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Effect of salicylic acid on growth, bio-chemical changes and yield of wheat (*Triticum aestivum* L.) under different date of sowing condition

Prashansha Singh, Vinaya Kumar Yadav, Pram Chandra Yadav and Girish Chandra Pandey

Abstract
The present investigation entitled “Effect of salicylic acid on growth, bio-chemical changes and yield of wheat (*Triticum aestivum* L.) under different date of sowing condition” was conducted at Students Instructional Farm of the Narendra Deva University of Agriculture and Technology, Kumarganj, Faizabad (U.P.) during r*abi* seasons of 2014-15 and 2015-16. The experiment was planned under RBD (Randomized Block Design) with three replications. The treatment consisted of two date of sowing *viz*;25th November and 25th December with two varieties NW-5054 and NW-2036 with ten salicylic acid treatment *viz*; (T1)Control, (T2)Seed soaking in (0.25mM) salicylic acid, (T3)Foliar spray of (0.25mM) salicylic acid at 30 DAS, (T4)Seed soaking in (0.25mM) salicylic acid + Foliar spray of (0.25mM) salicylic acid at 30 DAS,(T5)Seed soaking in (0.50mM) salicylic acid, (T6)Foliar spray of (0. 50mM) salicylic acid at 30 DAS, (T7) Seed soaking in (0.50mM) salicylic acid + Foliar spray of (0.5mM) salicylic acid at 30 DAS,(T8)Seed soaking in (0.75mM) salicylic acid, (T9)Foliar spray of (0.75mM) salicylic acid at 30 DAS, (T10)Seed soaking in (0.75mM) salicylic acid + Foliar spray of (0.75mM) salicylic acid at 30 DAS. When late sown variety was planted timely all the growth attributes showed drastic reduction with respect to late sowing (25th December).However, NW-5054 showed comparatively good performance in terms of growth attributes at timely sown (25th November). Performance of NW-5054 was very good as compared to NW-2036 due to delayed sowing on 25th December. Application of salicylic acid significantly increased all growth attributes in both varieties under both timely and late sown. Time of sowing decreased substantially almost in all the yield components and enzyme activity measured *viz*; number of ear per plant, ear length, number of grains per plant, test weight, grain yield per plant, straw yield, catalase activity, peroxidase activity, 50% flowering and days to physiological maturity which caused severe reduction in yield. Overall, T10 (Seed soaking in (0.75mM) salicylic acid + Foliar spray of (0.75mM) salicylic acid at 30 DAS) treatment showed best result and T2 Seed soaking in (0.25mM) salicylic acid gave least. All the salicylic acid treatments reduced the detrimental effect of heat stress on both the varieties by improving physiological traits which ultimately helped in obtaining higher yield.

Keywords: Growth, conditions, biochemical activity, enzyme, yield and yield parameter

Introduction
Wheat (*Triticum aestivum* L.) is the most important cereal crop belongs to family poaceae. It is staple diet for more than one third of the world population. Wheat crop occupies 21.8% of the total area under food grains. It constitutes the staple food for at least 43 countries including China, India, USA, France, Russia, Canada, Australia and a member of European countries. A record production of 99.70 million tonnes of wheat with a consistent barley output (1.7 million tonnes), in the past Rabi season (2017-18), has given much thrust and enthusiasm to research fraternity as well as farmers during the ongoing Rabi season (2018-19) which reckons for another unparalleled production. The current season has started on a good note during the sowing time and the prolonging cool weather is highly conducive to the crop expecting a gargantuan output. The Government’s policy decision on increasing the support price by 1.5 times the cost of production i.e., from ` 1735 to ` 1840 (+ ` 105: 6.1%) and ` 1410 to ` 1440 (+` 30: 2.1%) respectively per quintal of wheat and barley, to fulil the commitment to the farmers to provide 50 per cent returns over the production cost has been a remunerative reason for farmers to allocate more area under wheat. The northern and western part of India has maximum area and production under wheat cultivation. In Uttar Pradesh, area, production and productivity are 9.67 mha, 33.97 mt and 31.13q/ha, respectively Uttar Pradesh ranks first in

area (36.58% of India) and production (36.27% of India) of wheat in the country.

There are number of constraints which affect wheat production and decrease the nutritive value of wheat. Among them increase in temperature due to global warming is an important factor. Most of the world crops including wheat have an optimal range of temperature. Exposure to higher than optimal temperature reduced yield and decreased quality of wheat grain. Over 7 million hectares of wheat grown in approximately 50 countries are subjected to continual heat stressing environment and adversely affects wheat growth in many important production regions and is a major limitation to wheat productivity worldwide. Heat stress is a function of the magnitude and rate of temperature (Wahid *et al*., 2007) [30]. At present, 3 to 5-million-hectare area of sown wheat of northern gangetic plains come under high temperature stress. Sowing wheat usually gets delayed beyond November due to late harvesting of rice, cotton or sugarcane etc. In such case, wheat growth and yield are adversely affected due to high temperature during growth and reproductive phases. The duration of grain filling in cereals (wheat) is determined principally by temperature. In wheat, high temperature (< 31ºC) can decrease the rate of grain filling (Wardlaw IF and Moncur L 1995) [31]. Temperature above the optimum for growth can be deleterious, causing injury which is generally called heat stress. It causes an array of Morpho-anatomical, physiological and biochemical changes in plants, which affect plant growth and development and may lead to a drastic reduction in economic yield.

High temperature stress is a major cause of yield loss in cereal crops throughout many of the world's cereal growing areas, including India. Wheat plants are exposed to numerous biotic and abiotic stresses causing significant effect on the growth and cause changes in the normal physiological functions of the plants. The cultivation of wheat is limited by temperature at both ends of the cropping season and high temperature stress has an adverse effect on wheat productivity. The terminal heat stress was at anthesis and grain filling stages accelerate maturity and significantly reduce grain size, weight and yield (Kamal *et al.*, 2013) [11].

High temperature during the grain filling period of wheat causing constraints in yield potential in many of the world's wheat growing areas. Heat stress injury involves water deficit, cell turgor loss and chlorophyll degradation is accelerated at high level. Heat stress reduces the leaf area, the duration of vegetative growth and leaf number in wheat. Heat stress is injurious to the photosynthetic apparatus during reproductive growth of wheat, diminish source activity and sink capacity, which results in reduced productivity and enhance leaf senescence causing reduction in green leaf area during reproductive stages. The rapid leaf senescence ultimately resulted in less productive tillers/plant, which is one of the major causes of yield loss of wheat. High temperature above 32^0C has been reported reducing grain yield and grain weight during grain filling, it's considered as a major determinant of wheat development and growth, decreasing yields by 3-5% per 1^0C increase above 15^0C (Wollenweber *et al*.,2003) [31].

Salicylic acid (SA) is a phenolic compound involved in the regulation of growth and development of plants, and their responses to biotic and abiotic stress factors (Khan *et al*., 2013, Miura and Tada, 2014) [14, 18]. Salicylic acid can also play a significant role in plant water relations (Barkosky and Einhelling, 1993) [15] under abiotic stress conditions. SA is involved in the regulation of important plant physiological processes such as photosynthesis, nitrogen metabolism, proline (Pro) metabolism, production of glycine betaine (GB), antioxidant defense system, and plant-water relations under stress conditions and thereby provides protection in plants against abiotic stresses (Khan *et al*., 2014) [13]. Exogenously sourced SA to stressed plants, either through seed soaking, adding to the nutrient solution, irrigating, or spraying was reported to induce major abiotic stress tolerance-mechanisms (Anwar *et al*., 2013) [3]. Salicylic acid mediated improved plant tolerance to heat stress has also been reported (Khan *et al*., 2013) [14].

Material and Methods

The present investigation was conducted at Students Instructional Farm of the Narendra Deva University of Agriculture & Technology, Kumarganj, Faizabad (U.P) during *rabi* seasons of 2014-15 and 2015-16. The site has sub-humid climate and falls in the Indogangetic plains having an alluvial soil and lies between latitude 26.47^0 North and at a longitude 82.12^0 East with an elevation of about 113 meters from sea level and is subjected to extremes of weather conditions.

A different concentration of salicylic acid was prepared in one liter of water dissolving required amount to prepare 0.25mM, 0.50mM and 0.75mM solution, respectively for seed soaking treatments. The seeds of both the wheat varieties were soaked separate flask in the solution of different concentration of salicylic acid for 10 hours. After that seeds were taken out from the solution and kept on blotting paper to remove water from seeds.

The seeds were sown @ 100 kg ha^{-1} in row space 20 cm at average depth of 5 cm with the help of kudali. Nitrogen, phosphorus and potash were added at the rate of 120, 80 and 60 kg ha^{-1} through urea, DAP and murate of potash, respectively. Half of the nitrogen, total phosphorus and potash were added as basal dose before sowing of seeds. Remaining nitrogen was added in two equal split doses, one at tillering and other at the time of spike initiation.

Solution of different concentrations of salicylic acid was prepared in desired volume of water dissolving required amount to prepare 0.25mM, 0.50mM and 0.75mM solution, respectively for foliar spraying. In order to improve the spray retention, a sticky agent, teepol, was mixed into the spray solution @ 0.5ml/litre. A spray volume of 500 liters per hectare was used to spray the crop. The spraying was done with the help of knapsack sprayer at 30 DAS. Thirty plants of same vigour were tagged in each plot for the study of growth attributes and yield as well as yield components. Five tagged plants were randomly uprooted from each plot with the help of khurpi at each date of observation (i.e. 30 DAS, 60 DAS and at maturity).

The plant height was measured in cm from soil level to its tip at different crop growth stages. Number of tillers per plant under each treatment was recorded by counting tillers in five tagged plants at various stages of crop and average number of tillers per plant was calculated. Number of days of 50% flowering under each treatment was assessed by counting the number of days taken from sowing to the day when 50% plants showed ear emergence. It is also termed as days to 50% heading. The maturity duration of the crop for each treatment was assessed by visual appearance of grains and colour of flag leaves particularly flag leaf. The crop is mature when flag leaf becomes yellowish and the grain has lost its green chlorophyll colour and turns whitish. The number of total ear bearing tillers of each treatment from five randomly selected plants were counted carefully and average was taken to get the number of ear bearing tillers. Ear length was measured in centimeters from the top (excluding awns) to be base of the ear. Length of 5 randomly selected ear from each treatment was measured and averaged to get length of single ear. The average weight of grains from randomly selected plants of each treatment was recorded as grain yield per plant. Catalase activity can be assayed colorimetrically according to method given in analytical biochemistry (Sinha 1972) [27]. Catalase facilitates the dismutation of H_2O_2 to water and O_2 according to the reaction. The activity of peroxidase was determined by the method of (Curne and Galston 1959) [6]. The enzyme catalyses the oxidation of a substrate by removal of hydrogen which combines with H_2O_2.

Data recorded on various growth and yield attributes were subjected to statistical analysis by Fisher method of analysis of variance (Fisher and Yates 1949) [7]. The significance of various treatments was judged by comparing calculated, F' value with Fisher's, F' value at 5 percent level, incorporate in tables, were also calculated to compare the relative performance of various treatments by using the following formula:

$$SEm\pm = \sqrt{\frac{EMS}{N}}$$

EMS is mean sum of square of error
N = total number of experimental unit
Level of factors

$$CD = \sqrt{\frac{2EMS}{N}} \times t\,(5\%)$$

Where,
Value off's' from Fisher's table at error degree of freedom on 5% level of significance.

Results and Discussion

The growth and yield of wheat crop is adversely affected by environmental stresses such as high temperature stress. High temperature at flowering and grain filling stage shortens the duration of grain filling period, resulting in early maturity, thus reducing the crop yield. High temperature between flag leaf stage and flowering reduces sink period, reducing the grain size. (Sharma and Tandon 1997) [26]. Growth attributes like plant height and number of tillers per plant increase with the increase of plant age. The investigation shows that sowing of late variety on normal sowing date decreased significantly growth attributes (plant height and number of tillers plant^{-1}) of wheat plant as compared with timely sown variety at normal date. However, reduction in growth attributes was recorded in case of timely sown variety under late sown condition at all the stages of observation. These reductions may be attributed to the relatively higher temperature prevailing during the critical stages of growth in late sowing plant. In addition, the reduction in the studied growth parameters as plant height, ear length (cm) and ear bearing tillers per plant of wheat plant in response to late sowing date of timely sown variety can be ascribed to the effect of high temperature on the membrane permeability and the transpiration rate.

The data presented in (Table No. 1), application of SA as seed soaking and foliar spray as well as their combination significantly caused significant increase in all plant growth measurements as compared with the control treatment at 30 and 60 DAS under both timely and late sown condition. But the effect of salicylic acid was more pronounced on NW-5054 sown under late sown condition. In general, the favorable effect of SA on overall growth of wheat might be on account of increased photosynthetic efficiency. In the present investigation, due to application of SA could be ascribed to enhanced plant height and number of tillers over control. Similar results were reported by (Nainwal *et al*., 2000) [22] which showed maximum reduction in growth attributes of late sown crop. This might be due to lowering of temperature which results in decrease in cell activity like cell division and expansion. (Karim *et al*., 2011) [12] noted that the application of 100, 200 and 400 ppm salicylic acid increased plant height, ear length (cm) and ear bearing tillers per plant in wheat. Treatment with SA increased plant height in two different date of sowing. Similar findings related to increase in plant height was also reported by (Nagasubramaniam *et al*., 2007) [20] in baby corn.

Regardless of varietal variation, the days to 50% flowering and maturity duration were markedly reduced by delayed sowing of wheat. Temperature plays an important role in the completion of life cycle of any crop. (Yin *et al*., 1997) [37] reported that high temperature accelerates flowering and ultimately resulting in forced maturity. (Abrol *et al*., 1991) [1] reported that in late sown wheat a portion of maturity period of the crop pushed forward and thus has to face high temperature of the summer with hot spell often occurring at the time of the maturity. In general, both the varieties showed greater extent of variation in reduction to days 50% flowering and maturity (Table No. 4) duration under late sowing which perhaps maybe due to force maturity and premature senescence of wheat plant under extreme conditions, where plants are exposed to hyper thermal stress (Nagarajan *et al*., 2002) [21]. Similar results were also reported by (Rasal *et al*., 2006) [24]. A very slight increase in days to 50% flowering and maturity duration were observed with SA treatments which were statistically found significant. (Hayat and Ahmed 2007) [8] observed that salicylic acid plays diverse physiological roles in flower induction.

Maximum grain yield was recorded from the crop sown on 25th November and significantly differed from crop sown on 25th December. It might be concluded that the growth attributes are adversely affected by delayed sowing of wheat which leads to forced maturity because of high temperature prevailed during reproductive phase of the late sown crop. Due to that maximum grain yield was recorded in early sown wheat crop in comparison with late sown crop. Variety NW-2036 showed better response in terms of number of ear per plant (Table No. 3), number of grains per plant (Table No. 3) and grain yield per plant per plant, however, NW-5054 showed reduction under late sown condition in all the traits associated with yield and yield components. Similar findings were also reported by (Bangarwa *et al*., 1996) [4] observed that both the yield attributes such as number of effective tillers and 1000-grain weight are highest under timely sowing as compared to late sowing conditions. The reason for this is that with increase in temperature there is reduction in the growth period which results in decrease in yield attributing characters, affecting finally the grain yield.

Similar to our results reduction in number of ear per plant and ear length has been also reported by (Singh *et al*., 2007) [28]. In this respect, (Singh *et al*., 2003) [29] reported that high temperature and desiccating winds during the month of April might have caused forced maturity of late sown wheat. Grain yield is the product of number of grains per plant and ear length hence reduction in all these components under late sowing accounted for greater decrease in grain yield. Delay in sowing after the optimum date showed decreasing trend in the yield of the crop. The crop sown on 25th November showed maximum number of effective tillers as compared to late sown one (Jat *et al*., 2013 and Mukherjee *et al*., 2012) [10, 19].

Almost all the SA treatments showed significant increase in all the yield and yield attributes. Overall T_{10} (0.75mM seed soaking + foliar spray) treatment showed best result followed by T_8 (0.75mM seed soaking). The positive increases in the yield and its components in response to SA are in agreement with those obtained by (Mandavia *et al*., 2006) [16] who applied SA on chick pea plants. These increments in the yield component due to SA treatments may be attributed to the increase in growth rate. In this respect, (Mathur and Vyas 2007) [17] reported that SA play a critical role in yield and its components like ear length, ear diameter and grain yield per plant of pearl millet was significantly increased by bio regulators applications.

The activities of antioxidant enzymes *viz*, catalase and peroxidase increased gradually with increase in the age of the crop up to 60 DAS under the both sowing dates. Late sowing, induced higher activity of all above enzymes under both timely and late sown conditions in both the varieties (NW-5054 and NW-2036). Highest activities of all these enzymes were recorded at 60 DAS. In order to limit oxidative damage under stress condition plants have developed a series of detoxification systems that break down the highly toxic reactive oxygen species (Larkin dale *et al*., 2002) [15]. Tolerance to high temperature stress in crop plants has been reported to be associated with an increase in antioxidant enzymes activity (Sairam *et al*., 2000) [25]. It is clear from the data that there was a significant increase in the antioxidant enzymes in response to late sowing.

Application of SA showed a marked increase in catalase and peroxidase. The results (Table No. 2) show that at 30 DAS only the seed soaking treatment in SA registered significant increase in antioxidant enzyme activities with respect to control in both NW-5054 and NW-2036.The application of salicylic acid (0.75 mM, 0.50mM and 0.25mM) as seed soaking as well as foliar spray and seed soaking + foliar spray significantly increased antioxidant enzyme activities at 60 DAS of observations in both timely and late sown varieties (NW5054 and NW2036). Maximum antioxidant enzymes activity was obtained in T_{10} followed by T_8 and T_7 as compare to control in both the varieties. (Raifa *et al*., 2015) [23] also reported that application of salicylic acid as seed soaking and foliar spray treatments effectively improved the performance of wheat varieties by enhancing antioxidant enzymes (SOD and CAT). Results showed that foliar spray with different concentration of salicylic acid increased the activity of antioxidant enzymes like GPOX and SOD which prevent the plants from oxidative stress which is further produced by abiotic and biotic factors. (Jakhar and Sheokand 2015) [9] observed that exogenous application of different concentration of SA (10^{-4}, 10^{-5} M) resulted an increase in activities of antioxidant enzymes and best response occurred at (10^{-6} M).

Table 1: Effect of date of sowing and salicylic acid on plant height (cm) ear length (cm) and ear bearing tillers plant $^{-1}$ at various stages of wheat varieties

Treatments	Plant height (cm)															
	Timely sown				Late sown				Ear length (cm)				Ear bearing tillers plant $^{-1}$			
	30 DAS		60 DAS		30 DAS		60 DAS		Timely sown		Late sown		Timely sown		Late sown	
	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2
T_1-Control	30.33	26.33	79.00	77.67	26.67	33.33	76.67	81.33	8.81	8.62	8.54	8.18	10.00	7.33	8.33	8.33
T_2-0.25mMS	31.64	27.81	79.88	79.10	27.19	33.74	77.14	81.96	8.96	8.71	8.63	8.45	10.67	8.33	9.66	9.33
T_3-0.25mMF	30.48	26.56	79.22	78.56	26.82	33.37	76.92	81.73	8.92	8.61	8.54	8.27	10.33	7.83	9.08	8.67
T_4-0.25mMS+F	32.89	28.63	81.88	80.44	30.63	34.92	78.44	83.14	9.11	8.82	8.66	9.31	11.33	9.33	10.47	11.00
T_5-0.50mMS	33.12	29.05	82.10	80.92	31.02	35.73	78.92	83.47	9.12	8.86	8.70	9.33	12.67	9.50	11.23	12.00
T_6-0.50mMF	30.87	27.10	80.33	79.83	27.61	34.17	77.69	82.26	9.06	8.73	8.66	8.86	11.00	8.67	9.67	9.33
T_7-0.50mMS+F	33.60	29.25	82.46	81.22	31.50	35.97	79.49	84.20	9.12	8.86	8.76	9.33	12.67	9.56	11.25	12.00
T_8-0.75mMS	35.20	29.91	82.56	81.76	33.35	36.49	79.90	84.78	9.15	9.03	8.88	9.37	12.67	9.67	11.67	12.00
T_9-0.75mMF	30.95	27.12	81.25	80.13	26.59	34.56	78.05	82.78	9.11	8.79	8.66	9.10	11.00	8.87	9.83	10.67
T_{10}-0.75mMS+F	35.87	30.03	83.90	82.23	34.47	37.23	80.63	85.52	9.22	9.15	8.97	9.41	13.33	10.67	12.67	13.00
	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%
Variety (V)	0.57	1.61	0.68	1.92	0.61	1.66	0.72	1.94	0.114	0.326	0.112	0.322	0.064	0.184	0.060	0.171
Treatments (T)	0.66	4.03	0.79	4.81	0.69	4.01	0.83	4.85	0.255	0.729	0.251	0.719	0.144	0.411	0.133	0.382
V×T	1.15	3.21	1.37	3.83	1.21	3.22	1.42	3.86	0.360	1.031	0.355	1.017	0.203	0.582	0.189	0.540

Table 2: Effect of date of sowing and salicylic acid on catalase activity (g^{-1} fresh weight min^{-1}) and peroxidase activity (g^{-1}fresh weight min^{-1}) at various stages of wheat varieties:

Treatments	Catalase activity (g^{-1} fresh weight min^{-1})								Peroxidase activity (g^{-1}fresh weight min^{-1})							
	Timely sown				Late sown				Timely sown				Late sown			
	30 DAS		60 DAS		30 DAS		60 DAS		30 DAS		60 DAS		30 DAS		60 DAS	
	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2
T_1-Control	66.48	61.24	131.58	130.29	118.66	122.71	150.12	156.74	145.87	142.87	149.98	146.17	163.96	169.32	196.65	209.17
T_2-0.25mMS	66.77	61.71	132.87	131.20	119.10	123.87	151.05	157.34	145.70	142.75	149.54	145.87	163.60	169.10	196.10	208.54
T_3-0.25mMF	66.62	61.60	132.15	130.82	118.78	123.10	150.22	157.10	146.83	143.87	150.55	147.21	164.90	170.21	197.89	210.25
T_4-0.25mMS+F	67.32	62.72	134.10	131.82	119.57	124.21	152.98	159.04	147.48	144.10	151.10	148.10	164.40	171.24	198.87	210.96
T_5-0.50mMS	68.15	62.79	134.87	132.10	120.89	124.76	153.17	160.10	146.10	142.98	150.15	146.64	164.10	169.50	196.88	209.19
T_6-0.50mMF	67.15	62.00	133.10	131.42	119.22	123.90	152.20	157.71	147.92	144.37	152.12	148.96	165.92	171.50	199.36	211.92
T_7-0.50mMS+F	68.30	63.22	135.41	132.82	121.10	125.66	153.45	160.62	148.30	145.12	152.66	149.32	166.30	172.35	200.23	212.87
T_8-0.75mMS	69.10	63.87	135.92	133.22	121.32	126.41	153.82	161.18	146.12	143.20	150.20	146.85	164.50	170.20	197.22	209.72

T_9-0.75mMF	67.21	62.48	133.74	131.67	119.36	124.15	152.30	158.54	148.85	145.65	153.12	150.22	166.73	172.96	201.45	213.45
T_{10}-0.75mMS+F	69.25	64.10	136.67	134.67	122.92	127.48	155.36	162.89	149.25	146.21	154.10	151.12	167.41	173.65	203.12	214.52
	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%
Variety (V)	0.405	1.161	0.824	2.360	0.675	1.931	0.971	2.779	0.884	2.530	1.388	3.973	1.175	3.364	1.398	4.002
Treatments (T)	0.907	2.595	1.844	5.277	1.509	4.318	2.171	6.214	1.976	5.657	3.103	8.883	2.628	7.523	3.127	8.950
V×T	1.282	3.670	2.607	7.463	2.134	6.107	3.070	8.788	2.795	8.000	4.389	12.562	3.717	10.639	4.422	12.657

Table 3: Effect of date of sowing and salicylic acid on grain per plant, test weight (g), grain yield per plant (g) and straw yield per plant (g) of wheat varieties:

Treatments	Grain per plant				Test weight (g)				Grain yield per plant (g)					Straw yield per plant (g)		
	Timely sown				Late sown				Timely sown					Late sown		
	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2
T_1-Control	37.00	28.33	27.33	40.00	38.56	31.75	33.66	37.68	13.54	10.61	12.65	12.75	13.80	13.86	10.68	12.74
T_2-0.25mMS	37.67	29.00	28.00	40.33	39.00	32.00	35.59	37.76	13.60	10.71	12.82	12.98	14.35	13.98	11.02	13.36
T_3-0.25mMF	37.67	28.67	27.33	40.00	38.67	31.80	35.59	37.72	13.56	10.66	12.70	12.82	13.91	13.92	10.72	13.25
T_4-0.25mMS+F	38.33	30.33	28.33	41.00	39.56	32.45	35.80	37.94	13.94	10.95	13.12	13.33	15.20	14.42	11.84	14.24
T_5-0.50mMS	39.00	30.67	28.67	41.00	39.88	32.78	36.05	38.12	14.29	11.10	13.88	13.98	15.18	14.47	13.22	14.81
T_6-0.50mMF	38.00	29.00	28.00	40.67	39.20	32.10	35.63	37.88	13.70	10.78	12.90	13.10	14.60	14.15	11.27	13.44
T_7-0.50mMS+F	39.00	31.67	29.00	41.00	40.00	32.88	36.40	38.48	14.46	11.33	13.96	14.26	15.28	14.65	13.94	15.04
T_8-0.75mMS	39.67	32.33	30.33	42.00	40.20	32.92	36.81	38.92	14.90	11.66	14.15	14.81	15.32	14.78	14.31	15.66
T_9-0.75mMF	38.00	39.67	28.00	40.67	39.20	32.10	35.72	37.88	13.72	10.82	12.98	13.10	15.10	14.35	11.39	13.66
T_{10}-0.75mMS+F	40.67	39.33	31.67	42.33	42.72	33.16	37.10	39.33	15.24	11.57	14.54	15.25	15.38	14.80	15.54	16.63
	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%
Variety (V)	0.642	1.838	0.570	1.631	0.436	1.248	0.421	1.206	0.070	0.199	0.064	0.182	0.65	1.82	0.66	1.84
Treatments (T)	1.436	4.110	1.274	3.647	0.975	2.790	0.942	2.696	0.155	0.445	0.142	0.407	0.75	4.58	0.78	4.60
V×T	2.030	5.812	1.802	5.158	1.378	3.946	1.332	3.813	0.220	0.629	0.201	0.576	1.30	3.65	1.32	3.68

Table 4: Effect of date of sowing and salicylic acid on days to 50% flowering and days to physiological maturity of wheat varieties

Treatments	Days to 50% flowering				Days to physiological maturity			
	Timely sown				Late sown			
	V_1	V_2	V_1	V_2	V_1	V_2	V_1	V_2
T_1-Control	89.61	78.26	80.55	82.27	120.00	103.69	104.00	122.00
T_2-0.25mMS	91.00	78.52	81.00	83.28	121.00	104.00	106.35	122.81
T_3-0.25mMF	90.30	78.52	81.00	82.55	120.40	104.00	104.35	122.81
T_4-0.25mMS+F	91.30	79.26	81.54	84.00	122.81	105.35	107.71	124.83
T_5-0.50mMS	91.61	79.53	82.27	84.56	123.81	105.35	107.71	124.86
T_6-0.50mMF	91.00	79.00	81.07	83.55	122.81	104.69	106.40	123.41
T_7-0.50mMS+F	92.61	80.00	82.27	84.56	123.82	105.70	108.00	125.00
T_8-0.75mMS	92.23	80.05	82.55	85.12	124.64	106.40	109.73	125.65
T_9-0.75mMF	91.30	79.04	81.53	84.00	122.81	104.69	107.71	124.41
T_{10}-0.75mMS+F	93.23	80.53	83.09	85.12	124.64	107.41	110.45	126.67
	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%	SEm±	CD at 5%
Variety (V)	0.927	2.653	1.703	4.876	0.908	2.599	1.229	3.516
Treatments (T)	2.073	5.933	3.809	10.903	2.030	5.811	2.747	7.863
V×T	2.932	8.391	5.387	15.419	2.871	8.218	3.885	11.120

Conclusion

Growth attributes such as plant height, number of tillers plant[1] and plant biomass plant^{-1} recorded at 30 and 60 DAS showed that all the characters were significantly influenced under both the time of sowing. The effect of time of sowing registered higher reduction in all the parameters as compared to late sown variety sown under timely sown condition. The magnitude of reduction was more in case of NW-5054 compared to NW-2036. Delay in sowing of wheat than normal sowing date/ time decreased substantially almost all the yield and yield components measured *viz*; number of ear plant^{-1}, ear length and number of grains plant^{-1} which caused severe reduction in grain yield. Reduction percentage was more in case of NW-5054 compared to NW-2036. Temperature plays an important role in reduction of yield and yield components. Overall growth attributes and yield as well as yield components of wheat crop was adversely affected by time of sowing due to onset of high temperature during crop growth and particularly grain filling. Salicylic acid applied as seed soaking and foliar spray at 30 DAS and their combination significantly influenced growth attributes, physiological traits and yield and yield components. The combination of seed soaking and foliar spray of salicylic acid maximum improvement in all the characters in both the varieties at both the stages of sowing. But the maximum improvement was noted in late sown variety NW-2036 compared to timely sown variety NW5054. Physiological traits *viz*; catalase activity and peroxidase activity in leaves observed at 30 and 60 DAS, all the characters were significantly influenced under both the time of sowing. The effect of time of sowing drastically reduced all the characters as in timely sown variety NW 5054 compared to late sown variety NW-2036 sown under timely sown.

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