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Effect of PGRS on phenology and biochemical changes of mustard [*Brassica juncea* (L.) Czern. & Coss.]

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Abstract
The present investigation entitled "Effect of PGRs on phenology and biochemical changes of mustard [*Brassica juncea* (L.) Czern. & Coss.]" was conducted during *rabi* season, 2013-14 at the Student Instructional Farm of Narendra Deva University of Agriculture & Technology, Kumarganj, Faizabad (U.P.), India. The experiment was laid out in randomized block design with ten treatments, three replications and one variety *i.e.* 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. The observations were taken on phenology parameters like number of flower plant^{-1} at full blooming stage and biochemical parameters like chlorophyll content and NPK uptake. All the PGRs *viz*., salicylic acid, GA_3 and kinetin induced positive influence on number of flower plant^{-1}, chlorophyll content and NPK uptake in plants but the foliar spraying of GA_3 50 ppm at 30 DAS was found more profound among all treatments. On the basis of above investigation it may be concluded that foliar spray of PGRs at 30 DAS may be used to increase in number of flowers per plant chlorophyll and NPK uptake in mustard.

Keywords: Mustard, GA_3, SA, kinetin, phenology, biochemical.

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. India occupies the second position in area after china and third position in production of rapeseed-mustard in the world after China and Canada. In India, it is the second most important edible oilseed crop after groundnut sharing 25-30 percent Indian oilseed economy. 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) [17]. 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) [4].

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) [16]. Gibberellic acid (GA_3) is a phytohormone that is needed in small amounts at low concentration to accelerate plant growth and development. So, favorable condition may be induced by applying growth regulators like GA_3 exogenously in proper concentration at a proper time in a specific crop. 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) [14, 14].

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) [1], transpiration, stomatal regulation, nutrient uptake and transport (Gunes *e. al*., 2005) [6], flowering, inhibition of fruit ripening (Srivastava and Dwivedi, 2000) [18]. Salicylic acid has drawn the great attention of researchers due to its ability to induce systemic acquired resistance (SAR) in plants leading to defense mechanism against various biotic and abiotic stresses (Syeed *et al.*, 2011 and Idress *et al.*, 2011) [20, 10]. 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) [9]. CKs are involved in various processes of growth and development in plants (Takei *et al.*, 2012) [21]. These effects of CKs are due to interactions with other plant harmones and environmental signals (Hare *et al.*, 1997) [7]. Cytokinins promote cotyledon expansion, leaf development and chloroplast differentiation (Stetler and Laetsch, 1965; Huff and Ross, 1975) [8]. During later vegetative growth, cytokinins and ethylene control the onset of leaf senescence (Gepstein and Thimann, 1981) [5].

Materials and Methods

The present investigation was conducted at Instructional Farm of Narendra Deva University of Agriculture & Technology, Kumarganj Faizabad (U.P.) during *Rabi* season of 2013-2014. The experiment constituted of 10 treatment combinations were laid out in randomized block design (RBD) with three replications. Solution of GA_3 25 ppm, GA_3 50 ppm, $GA_3$100 ppm, Salicylic acid 0.1mM, Salicylic acid 0.3 mM and Salicylic acid 0.5 mM and kinetin 25 ppm, kinetin 50 ppm and kinetin 100 ppm 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. The nitrogen and phosphorus of shoot and grain was determined separately using colorimetric method of Linder (1944). The Potassium of shoot and grain was determined separately using flame photometer.

Results and Discussion

The data pertaining to the number of flowers $plant^{-1}$ at full blooming stage is given in Table 1 show that all the doses of plant growth regulators enhanced the number of flowers $plant^{-1.}$ The maximum increase in number of flowers $plant^{-1}$ observed in GA_3 50 ppm followed by salicylic acid 0.5 mM and minimum increase in kinetin 25 ppm at full blooming stage over control. These findings are well supported by Chauhan *et al*. (2010) also reported that GA_3 positively influence the number of flowers $plant^{-1}$.

The data presented in Table 2 clearly indicate that all the foliar application of plant growth regulators significantly improved the total chlorophyll contents in leaf upto 60 DAS and after 60 DAS the decline trend was recorded in total chlorophyll content in leaf. The maximum increase in total chlorophyll content 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. These results corroborated the findings of Senthil (2003) [15] in soybean, Travaglia *et al*. (2009) [22] and Islam *et al*. (2010) [11] in soybean.

It is evident from the data presented in Table 3 that all the foliar spray of plant growth regulators significantly increased the uptake of NPK in mustard as compared to control except salicylic acid 0.1 mM and kinetin 25 ppm. Maximum increase in uptake of NPK was recorded in case of GA_3 50 ppm followed by salicylic acid 0.5 mM and minimum increase in kinetin 25 ppm. These findings are in confirmation of the earlier report of Khan *et al.* (1996) [12] in corn plants.

Table 1: Effect of PGRs on number of flowers $plant^{-1}$ of mustard at full blooming stage

Treatment	Number of flowers $plant^{-1}$
Control	252.4
Salicylic acid (0.1mM)	273.2
Salicylic acid (0.3mM)	291.6
Salicylic acid (0.5mM)	307.3
GA_3(25 ppm)	274.7
GA_3 (50 ppm)	327.2
GA_3 (100 ppm)	316.4
Kinetin (25 ppm)	272.5
Kinetin (50 ppm)	309.5
Kinetin (100 ppm)	305.7
SEm±	**6.41**
CD at 5%	**19.04**

Table 2: Effect of PGRs on total chlorophyll content (mg g^{-1} fresh weight) of mustard at different growth stages

Treatments	Total Chlorophyll content (mg g^{-1} fresh weight)	
	60 DAS	90 DAS
Control	1.48	1.08
Salicylic acid (0.1mM)	1.67	1.22
Salicylic acid (0.3mM)	1.74	0.74
Salicylic acid (0.5mM)	2.04	1.42
GA_3(25 ppm)	1.78	1.25
GA_3 (50 ppm)	2.14	1.45
GA_3 (100 ppm)	2.01	1.36
Kinetin (25 ppm)	1.65	1.18
Kinetin (50 ppm)	1.97	1.32
Kinetin (100 ppm)	1.92	1.29
SEm±	**0.04**	**0.02**
CD at 5%	**0.12**	**0.05**

Table 3 (a): Effect of PGRs on NPK Content (%) of mustard at maturity

Treatments	NPK uptake (%)					
	N Content (%)		P Content (%)		K Content (%)	
	Seed	Stover	Seed	Stover	Seed	Stover
Control	2.604	0.605	0.53	0.41	0.60	1.30
Salicylic acid (0.1mM)	2.609	0.608	0.54	0.43	0.61	1.32
Salicylic acid (0.3mM)	2.611	0.612	0.56	0.46	0.63	1.35
Salicylic acid (0.5mM)	2.642	0.631	0.59	0.49	0.67	1.39
GA3(25 ppm)	2.610	0.611	0.55	0.44	0.62	1.33
GA3 (50 ppm)	2.661	0.642	0.61	0.51	0.68	1.41
GA3 (100 ppm)	2.647	0.627	0.59	0.49	0.67	1.39
Kinetin (25 ppm)	2.607	0.607	0.53	0.42	0.60	1.31
Kinetin (50 ppm)	2.640	0.629	0.59	0.47	0.66	1.38
Kinetin (100 ppm)	2.627	0.624	0.57	0.45	0.65	1.37
SEm±	**0.06**	**0.01**	**0.01**	**0.01**	**0.01**	**0.03**
CD at 5%	**NS**	**NS**	**0.04**	**0.04**	**0.04**	**NS**

Table 3 (b): Effect of PGRs on NPK uptake (kg ha^{-1}) of mustard at maturity

Treatments	**NPK uptake (kg ha^{-1})**								
	N uptake (kg ha^{-1})			**P uptake (kg ha^{-1})**			**K uptake (kg ha^{-1})**		
	Seed	Stover	**Total**	Seed	Stover	**Total**	Seed	Stover	**Total**
Control	40.15	32.56	72.71	8.17	22.06	30.23	9.25	69.96	79.21
Salicylic acid (0.1mM)	43.07	33.07	76.14	8.91	23.39	32.30	10.07	71.80	81.87
Salicylic acid (0.3mM)	46.97	35.43	82.40	10.07	26.63	36.70	11.33	78.16	89.49
Salicylic acid (0.5mM)	52.20	38.29	90.49	11.65	29.73	41.38	13.23	84.35	97.58
GA3(25 ppm)	44.60	35.12	79.72	9.39	25.29	34.68	10.59	76.44	87.03
GA3 (50 ppm)	54.65	39.73	94.38	12.52	31.56	44.08	13.96	87.26	101.22
GA3 (100 ppm)	50.69	37.92	88.61	11.29	29.64	40.93	12.83	84.08	96.91
Kinetin (25 ppm)	42.10	33.77	75.87	8.55	23.37	31.92	9.69	72.90	82.59
Kinetin (50 ppm)	50.52	37.99	88.51	11.29	28.39	39.68	12.63	83.36	95.99
Kinetin (100 ppm)	47.28	37.52	84.80	10.26	27.06	37.32	11.70	82.39	94.09
SEm±	**1.04**	**0.79**	**1.83**	**0.23**	**0.59**	**0.81**	**0.25**	**1.73**	**1.89**
CD at 5%	**3.09**	**2.35**	**5.44**	**0.67**	**1.74**	**2.41**	**0.75**	**5.14**	**5.89**

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