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EFFECT OF PLANT GROWTH REGULATORS ON GROWTH, BIOCHEMICAL CHANGES AND YIELD OF MUSTARD [*BRASSICA JUNCEA* (L.) CZERN. & COSS.]

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Abstract

The investigation entitled "Effect of plant growth regulators (PGRs) on growth, biochemical changes & yield of mustard [*Brassica juncea* (L.) Czern.& Coss.]" was conducted during *rabi* season, 2013-2014 at the Instructional Farm of Narendra Deva University of Agriculture & Technology, Kumarganj, Faizabad (U.P.), India in randomized block design with ten treatments, three replications and variety Narendra rai (NDR-8501). The treatments were comprised of foliar spray of 3 plant growth regulators (PGRs) of different concentrations *viz*., Salicylic acid (0.1 mM. 0.3 mM, 0.5 mM), GA_3 (25 ppm, 50 ppm, 100 ppm) and kinetin (25 ppm, 50 ppm, 100 ppm) along with untreated control (distilled water spray) & spraying was done at 30 DAS. Observations were recorded at 60, 90 DAS and at maturity. The observations were taken on growth parameters like plant height, number of branches plant^{-1}, biochemical parameters like chlorophyll a & b content, oil content, yield characters like no. of siliquae plant^{-1}, no. of seeds plant^{-1}, setting percentage of siliquae. All the PGRs *viz*., salicylic acid (0.1 mM, 0.3mM, 0.5mM), GA_3 (25 ppm, 50 ppm, 100 ppm) and kinetin (25 ppm, 50 ppm, 100 ppm) induced positive influence on the growth characters and chlorophyll content in plants but the foliar spraying of GA_3 50 ppm at 30 DAS was found more profound among all treatments. All the treatments enhanced the yield and yield contributing characters at all the doses in mustard. On the basis of above investigation it may be concluded that foliar spray of PGRs at 30 DAS may be used as a potential tool to improve growth and yield of mustard.

Key words : Mustard, GA_3, SA, kinetin, morphological traits 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.). Mustard is an important *rabi* crop of Rajasthan, Gujarat, M.P, Uttarakhand, Uttar Pradesh, Bihar, West Bengal and Assam. India is one of the largest rapeseed-mustard growing countries in the world, occupying the first position in area and second position in production after China.

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. Rapeseed-mustard seed was primarily used for human consumption because of low erucic acid and thus, becoming desirable edible oil. With the invention of steam power, it was found that the oil could be used as a lubricant that would be used for cleaning water steam-washed metal surfaces better than any other lubricant.

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

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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. 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).

Salicylic acid is a signaling molecule, naturally occurs in plants and plays a major role in regulating plant growth and development (Huang *et al*., 2008). Salicylic acid is mediated in photosynthesis (Cag *et al*., 2009), transpiration, stomatal regulation, nutrient uptake and transport (Gunes *et al*., 2005), flowering, inhibition of fruit ripening (Srivastava and Dwivedi, 2000).

Gibberellic acid is an essential growth harmone that is known to be actively involved in various physiological activities such as growth, flowering, ion transport (Shah, 2004). Gibberellic acid (GA_3) is a phytohormone that is needed in small amounts at low concentration to accelerate plant growth and development. Gibberellic acid is such a plant growth regulator, which can manipulate a variety of growth and development phenomena in various crops. GA_3 enhances growth activities to plant, stimulates stem elongation (Lee, 1990), and increases dry weight and yield (Deotale *et al*., 1998 and Maske *et al*., 1998).

Cytokinins (CKs) play a crucial role in various phases of plant growth and development, but the basic molecular mechanisms of their biosynthesis and signal transduction became clear recently. Cytokinins (CKs) have been implicated to control many developmental processes and environmental responses of plants, including leaf senescence, apical dominance, chloroplast development and regulation of cell division (Hutchison & Kieber, 2002). CKs are involved in various processes of growth and development in plants (Takei *et al*., 2002). These effects of CKs are due to interactions with other plant harmones and environmental signals (Hare *et al*., 1997). Cytokinins promote cotyledon expansion, leaf development and chloroplast differentiation (Stetler and Laetsch, 1965; Huff and Ross, 1975). During later vegetative growth, cytokinins and ethylene control the onset of leaf senescence (Gepstein and Thimann, 1981).

Materials and Methods

The present investigation was conducted at Instructional Farm of Narendra Deva University of Agriculture and Technology Kumarganj, Faizabad (U.P.) during *rabi* season of 2013-2014. The soil of the experimental plot was sandy loam having pH 7.8, nitrogen 145.72 kg ha^{-1}, phosphorous 17.50 kg ha^{-1} and potassium 215.20 kg ha^{-1}. The experiment constituted of 10 treatment combinations were laid out in randomized block design (RBD) with three replications. Solutions of salicylic acid 0.1 mM, 0.3 mM, 0.5 mM, GA_3 25 ppm, 50 ppm, 100 ppm and kinetin 25 ppm, 50 ppm, 100 ppm were prepared and sprayed on the foliage of plants at 30 DAS with the help of hand sprayer as per treatment while in untreated controldistilled 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 40 kg ha^{-1}, respectively. Half of the nitrogen and full phosphorus and potassium were given as basal dose through urea, single superphosphate and muriate of potash respectively and half of the nitrogen was applied at 6 days after first irrigation. First irrigation was done at 30 DAS as per requirement. The total chlorophyll estimation of leaves was made following the method of Arnon (1949) as modified by Kirk (1968).

Results and Discussion

Data pertaining to plant height as affected by plant growth regulators recorded at different growth stages have been presented in table 1 show that plant height progressively increased with the age of the plant. All the treatments registered significant increase in plant height over control at all the stages of observation except 25 ppm kinetin at 60 DAS. The effect of 50 ppm GA_3 was more pronounced followed by 0.5 mM salicylic acid and kinetin 50 ppm. Among these, GA_3 recorded maximum plant height at all the stages *i.e.* 60 DAS, 90 DAS and at maturity when applied @ 50 ppm at 30 DAS followed by salicylic acid 0.5 mM. Increase in the plant height by the spraying of PGRs might be due to stimulation, cell elongation, cell division and cell enlargement as GA_3 is known to enhance cell elongation (Jupe *et al*., 1988). The results corroborated with the findings of Chauhan *et al*. (2009) in black gram, Castro *et al*. (2010) in rapes and Fawzy *et al*. (2011) in Snap bean.

Data with respect to total number of branches $plant^{-1}$ affected by plant growth regulators recorded at different growth stages have been presented in table 2. All the treatments significantly increased the number of branches $plant^{-1}$ at all the growth stages. The maximum increase in number of branches $plant^{-1}$ was recorded in case of GA_3 50 ppm followed by salicylic acid 0.5 mM and minimum increase was seen in kinetin 25 ppm at all stages of observation over control. The data indicated that all

Table 1 : Effect of PGRs on plant height (cm) of mustard at different growth stages.

Treatments	Plant height (cm)		
	60 DAS	90 DAS	At maturity
T_1 : Control	52.70	113.91	135.12
T_2 : Salicylic acid (0.1 mM)	61.12	126.21	148.25
T_3 : Salicylic acid (0.3 mM)	63.92	132.81	153.82
T_4 : Salicylic acid (0.5 mM)	66.49	136.37	156.81
T_5 : GA_3 (25 ppm)	63.54	127.84	149.15
T_6 : GA_3 (50 ppm)	67.88	139.52	159.44
T_7 : GA_3 (100 ppm)	65.26	135.64	155.42
T_8 : Kinetin (25 ppm)	54.79	125.72	145.86
T_9 : Kinetin (50 ppm)	65.05	135.07	152.82
T_{10} : Kinetin (100 ppm)	64.07	132.02	151.47
SEm±	**1.37**	**2.83**	**3.30**
CD at 5%	**4.06**	**8.41**	**9.81**

Table 2 : Effect of PGRs on number of branches plant^{-1} of mustard at different growth stages.

Treatments	Number of branches plant^{-1}		
	60 DAS	90 DAS	At maturity
T_1 : Control	10.76	20.20	21.02
T_2 : Salicylic acid (0.1 mM)	14.25	28.73	29.45
T_3 : Salicylic acid (0.3 mM)	16.66	32.86	33.80
T_4 : Salicylic acid (0.5 mM)	19.86	34.26	35.83
T_5 : GA_3 (25 ppm)	16.02	29.60	31.63
T_6 : GA_3 (50 ppm)	22.46	35.33	36.03
T_7 : GA_3 (100 ppm)	21.40	32.92	34.30
T_8 : Kinetin (25 ppm)	13.86	28.66	29.26
T_9 : Kinetin (50 ppm)	18.53	33.86	34.48
T_{10} : Kinetin (100 ppm)	15.80	31.06	33.96
SEm±	**0.38**	**0.67**	**0.69**
CD at 5%	**1.12**	**1.98**	**2.05**

Table 3 : Effect of PGRs on chlorophyll 'a' and 'b' content (mg g^{-1} fresh weight) of mustard at different growth stages.

Treatments	Chlorophyll 'a' and 'b' content and chlorophyll a-b ratio (mg g^{-1} fresh weight)			
	60 DAS		90 DAS	
	Chl 'a' content	Chl 'b' content	Chl 'a' content	Chl 'b' Content
Control	0.92	1.44	0.72	0.53
Salicylic acid (0.1 mM)	1.06	1.65	0.85	0.65
Salicylic acid (0.3 mM)	1.09	1.70	0.89	0.74
Salicylic acid (0.5 mM)	1.31	1.99	0.91	0.82
GA_3 (25 ppm)	1.14	1.74	0.89	0.65
GA_3 (50 ppm)	1.69	2.04	0.92	0.85
GA_3 (100 ppm)	1.54	1.98	0.87	0.76
Kinetin (25 ppm)	1.04	1.62	0.82	0.62
Kinetin (50 ppm)	1.44	1.93	0.91	0.82
Kinetin (100 ppm)	1.24	1.90	0.88	0.73
SEm±	**0.03**	**0.04**	**0.02**	**0.02**
CD at 5%	**0.08**	**0.12**	**0.06**	**0.05**

the doses of plant growth regulators had significant influence on total number of branches. Among these, GA_3 50 ppm produced maximum number of branches plant^{-1} at all the stages of observation i.e. 60 DAS, 90 DAS and at maturity. These results are in accordance to Bora and Sarma (2006) and Fawzy *et al*. (2011).

The data presented in table 3 clearly indicate that all the foliar application of plant growth regulators significantly improved the chlorophyll 'a' and 'b' contents in leaf upto 60 DAS and after 60 DAS the decline trend was recorded in chlorophyll 'a' and 'b' content in leaf. The maximum increase in chlorophyll 'a' and 'b' contents in leaf was registered in GA_3 50 ppm followed by salicylic acid 0.5 mM and minimum increase in kinetin 25 ppm at 60 and 90 DAS over control. Chlorophylls have been rightly designated as "pigments of life" because of their central importance in living systems responsible for harvesting sunlight and transforming its energy into biochemical energy essential for life on earth. Similar results were reported by Singh and Jain (1981) and Shairy and Hegazi (2009). The leaves of the plants receiving the exogenous GA_3 treatment had a higher chlorophyll content, which may be explained on the basis of the GA_3 generated enhancement of ultra structural morphogenesis of plastids (Arteca, 1997), coupled with the retention of

Table 4 : Effect of PGRs on oil content (%) of mustard.

Treatments	Oil content (%)
T_1 : Control	38.67
T_2 : Salicylic acid (0.1 mM)	39.18
T_3 : Salicylic acid (0.3 mM)	39.65
T_4 : Salicylic acid (0.5 mM)	39.96
T_5 : GA_3 (25 ppm)	39.26
T_6 : GA_3 (50 ppm)	40.15
T_7 : GA_3 (100 ppm)	39.80
T_8 : Kinetin (25 ppm)	38.95
Kinetin (50 ppm)	39.90
T_{10} : Kinetin (100 ppm)	39.71
SEm±	**2.58**
CD at 5%	**NS**

Data with respect to number of siliquae plant^{-1} as affected by spraying of different plant growth regulators are presented in table 5 reveal that spraying of different plant growth regulators improved the number of siliquae plant^{-1}. All the treatments significantly increase number of siliquae plant^{-1} except salicylic acid 0.1 and 0.3 mM, GA_3 25 ppm and kinetin 25 ppm over control. The maximum increase in number of siliquae plant^{-1} was recorded in GA_3 50 ppm followed by salicylic acid 0.5 mM and the minimum increase was noted in kinetin 25 ppm over control.

The perusal of the data presented in table 5 reveal that spraying of different plant growth regulators improves the number of seeds plant^{-1}. GA_3 at 50 and 100 ppm, kinetin at 50 and 100 ppm as well as salicylic acid 0.3 and 0.5 mM registered significant increase in number of seeds plant^{-1} over control however the effect of GA_3 50 ppm was more pronounced and maximum increase in number of seeds plant^{-1} was noted followed by salicylic acid 0.5 mM and kinetin 50 ppm in comparison to control

Table 5 : Effect of PGRs on siliquae plant^{-1}, seeds plant^{-1}and setting percentage of siliquae of mustard.

Treatments	Siliquae plant^{-1}	Seeds plant^{-1}	Setting percentage of siliquae
T_1 : Control	226.3	2308.26	63.92
T_2 : Salicylic acid (0.1 mM)	233.3	2430.48	66.57
T_3 : Salicylic acid (0.3 mM)	241.2	2580.84	70.21
T_4 : Salicylic acid (0.5 mM)	249.7	2746.70	74.53
T_5 : GA_3 (25 ppm)	234.5	2426.25	68.17
T_6 : GA_3 (50 ppm)	253.4	2838.08	75.14
T_7 : GA_3 (100 ppm)	247.3	2670.84	74.64
T_8 : Kinetin (25 ppm)	231.4	2383.42	66.51
T_9 : Kinetin (50 ppm)	248.6	2709.74	72.04
T_{10} : Kinetin (100 ppm)	244.5	2591.70	69.97
SEm ±	**5.29**	**56.47**	**1.54**
CD at 5%	**15.73**	**167.76**	**4.57**

chlorophyll and delay of senescence due to hormone treatment (Ouzounidou and Ilias, 2005) and an efficient utilization of optimally available N-which is a key constituent of chlorophyll.

It is clear from the data presented in table 4 that all the foliar spray of different plant growth regulators did not affect much on oil content (%) in mustard. The data shows non significant increase in oil content (%) over control.The maximum increase in oil content (%) was seen in GA_3 50 ppm followed by salicylic acid 0.5 mM and the minimum increase in kinetin 25 ppm over control. The oil content (%) increased non significantly in all the treatments over control. This show that the plant growth regulators has not much influence on oil content. The maximum oil content was recorded in GA_3 50 ppm followed by salicylic acid 0.5 mM and lowest increase was recorded in kinetin among all treatments. This findings is well supported by Mobin (1999).

It is evident from the data presented in table 5 that different doses of plant growth regulators improved the setting percentage of siliquae. All the treatments registered significant increase in setting percentage of siliquae except salicylic acid 0.1 mM, GA_3 25 ppm and kinetin 25 ppm over control. The maximum increase in setting percentage of siliquae was recorded in GA_3 50 ppm followed by salicylic acid 0.5 mM and the minimum increase was noted in kinetin 25 ppm over control.

Maximum number of siliquae plant^{-1}, seeds plant^{-1} and setting percentage of siliquae was recorded in GA_3 50 ppm followed by salicylic acid 0.5 mM while minimum increase was observed in kinetin 50 ppm These results were strongly supported by Khan *et al*. (2002), he observed an increase in the number of siliquae plant^{-1}, number of seeds plant^{-1}, setting percentage of siliquae with GA_3 application. Khan *et al*. (1977) reported an increase in yield by GA_3 and Mobin (2001) recorded that GA_3 at the optimal level of sulphur increases the biological yield. Etmal (1992) observed an increase in harvest index by the application of GA_3. Khan (1997) reported an increase in harvest index with the application of GA_3 in mustard. Khan *et. al*., (1999) reported that GA_3 increased the yield and yield components.

References

Anonymous (2013). *Economic Survey of India*. Economic Division, Ministry of Finance, Govt. of India, New Delhi.

Arnon, D. J. (1949). Copper enzymes in isolated chloroplast, polyphenyl oxidase in *Beta vulgaris*. *Plant Physiol*., **24** : 1-15.

Arteca, R. N. (1997). *Plant Growth Substances*. Principles and Applications. CBS Publishers, New Delhi.

Bora, R. K. and C. M. Sarma (2006). Effect of Gibberellic Acid and Cycocel on Growth, Yield and Protein Content of Pea. *Asian J. Plant Sc*., **5(2)** : 324-330.

Cag, S., G. Cevahir-oz, M. Sarsag and N. Goren-Saglam (2009). Effect of salicylic acid on pigment, protein content and peroxide activity in excised sunflower cotyledons. *Pak. J. Bot*., **41** : 2297-2303.

Castro, P. R. C., E. S. Evangelista, E. Melotto and E. Rodrigues (1989). Action of growth regulators on rape (*Brassica napus* L.). Revista decreasing Agriculture (Piracicaba). *Plant Growth Reg*., **64 (1)** : 35-44.

Chauhan, J. S., Y. K. Tomar, A. Badoni, N. I. Singh, S. Ali and L. Debarati (2009). Morphology, germination and early seedling growth in *Phaseolus mungo* L. with reference to the influence of various plant growth substances. *J. American Sc*., **6** : 34–41.

Deotale, R. D., V. G. Mask, N. V. Sorte, B. S. Chimurkar and A. Z. Yerne (1998). Effect of GA_3 and IAA on morpho-physiological parameters of soybean. *J. Soils & Crops*, **8** : 91-94.

Dulizhao, Derrick M. M. and Ooterhuis (2000). Effect of growth regulators on sugar content of French bean. **11(2)** : 156.

Fawzy, Z. F., A. M. El-Bassinoy, M. A. El-Nemr and M. El-Desuki (2011). Improvement growth, yield and quality of two snap bean (*Phaseolus vulgaris* L.) varieties using some growth regulators. *J. Applied Sc. Res*., **7(12)** : 2047-2055.

Gepstein, S. and K. V. Thimann (1981). The role of ethylene in the senescence of oat leaves. *Plant Physiol*., **68** : 349-354.

Gunes, A., A. Inal, M. Alpaslan, N. Cicek, E. Guneri, F. Eraslan and T. Guzelordu (2005). Effects of exogenously applied salicylic acid on the induction of multiple stress tolerance and mineral nutrition in maize (*Zea mays* L.). *Archives of Agron. and Soil Sc*., **51** : 687-695.

Hare, P. D., W. A. Cress and J. Van Staden (1997). The involvement of cytokinin in plant responses to environmental stress. *Plant Growth Regul*., **23** : 79-103.

Huang, R. H., J. H. Liu, Y. M. Lu and R. X. Xia (2008). Effect of salicylic acid on the antioxidant system in the pulp of 'Cara cara' navel orange (*Citrus sinensis*(L.) Osbeck) at different storage temperatures. *Postharvest Biology and Technology*, **47** : 168-175.

Huff, A. K. an C. W. Ross (1975). Promotion of radish cotyledon enlargement and reducing sugar content by zeatin and red light. *Plant Physiol*., **56** : 429-433.

Hutchison, C. E. and J. J. Kieber (2002). Cytokinin signaling in Aradiopsis. *Plant Cell*., **14** : 47-59.

Jupe, S. C., D. R. Causton and I. M. Scott (1988). Cellular basis of the effects of gibberellin and the pro gene on stem growth in tomato. *Planta*, **176** : 106-1011.

Khan, M. A. and M. A. Chowdhary (1977). Effect of growth regulators on flowering and yield of gram (*Cicer arietinum* L.). *Plant Growth Regu.. Abst*., **3(6)** : 66.

Khan, M. S. K. (1997). Effect of different levels of nitrogen on growth, yield and quality of wheat. A thesis submitted to the Department of Agronomy in partial fulfilment of the requirements for the degree of Master of Science in Agronomy, BAU, Mymensingh, Bangladesh.

Khan, N. A., R. Mir, M. Khan, S. Javid and L. Samiullah (2002). Effects of gibberellic acid spray on nitrogen yield efficiency of mustard grown with different nitrogen levels. *Plant Growth Regu*., **38** : 243–247.

Khan, N. A., H. R. Ansari, M. Khan, R. Mir and Sanuiullah (2002). Effect of phytohormones on growth and yield of Indian mustard. *Indian J. Plant Physiol*., **7(1)** : 75-78.

Lee, H. S. (1990). Effect of pre-sowing seed treatments with GA_3 and IAA on flowering and yield components in groundnuts. *Korean J. Crop Sci*., **35** : 1-9.

Maske, V. G., R. D. Deotale, N. B. Sorte, H. B. Gorammagar and C. N. Chore (1998). Influence of GA_3 and NAA on growth and yield contributing parameters of soybean. *J. Soils Crops*, **8** : 20-21.

Mobin, M. (1999). Morphophysiology and productivity of mustard in relation to gibberellic acid and sulphur application. *Ph. D. Thesis*. Aligarh Muslim University, Aligarh, India.

Ouzounidou, G. and Ilias (2005). Hormone induced protection of sunflower photosynthetic apparatus against copper toxicity. *Biol. Plant*., **49** : 223-228.

Shah, S. H. (2004). Morphophysiological response of black cumin (*Nigella sativa* L.) to nitrogen, gibberellic acid and kinetin application. *Ph D. Thesis*, AMU, Aligarh, India.

Shairy, A. M. E. I. and H. M. Amira (2009). Effect of acetylsalicylic acid, Indole-3-Bytric acid and Gibberellic Acid on plant growth and yield of pea (*Pisum sativum* L.). *Australian J. Basic and App. Sc*., **3(4)** : 3514-3523.

Sharma, K. and S. Kaur (2006). Effect of salicylic acid, caffeic acid and light intensity on yield and yield contributing parameters in soybean. *Environ. Ecol*., **21(2)** : 332-335.

Singh, G. and N. Jain (1901). Effect of some growth regulators on certain biochemical parameters during seed development in chickpea under salinity. *Ind. J. Pl. Physio*., **22(1-4)** : 191-197.

Srivastava, M. K. and U. N. Dwivedi (2000). Delayed ripening of banana fruit by salicylic acid. *Plant Sci*., **158** : 87-96.

Steller, D. A. and W. M. Laetsch (1965). Kinetin- induced chloroplast maturation in cultures of tobacco tissue. *Science*, **149** : 1387-1388.

Takei, K. T., T. Takahashi, H. Sugiyama and Sakakibara (2012). Multiples routes communicating nitrogen availability from roots to shoots, a signal transduction pathway mediated by Cytokinin. *J. Exp. Bot*., **53** : 971-977.