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Effect of elicitors on growth, biochemical and antioxidant activity in two varieties of wheat (*Triticum aestivum* L.) under drought

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ABSTRACT

The study investigated the effect of different elicitors on two varieties of *Triticum aestivum* (10 days old seedlings) under drought stress. The growth of plants along with various biochemical and antioxidant parameters was determined on 5th, 10th and 15th day of drought stress. Six varieties of wheat *viz.* RAJ-4120, RAJ-4079, RAJ-3077, RAJ-4238, RAJ-4037 and RAJ-3765 were treated with different elicitors i.e. sodium nitroprusside (0.5mM), salicylic acid (10mM) and silver nitrate (10mM) for six hours before sowing and exposed to drought stress. Chemically primed seeds were sown in pots containing soil along with hydro primed seeds which were not pretreated with any chemical and were used as control. The results indicated that in all the control plants, growth of the seedlings increased with time. In drought stressed seedlings the growth was less than the control plants. Seedlings pretreated with sodium nitroprusside showed the highest growth, biochemical and antioxidant activity. Under drought stress also these parameters were higher in sodium nitroprusside pretreated plants when compared to stressed plants having no pretreatment.

Key words: Drought, Elicitors, Growth parameters, Wheat varieties.

INTRODUCTION

Plants possess the ability to deal with different abiotic stresses which include drought stress, flooding, extreme temperatures and soils with varying nutrients and salt concentrations and high winds. Drought is a major abiotic stress which restricts the growth and production of plants worldwide (Almeselmani and Abd, 2011). In both arid and semiarid areas drought stress causes important agricultural losses (Boyers, 1982). Worldwide approximately 45% of the agricultural land is subjected to drought stress (Ashraf and Foolad, 2007).

Wheat (*Triticum aestivum* L.) is cultivated on 220 million hectares approx. worldwide. Wheat accounts for 20% of the human food consumption (Chachar *et al*., 2016). It requires rainfall between 30cm and 90cm and warm temperature conditions. Wheat contains calories and proteins which are approximately 72% in a normal diet. Wheat is the main staple food of South Asia. However, the current production of wheat is not able to meet the demand of population. Efforts are being done to increase wheat production, but it is very difficult to attain under drought conditions (Jatoi *et al*., 2011).

Elicitors are the intrinsic, foreign molecules that get attached to special receptor proteins present on plant cell membrane. Elicitors are the agents that induce defense reaction in the plants. Elicitors have significant role in various biosynthetic pathways; they enhance both production of commercially important compounds and also the synthesis of plant secondary metabolites which are released during defense responses. Elicitors can be categorized as abiotic and biotic elicitors and are known to provide protection against drought condition in plants (Zhao *et al*., 2005). Salicylic acid (SA) provides tolerance to plants against various abiotic stresses including UV, drought, osmotic and heat stress (Khan *et al*., 2013). Sodium nitroprusside (SNP) donates nitric oxide (NO) whichis used for plants responses to various environmental stimuli as mechanical wounding, high light intensity, drought stress and salinity conditions (Filippou *et al*., 2011). Silver nitrate ($AgNO_3$) modifies the total antioxidant status in fruits. Silver nitrate prevents the abscission of fruits, flowers and leaves caused by ethylene (Beyer, 1976).

MATERIALS AND METHODS

Plant growth: Seeds of six varieties of *Triticum aestivum* L. *viz*. RAJ-4120, RAJ-4079, RAJ-3077, RAJ-4238, RAJ-4037 and RAJ-3765 were obtained from the Krishi Vigyan Kendra, Banasthali Vidyapith, Rajasthan. These varieties were treated with different elicitors *viz*., sodium nitro prusside (500uM), salicylic acid (10mM) and silver nitrate (10mM) for six hours before sowing. The chemically primed seeds were sown in pots containing soil along with hydro primed seeds which were not pretreated with any chemical and were used as control. The plants were watered regularly for 10 days and after 10 days two sets were made for each treatment.

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The control was watered regularly. In the drought stressed plants water was not given. For each treatment three replicates were taken. The measurements were carried out on 5th, 10th and 15th day of stress.

The root length, shoot length, fresh weight and dry weight of plants were determined after 5th, 10th and 15th day of drought. The estimation of chlorophyll content was done by following the method given by Arnon (1949). The flavonoid content was estimated by using the technique given by Chang *et al*. (2002). The polyphenol content was determined according the method given by Mc Donald *et al*. (2001).

The total protein content was determined according to method given by Lowry *et al*. (1951). The activity of peroxidase (POX) was determined by the procedure given by Putter (1974). The activity of phenylalanine ammonia lyase (PAL) was determined by the method of Camn and Towers (1973).

Statistical analyses: The data were presented as mean ± standard deviation of three replicates. The data was subjected to analysis of variance (ANOVA).

RESULTS AND DISCUSSION

Growth analysis: In the present study, six wheat varieties were treated with sodium nitroprusside (0.5mM), salicylic acid (10mM) and silver nitrate (10mM) for six hours before sowing and were screened to see the effect of different elicitors under drought stress. The growth response of 10 days old wheat plants was studied by evaluating root length, shoot length, fresh weight and dry weight under both control and drought stressed condition on 5th, 10th and 15thday. The growth parameters were found higher in variety RAJ-4120 whereas in variety RAJ-3765 the growth parameters were found to be lower (Table 1). In drought stressed seedlings the values were lower than control for all parameters. The seedlings pretreated with SNP showed the highest value of growth parameters when compared with drought affected seedlings, having no pre-treatment, salicylic acidand silver nitratetreated plants.Sodium nitroprusside was found to be better elicitor than salicylic acid and silver nitrate. In drought stressed plants the highest value of root length, shoot length, fresh weight and dry weight was measured in SNP pretreated seedlings on 15th day of stress in variety RAJ-4120. Our findings showed that pre-treatment of wheat plant under drought stress with sodium nitroprusside, salicylic acid and silver nitrate decreased the adverse effects of drought stress and are involved in the regulation of plant growth.

Aftab *et al*. (2012) concluded that exogenous application of SNP increased root length in plants treated with boron and aluminium.

Biochemical parameters: The analysis of biochemical parameters was carried out in two varieties i.e. RAJ-4120 (resistant) and RAJ-3765 (susceptible), which were selected after screening six varieties.

Table 1: Effect of different elicitors on root length, shoot length, fresh weight and dry weight in ten days old wheat cultivars under control and drought conditions.

			Root Length (cm)		Shoot Length (cm)		Shoot Fresh Weight (gm)		Shoot Dry Weight (gm)		Root Fresh Weight (gm)		Root Dry Weight (gm)	
Treat ment	Days	Cultivar	Control	Drought	Control	Drought	Control	Drought	Control	Drought	Contorl	Drought	Control	Drought
No-pre treatment	5	RAJ-3765	6.53a ± 2.05	14.9b ± 2.59	3.26a ± 0.75	3.6a ± 0.51	0.04a ± 0.04	0.024b ± 0.004	0.009a ± 0.00	0.005a ± 0.00	0.065a ± 0.043	0.0043a ± 0.0057	0.0043a ± 0.004	0.0023a ± 0.004
		RAJ-4120	25.56b ± 1.06	22.33b ± 2.30	4.1a ± 0.173	4.93b ± 0.11	0.21a ± 0.14	0.008a ± 0.00	0.018*a ± 0.00	0.01a ± 0.01	0.181a ± 0.031	0.0146a ± 0.0063	0.015a ± 0.008	0.010a ± 0.008
		RAJ-4079	22.86b ± 2.042	17c ± 5.41	3.33a ± 1.10	3.33a ± 0.57	0.020a ± 0.15	0.032a ± 0.00	0.0126a ± 0.10	0.0110a ± 0.01	0.016a ± 0.006	0.0046a ± 0.0063	0.013a ± 0.005	0.009a ± 0.005
		RAJ-3077	24b ± 0.78	16.23b ± 2.43	3.56a ± 0.513	4.66a ± 0.66	0.178b ± 0.03	0.048a ± 0.00	0.01a ± 0.01	0.001a ± 0	0.138a ± 0.054	0.0034a ± 0.000	0.012a ± 0.006	0.032a ± 0.00
		RAJ-4238	15.46a ± 1.36	17.63b ± 0.55	3.83a ± 0.288	4.56c ± 0.23	0.208a ± 0.15	0.079a ± 0.057	0.146a ± 0.010	0.0136a ± 0.010	0.083a ± 0.092	0.004a ± 0.0051	0.004a ± 0.001	0.002a ± 0.001
		RAJ-4037	25.06c ± 1.61	16.73b ± 1.27	3.73a ± 0.56	4.16b ± 0.057	0.089a ± 0.019	0.047a ± 0.054	0.16a ± 0.007	0.015a ± 0.007	0.171a ± 0.049	0.006a ± 0.0069	0.022a ± 0.01	0.011a ± 0.01
	10	RAJ-3765	9.23a ± 2.052	10.33b ± 1.154	3.33a ± 0.49	4.03c ± 0.057	0.088b ± 0.020	0.020a ± 0.001	0.009a ± 0.0005	0.005a ± 0.0005	0.102a ± 0.008	0.0083a ± 0.0063	0.016a ± 0.005	0.005a ± 0.004
		RAJ-4120	26.16a ± 1.44	19.66a ± 3.28	6.3a ± 0.519	4.73ab ± 0.46	0.28a ± 0.12	0.05a ±0.07	0.046a ± 0.0017	0.018*a ± 0.001	0.194a ± 0.009	0.007a ± 0.0051	0.103a ± 0.015	0.023a ± 0.027
		RAJ-4079	23c ± 2.64	10.53a ± 5.53	3.76a ± 0.404	3.93b ± 0.11	0.21a ± 0.19	0.028a ± 0.005	0.013ab ± 0.005	0.011ab ± 0.005	0.53a ± 0.420	0.0133a ± 0.0057	0.016a ± 0.005	0.0106a ± 0.009
		RAJ-3077	25.33c ± 1.67	13.3a ± 3.10	4.4a ± 0.69	4a ± 1	0.18a ± 0.017	0.045a ± 0.057	0.019a ± 0.046	0.026a ± 0.012	0.145a ± 0.050	0.0024a ± 0.000	0.079b ± 0.035	0.033b ± 0.001
		RAJ-4238	16.26a ± 7.58	12.33a ± 1.52	4.96a ± 0.057	74.23a ± 0.63	0.24a ± 0.18	0.047a ± 0.038	0.017a ± 0.004	0.010a ± 0.004	0.086a ± 0.098	0.0034a ± 0.0005	0.0010a ± 0.000	0.008a ± 0.010
		RAJ-4037	26.66*a ± 0.57	12.56a ± 0.47	4.43a ± 1.98	3.66a ± 0.56	0.091a ± 0.014	0.037a ± 0.030	0.017a ± 0.011	0.011a ± 0.008	0.209a ± 0.086	0.0036a ± 0.0011	0.084a ± 0.027	0.043a ± 0.01
	15	RAJ-3765	15.33a ± 0.577	8.33a ± 0.57	4a ± 0.1	3.13a ± 0.057	0.229a ± 0.15	0.0277a ± 0.019	0.016a ± 0.006	0.010a ± 0.004	0.155a ± 0.05	0.0103a ± 0.005	0.033a ± 0.015	0.0103a ± 0.009
		RAJ-4120	27.83a ± 2.36	8.76a ± 0.40	8.46a ± 0.808	4.53a ± 0.55	0.42a ± 0.00	0.06a ± 0.05	0.02a ± 0.010	0.01a ± 0.01	0.300a ± 0.099	0.0093a ± 0.0063	0.161a ± 0.067	0.031a ± 0.005
		RAJ-4079	23.33a ± 5.77	12.33b ± 1.20	6.96b ± 0.05	4.16a ± 0.28	0.40a ± 0.19	0.024a ± 0.004	0.0076a ± 0.005	0.0036a ± 0.005	0.242a ± 0.005	0.0026a ± 0.0011	0.020a ± 0.009	0.011a ± 0.01
		RAJ-3077	25.66a ± 2.05	13.66a ± 2.51	4.96a ± 0.05	3.76a ± 0.40	0.40a ± 0.008	0.040a ± 0.050	0.024a ± 0.009	0.012a ± 0.009	0.189a ± 0.017	0.0016a ± 0.0005	0.122a ± 0.068	0.109a ± 0.08
		RAJ-4238	21.4a ± 4.32	10.26a ± 2.96	6.5a ± 3.041	4a ± 1	0.41a ± 0.177	0.044a ± 0.056	0.019a ± 0.00	0.0136a ± 0.010	0.1a ± 0.001	0.0026a ± 0.0005	0.016a ± 0.013	0.009a ± 0.007
		RAJ-4037	27.06a ± 0.98	10.16a ± 5.00	4.4a ± 1.92	3.6a ± 0.17	0.38a ± 0.22	0.027a ± 0.019	0.0186a ± 0.010	0.0166a ± 0.010	0.214a ± 0.079	0.0033a ± 0.00057	0.015b ± 0.05	0.013a ± 0.053
Silver nitrate	5	RAJ-3765	7.6a ± 1.044	6.16*a ± 0.76	3.01a ± 0.028	3.53a ± 0.057	0.01a ± 0.01	0.014a ± 0.011	0.0106a ± 0.009	0.0100a ± 0.009	0.053a ± 0.059	0.002a ± 0.0057	0.005 ± 0.004	0.001a ± 0.00
		RAJ-4120	14*a ± 5.19	15.5*a ± 4.69	4.3ab ± 0.1	3.4*a ± 0.17	0.12a ± 0.09	0.04a ± 0.06	0.015*a ± 0.008	0.010a ± 0.001	0.154a ± 0.047	0.0116a ± 0.0051	0.01a ± 0.004	0.002a ± 0.001
		RAJ-4079	15.2ab ± 4.2	5*a ± 1	4.16a ± 0.25	3.23a ± 0.40	0.058a ± 0.04	0.016a ± 0.01	0.015a ± 0.10	0.011a ± 0.001	0.056a ± 0.048	0.004a ± 0.0051	0.006a ± 0.01	0.006a ± 0.00
		RAJ-3077	9.83*a ± 1.71	8*a ± 3.46	4.3a ± 0.72	4.16a ± 0.28	0.102ab ± 0.003	0.044a ± 0.001	0.0116a ± 0.002	0.0110a ± 0.01	0.066a ± 0.045	0.004a ± 0.0051	0.005a ± 0.001	0.002 ± 0

Table 1: Continue..........

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		RAJ-4238	8.33a ± 1.41	10.73*a ± 0.23	3.9a ± 0.1	3.86*ab ± 0.11	0.045a ± 0.04	0.14a ± 0.011	0.0136a ± 0.010	0.012a ± 0.009	0.05a ± 0.051	0.008a ± 0.0011	0.006a ± 0.001	0.003a ± 0.001
		RAJ-4037	14.66*a ± 0.57	8.56*a ± 1.28	3.53a ± 0.50	3.23*a ± 0.25	0.061a ± 0.051	0.0143a ± 0.011	0.014a ± 0.009	0.012a ± 0.009	0.060a ± 0.053	0.0026a ± 0.0005	0.005a ± 0.001	0.002a ± 0.001
	10	RAJ-3765	9.53a ± 1.28	6.83ab ± 0.57	3.8a ± 0.17	3.56*ab ± 0.05	70.046ab ± 0.01	0.009ab ± 0.006	0.0116a ± 0.007	0.0113a ± 0.002	0.054a ± 0.053	0.008ab ± 0.0057	0.009a ± 0.001	0.004a ± 0.04
		RAJ-4120	16.26a ± 4.36	19.63a ± 4.32	5a ± 0.866	3.93a ± 0.11	0.15a ± 0.07	0.06a ± 0.05	0.05a ± 0.007	0.013a ± 0.007	0.198a ± 0.080	0.02a ± 0.0055	0.041a ± 0.001	0.016a ± 0.001
		RAJ-4079	9.5*a ± 1.41	7.33a ± 0.57	3.83a ± 0.64	3.96b ± 0.057	0.096a ± 0.005	0.027a ± 0.022	0.0133ab ± 0.005	0.0122a ± 0.005	0.066a ± 0.007	0.0073a ± 0.0057	0.026a ± 0.005	0.013a ± 0.005
		RAJ-3077	10.26*a ± 1.79	10.06a ± 0.11	4.86a ± 0.35	4.83a ± 0.28	0.11a ± 0.078	0.061a ± 0.051	0.0163a ± 0.006	0.0123a ± 0.006	0.094a ± 0.112	0.0143a ± 0.0098	0.034a ± 0.00	0.006a ± 0.001
		RAJ-4238	9.73a ± 2.19	12.66a ± 1.19	4.566a ± 0.98	4.06a ± 1.20	0.086a ± 0.023	0.09a ± 0.069	0.017a ± 0.004	0.0135a ± 0.004	0.11a ± 0.173	0.0136a ± 0.0055	0.009a ± 0.008	0.0076a ± 0.003
		RAJ-4037	16.6*a ± 2	9.96a ± 1.00	3.93a ± 0.513	3.3a ± 0.17	0.144a ± 0.096	0.016a ± 0.014	0.016*a ± 0.051	0.024a ± 0.051	0.070a ± 0.052	0.0103 ± 0.0052	0.014a ± 0.010	0.009a ± 0.001
	15	RAJ-3765	15.83a ± 2.02	8.66a ± 3.40	4.2a ± 0.346	3.36*b ± 0.057	0.12a ± 0.069	0.073a ± 0.055	0.0163a ± 0.006	0.0133a ± 0.003	0.065a ± 0.044	0.015 ± 0.0055	0.0104a ± 0.011	0.012a ± 0.011
		RAJ-4120	19.63a ± 0.89	22.53*bc ± 3.48	5.366a ± 0.32	4.76a ± 0.40	0.30a ± 0.15	0.14a ± 0.06	0.019b ± 0.001	0.015b ± 0.001	0.209a ± 0.087	0.0233*a ± 0.0060	0.073a ± 0.011	0.024a ± 0.011
		RAJ-4079	16.16a ± 5.39	8*a ± 2	4.33*a ± 0.57	4a ± 2	0.21a ± 0.18	0.064a ± 0.057	0.017a ± 0.006	0.012a ± 0.006	0.08a ± 0.100	0.018a ± 0.010	0.076a ± 0.005	0.020a ± 0.00
		RAJ-3077	13.63a ± 2.30	11.63a ± 0.32	5.46a ± 0.80	5.23*b ± 0.30	0.26a ± 0.12	0.064a ± 0.049	0.0153a ± 0.008	0.0123a ± 0.006	0.104a ± 0.012	0.021a ± 0.015	0.050a ± 0.005	0.012a ± 0.018
		RAJ-4238	11.66a ± 0.57	16.26ab ± 4.25	4.86a ± 0.23	4.66a ± 0.57	0.18a ± 0.03	0.138a ± 0.118	0.019a ± 0.0017	0.014a ± 0.010	0.15a ± 0.005	0.193*b ± 0.0057	0.03a ± 0.00	0.014a ± 0.001
		RAJ-4037	18.06a ± 0.90	10.5a ± 0.86	4.3a ± 0.264	4.63*b ± 0.057	0.26a ± 0.12	0.105a ± 0.095	0.0193a ± 0.0011	0.014a ± 0.010	0.073a ± 0.052	0.0133a ± 0.0057	0.04a ± 0.005	0.021a ± 0.018
Salicylic acid	5	RAJ-3765	15.06*b ± 2.61	6.3*a ± 1.50	3.63a ± 0.472	2.66a ± 0.057	0.006a ± 0.00	0.012ab ± 0.008	0.0163a ± 0.006	0.0133a ± 0.003	0.040a ± 0.052	0.0073a ± 0.0055	0.007a ± 0.001	0.003a ± 0.001
		RAJ-4120	19.26ab ± 2.74	15.5*a ± 5.09	4.36ab ± 0.152	3.83*a ± 0.288	0.09a ± 0.08	0.08a ± 0.04	0.016a ± 0.011	0.013a ± 0.007	0.107a ± 0.057	0.0103a ± 0.004	0.0076a ± 0.004	0.004 ± 0.001
		RAJ-4079	13.46*b ± 4.63	13.93bc ± 3.99	3.8a ± 0.26	3.1a ± 0.17	0.045a ± 0.04	0.049b ± 0.001	0.015a ± 0.006	0.012a ± 0.001	0.091a ± 0.056	0.0056a ± 0.0064	0.006a ± 0.001	0.003a ± 0.001
		RAJ-3077	15.46*a ± 4.23	7.53*a ± 3.50	4.26a ± 0.46	3.33a ± 1.25	0.024*a ± 0.009	0.044a ± 0.001	0.014a ± 0.010	0.012a ± 0.001	0.066a ± 0.098	0.009a ± 0.006	0.006 ± 0.003	0.02a ± 0.001
		RAJ-4238	13.06a ± 4.08	8*a ± 1.73	4.06a ± 0.115	3.46*a ± 0.057	0.056a ± 0.038	0.015a ± 0.010	0.019a ± 0.0017	0.014a ± 0.010	0.047a ± 0.056	0.014a ± 0.0051	0.007a ± 0.004	0.0035a ± 0.001
		RAJ-4037	16.33*ab ± 0.28	10.2*a ± 1.31	3.8a ± 0.754	3.06*a ± 0.011	0.017a ± 0.011	0.053a ± 0.057	0.0086a ± 0.0023	0.0043a ± 0.002	0.053a ± 0.059	0.0083a ± 0.0057	0.008a ± 0.002	0.0032a ± 0.00
	10	RAJ-3765	15.66*b ± 2.88	9.93b ± 2.74	3.93a ± 0.305	3.86bc ± 0.02	0.016*a ± 0.006	0.019a ± 0.018	0.017a ± 0.005	0.013a ± 0.007	0.073a ± 0.11	0.012a ± 0.0017	0.014a ± 0.009	0.06a ± 0.01
		RAJ-4120	22.93a ± 0.75	19.47a ± 4.28	4.73a ± 1.150	4.4ab ± 0.34	0.14a ± 0.09	0.09a ± 0.05	0.023*a ± 0.01	0.012a ± 0.01	0.211a ± 0.0317	0.0133a ± 0.0064	0.021a ± 0.001	0.09a ± 0.001
		RAJ-4079	14.6*a ± 0.88	14.16a ± 6.04	4.23a ± 0.40	3.56*a ± 0.11	0.084a ± 0.027	0.061a ± 0.06	0.006*a ± 0.006	0.0023a ± 0.003	0.118a ± 0.009	0.0056a ± 0.0057	0.015a ± 0.011	0.07a ± 0.001
		RAJ-3077	20.5*b ± 0.70	10.56a ± 2.48	4.53a ± 0.50	3.43a ± 0.40	0.044a ± 0.050	0.084a ± 0.064	0.0143a ± 0.009	0.0123a ± 0.006	0.083a ± 0.109	0.01a ± 0.0069	0.023a ± 0.015	0.0126a ± 0.006
		RAJ-4238	19.06a ± 10.12	11.63a ± 0.32	4.133a ± 0.230	3.96a ± 0.057	0.07a ± 0.051	0.055a ± 0.001	0.021a ± 0.014	0.011a ± 0.014	0.054a ± 0.051	0.0096a ± 0.0057	0.017a ± 0.004	0.013a ± 0.005
		RAJ-4037	15.93*a ± 2.92	16.8*b ± 1.38	4.66a ± 0.763	3.35a ± 0.04	0.020a ± 0.009	0.068a ± 0.057	0.0113a ± 0.002	0.010a ± 0.001	0.061a ± 0.057	0.0113ab ± 0.0057	0.016a ± 0.005	0.013a ± 0.005
	15	RAJ-3765	19.6a ± 4.85	11.7a ± 0.26	3.83a ± 0.577	3.9*c ± 0.1	0.194a ± 0.17	0.024a ± 0.023	0.0173a ± 0.004	0.0133a ± 0.003	0.113a ± 0.002	0.0103a ± 0.0005	0.024a ± 0.009	0.012a ± 0.001
		RAJ-4120	24a ± 1.63	21.26*b ± 2.90	6.5a ± 3.041	4.5a ± 0.43	0.12a ± 0.00	0.025a ± 0.008	0.025a ± 0.008	0.14a ± 0.008	0.205a ± 0.035	0.015a ± 0.0066	0.08a ± 0.011	0.041a ± 0.005
		RAJ-4079	19.6a ± 4.85	14.93*c ± 6.05	4.26*a ± 0.40	3.96a ± 0.63	0.22a ± 0.16	0.064a ± 0.068	0.023a ± 0.019	0.013a ± 0.007	0.125a ± 0.015	0.014a ± 0.011	0.019a ± 0.014	0.014a ± 0.006
		RAJ-3077	23a ± 1.41	14.6a ± 3.1	4.93a ± 0.11	4.4a ± 0.17	0.165a ± 0.060	0.088a ± 0.059	0.0256a ± 0.007	0.014a ± 0.010	0.123a ± 0.001	0.011a ± 0.0069	0.045a ± 0.005	0.03a ± 0.017
		RAJ-4238	21.96a ± 3.40	16.93ab ± 3.34	4.96a ± 0.057	4.33a ± 1.15	0.27a ± 0.22	0.056a ± 0.058	0.023a ± 0.010	0.011a ± 0.010	0.063a ± 0.049	0.0113*b ± 0.0005	0.030a ± 0.001	0.01a ± 0.055
		RAJ-4037	20.2a ± 2	19.16*b ± 0.76	4.7a ± 1.03	4.26*b ± 0.46	0.061a ± 0.031	0.107a ± 0.006	0.021a ± 0.018	0.013a ± 0.007	0.074a ± 0.062	0.0083a ± 0.0043	0.033a ± 0.011	0.011a ± 0.01
Sodium nitro prusside	5	RAJ-3765	7.9*b ± 3.63	7.5*a ± 1	3.56a ± 0.503	2.83a ± 0.057	0.048a ± 0.027	0.006*a ± 0.005	0.0086a ± 0.0023	0.0043a ± 0.002	0.083a ± 0.092	0.005a ± 0.0060	0.009a ± 0.000	0.0025a ± 0.01
		RAJ-4120	22.83b ± 0.47	19.76ab ± 1.20	4.53*b ± 0.057	4.43b ± 0.15	0.14a ± 0.10	0.08a ± 0.001	0.026a ± 0.006	0.012a ± 0.003	0.214a ± 0.005	0.0133a ± 0.0057	0.012a ± 0.002	0.004a ± 0.001
		RAJ-4079	19.23ab ± 1.96	11.83*b ± 3.93	3.33a ± 0.37	3.56a ± 0.057	0.099a ± 0.081	0.024a ± 0.12	0.0216a ± 0.007	0.011a ± 0.007	0.093a ± 0.055	0.014a ± 0.0060	0.008a ± 0.008	0.06a ± 0.01
		RAJ-3077	13.83*a ± 1.34	9.76ab ± 0.057	4.36a ± 0.68	3.46a ± 0.057	0.068a*± 0.054	0.066a ± 0.057	0.0163a ± 0.006	0.0133a ± 0.003	0.053a ± 0.058	0.0116a ± 0.0011	0.007a ± 0.005	0.0035a ± 0.001
		RAJ-4238	17.06a ± 11.21	9.93*a ± 3.88	3.6a ± 1.03	3.96*b ± 0.23	0.105a ± 0.168	0.038a ± 0.055	0.01a ± 0.01	0.001a ± 0	0.067a ± 0.046	0.0086a ± 0.0049	0.008a ± 0.002	0.003a ± 0.00
		RAJ-4037	18.2*b ± 0.72	7.56*a ± 1.74	3.7a ± 0.556	3.23*a ± 0.25	0.115a ± 0.11	0.016a ± 0.013	0.0116a ± 0.007	0.011a ± 0	0.18a ± 0.001	0.0133a ± 0.0057	0.01a ± 0.01	0.0016a ± 0.002
	10	RAJ-3765	15.83*b ± 2.02	3.28*a ± 0.075	3.83a ± 0.577	3.28*a ± 0.075	0.097b ± 0.004	0.021a ± 0.016	0.015a ± 0.008	0.010a ± 0.001	0.156 ± 0.001	0.0093a ± 0.000	0.019a ± 0.001	0.09a ± 0.001
		RAJ-4120	22.96a ± 5.13	24.33a ± 6.42	5.16a ± 0.28	4.83b ± 0.288	0.20a ± 0.00	0.10 a ± 0.00	0.09a ± 0.003	0.004a ± 0.003	0.258a ± 0.009	0.0213*b ± 0.0063	0.047a ± 0.01	0.031a ± 0.01
		RAJ-4079	13.46*ab ± 1.76	19.33a ± 4.19	4.03a ± 0.28	3.8b ± 0.005	0.14a ± 0.10	0.066a ± 0.005	0.032b ± 0.013	0.012b ± 0.01	0.126a ± 0.097	0.055a ± 0.068	0.013a ± 0.006	0.06a ± 0.01
		RAJ-3077	17.86*b ± 0.52	16.7a ± 7.25	4.73a ± 0.72	4.36a ± 0.23	0.165a ± 0.06	0.089a ± 0.068	0.060a ± 0.052	0.030a ± 0.001	0.103a ± 0.010	0.0146a ± 0.0055	0.011a ± 0.008	0.016a ± 0.005
		RAJ-4238	21.16a ± 4.07	14.66a ± 4.93	4.1a ± 0.173	4.1a ± 1.15	0.117a ± 0.10	0.078a ± 0.058	0.011a ± 0.008	0.001a ± 0	0.063a ± 0.058	0.0136a ± 0.0055	0.015a ± 0.007	0.009a ± 0.000
		RAJ-4037	21.6*b ± 0.26	11.83a ± 1.44	4a ± 0.1	3.7a ± 0.005	0.12a ± 0.067	0.020a ± 0.010	0.0673a ± 0.056	0.032a ± 0.001	0.243a ± 0.095	0.0173*ab ± 0.0046	0.036a ± 0.02	0.012a ± 0.006
	15	RAJ-3765	16a ± 6.41	9.5a ± 2.59	3.93a ± 0.513	3.96*c ± 0.05	70.100a ± 0.00	00.081a ± 0.06	80.0107a ± 0.01	00.01a ± 0.01	0.090a ± 0.001	0.0183a ± 0.0011	0.020a ± 0.000	0.010a ± 0
		RAJ-4120	25.93a ± 7.04	25*c ± 4.52	6.73a ± 2.83	5.03a ± 0.90	0.43a ± 0.05	0.17a ± 0.06	0.10a ± 0.08	0.09a ± 0	0.314a ± 0.048	0.097*b ± 0.0057	0.086a ± 0.02	0.046a ± 0.01
		RAJ-4079	18.16a ± 3.01	19.66*d ± 2.12	4.5*a ± 0.5	4.23a ± 0.40	0.25a ± 0.12	0.137a ± 0.054	0.02a ± 0.00	0.007a ± 0	0.244a ± 0.056	0.0153a ± 0.0577	0.016a ± 0.005	0.08a ± 0.005
		RAJ-3077	25.46a ± 7.73	20.5b ± 0.5	4.83a ± 0.81	4.33a ± 0.28	0.27a ± 0.24	0.131a ± 0.1	0.100a ± 0.113	0.072a ± 0.001	0.180a ± 0.009	0.0206*b ± 0.010	0.06a ± 0.01	0.03a ± 0.017
		RAJ-4238	23.46a ± 4.27	20.86*b ± 0.23	4.76a ± 0.404	4.8a ± 1.05	0.30a ± 0.17	0.113a ± 0.1	0.021a ± 0.015	0.011a ± 0.011	0.296a ± 0.056	0.0213*c ± 0.00	050.076a ± 0.005	0.023a ± 0.012
		RAJ-4037	22.33a ± 0.28	19*b ± 1	4.23a ± 0.503	4.13ab ± 0.11	0.27a ± 0.23	0.120a ± 0.017	0.067a ± 0.057	0.033a ± 0.02	0.32a ± 0.002	0.042a ± 0.052	0.066a ± 0.005	0.022a ± 0.016

Mean ± SD, n = 3. Values followed by different letters are significantly different at P < 0.05 according to Tukey's test. * The mean difference is significant at 0.05 level.

The polyphenol content was determined on 5th, 10th and 15th day in both control and drought stressed plants. The increasing duration of drought stress in wheat plants resulted in proportional increase in polyphenol content. The increase in polyphenol content was noticed in SNP pretreated plants on 15th day of stress as compared to 5th and 10th day (Fig 1). All the three elicitors increased the polyphenol content in drought stressed plants in comparison to the seedlings which were not pretreated. Of these SNP was found to be more efficient. In control plants the polyphenol content was lower in comparison to drought stressed plants. The increase in polyphenol content was 80.3% in variety RAJ-4120 and 39.58% in variety RAJ-3765 when pre-treated with SNP on 15th day of stress.

The phenolic compounds have antioxidative property. These are able to chelate transition metal ions, inhibit Superoxide Fenton reaction (Arora *et al*., 1998) and stabilize the membranes by decreasing its fluidity (Blokhina *et al*., 2003).

The protein content was determined on 5th, 10thand 15thday in both control and drought stressed plants. The protein content also showed increase in SNP pretreated drought stressed plants in comparison to control conditions (Table 2). The increase in soluble protein content was found to be 65.71% in variety RAJ-4120 and 60.81% in variety RAJ-3765 in SNP pre-treated seedlings on 15th day of drought stress.

In a study conducted by Hameed and Iqbal (2014), drought stress raised the soluble protein content in wheat leaves.

The flavonoid content was also studied on 5th, 10th and 15th day in both control and drought stressed plants. In the current study, flavonoid content showed increase in drought stressed plant in comparison to control. The highest increase in flavonoid content was noticed in SNP pretreated plants on 15th day of stress in variety RAJ-4120 (Fig 2). It was found to be 168% in variety RAJ-4120 in SNP pre-treated seedling under drought condition and 93.61% in variety RAJ-3765 on 15th day of stress.

The chlorophyll content showed decrease in wheat plants when exposed to drought stress in comparison to control plants. In SNP pretreated seedlings the chlorophyll content was minimum as compared to silver nitrate and salicylic acid treated plants.With increasing period of drought stress, plants showed decrease in chlorophyll content. However, SNP and silver nitrate were found to be more efficient in this aspect as compared to salicylic acid. With increase in duration there is increase in chlorophyll content under control conditions. In control conditions the highest chlorophyll content was found in seeds pretreated with SNP

Table 2: Effect of different elicitors on total protein content in two wheat cultivar under control and drought conditions.

			Total protein content (mg/g FW)	
Treatment	**Days**	**Cultivar**	**Control**	**Drought**
No-pretreatment	5 Days	RAJ-4120	0.426a ± 0.001	0.60c ± 0.025
		RAJ-3765	0.210a ± 0.010	0.21a ± 0.105
	10 Days	RAJ-4120	0.74b ± 0.02	0.72a ± 0.015
		RAJ-3765	0.3a ± 0.10	0.27a ± 0.055
	15 Days	RAJ-4120	1.33b ± 0.01	2.02a ± 0.01
		RAJ-3765	1.12b ± 0.015	1.40ab ± 0.61
Silver nitrate	5 Days	RAJ-4120	0.48*b ± 0.01	0.33*a ± 0.001
		RAJ-3765	0.13a ± 0.01	0.14a ± 0.063
	10 Days	RAJ-4120	0.77b ± 0.02	0.83*c ± 0.02
		RAJ-3765	0.43a ± 0.015	0.28a ± 0.049
	15 Days	RAJ-4120	1.16*a ± 0.057	1.8a ± 0.173
		RAJ-3765	1.06b ± 0.051	0.73a ± 0.02
Salicylic acid	5 Days	RAJ-4120	0.423a ± 0.001	0.55*b ± 0.005
		RAJ-3765	0.24a ± 0.121	0.24a ± 0.005
	10 Days	RAJ-4120	0.65*a ± 0.01	0.78*b ± 0.01
		RAJ-3765	0.43a ± 0.02	0.28a ± 0.057
	15 Days	RAJ-4120	1.28b ± 0.063	2.50*b ± 0.011
		RAJ-3765	0.86*a ± 0.02	0.98a ± 0.083
Sodium nitroprusside	5 Days	RAJ-4120	0.753*c ± 0.001	1.05*d ± 0.02
		RAJ-3765	0.5*b ± 0.02	0.45*b ± 0.015
	10 Days	RAJ-4120	1.33*c ± 0.01	2.04*d ± 0.02
		RAJ-3765	0.82*b ± 0.02	0.86*b ± 0.015
	15 Days	RAJ-4120	2.33*c ± 0.015	3.25*c ± 0.064
		RAJ-3765	1.28*c ± 0.060	2.32b ± 0.005

Mean ± SD, n = 3. Values followed by different letters are significantly different at $P < 0.05$ according to Tukey's test.
*The mean difference is significant at 0.05 level.

during 15th day of growth (Fig 3). The chlorophyll content was found maximum in variety RAJ-4120 in comparison to variety RAJ-3765. The increase in chlorophyll content was found to 46.30% in variety RAJ-4120 under control conditions and 26.2% in variety RAJ-3765 on 15th day of growth under control conditions. The increase in chlorophyll content was 8.78% on 5th day in RAJ-4120 when pre-treated with salicylic acid under control conditions.It decreased by 3.43% on 10th day and further increase of 23.25% was noticed under control condition when pre-treated with salicylic acid.

The decrease in chlorophyll a and b due to water deficit has been noticed by Nyachiro *et al*. (2001) in *Triticum aestivum* cultivar. Kpyoarissis *et al*. (1995) also reported decreased or unchanged chlorophyll level in other species under drought stress depending on duration and severity of drought.

Antioxidant activity: The peroxidase activity was determined in two selected varieties *viz*., RAJ-4120 (resistant) and RAJ-3765 (susceptible). The peroxidase activity was studied on 5th, 10th and 15th day in both control and drought stressed plants. It was found that with increase in duration of water stress there was increase in peroxidase activity. Among the three elicitors, SNP proved to be the best elicitor The peroxidase activity was found maximum in variety RAJ-4120 under drought conditions on 15th day of stress (Fig 4). The increase in peroxidase activity was found to be 25.74% in variety RAJ-4120 in SNP pre-treated seedlings as comparedto 24% in variety RAJ-3765 under drought conditionson 15th day of stress. Sodium nitroprusside pre-treatment increased peroxidase activity under water stress (Elhami *et al*., 2015). Chugh *et al*. (2011) reported increase in peroxidase activity in drought tolerant and susceptible maize genotypes under 72 h drought stress.

The Phenylalanine Ammonia Lyase (PAL) activity was studied on 5th, 10th and 15th day in both control and drought stressed plants. Under drought stress the increase in PAL activity was higher on 10th day of stress (Fig 5). The PAL activity was found higher in variety RAJ-4120 as

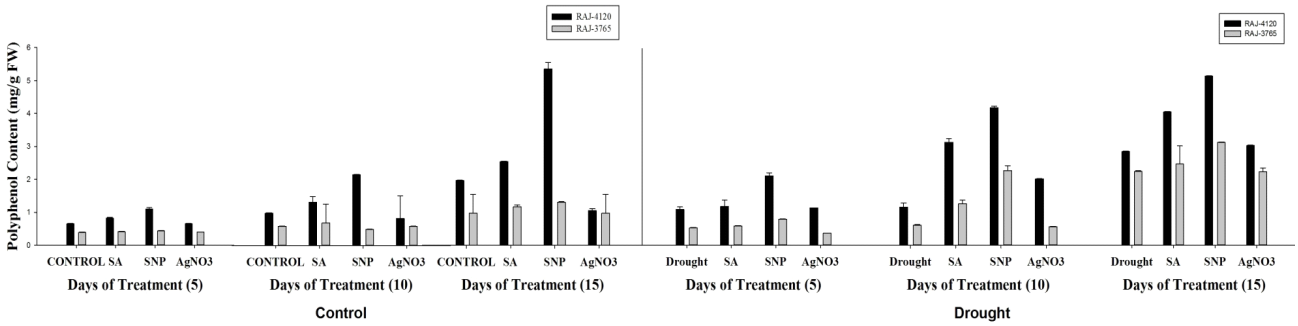

Fig 1: The effect of elicitors on polyphenol content in two wheat cultivars under control and drought conditions.

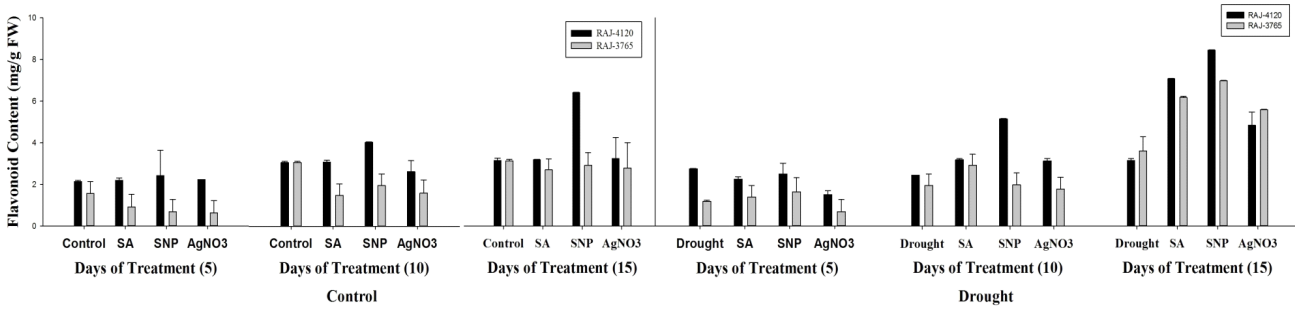

Fig 2: The effect of elicitors on flavonoid content in two wheat cultivars under control and drought conditions.

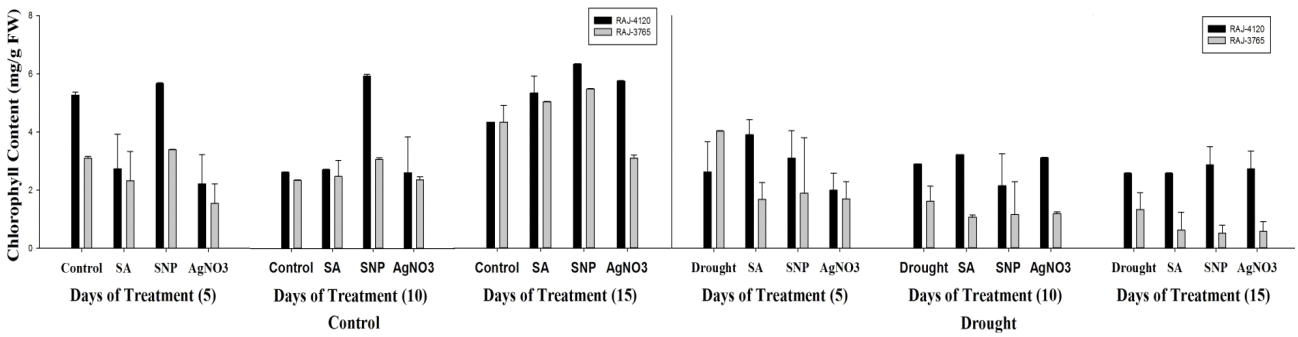

Fig 3: The effect of elicitors on chlorophyll content in two wheat cultivars under control drought conditions.

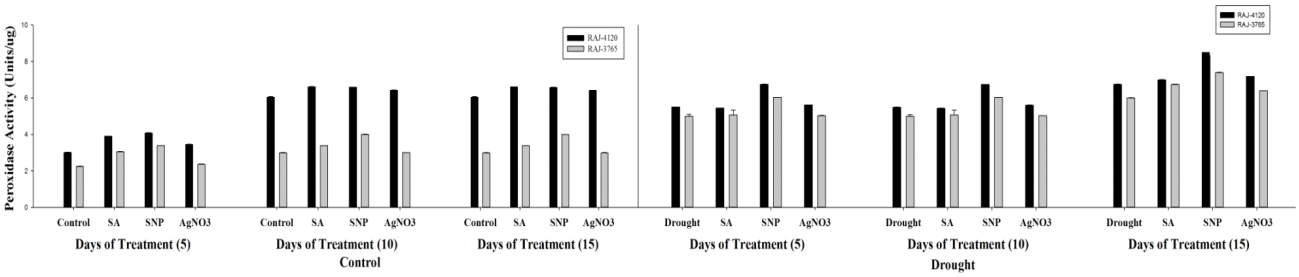

Fig 4: The effect of elicitors on peroxidase activity in two wheat cultivars under control and drought conditions.

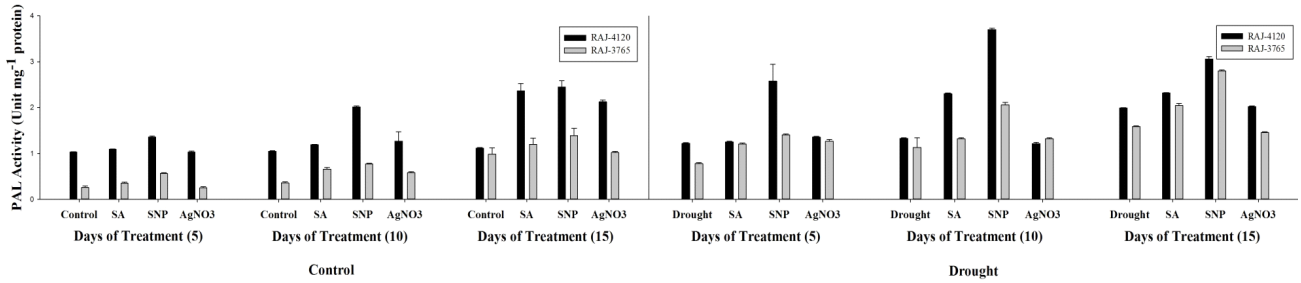

Fig 5: The effect of elicitors on phenylalanine ammonia lyase activity in two wheat cultivars under control and drought conditions.

compared to variety RAJ-3765. It was found to be 178.4% in variety RAJ-4120 in sodium nitroprusside pre-treated seedlings under drought condition and 53.76% in RAJ-3765 on 10th day of stress. The increase in PAL activity has been found in winter triticale and a drought resistant maize genotype (A-619) (Hura, 2008).

CONCLUSION

In the present study the results showed that considering all the growth, biochemical and antioxidant parameters, sodium nitroprusside proved to be best elicitor in mitigation of drought stress in wheat seedlings in comparison to salicylic acid and silver nitrate.

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