5 mM, Salicylic acid 0.7 mM and ABA 10^{-5} M were prepared and spraying was done on the foliage of plants at 30 DAS. While in untreated control distilled water was sprayed. The crop was fertilized with a uniform dose of nitrogen, phosphorus and potassium at the rate of 120 kg, 60 kg and 40kg ha^{-1}, respectively. In one set of treatment crop was irrigated at 30 DAS while in other set 30 days drought was imposed by curtailing water supply to crop at 30 DAS. At 60 DAS both sets of treatments were irrigated. The relative water content (RWC) was determined by method described by Turner and Beg (1981) [5].

Results and Discussions

It is evident from the data presented in fig 1 that dry matter of leaf increased with increase of plant age upto 90 DAS but in mustard all the leaves dropped at maturity. SA was found most effective and significantly increased the leaf at both the concentrations followed by GA_3 100 ppm and the minimum increase was recorded with ABA 10^{-5} M under normal condition. Dry biomass of stem increases with the respect to age of the plant at all the stages of observation in all the treatments. The maximum and significantly increase in stem was recorded with SA 0.7 mM followed by SA 0.5 mM under normal condition. All the treatments significantly increased dry matter partitioning as compared to control. Under drought condition, plant growth regulators enhanced dry matter production and minimized the effect of drought in reduction of dry matter production and partitioning in different parts as compared to normal condition. The increase in plant dry matter production due to plant growth regulators indicate that the photosynthetic activity and efficiency of the leaves have been increased which contributed to dry matter production and improve the movement of dry matter towards sink for better yield. These findings are in confirmation of the earlier report of Khan *et al*. (2008) in soybean. Drought stress decreased dry matter formation in different parts of plant but application of PGRs (GA_3, SA and ABA) ameliorated detrimental effect of drought and improved dry matter production of plants as compared to control. These findings coincide with the results of Kaya *et al*. (2006) [19] in maize, Bideshki *et al*. (2010) [6] in garlic and Habibi (2012) [16] in barley.

The mean data pertaining to relative water content in leaf under various treatments are presented in fig 2. It is clear from the data that relative water content in leaf increased upto 60 DAS of plant after that it declined. The effect of SA was more pronounced and increased in relative water content at all the stages of observation at both the concentrations under normal condition. Under drought stress condition, less relative water content in plant was recorded as compared to plant grown under normal condition but application of plant growth regulator improved relative water content as compared to control and maximum relative water content was recorded with SA 0.7 mM followed by SA 0.5 mM and the minimum relative water content was recorded with GA_3. Spraying of PGRs under drought condition, helps plant to absorb more water than control (non PGRs treated). The increase in relative water content might be due to increase in osmotic pressure of cytoplasm by synthesis of more proline (osmolytes) as compared to control which ultimately help in absorbing water under adverse condition. The results corroborated the findings of Kaya *et al*. (2006) [19] in maize, Moghaddam *et al*. (2011) [25] in maize and Ullah *et al*. (2012) [36] in canola.

The data regarding seed yield plant^{-1} are presented in table 1. The data reveal that all the treatments increase the seed yield plant^{-1}. The effect of SA 0.7 mM was found more found over control followed by GA_3. Under drought condition, reduction in seed yield plant^{-1} was noted as compared to normal condition. Application of PGRs improved the seed yield plant^{-1} as compared to control and maximum seed yield plant^{-1} was pronounced in case of SA at both the concentrations followed by GA_3.The results are in close agreement with those reported by Dawood *et al*. (2012) that GA_3, IAA and salicylic acid increased the seed yield upto 35% over control. These findings were also supported by Tripathi *et al*. (2009) [34] and Islam *et al*. (2010) [28] in bean. Foliar spray of plant growth regulators improved seed yield plant^{-1} as compare to untreated plants under drought condition. These findings were recorded Elgamaal and Maswada (2013) [12].

The data pertaining to this character are presented in table 1. It is apparent from the data that all the treatments increased the seed yield plot^{-1} both under normal and drought conditions. The effect of SA 0.7 mM was found more pronounced and produced significantly higher seed yield plot^{-1}. Under drought condition, reduction in seed yield plot^{-1} was recorded as compared to normal conditions. Application of PGRs showed improvement in yield as compared to control and maximum and significant increase in seed yield plot^{-1} was noticed with SA at both the concentration followed by GA_3 and the minimum seed yield per plot was registered by ABA. Application of plant growth regulators produced significantly higher seed yield plot^{-1} over control. SA registered significantly increased the seed yield plot^{-1}. Similar findings were reported by Umair *et al*. (2011). Foliar spray of SA increased the seed yield plot^{-1} under drought condition. These findings were supported by El-Razek *et al*. (2013) [13].

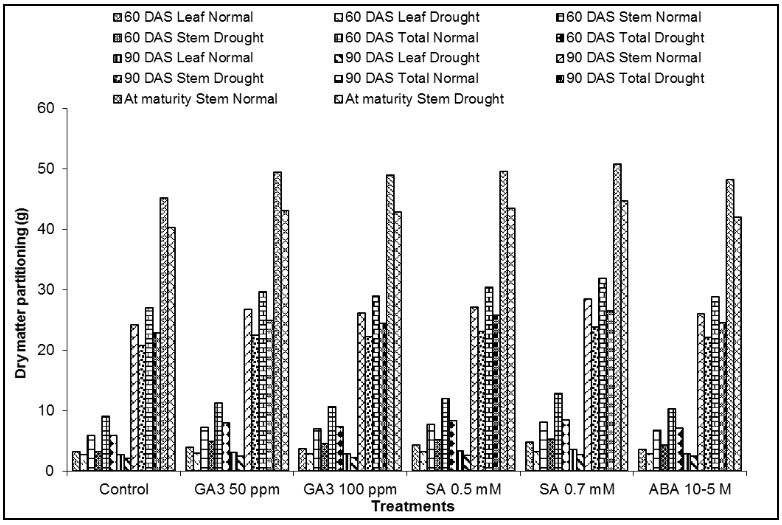

Fig 1: Effect of plant growth regulators on dry matter partitioning of Indian mustard at different growth stages under drought stress condition

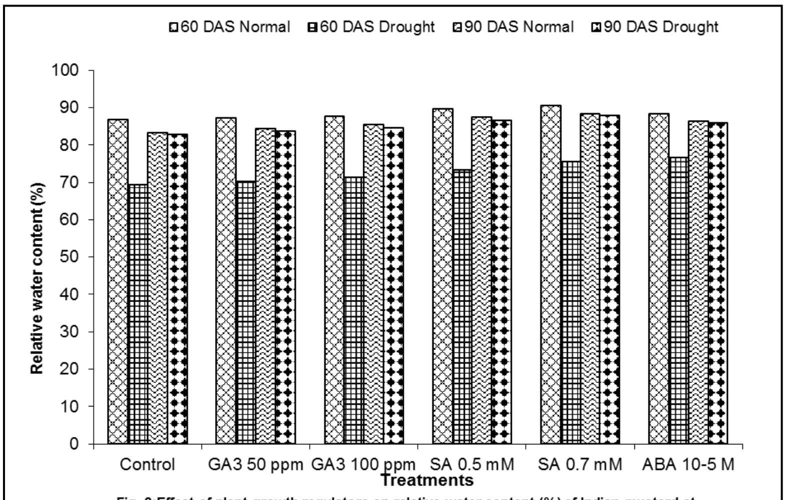

Fig. 2:Effect of plant growth regulators on relative water content (%) of Indian mustard at different growth stages under drought stress condition

Fig 2: Effect of plant growth regulators on relative water content (%) of Indian mustard at different growth stages under drought stress condition

Table 1: Effect of plant growth regulators on seed yield plant^{-1} (g) and seed yield plot^{-1} (g) of Indian mustard under drought stress conditions

Treatments	Seed yield plant^{-1} (g)		Seed yield plot^{-1} (g)	
	Normal	Drought	Normal	Drought
Control	11.40	9.37	790.00	650.50
GA3 50 ppm	12.90	10.22	815.35	684.33
GA3 100 ppm	12.63	10.06	810.10	678.20
SA 0.5 mM	13.10	10.42	820.50	690.00
SA 0.7 mM	13.87	10.85	827.00	696.50
ABA 10^{-5} M	12.42	9.82	805.60	670.25
SEm±	0.09		4.86	
CD at 5%	0.27		14.24	

References

1. Anderson BE, Ward JM, Schroeder JI. Evidence for an extra cellular reception site for abscisic acid in *Commelina* guard cells. Plant Physiol. 1994; 104:1177-1183.
2. Ashraf M, Foolad MR. Roles of Glycine Betaine and Proline in Improving Plant Abiotic Stress Resistance. Environmental & Experimental Botany. 2007; 59:206-16.
3. Ashraf M, Akram NA, Arteca RN, Foolad MR. The Physiological, Biochemical and Molecular Roles of Brassinosteroids and Salicylic Acid in Plant Processes and Salt Tolerance. Critical Reviews in Plant Sciences, 2010; 29:162-90.
4. Ashraf M, Akram NK, Al-Qurainy F, Foolad MR. Drought Tolerance: Roles of Organic Osmolytes, Plant Growth Regulators and Mineral Nutrients. Advances in Agronomy. 2011; 111:249-96.
5. Bates LS, Waldren RP, Teare ID. Rapid Determination of Free Proline for Water-Stress Studies. Plant Soil. 1973; 39:205-07.
6. Bideshkia A, Arvinb MJ. Effect of salicylic acid (SA) and drought stress on growth, bulb yield and allicin content of garlic (*Allium sativum*) in field. Plant Ecophysiology. 2010; 2:73-79.
7. Bora RK, Sarma CM. Effect of Gibberellic Acid and Cycocel on Growth, Yield and Protein Content of Pea. Asian Journal of Plant Sciences. 2006; 5(2):324-330.
8. Cag S, Cevahir-oz G, Sarsag M, Goren-Saglam N. Effect of salicylic acid on pigment, protein content and peroxide activity in excised sunflower cotyledons. Pak. J Bot. 2009; 41:2297-2303.
9. Chauhan JS, Tomar YK, Badoni A, Singh NI, Ali S, Debarati L. Morphology, germination and early seedling growth in *Phaseolus mungo* L. with reference to the influence of various plant growth substances. Journal of American Science. 2010; 6:34-41.
10. Chaves MM, Oliveira MM. Mechanisms underlying Plant Resilience to Water Deficits: Prospects for Water-Saving Agriculture. Journal of Experimenal Botany. 2004; 55:2365-84.
11. Dulizhao, Derrick MM, Ooterhuis. Effect of growth regulators on sugar content of French bean. 2000; 11(2):156.
12. Elgamaal AA, Maswada HF. Response of three yellow maize hybrids to exogenous salicylic acid under two irrigation intervals. Asian Journal of Crop Science, 2013; 5(3):264-274.
13. El-Razek EA, Hassan H, El-Din KMG. Effect of foliar application with salicylic acid, benzyladenine and gibberellic acid on flowering, yield and fruit quality of olive trees (*Olea europaea* L.). Middle-East Journal of Scientific Research. 2013; 14(11):1401-1406.
14. Farooq U, Bano A. Effect of Abscisic Acid and Chlorocholine Chloride on Nodulation and Biochemical Content of *Vigna radiata* L, under Water Stress. Pakistan Journal of Botany. 2006; 38:1511-18.
15. Gunes A, Inal A, Alpaslan M, Cicek N, Guneri E, Eraslan F, Guzelordu T. Effects of exogenously applied salicylic acid on the induction of multiple stress tolerance and mineral nutrition in maize (*Zea mays* L.) Archives of Agronomy and Soil Science. 2005; 51:687-695.
16. Habibi, Ghaber. Exogenous salicylic acid alleviates oxidative damage of barley plants under drought stress. Acta Biologica Szegediensis, 2012; 56(1):57-63.
17. Hornberg C, Weiler EW. High affinity binding sites for abscisic acid on the plasmalemma of *Vicia faba* guard cells. Nature. 1984; 310:321-324.
18. Islam MR, Prodhan AKMA, Islam MO, Uddin MK. Effect of plant growth regulators (GABA) on Morphological Characters and yield of Blackgram (*Vigna mungo* L.). J Agric. Res. 2010; 48(1):97-101.
19. Kaya C, Tuna AL, Alves AAC. Gibberellic acid improves water deficit tolerance in maize plants. Acta Physiologiae Plantarum. 2006; 28(4):331-337.
20. Khan NA. Effect of gibberellic acid on carbonic anhydrase, photosynthesis, growth and yield of mustard. Biologia Plantarum. 1996; 38:145-147.
21. Khan NA, Mir R, Khan M, Javid S, Samiullah L. Effects of gibberellic acid spray on nitrogen yield efficiency of mustard grown with different nitrogen levels. Plant Growth Regulation. 2002; 38:243-247.
22. Khan NA, Mohammad Mobin and Singh, Sarvajeet. Effects of gibberellic acid and sulphur on yield efficiency of mustard. Advances in plant physiology. 2008; 10:455-461.
23. Lehmann J, Atzorn R, Bruckner C, Reinbothe S, Leopold J, Wasternack C, Parthier B. Accumulation of jasmonate, abscisic acid, specific transcripts and proteins in osmotically stressed barley leaf segments. Planta. 1995; 197:156-162.
24. McConn M, Creelman RA, Bell F, Mullet JE, Browse J. Jasmonate is essential for insect defense in Arabidopsis. Proc Natl Acad Sci USA. 1997; 94:5473-5477.
25. Moghaddam NM, Arvin MJ, Nezhad GRK, Maghsoudi K. Effect of salicylic acid on growth and forage and grain yield of maize under drought stress in field conditions. [Persian]. Seed and Plant Production Journal. 2011; 27-2(1):41-55.
26. Nikolaeva MK, Maevskaya SN, Shugaev AG, Bukhov NG. Effect of Drought on Chlorophyll Content and Antioxidant Enzyme Activities in Leaves of Three Wheat Cultivars Varying in Productivity. Russian Journal of Plant Physiology. 2010; 57:87-95.
27. Pressman E, Shaked R. Regulation of stem elongation in Chinese cabbage by inflorescence removal and application of growth regulators. Journal of Plant Growth

Regulation. 1991; 10:225-228.
28. Rahman MS, Islam MN, Tahar A, Karim MA. Influence GA, and MH and their time of spray on morphology, yield contributing characters and yield of Soybean. Asian Journal of plant Science. 2004; 3:602-609.
29. Shinozaki K, Yamaguchi-Shinozaki K. Molecular responses to drought stress. In: Yamaguchi-Shinaozaki, (Ed). Molecular responses to cold, drought, heat and salt stress in higher plants. Austin, TX: R.G. Landes Company. 1999, 11-28.
30. Sidiras N, Karsioti S. Effects of seed size and seed substances of lupins on seedling emergence and root system development in relation to sowing depth, soil water and gibberellin. Journal of Agronomy and Crop Science. 1996; 177:73-83.
31. Sinha SK, Ghildyal MC. Increase in yield of bengal gram by 2, 3, 5 triiodobenzoic acid. Crop Science. 1973; 13:283.
32. Srivastava MK, Dwivedi UN. Delayed ripening of banana fruit by salicylic acid. Plant Sci. 2000; 158:87-96.
33. Szabados L, Savoure A. Proline: A Multifunctional Amino Acid. Trends In Plant Sciences. 2010; 15:89-97.
34. Tripathi DK, Lalla Bhushan C, Baghel RS. Effect of some growth regulators on flower drop and yield of chickpea. J. Food Legume. 2009; 20(1):117-118.
35. Turner NC, Beg. Techniques and experimental approaches for the measurement of plant water status, Plant and Soil. 1981; 58:339-366.
36. Ullah, Faizan, Bano Asghari, Nosheen Asia. Effects of plant growth regulators on growth and oil quality of canola (*Brassica napus* L.) under drought stress. Pak. J. Bot. 2012; 44(6):1873-1880.
37. Wang WX, Vinocur B, Altman A. Plant Responses to Drought, Salinity and Extreme Temperatures: Towards Genetic Engineering for Stress Tolerance. Planta. 2003; 218:1-14.
38. Yamaguchi S. Gibberellin metabolism and its regulation. Annual Review of Plant Biology. 2008; 59:225-251.
39. Zhang J, Davies WJ. Changes in the concentration of ABA in the xylem sap as a function of changing soil water status can account for changes in leaf conductance and growth. Plant Cell Environ. 1990; 13:277-285.
40. Zhang J, Schurr U, Davies WJ. Control of stomatal behavior by abscisic acid which apparently originates in roots. J Exp. Bot. 1987; 38:1174-1181.