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STUDY OF EXOGENOUS APPLICATION OF CHEMICALS AND DATE OF SOWING IN MITIGATING THE HEAT STRESS IMPACT ON YIELD AND YIELD CONTRIBUTING TRAITS IN WHEAT (*TRITICUM AESTIVUM* L.)

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ABSTRACT

A field experiment was conducted RBD design for the two successive seasons at New Dairy Farm, Kalyangur, C. S. Azad University of Agriculture and Technology Kanpur (U.P.) during *rabi* 2016-17 and 2017-18. A single wheat variety "K 1006" is used as experimental material to study the effect of date of sowing *i.e.*, 1st DOS – 3rd week of November and 2nd DOS- 1st week of December and foliar spray of chemicals *viz.*, Glycine betaine- 600ppm, Salicylic acid - 800ppm and 400ppm, Ascorbic acid - 10ppm + Citric acid - 1.3%, Alfa Tocopherol - 150ppm and KCl - 1% in different combinations and doses to mitigate the effect of elevated temperature in late sown wheat. Results displayed that sowing in 3rd week of November (S_1) and foliar spray of Salicylic acid 800ppm (T_2) recorded significantly increased chlorophyll content Index (%), number of effective tillers per plant, spike length, number of seeds per spike, 1000 seed weight (g), seed yield per plant (g), seed yield per plot (kg) and seed yield quintal per hectare (q/ha) during the first year and second year, respectively, over the second date of sowing and rest of the foliar applied chemicals.

Key words : Wheat, Glycine betaine, Salicylic acid, Ascorbic acid, Citric acid, α-tocopherol (150ppm), KCL 1%.

Introduction

Wheat is a self-pollinated cereal crop that belongs to the Poaceae family. Wheat is cultivated throughout the world on a large acreage. In India, wheat comes just after rice in the area and production. It is also called as King of Cereals. Wheat is the main source of vegetarian protein and energy. Consumption of wheat is done in various ways, such as flour, bread, chapatti, suji, roasted seeds, porridge etc. Two important micronutrients niacin and thiamine are found in relatively high amounts component of a special protein called Glutin. Wheat protein is of special significance because glutin provides the framework of spongy cellular texture of bread and baked products. Among abiotic stresses high temperature is a major constraint in reducing the yield performance of late sown rabi crops. Especially during the reproductive phase temperature adversely affects the flower production rate, spikelet fertility, grain filing and seed setting. It shortens the reproductive phase, which reduces the economic yield. Rise in temperature during growth and development reduces photosynthetic rate, leaf area, short stature, grain weight, and shriveled kernels which results in yield reduction. In field conditions sown wheat facing terminal heat stress can be managed by applying chemicals like Ascorbic acid, Glycine betaine, salicylic acid, potassium chlororide, Aphatocophero, citric acid that can be helpful in maintaining the yield performance as well as the quality of the produce. In the current study, an attempt is made to mitigate the effect of heat stress by manipulating sowing dates and spraying various chemicals, which may improve various physiological processes, growth, seed set, seed yield and quality of wheat.

Materials and Methods

The experiment was conducted with a single wheat variety "K 1006" at New Dairy Farm, Kalyanpur, C. S. Azad University of Agriculture and Technology, Kanpur (UP) during *rabi* 2016-17 and 2017-18. The Factorial RBD design is used to lay out the experiment in three replications and two different dates of sowing, *i.e.*, 1st DOS – 3rd week of November (S_1) and 2nd DOS- 1st week of December (S_2). Various chemicals *viz*., Glycine betaine- 600ppm, Salicylic acid- 800ppm and 400ppm, Ascorbic acid - 10ppm + Citric acid - 1.3%, Alfa Tocopherol - 150ppm and KCl - 1% in different combinations and doses were used for foliar spray at two different growth and development stages. The first spray was done at the vegetative stage at 40 DOS and second spray during the filling phase of the reproductive stage at 65 DOS to study the effect on various parameters *viz*., chlorophyll content index (%), days of 50% flowering, number of effective tillers, number of seeds per spike, spike length (cm), days of 50% maturity, 1000 seed weight (g), seed yield per plant(g), seed yield per lot (kg) and seed yield (q/ha).

Statistical analysis

The experimental data were compiled by taking the mean over selected plants of each treatment for each replication. The mean data for different traits was analyzed using the online OPSTATE program. The mean values of different treatments were then worked out along with the corresponding standard error of the mean (SEm). The critical difference at 5 per cent level of significance was computed.

Results

The chlorophyll content index was noted 38 days after sowing before the spray of chemicals and foliar application of chemicals was done at 40 days after sowing and chlorophyll content index was noted 50 days after the spray of chemicals using SPAD meter on five randomly selected plants. Data pertaining to chlorophyll content index (%) as influenced by different sowing dates and foliar application of treatments in first year and second year are presented in Table 1.

The chlorophyll content index (%) was influenced significantly due to different sowing dates during both years. Sowing in 3rd week of November recorded significantly more chlorophyll content index (%) 43.93 and 43.99 whereas, sowing in 1st week of December recorded significantly less chlorophyll content index (%) 43.28 and 43.37 (%) before spraying of chemicals during the first year and second year, respectively. After foliar spray of chemicals sowing in 3rd week of November recorded significantly more chlorophyll content Index (%) 46.41 and 46.33 over the second date of sowing *i.e.*, 1st week of December with value of 45.32 and 45.41 (%) during first year and second year, respectively. It is observed from table 1 that foliar application of T_2 (Salicylic acid @ 800ppm) was significantly superior over rest of the treatments after spray of chemicals. Chlorophyll content index (%) was found 49.33 and 49.50 (%) during the first year and second year respectively. Treatment T_2 was followed by T_4, T_6, T_5, T_3 and T_1 in the first year and second year over the control. The chlorophyll content

Table 1 : Influence of sowing dates (S) and before and after chemicals spray (T) on chlorophyll content index (%) in wheat.

Treatment	Chlorophyll content index (%)											
	Before spray						After spray					
	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean
T_0	43.30	42.07	42.68	43.43	42.70	43.06	43.80	42.87	43.33	43.50	42.80	43.15
T1	43.23	42.73	42.98	43.32	42.33	42.82	44.27	43.90	44.08	44.20	43.70	43.95
T_2	44.57	44.50	44.53	44.79	44.40	44.59	50.50	48.17	49.33	50.30	48.70	49.50
T_3	43.63	42.57	43.10	43.60	42.79	43.19	44.77	44.13	44.45	44.70	44.19	44.44
T_4	44.70	44.30	44.50	44.30	44.32	44.31	48.83	47.03	47.93	48.89	47.30	48.09
T_5	43.27	42.50	42.88	43.70	42.45	43.07	45.60	44.70	45.15	45.57	44.52	45.04
T_6	44.83	44.30	44.56	44.80	44.63	44.71	47.10	46.47	46.78	47.17	46.67	46.92
Mean	43.93	43.28	43.60	43.99	43.37	43.68	46.41	45.32	45.86	46.33	45.41	45.87
	S	T	S x T	S	T	S x T	S	T	S x T	S	T	S x T
S.E. (d)	0.23	0.44	0.62	0.12	0.22	0.01	0.24	0.45	0.64	0.16	0.29	0.42
S.E. (m)	0.16	0.31	0.44	0.08	0.16	0.45	0.17	0.32	0.45	0.11	0.21	0.29
CD(P=0.05)	0.48	N.S.	N.S.	0.24	N.S.	N.S.	0.49	0.93	N.S	0.32	0.61	N.S.

T_1= Glycine betaine- 600ppm, **T_2**= Salicylic acid - 800ppm, **T_3**= Salicylic acid - 400ppm, **T_4**= Ascorbic acid - 10ppm + Citric acid - 1.3%, **T_5**= Alfa Tocopherol - 150ppm and **T_6**= KCl - 1%.

Table 2 : Influence of sowing dates (S) and chemicals spray (T) on days to 50% flowering and Number of effective tillers per plant in wheat.

Treatment	Days to 50% flowering						Number of effective tillers per plant					
	Ist year			IInd year			Ist year			IInd year		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
T_0	81.33	80.33	80.83	81.33	80.66	81.00	13.33	12.00	12.66	13.67	13.00	13.33
T_1	81.33	81.00	81.16	81.33	81.00	81.16	14.00	12.33	13.16	14.33	12.67	13.50
T_2	79.33	78.00	78.66	77.66	77.66	77.66	16.33	15.33	15.83	16.67	15.33	16.00
T_3	82.00	81.33	81.66	81.66	82.66	82.16	14.33	13.33	13.83	14.67	14.00	14.33
T_4	81.00	79.00	80.00	79.66	80.00	79.83	15.33	15.00	15.16	15.67	15.33	15.50
T_5	81.00	81.00	81.00	81.33	80.33	80.83	14.67	13.67	14.17	15.00	14.00	14.50
T_6	82.33	81.00	81.66	81.00	81.33	81.16	15.00	14.67	14.83	15.33	14.00	14.66
Mean	81.19	80.23	80.71	80.57	80.52	80.54	14.71	13.76	14.23	15.04	14.04	14.55
	S	T	S x T	S	T	S x T	S	T	S x T	S	T	S x T
S.E. (d)	0.42	0.79	1.12	0.31	0.59	0.84	0.30	0.56	0.79	0.22	0.42	0.56
S.E. (m)	0.30	0.56	0.79	0.22	0.42	0.59	0.21	0.40	0.56	0.16	0.30	0.40
CD (P=0.05)	0.87	1.63	N.S.	N.S.	1.22	N.S.	0.62	1.16	N.S.	0.46	0.87	N.S.

Table 3 : Influence of sowing dates (S) and chemicals spray (T) on Spike length (cm) and Number of seeds per spike in wheat.

Treatment	Spike Length (cm)						Number of seeds per spike					
	Ist year			IInd year			Ist year			IInd year		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
T_0	14.37	13.17	13.77	14.00	13.37	13.68	48.66	47.33	47.99	48.33	47.66	47.99
T_1	14.97	14.00	14.48	14.97	14.37	14.67	49.33	47.66	48.49	49.00	48.00	48.50
T_2	16.20	15.97	16.08	16.37	15.90	16.13	52.66	51.66	52.16	52.33	51.33	51.83
T_3	15.03	14.87	14.95	15.09	14.580	14.79	50.00	48.66	49.33	50.33	48.33	49.33
T_4	15.87	15.63	15.75	15.97	15.67	15.82	51.33	51.00	51.16	51.33	50.00	50.66
T_5	15.20	15.00	15.10	15.37	15.17	15.27	51.00	49.66	50.33	51.00	49.00	50.00
T_6	15.63	15.33	15.48	15.87	15.53	15.70	50.66	50.66	50.66	51.33	50.66	50.99
Mean	15.32	14.85	15.09	15.37	14.93	15.15	50.52	49.51	50.02	50.52	49.28	49.90
	S	T	S x T	S	T	S x T	S	T	S x T	S	T	S x T
S.E. (d)	0.05	0.10	0.14	0.21	0.39	0.55	0.25	0.47	0.67	0.42	0.78	1.11
S.E. (m)	0.03	0.07	0.10	0.15	0.28	0.39	0.17	0.33	0.47	0.29	0.55	0.78
CD(P=0.05)	0.11	0.21	N.S.	0.43	0.81	N.S.	0.52	0.97	N.S.	0.86	1.61	N.S.

index (%) was found non-significant due to the interaction of sowing date and foliar application of treatments during both years of experimentation.

Characters significantly influenced due to different sowing dates during both the years of experimentation (Tables 2 to 5) showed that sowing in 3rd week of November (S_1) recorded significantly more number of effective tillers per plant *i.e.*, 14.71 and 15.04; more spike length 15.32 and 15.37 (cm); number of seeds per spike 50.52 and 50.52; 1000 seed weight (g) 36.80 and 36.90; seed yield per plant (g) 27.30 and 27.52 (g); seed yield per plot (kg) 9.64 and 9.79 (kg) and seed yield quintal per hectare (q/ha) *i.e.*, 48.42 and 48.52 during first year and second year over the second date of sowing *i.e.*, 1st week of December (S_2). Whereas, sowing in 1st week of December (S_2) displayed a significant decrease in days to 50% flowering with value of 80.23 and 80.52 and date of 50% maturity 120.52 and 120.42 respectively, during both the years as early flowering and early maturity is considered desirable trait.

Data pertaining to characters under study as influenced by foliar application of different chemicals in first year and second year during experimentation are presented in Tables 2 to 5. The result displayed a significant reduction in a number of days to 50% flowering *i.e.*, (78.66 and 77.66 days) and days to 50% maturity

Table 4 : Influence of sowing dates (S) and chemicals spray (T) on Days to 50% maturity and 1000 grain weight (cm) in wheat.

Treatment	Days to 50% maturity						1000 grain weight					
	Ist year			IInd year			Ist year			IInd year		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
T_0	123.33	119.33	121.33	122.66	119.00	120.83	35.00	33.66	34.33	35.33	33.33	34.33
T_1	124.00	120.66	122.33	125.00	120.00	122.50	35.67	34.00	34.83	36.00	34.33	35.16
T_2	126.00	122.66	124.33	125.33	122.33	123.83	39.33	37.00	38.16	39.66	37.33	38.49
T_3	122.66	119.33	121.00	122.00	119.33	120.66	36.33	34.00	35.16	36.66	33.66	35.16
T_4	124.33	121.00	122.66	124.00	121.00	122.50	37.66	35.66	36.66	37.33	36.00	36.66
T_5	123.00	119.66	121.33	124.00	120.33	122.16	36.00	35.33	35.66	36.33	35.33	35.83
T_6	124.00	121.00	122.50	124.33	121.00	122.66	37.66	35.66	36.66	37.00	35.66	36.33
Mean	123.90	120.52	122.21	123.90	120.42	122.16	36.80	35.04	35.92	36.90	35.09	35.99
	S	T	S x T	S	T	S x T	S	T	S x T	S	T	S x T
S.E. (d)	0.35	0.65	0.93	0.37	0.69	0.98	0.31	0.59	0.84	0.41	0.77	1.10
S.E. (m)	0.24	0.46	0.65	0.26	0.49	0.69	0.22	0.42	0.59	0.29	0.55	0.77
CD(P=0.05)	0.72	1.35	N.S.	0.76	1.42	N.S.	0.65	1.22	N.S.	0.85	1.59	N.S.

Table 5 : Influence of sowing dates (S) and chemicals spray (T) on Seed yield per plant (g) and Seed yield (q/ha) in wheat.

Treatment	Seed yield per plant						Seed yield (q/ha)					
	Ist year			IInd year			Ist year			IInd year		
	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean	S_1	S_2	Mean
T_0	21.62	17.23	19.42	22.10	18.06	20.08	45.66	40.83	43.24	45.70	40.73	43.21
T_1	24.45	18.60	21.52	24.85	18.70	21.77	46.66	42.00	44.33	46.71	42.10	44.40
T_2	33.85	29.33	31.59	33.95	29.66	31.80	52.00	49.16	50.58	52.10	49.26	50.68
T_3	26.02	22.10	24.06	26.16	23.12	24.64	47.16	43.83	45.49	47.16	43.50	45.33
T_4	29.66	27.03	28.34	29.96	27.33	28.64	50.33	47.16	48.74	50.43	47.30	48.86
T_5	26.87	23.98	25.42	26.80	26.47	26.63	48.00	44.50	46.25	48.30	45.10	46.70
T_6	28.66	26.52	27.59	28.88	26.59	27.73	49.16	45.33	47.24	49.26	45.45	47.35
Mean	27.30	23.54	25.42	27.52	24.27	25.90	48.42	44.69	46.55	48.52	44.78	46.65
	S	T	S x T	S	T	S x T	S	T	S x T	S	T	S x T
S.E. (d)	0.63	1.18	1.67	0.36	0.68	0.97	0.20	0.37	0.53	0.64	1.20	1.70
S.E. (m)	0.44	0.83	1.18	0.25	0.48	0.68	0.14	0.26	0.37	0.45	0.85	1.20
CD(P=0.05)	1.30	2.43	N.S.	0.77	1.41	N.S.	0.41	0.77	N.S.	1.32	2.48	N.S.

(121.00 and 120.66 days) over the control by the application of Salicylic acid 800ppm (T_2) during the first year and second year, respectively. Among the treatments Salicylic acid 800ppm (T_2) significantly improved the characters *viz*., number of effective tillers per plant with values of (15.83 and 16.00), number of seeds per spike (52.16 and 51.83), 1000 seed weight (38.16 and 38.49g), spike length (16.08 and 16.13cm), seed yield per plant (31.59 and 31.80g), seed yield per plot (10.11 and 10.14kg) and seed yield quintal per hectare (50.58 and 50.68q/ha) during first year and second year, respectively.

The characters *viz*., days to 50% flowering, days to 50% maturity, number of effective tillers per plant, number of seeds per spike, 1000 seed weight (g), spike length (cm), seed yield per plant (g), seed yield per plot(kg) and seed yield quintal per hectare were found non-significant due to interaction of sowing date and foliar application of different treatments during both the years of experimentation.

Discussion

In the present study results, the chlorophyll content index (%) determined was significantly influenced due to different sowing dates during both the year 2016-17 and 2017- 18 (Table 1). The sowing of wheat at 3rd week of November recorded significantly more chlorophyll content index (%) than sowing in 1st week of December before spray as well as after foliar spray of chemicals but chlorophyll content index was significantly higher than control. The maximum chlorophyll content index (%) was found with foliar application of chemical T_2 (Salicylic acid @ 800ppm) that was significantly superior over rest of the chemicals treatments. Kousar *et al*. (2018), reported 24% chlorophyll increase by application of Salicylic acid.

Generally early sowing results better than late sowing in wheat because early sown crop get proper time for vegetative as well as reproductive growth and development. In present study also early sowing date i.e., 3rd week of November (S_1) recorded significantly more effective tillers per plant more spike length, more number of seeds per spike, 1000 seed weight, seed yield per plant, seed yield per plot and seed yield quintal per hectare during both the year over second date of sowing *i.e.,* 1st week of December (S_2). Early flowering and early maturityis noticed in late sowing i.e., 1st week of December (S_2). Wheat is a cool season crop on late sowing its reproductive growth and development phase faces heat stress that shortens its flowering as well as maturity time. Although, early flowering and early maturity is considered desirable trait but it results in significant yield loss. In the present study foliar spray of chemicals is done to mitigate the effect of heat stress on yield and yield contributing traits in late sowing wheat.

Foliar spray of chemicals to mitigate the effect of heat stress in late-sown wheat showed significant improvement in the characters under study. Glycine betaine plays an important role in osmoregulation in plants subjected to extreme environmental stresses, including high- temperature stress (Annunziata *et al.*, 2019; Al-Huqail *et al.*, 2020). GB can stabilize photosynthesis in heat-stressed plants, promoting growth under heat stress.Yield enhancement due to effect of treatment Glycine betaine was recorded 41.30% higher under normal sown conditions whereas 44.92% higher under delayed sown conditions in comparison to control T1 (Bharati *et al*., 2018). Salicylic acid (SA), a common phenolic compound functions as a plant growth regulator and promotes photosynthesis under heat stress by influencing various physiological processes and biochemical reactions. Investigations have shown SA as a strong and potential tool in reducing or alleviating the adverse effects of abiotic stress in plants. Application of SA has been shown to be beneficial for plants either in optimal or stressful environments (Wang *et al*., 2010; Khan *et al.*, 2013). Ascorbic acid (Vitamin C) is water soluble and acts as a modulator of plant development through hormone signaling and as coenzyme in reactions by which carbohydrates and proteins are metabolized. They catch the free radicals or the reactive oxygen species produced during altered photosynthesis and respiration processes under heat stress. They also regulate photosynthesis flowering and senescence (Barth *et al*., 2006) under elevated temperature. Tocopherol (Vitamin E) is a lipophylic antioxidant that establishes membranes, scavenges various ROS (Maeda and Dellapenna, 2007) and preserves PS II photoinactivation and membrane lipids from photo oxidation. Tocopherol (vitamin E) plays a protective role to the membrane system in the cell of higher plants (Fryer, 1992; Wang and Quinn, 2000); assists in maintaining membrane stability (Munné-Bosch and Falk, 2004) and regulates the transport of electrons in the photo system-II system (Munné-Bosch and Alegre, 2002). Potassium fertilization which can improve crop yield under adverse conditions has been interpreted as evidence that K increasesthe resistance of plants to abiotic stresses (Cakmak *et al*., 2005; Marschner and Marschner, 2012).

Cumulative effect of these chemicals is displayed in the results (Tables 2 to 5). Result displayed a significant reduction in a number of days to 50% flowering and days to 50% maturity over the control by the application of Salicylic acid 800ppm (T_2) during both the years of experimentation. Among the treatments Salicylic acid 800ppm (T_2) was found more significant in improving the characteristics *viz.*, a number of effective tillers per plant number of seeds per spike, 1000 seed weight, spike length, seed yield per plant, seed yield per plot and seed yield quintal per hectare during first year and second year, respectively. These traita are in close agreement with Chouhan*et al.* (2017), Ziasmin *et al*. (2017) and Gitte *et al.* (2018).

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