Plant Archives Vol. 17 No. 1, 2017 pp. 580-584 *ISSN 0972-5210*

EFFECT OF PLANT GROWTH REGULATORS ON GROWTH, BIOCHEMICAL AND YIELD OF INDIAN MUSTARD [*BRASSICA JUNCEA* (L.) CZERN. & COSS.] UNDER DROUGHT STRESS CONDITION

Nikita Nehal*, Nitish Sharma, Monika Singh, Prashansha Singh, Priyanka Rajpoot[1], Anand Kumar Pandey, A. H. Khan, A. K. Singh and R. K. Yadav

Department of Crop Physiology, Narendra Deva University of Agriculture & Technology, Narendra Nagar, (Kumarganj), Faizabad - 224229 (Uttar Pradesh), India.

[1]Department of Genetics and Plant Breeeding, Narendra Deva University of Agriculture & Technology, Narendra Nagar, (Kumarganj), Faizabad - 224 229 (Uttar Pradesh), India.

Abstract

The present investigation entitled "Effect of plant growth regulators on growth and yield of Indian mustard [*Brassica juncea* (L.) Czern. & Coss.] under drought stress 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. Experiment was setup in randomized block design with twelve treatments, *viz*. and three replications on mustard variety Narendra rai under normal and drought 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 drought conditions plots were irrigated at 60 DAS. On the basis of results obtained foliar application of plant growth regulators improved all the growth (plant height and number of branches plant^{-1}) and biochemical parameters (chlorophyll and proline content in leaves) as well as the yield and yield attributing characters under normal and drought conditions. But the effect of PGRs were more pronounced under drought condition and they minimize the detrimental effect on mustard.

Key words : Mustard, GA_3, SA, ABA, Morphological traits and Grain yield

Introduction

Rapeseed-mustard is the third important oilseed crop in the world after soybean (*Glycine max*) and palm oil (*Elaeis guineensis* Jacq.). India is the fourth largest oilseed economy in the world. Among the seven edible oilseeds cultivated in India, rapeseed-mustard contributes 28.6% in the total oilseeds production and ranks second after groundnut sharing 27.8% in the India's oilseed economy. The share of oilseeds is 14.1% out of the total cropped area in India, rapeseed-mustard accounts for 3% of it. The global production of rapeseed-mustard and its oil is around 38-42 and 12-14MT, respectively. India contributes 28.3% and 19.8% in world acreage and production. India produces around 6.7MT of rapeseed-mustard next to China (11-12MT) and EU (10-13MT) with significantly contribution in world rapeseed-mustard industry.

***Author for correspondence :** E-mail : nikitanehal1989@gmail.com

Rapeseed and mustard occupy an important position among oilseed. In world the total area under rapeseed-mustard during 2012-2013, was 34.19 M ha with the production of 63 m t and productivity was 1850 kg/ha. In India, the total area under rapeseed-mustard during 2012-13 was 6.3 M ha with the production of 7.4 MT and productivity of 1176 kg/ha. During 2011-12 in Uttar Pradesh, the total area of rapeseed was 0.64 M ha with the production of 0.79 MT and productivity of 1236 kg/ha (Anonymous, 2013).

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). For example, drought stress elevates generation of reactive oxygen species,

an effect common in plants exposed to most abiotic stresses (Foyar and Noctor, 2005). Increased accumulation of reactive oxygen species, including superoxide, hydroxyl radicals and hydrogen peroxide, is one of the earliest plant responses to drought stress (Apel and Hirt, 2004; Ashraf, 2009; Ashraf and Akram, 2009 and Mittler, 2002). Such reactive oxygen species accumulation may lead to many deleterious effects, protein degradation, lipid peroxidation and pigment bleaching. To protect cells from such deleterious effects, plants increase activities of key antioxidant enzymes in the cytosol, including superoxide dismutase, peroxidase and catalase, which are believed to counteract the effects of reactive oxygen species (Foyar *et al*., 1997; Foyar and Noctor, 2000).

Gibberellins (GAs) are generally involved in growth and development. Gibberellic acid (GA) accumulates rapidly when plants are exposed to both biotic (McConn *et al*., 1997) and abiotic stresses (Lehmann *et al*., 1995). GAs interacts with other hormones to regulate various metabolic processes in the plants.

Salicylic acid (SA) is a naturally occuring plant hormone, influences various physiological and biochemical functions in plants. 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). Exogenous application of SA has been shown to induce plant stress tolerance. A number of research demonstrate protective effects of exogenous SA on plants against salinity (Wang and Li, 2006), drought (Senaratna *et al*., 2000; Shakirova *et al*., 2003; Singh and Usha 2003).

ABA has been associated as a stress hormone in vascular plants. 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). 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). Stomata respond to the concentration of ABA in the guard cell apoplast (Hornberg and Weiler, 1984; Anderson *et al*., 1994).

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 total chlorophyll estimation of leaves was made following the method of Arnon (1949) as modified by Kirk (1968). Free proline content in leaves was estimated spectrophotometrically according to the methods of Bates *et al*. (1973).

Results and Discussion

It is clear from the data in table 1 that plant height progressively increased with the increase of plant age. All the treatments significantly increased the plant height as compared to control under both normal and drought condition, but the effect of GA_3 at 100 ppm was more pronounced than rest of the treatments. The increase in plant height may be due to stimulation of cell elongation, division and enlargement as reported by Leite *et al*. (2003). Similar findings related to increase in plant height were also reported by Kothule *et al*. (2003) in soybean. Under drought condition, reduction in plant height was observed in control as well as treated plots in comparison to normal condition. Applications of plant growth regulators improved plant height as compared to control. The maximum and significant increase in plant height was recorded in case of GA_3 100 ppm and the minimum was recorded with ABA 10^{-5} M. These findings are in confirmation of the earlier reports of Akhter *et al*. (2007) and Khan *et al*. (2002) in mustard.

All the treatments in table 2 showed increase in number of branches $plant^{-1}$ over the control. The maximum and significant increase in number of branches $plant^{-1}$ was recorded with SA at both concentrations at all the stages of observation under normal condition. Kothule *et al*. (2003) also reported an increase in number of branches $plant^{-1}$ in soybean due to the application of PGRs. Under drought condition, less number of branches $plant^{-1}$ was observed as compared to plants under normal condition. Foliar spray of PGRs improved number of

Table 1 : Effect of plant growth regulators on plant height of Indian mustard at different growth stages under drought stress condition.

Treatments	Plant height (cm)					
	60DAS		90 DAS		At maturity	
	Normal	Drought	Normal	Drought	Normal	Drought
Control	68.75	50.37	115.12	100.35	150.33	135.42
GA3 50 ppm	76.69	59.13	125.35	110.28	162.29	145.34
GA3 100 ppm	79.15	62.34	128.27	113.59	165.77	148.51
SA 0.5 mM	73.35	57.47	121.28	106.57	158.21	132.56
SA 0.7 mM	75.40	59.27	123.64	108.26	160.74	134.45
ABA 10^{-5} M	72.44	56.48	120.79	105.49	156.29	131.67
S.Em.±	**0.71**		**0.26**		**0.07**	
CD	**2.10**		**0.77**		**0.49**	

Table 2 : Effect of plant growth regulators on number of branches plant^{-1} of Indian mustard at different growth stages under drought stress condition

Treatments	Number of branches plant^{-1}					
	60DAS		90 DAS		At maturity	
	Normal	Drought	Normal	Drought	Normal	Drought
Control	21.32	14.82	31.38	25.35	32.12	26.59
GA3 50 ppm	26.72	19.82	35.87	29.58	34.61	27.38
GA3 100 ppm	26.22	19.16	35.42	29.12	33.52	27.71
SA 0.5 mM	27.24	20.33	38.69	30.72	34.19	28.16
SA 0.7 mM	28.72	20.89	39.29	31.23	34.48	28.47
ABA 10^{-5} M	25.86	18.54	34.74	28.91	33.23	27.14
S.Em±	**0.59**		**0.60**		**0.92**	
CD	**1.74**		**1.77**		**2.69**	

branches plant^{-1} as compared to the control and the maximum and significant increase in number of branches plant^{-1} was recorded with SA 0.7 mM. These findings were in agreement with Rao *et al*. (2009), who reported that SA minimized the drought stress and improved the number of branches. Similar findings were also reported by Sadeghipour and Aghaei (2012) in bean.

It is evident from the data in table 3 that total chlorophyll content in leaf increased upto 60 DAS of plant after that it declined. All the treatments significantly increased total chlorophyll content over control at all the stages of observations. The effect of SA was more pronounced and the maximum increase in chlorophyll content was recorded at all the stages of observation at both the concentrations under normal condition. Under drought condition, the maximum chlorophyll content was recorded in case of SA followed by ABA and the minimum chlorophyll content was recorded with GA_3 100 ppm. Sharma and Kaur (2003) also reported that foliar application of SA on soybean increased chlorophyll content. Under drought stress condition, chlorophyll content decreased but foliar spray of SA 0.7 mM produced maximum chlorophyll content followed by SA 0.5 mM compared to control. These findings are well supported by Moghaddam, *et al*. (2011) in maize, Hayat *et al*. (2009) and Alam *et al*. (2013) in mustard.

The perusal of data presented in Table 4 show that proline content in leaf increased upto 60 DAS after that it declined. The effect of ABA 10^{-5} M was more promising and increased proline content activity at all the stages of observation. Under drought condition, maximum proline content was recorded with ABA 10^{-5} M followed by SA at both the concentration and the minimum proline content was recorded with GA_3 at both the concentration. Proline content was improved with the application of all PGRs in both normal and drought conditions. But the application of ABA drastically increased proline level as compared to salicylic acid and GA_3. ABA is a stress hormone. In normal condition, maximum proline content was recorded with ABA 10^{-5} M with respect to control.

Table 3 : Effect of plant growth regulators on chlorophyll content of Indian mustard at different growth stages under drought stress condition.

Treatments	Chlorophyll content (mg g^{-1} fresh weight)			
	60 DAS		90 DAS	
	Normal	Drought	Normal	Drought
Control	1.36	1.19	1.32	1.27
GA3 50 ppm	2.70	1.44	2.28	2.09
GA3 100 ppm	2.67	1.39	2.23	2.06
SA 0.5 mM	2.79	1.54	2.36	2.18
SA 0.7 mM	2.83	1.59	2.41	2.21
ABA 10^{-5} M	2.76	1.48	2.31	2.14
SEm±	0.03		0.09	
CD at 5%	0.09		0.26	

Table 4 : Effect of plant growth regulators on proline content of Indian mustard at different growth stages under drought stress condition.

Treatments	Proline content (µg ml^{-1})			
	60 DAS		90 DAS	
	Normal	Drought	Normal	Drought
Control	2.40	4.88	3.52	3.64
GA3 50 ppm	2.60	5.23	3.87	3.89
GA3 100 ppm	2.84	5.77	3.98	4.12
SA 0.5 mM	3.31	6.33	4.07	4.27
SA 0.7 mM	3.50	6.73	4.59	4.58
ABA 10^{-5} M	3.87	7.75	4.65	4.73
SEm±	0.06		0.08	
CD	0.19		0.23	

Table 5 : Effect of plant growth regulators on number of siliquae $plant^{-1}$ and number of seeds $siliqua^{-1}$ of Indian mustard under drought condition.

Treatments	Number of siliquae $plant^{-1}$		Number of seeds $siliqua^{-1}$	
	Normal	Drought	Normal	Drought
Control	230.35	180.60	11.67	9.27
GA3 50 ppm	236.66	186.25	12.71	10.79
GA3 100 ppm	235.46	185.39	12.33	10.38
SA 0.5 mM	239.35	189.15	13.54	11.21
SA 0.7 mM	240.49	190.74	13.89	11.43
ABA 10^{-5} M	234.40	184.52	12.13	10.11
SEm±	0.87		0.57	
CD at 5%	2.55		1.68	

Similar findings have been reported by Unyayar *et al*., (2004). Under drought condition, the maximum increase in proline content was observed with ABA 10^{-5} M and minimum in GA_3 50 ppm over control. These findings are in the line of the reports by Gupta (2006) and Rabert *et al*. (2014) in sunflower.

Yield parameters

It is evident from the data presented in the table 5 that all the treatments increased the number of siliquae $plant^{-1}$. The treatment SA 0.7 mM registered maximum and significant increase in number of siliquae $plant^{-1}$ over control followed by SA 0.5 mM. The increased number of siliquae $plant^{-1}$ could be due to better translocation of nutrient and assimilates to the reproductive regions. These results are in accordance to Akhter *et al*. (2007) in mustard. Under drought condition, number of siliquae $plant^{-1}$ decreased but plant growth regulators increased number of siliquae $plant^{-1}$. The maximum number of siliquae $plant^{-1}$ was recorded by SA 0.7 mM followed by SA 0.5 mM. Earliar findings of Singh *et al*. (2003) in mustard is in support of this result.

All the treatments increased the number of seeds $siliquae^{-1}$ significantly over control. The treatment GA_3 100 ppm was recorded maximum number of seeds $siliquae^{-1}$ over control. Under drought stress condition, reduction in number of seeds $siliquae^{-1}$ was recorded in control as well as treated plots as compared to normal condition. Application of PGR improved number of seeds $siliquae^{-1}$ as compared to control and maximum number of seeds $siliquae^{-1}$ was registered in GA_3 at both the concentrations followed by SA. Drought condition adversely affected number of seeds $siliquae^{-1}$ however the application of PGRs increased the number of seeds $siliquae^{-1}$ as compared to control. These findings were supported by Singh *et al*. (2003) in mustard.

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