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Standardization of plant growth regulator for optimization of seed yield and it's contributing parameters in wheat (*Triticum aestivum* L.)

Dheeraj Katiyar, SC Vimal, Mohit Gupta, Jitender Bhati and Maneesh Kumar

Abstract
The objective of the study was to standardize the plant growth regulators doses with the effect of Salicylic acid (400 ppm), KNO3 and Salicylic acid (800 ppm) were positive effect on yield and yield contributing traits like number of tillers per plant, number of spikes per plant, spikelets per spike, 1000 seed weight and seed yield per plant (g) both of the varieties PBW-373 and NW-5054 were evaluated following 9 quantitative parameters *viz.*, Days to 50% flowering, Days to maturity, Plant height (cm), Number of tillers per plant, Length of spike (cm), Number of spike per plant, Number of spikelets per spike, 1000 seed weight and Seed yield per plant (g). The maximum number of tillers per plant of Salicylic acid @ 400 ppm (8.88) followed by KNO_3 @ 100 ppm (7.51), Salicylic acid @ 800 ppm (7.22), KCl @ 1% (6.79), Ascorbic acid @ 10 ppm (6.76), GA_3 @ 100 ppm (6.66),, IAA @ 100 ppm (6.32), NAA @ 100 ppm (6.16) and Thiourea @ 400 ppm (6.10) as compared to control (4.97) during 2018-19 mean both of the varieties and maximum number of tillers per plant of Salicylic acid @ 400 ppm (8.74) followed by KNO_3 @ 100 ppm (7.82), Salicylic acid @ 800 ppm (7.42), KCl @ 1% (7.10), Ascorbic acid @ 10 ppm (6.63), GA_3 @ 100 ppm (6.66), IAA @ 100 ppm (6.32), NAA @ 100 ppm (6.11) and Thiourea @ 400 ppm (5.51) as compared to control (4.82) during 2019-20 mean both of the varieties and maximum seed yield per plant (g) of Salicylic acid @ 400 ppm (11.47) followed by KNO_3 @ 100 ppm (10.74), Salicylic acid @ 800 ppm (10.16), KCl @ 1% (9.61), Ascorbic acid @ 10 ppm (9.57), GA_3 @ 100 ppm (9.25), NAA @ 100 ppm (9.13), Thiourea @ 400 ppm (9.03) and IAA @ 100 ppm (8.88) as compared to control (8.33) during 2018-19 mean both of the varieties and maximum seed yield per plant (g) of Salicylic acid @ 400 ppm (11.24) followed by KNO_3 @ 100 ppm (10.47), Salicylic acid @ 800 ppm (10.01), KCl @ 1% (9.59), Ascorbic acid @ 10 ppm (9.54), GA_3 @ 100 ppm (9.26), NAA @ 100 ppm (9.12), Thiourea @ 400 ppm (8.79) and IAA @ 100 ppm (8.30) as compared to control (7.91) during 2019-20 mean both of the varieties was noticed.

Keywords: Wheat, PGR, salicylic acid, KNO_3

Introduction
Wheat (*Triticum aestivum* L.) is one of the most important cereal crop belongs to *Poaceae* family and staple food crop of the world. Wheat is also called as "King of Cereals". Wheat is a grass mainly cultivated for its seed. It is native of South West Asia (Turkey). Wheat possess 2n=42 chromosomes with self-pollination as a mode of pollination. Wheat is one of the second most significant cereals in India following rice, contributing substantially to the national food security by providing more than 50% of the calories to the people who mainly depend on it. Plant hormones are chemical stimulants that regulate the plant growth; these are the molecules that stimulate within the plant, and occur in extremely low concentrations. PGRs are the organic compounds, other than nutrients that stimulate the plant physiological process, they are the biostimulants that stimulate or inhibit the specific enzymes which help to regulate or enhance the plant metabolism process [4]. Salinity is a major factor limiting the crop productivity in the arid and semi-arid areas of the world are caused adversely affected in plant growth and development [10, 16]. Salicylic acid (SA) acts as an endogenous signal molecule responsible for inducing abiotic stress tolerance in plants [6]. Salicylic acid is an endogenous growth regulator of phenolic nature, which participates in the regulation of physiological processes in plant [14]. Plant growth regulators are commonly employed in different crops in Europe and New Zealand where the main input of the PGRs is the prevention of crop lodging by different experimental data and inconsistent results, the crop height is significantly reduced by using the growth hormones, and interaction on wheat grain yield quality in the

without lodging [15].

Therefore, the present study was undertaken to investigate the effect of foliar spray with PGR, i.e. salicylic acids and KNO_3 etc. at a rate of 400 ppm and 100 ppm on vegetative criteria, some physiological, yield, nutrient uptake and anatomical structure of leaf blade of wheat plants grown under different levels of salinity stress. The hormonal treatments stimulated significant increase in No. of tillers, spike length, biomass and grain yield of the plants when composition was sprayed [2]. Nutrients concentrations in plant were increased slightly by applying growth regulators in various filed trials that suggested that physiological rate of plants were increased by using these PGRs [11].

Materials and Methods

The field experiments under present investigation were conducted during *Rabi* 2018-19 and 2019-20 at Main Experimental Station (MES) and lab experiments were carried out in Seed Testing Laboratory of Seed Technology Section, A. N. D. University of Agriculture and Technology, Kumarganj, Ayodhya (U. P.). Geographically, Narendra Nagar situated between 26.470 N latitude, 82.120 longitude and at an altitude of 113 meters above the mean sea level. The wheat crop was sown in the field using randomized block design (Factorial) with nine treatments, one control and three replications. The treatment details are predicted in Table 1.

The plant growth regulators obtained from Ayodhya and wheat variety PBW-373, NW-5054 from ANDUA&T Ayodhya. Plant growth regulator dissolved in water and some chemical dissolved in alcohol prepared solution there was foliar spray over the standing crop at vegetative and pre booting stage.

Plant to plant distance and row to row distance was kept 25 and 15 cm, respectively. Fertilizer was applied @ 120:60:40 (kg ha^{-1}) N:P:K at the time of sowing. The wheat crop was cultivated using standard agronomic practices. The observations were recorded on days to 50% flowering, days to maturity, plant height (cm), number of tillers/plant, length of spike (cm), number of spike/plant, number of spikelets/spike, 1000 seed weight and seed yield/plant (g).

Table 1: Treatments used in this study

Treatment No.	Description
T0	Control (without any chemical spraying)
T1	Salicylic acid (400 ppm) foliar spray at vegetative and pre booting stage
T2	Salicylic acid (800 ppm) foliar spray at vegetative and pre booting stage
T3	Ascorbic acid (10 ppm) foliar spray at vegetative and pre booting stage
T4	KCl (1%) foliar spray at vegetative and pre booting stage
T5	Thiourea (400 ppm) foliar spray at vegetative and pre booting stage
T6	IAA (100 ppm) foliar spray at vegetative and pre booting stage
T7	GA_3 (100 ppm) foliar spray at vegetative and pre booting stage
T8	KNO_3 (100 ppm) foliar spray at vegetative and pre booting stage
T9	NAA (100 ppm) foliar spray at vegetative and pre booting stage

Results and Discussion

Mean performance

The data given in Table 2, show mean performance of 9 treatments for 9 parameters and two varieties PBW-373 and NW-5054. The mean and grand mean for all the traits are also depicted in table 2.

Days to 50% flowering

Effect of plant growth regulators under study were found to be most effective for significant decreasing the days to 50% flowering in all two varieties *viz.*, PBW-373, NW-5054 during both the year. The most effective treatment was found to be GA_3 @ 100 ppm, KNO_3 @ 100 ppm, Salicylic acid @ 400 ppm, in PBW-373, and GA_3 @ 100 ppm, KNO_3 @ 100 ppm, Salicylic acid @ 400 ppm in NW-5054.

Days of maturity

Performance of plant growth regulators under study were found to be most effective for significant decreasing the days of maturity in all two varieties *viz.*, PBW-373, NW-5054. The most effective treatment was found to be GA_3 @ 100 ppm, KNO_3 @ 100 ppm, Salicylic acid @ 400 ppm during 2018-19, GA_3 @ 100 ppm, KNO_3 @ 100 ppm, KCL @ 1% ppm, Salicylic acid @ 400 ppm during 2019-20 in PBW-373 and GA_3 @ 100 ppm, KNO_3 @ 100 ppm, Salicylic acid @ 400 ppm in NW-5054 during both the years.

Plant height (cm)

Influence of plant growth regulators under study were found to be most effective for significant increasing the plant height (cm) in all two varieties *viz.*, PBW-373, NW-5054 during both the years. The most efficient plant growth regulators were GA_3 @ 100 ppm fallowed by NAA @ 100 ppm and IAA @ 100 ppm. These results are in accordance to [5, 7, 12].

Number of tillers/plant

Effect of plant growth regulators under study were found to be most effective for significant increasing the number of tillers/plant in all two varieties *viz.*, PBW-373, NW-5054 during both the years. The most effective treatment was found to be Salicylic acid @ 400 ppm, KNO_3 @ 100 ppm, Salicylic acid @ 800 ppm in PBW-373 and Salicylic acid @ 400 ppm, KNO_3 @ 100 ppm, Salicylic acid @ 800 ppm in NW-5054. It again showed that there was genetic response in wheat to plant growth regulators. A similar type of result was also reported by [13, 18].

Number of spikes/plant

Performance of plant growth regulators under study were found to be most effective for significant increasing the number of spikes/plant in all two varieties *viz.*, PBW-373, NW-5054 during both the years. The most effective treatment was found to be Salicylic acid @ 400 ppm, KNO_3 @ 100 ppm, Salicylic acid @ 800 ppm in PBW-373 and Salicylic acid @ 400 ppm, KNO_3 @ 100 ppm, Salicylic acid @ 800 ppm in NW-5054. It again showed that there was interaction on between the nature of wheat and plant growth regulators these findings are in accordance to the results reported by [13].

Length of spike (cm)

Effect of plant growth regulators under study were found to be most effective for significant increasing the length of spike (cm) in all two varieties *viz.*, PBW-373, NW-5054 during both the years. The most effective treatment was found to be GA_3 @ 100 ppm fallowed by NAA @ 100 ppm and Salicylic acid @ 400 ppm in PBW-373 and GA_3 @ 100 ppm fallowed by NAA @ 100 ppm and Salicylic acid @ 400 ppm in NW-5054. It again showed that there was genetic response in wheat to plant growth regulators. A similar type of result was also reported by [15, 18].

Number of spikelets/spike

Performance of plant growth regulators under study were found to be most effective for significant increasing the number of spikelets/spike in all two varieties *viz.*, PBW-373, NW-5054 during both the years. The most effective treatment was found to be Salicylic acid @ 400 ppm, KNO_3 @ 100 ppm, Salicylic acid @ 800 ppm in PBW-373 and Salicylic acid @ 400 ppm, KNO_3 @ 100 ppm, Salicylic acid @ 800 ppm in NW-5054. It again showed that there was interaction on between the nature of wheat and plant growth regulators these findings are in accordance to the results reported by [18].

1000 seed weight

Performance of plant growth regulators under study were found to be most effective for significant decreasing the 1000 seed weight in all two varieties *viz.*, PBW-373, NW-5054. The most effective treatment was found to be Salicylic acid @ 400 ppm, KNO_3 @ 100 ppm, Salicylic acid @ 800 ppm during 2018-19, KNO_3 @ 100 ppm, KCL @ 1%, Salicylic acid @ 400 ppm during 2019-20 in PBW-373 and Salicylic acid @ 400 ppm, KNO_3 @ 100 ppm, KCl @ 1% in NW-5054 during both the years. It again showed that there was interaction on between the nature of wheat and plant growth regulators these findings are in accordance to the results reported by [13, 15, 18].

Seed yield/plant

Plant growth regulator was found to be most effective for significant increasing the seed yield/plant in all two varieties *viz.*, PBW-373, NW-5054 during both the years under study. The most efficient growth regulator was Salicylic acid @ 400 ppm, KNO_3 @ 100 ppm, Salicylic acid @ 800 ppm [1, 17] also reported similar results.

Table 2: Effects of plant growth regulators on nine characters in wheat

Treatment	Days to 50% flowering					
	2018-19			2019-20		
	V1 (PBW-373)	V2 (NW-5054)	Mean	V1 (PBW-373)	V2 (NW-5054)	Mean
Control	63.67	65.00	64.33	63.00	63.67	63.33
Salicylic acid (800 ppm)	61.33	62.33	61.83	61.33	60.33	60.83
Salicylic acid (400 ppm)	59.00	60.00	59.50	59.67	60.33	60.00
Ascorbic acid (10 ppm)	61.00	62.33	61.67	61.00	62.33	61.67
KCl (1%)	61.33	59.67	60.50	61.33	60.00	60.67
Thiourea (400 ppm)	63.33	63.67	63.50	61.67	62.33	62.00
IAA (100 ppm)	62.33	63.67	63.00	61.67	61.67	61.67
GA3 (100 ppm)	57.67	58.67	58.17	58.33	57.67	58.00
KNO3 (100 ppm)	59.00	60.00	59.50	57.67	58.33	58.00
NAA (100 ppm)	62.00	62.67	62.33	61.67	61.67	61.67
Mean	61.07	61.80	61.43	60.73	60.83	60.78
	SE	CD 5%	CV	SE	CD 5%	CV
V	0.163	0.330	1.452	0.13	0.27	1.21
T	0.364	0.737		0.30	0.61	
V x T	0.515	1.043		0.43	0.86	

Continued----

Treatment	Days to maturity					
	2018-19			2019-20		
	V1 (PBW-373)	V2 (NW-5054)	Mean	V1 (PBW-373)	V2 (NW-5054)	Mean
Control	128.67	129.67	129.17	129.33	129.67	129.50
Salicylic acid (800 ppm)	127.33	127.33	127.33	126.33	127.00	126.67
Salicylic acid (400 ppm)	125.00	124.67	124.83	125.33	126.00	125.67
Ascorbic acid (10 ppm)	126.67	127.00	126.83	126.33	128.33	127.33
KCl (1%)	125.33	126.33	125.83	124.67	126.33	125.50
Thiourea (400 ppm)	127.67	128.67	128.17	127.67	129.00	128.33
IAA (100 ppm)	127.67	128.33	128.00	128.33	128.00	128.17
GA3 (100 ppm)	119.67	122.33	121.00	119.67	123.33	121.50
KNO3 (100 ppm)	122.00	123.67	122.83	120.67	124.33	122.50
NAA (100 ppm)	126.67	128.00	127.33	127.33	128.00	127.67
Mean	125.67	126.60	126.13	125.57	127.00	126.28
	SE	CD 5%	CV	SE	CD 5%	CV
V	0.212	0.429	0.921	0.17	0.35	0.75
T	0.474	0.960		0.39	0.78	
V x T	0.670	1.357		0.55	1.11	

Continued----

Treatment	Plant height (cm)					
	2018-19			2019-20		
	V1 (PBW-373)	V2 (NW-5054)	Mean	V1 (PBW-373)	V2 (NW-5054)	Mean
Control	91.91	66.55	79.23	85.67	75.00	80.34
Salicylic acid (800 ppm)	96.78	83.62	90.20	94.38	81.93	88.16
Salicylic acid (400 ppm)	98.29	86.23	92.26	95.82	83.67	89.75
Ascorbic acid (10 ppm)	94.22	76.12	85.17	87.70	77.41	82.55
KCl (1%)	94.31	81.59	87.95	92.43	78.81	85.62
Thiourea (400 ppm)	94.86	82.43	88.64	94.11	81.56	87.84
IAA (100 ppm)	99.30	86.29	92.80	95.87	84.72	90.29
GA3 (100 ppm)	108.69	92.67	100.68	104.25	90.15	97.20
KNO3 (100 ppm)	98.27	83.88	91.08	94.63	82.97	88.80
NAA (100 ppm)	101.28	87.42	94.35	99.31	84.96	92.14
Mean	97.79	82.68	90.235	94.42	82.12	88.27
	SE	CD 5%	CV	SE	CD 5%	CV
V	0.598	1.211	3.631	0.64	1.29	3.94
T	1.337	2.708		1.42	2.88	
V x T	1.891	3.829		2.01	4.07	

Continued----

Treatment	Number of tillers/plant					
	2018-19			2019-20		
	V1 (PBW-373)	V2 (NW-5054)	Mean	V1 (PBW-373)	V2 (NW-5054)	Mean
Control	4.57	5.36	4.97	4.89	4.74	4.82
Salicylic acid (800 ppm)	7.68	6.76	7.22	7.82	7.03	7.42
Salicylic acid (400 ppm)	9.26	8.49	8.88	9.69	7.79	8.74
Ascorbic acid (10 ppm)	6.79	6.73	6.76	6.98	6.27	6.63
KCl (1%)	6.82	6.75	6.79	7.36	6.84	7.10
Thiourea (400 ppm)	6.27	5.93	6.10	5.84	5.18	5.51
IAA (100 ppm)	6.53	6.11	6.32	6.82	5.82	6.32
GA3 (100 ppm)	6.68	6.64	6.66	6.95	6.20	6.58
KNO3 (100 ppm)	8.00	7.03	7.51	8.36	7.27	7.82
NAA (100 ppm)	6.31	6.05	6.18	6.43	5.78	6.11
Mean	6.89	6.58	6.738	7.12	6.29	6.70
	SE	CD 5%	CV	SE	CD 5%	CV
V	0.186	0.376	15.118	0.17	0.34	13.77
T	0.416	0.842		0.38	0.76	
V x T	0.588	1.191		0.53	1.08	

Continued----

Treatment	Number of spikes/plant					
	2018-19			2019-20		
	V1 (PBW-373)	V2 (NW-5054)	Mean	V1 (PBW-373)	V2 (NW-5054)	Mean
Control	4.45	4.62	4.53	4.89	4.52	4.71
Salicylic acid (800 ppm)	7.53	6.58	7.05	7.49	6.73	7.11
Salicylic acid (400 ppm)	8.55	8.27	8.41	9.39	7.10	8.25
Ascorbic acid (10 ppm)	6.67	6.43	6.55	6.70	6.26	6.48
KCl (1%)	6.81	6.52	6.67	6.93	6.60	6.77
Thiourea (400 ppm)	6.13	5.92	6.03	5.80	5.16	5.48
IAA (100 ppm)	5.20	5.87	5.54	5.73	4.95	5.34
GA3 (100 ppm)	6.22	6.21	6.22	6.53	6.12	6.33
KNO3 (100 ppm)	7.69	6.65	7.17	8.24	6.75	7.49
NAA (100 ppm)	6.15	6.04	6.10	6.32	5.75	6.04
Mean	6.54	6.31	6.425	6.80	5.99	6.40
	SE	CD 5%	CV	SE	CD 5%	CV
V	0.183	0.370	15.589	0.16	0.33	13.86
T	0.409	0.828		0.36	0.73	
V x T	0.578	1.171		0.51	1.04	

Continued----

Treatment	Length of spike (cm)					
	2018-19			2019-20		
	V1 (PBW-373)	V2 (NW-5054)	Mean	V1 (PBW-373)	V2 (NW-5054)	Mean
Control	8.55	8.70	8.62	7.64	7.90	7.77
Salicylic acid (800 ppm)	9.55	9.44	9.49	9.22	9.17	9.20

Salicylic acid (400 ppm)	10.30	10.16	10.23	10.18	9.47	9.83
Ascorbic acid (10 ppm)	8.08	9.15	8.61	8.26	8.94	8.60
KCl (1%)	9.56	9.46	9.51	9.34	9.24	9.29
Thiourea (400 ppm)	9.54	9.28	9.41	9.12	9.01	9.06
IAA (100 ppm)	9.29	9.24	9.26	8.89	8.97	8.93
GA3 (100 ppm)	11.78	10.90	11.34	10.77	10.26	10.51
KNO3 (100 ppm)	9.75	9.75	9.75	10.10	9.40	9.75
NAA (100 ppm)	10.43	10.21	10.32	10.42	10.08	10.25
Mean	9.68	9.63	9.655	9.39	9.24	9.32
	SE	CD 5%	CV	SE	CD 5%	CV
V	0.125	0.254	7.109	0.13	0.27	7.93
T	0.280	0.567		0.30	0.61	
V x T	0.396	0.802		0.43	0.86	

Continued----

Treatment	**Number of spikelets/spike**					
	2018-19			**2019-20**		
	V1 (PBW-373)	**V2 (NW-5054)**	**Mean**	**V1 (PBW-373)**	**V2 (NW-5054)**	**Mean**
Control	17.17	17.21	17.19	15.24	17.21	16.22
Salicylic acid (800 ppm)	19.43	19.17	19.30	19.68	19.99	19.84
Salicylic acid (400 ppm)	20.35	20.15	20.25	20.45	20.58	20.52
Ascorbic acid (10 ppm)	18.29	18.58	18.44	17.02	19.29	18.16
KCl (1%)	19.27	18.65	18.96	17.13	19.69	18.41
Thiourea (400 ppm)	17.60	18.25	17.93	16.08	18.98	17.53
IAA (100 ppm)	17.39	17.81	17.60	15.88	18.51	17.20
GA3 (100 ppm)	18.09	18.50	18.29	16.95	19.13	18.04
KNO3 (100 ppm)	19.90	19.73	19.82	20.00	20.07	20.04
NAA (100 ppm)	17.79	18.35	18.07	16.51	19.06	17.78
Mean	18.53	18.64	18.584	17.49	19.25	18.37
	SE	CD 5%	CV	SE	CD 5%	CV
V	0.163	0.330	4.799	0.16	0.32	4.77
T	0.364	0.737		0.36	0.72	
V x T	0.515	1.042		0.51	1.02	

Continued----

Treatment	**1000 seed weight**					
	2018-19			**2019-20**		
	V1 (PBW-373)	**V2 (NW-5054)**	**Mean**	**V1 (PBW-373)**	**V2 (NW-5054)**	**Mean**
Control	27.28	25.36	26.32	24.70	25.15	24.92
Salicylic acid (800 ppm)	37.53	32.61	35.07	36.96	38.87	37.92
Salicylic acid (400 ppm)	41.16	37.93	39.55	39.06	39.49	39.27
Ascorbic acid (10 ppm)	34.36	31.40	32.88	35.52	33.16	34.34
KCl (1%)	34.41	32.96	33.69	35.58	33.43	34.51
Thiourea (400 ppm)	32.33	30.98	31.65	31.80	31.92	31.86
IAA (100 ppm)	31.32	30.74	31.03	31.41	29.51	30.46
GA3 (100 ppm)	33.79	33.07	33.43	33.51	32.99	33.25
KNO3 (100 ppm)	39.30	37.44	38.37	38.35	39.08	38.72
NAA (100 ppm)	32.98	31.41	32.20	31.81	32.76	32.28
Mean	34.45	32.39	33.418	33.87	33.64	33.75
	SE	CD 5%	CV	SE	CD 5%	CV
V	0.361	0.731	5.920	0.44	0.89	7.17
T	0.808	1.635		0.99	2.00	
V x T	1.142	2.312		1.40	2.83	

Continued----

Treatment	**Seed yield/plant (g)**					
	2018-19			**2019-20**		
	V1 (PBW-373)	**V2 (NW-5054)**	**Mean**	**V1 (PBW-373)**	**V2 (NW-5054)**	**Mean**
Control	7.98	8.68	8.33	7.92	7.89	7.91
Salicylic acid (800 ppm)	10.19	10.12	10.16	9.91	10.11	10.01
Salicylic acid (400 ppm)	11.80	11.14	11.47	11.34	11.15	11.24
Ascorbic acid (10 ppm)	9.79	9.35	9.57	9.39	9.68	9.54
KCl (1%)	9.80	9.42	9.61	9.40	9.77	9.59
Thiourea (400 ppm)	9.08	8.98	9.03	9.08	8.51	8.79
IAA (100 ppm)	8.87	8.88	8.88	8.56	8.04	8.30
GA3 (100 ppm)	9.32	9.18	9.25	9.31	9.20	9.26
KNO3 (100 ppm)	10.84	10.65	10.74	10.66	10.27	10.47

NAA (100 ppm)	9.11	9.14	9.13	9.17	9.08	9.12
Mean	9.68	9.56	9.617	9.47	9.37	9.42
	SE	CD 5%	CV	SE	CD 5%	CV
V	0.108	0.219	6.174	0.10	0.21	6.01
T	0.242	0.491		0.23	0.47	
V x T	0.343	0.694		0.33	0.66	

Conclusion

Effect of Salicylic acid (400 ppm), KNO3 (100 ppm) and Salicylic acid (800 ppm) were positive effect on yield and yield contributing traits like number of tillers/plant, number of spikes/plant, spikelets/spike, 1000 seed weight and seed yield/plant (g).

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