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Effect of heat stress on growth, seed yield and its management through chemical sprays in wheat (*Triticum aestivum* L.)

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Abstract
A field experiment was conducted during *rabi* season of 2017-18. On silty clay loam soil at MPKV, Rahuri (MS), to study the effect of heat stress on seed quality and its management through different chemical sprays in wheat (*Triticum aestivum* L.). The experiment was laid out in factorial randomized block design with combinations of two sowing dates i.e. S_1- 21st Dec. and S_2-16th Jan, two varieties of wheat *viz.*, V_1-Trimbak (NIAW-301) and V_2-Phulesamadhan (NIAW-1994) and seven chemical spray treatments *viz.*, T_1- Control, T_2-Water spray, T_3-Spraying of salicylic acid @50 ppm, T_4-Spraying of salicylic acid @ 100 ppm, T_5-spraying of potassium chloride @ 3 %, T_6-Spraying of ascorbic acid @50 ppm and T_7- Spraying of humic acid @ 3 %. From the data it was revealed that the seed yield (43.41 q/ha) of 21st December was significantly higher than the 16th January sowing. Among the varieties, the variety Phule Samadhan recorded significantly higher seed yield (42.65 q/ha) than other variety Trimbak (39.59 q/ha). The seed yield in wheat showed significant effect due to the heat stress mitigating chemical sprays. The highest seed yield (45.35 q/ha) was recorded in spraying with humic acid @ 3 % treatment whereas the lowest was found (35.01 q/ha) in control treatment. The highest seed yield (49.04 q/ha) was recorded in interaction combination of variety Phule Samadhan which was sown on 21st December and spraying with humic acid @ 3 % treatment and the lowest seed yield (21.78 q/ ha) was recorded in variety Trimbak which was sown on 16th January in control treatment. On the basis of experiment, it could be concluded that the wheat crop sown on 21st December along with the variety Phule Samadhan and spraying of humic acid @ 3% is recommended for enhancement of growth, seed yield and quality parameters in wheat.

Keywords: Heat stress, grain yield and economics

Introduction
Wheat (*Triticum aestivum* L.) is the first important and strategic cereal crop for the majority of world population. Area under wheat cultivation in India during 2017-18 was 30.59 million hectare and it produced about 98.51 million tone and productivity of 3216 kg/ha (Anonymous, 2017-18) [4] Area under cultivation in Maharashtra is 1.558 million hectare having production of 16.72 million tons and productivity of 1226 kg/ha (Anonymous, 2017-18) [4].

Wheat yield losses due to heat stress average 10-15 per cent per annum (Wardlaw and Wrigley, 1994) [18]. In India particularly Punjab, farmers by and large delay wheat sowing due to intensive cropping system, which pushes the grain filling stage to high temperature stress. This increased temperature not only hastens the phonological stages of crops development but also reduces duration of grain filling stages there by lowering the grain yield and its quality (Farooq *et al*., 2011) [9]. The adverse effects of heat stress can be mitigated by developing crop plants with improved resistance against heat. The heat stress induces formation of toxic reactive oxygen species (ROS) and these ROS (Apel and Hirt, 2004) [5] cause oxidative damage to chloroplast and mitochondria by damaging cellular structures. Tomitigate heat induced damage, plants may up-regulate various scavenging mechanism like enzymatic antioxidants (superoxide dismutase, peroxide as end catalase), non-enzymatic metabolites like ascorbic acid and plant growth regulators (salicylic acid) and osmoprotectants (Ahmad *et al*., 2013) [2]. The sachem icals protect membranes and photosynthetic apparatus from the injurious effects caused by environmental stresses (Foyer and Noctor, 2003). Ascorbicacid also modulates the tocopherol synthesis, which protects the plant from several environmental stresses (Conklin and Barth, 2004). Likewise, salicylic acid (SA) is an important signaling molecule in plants, which helps to regulate plant resistance against chilling drought and heat stresses (Ahmad *et al*., 2013) [2]. Wheat is a major crop in India. The existence of the different growth regulator treatments, which can respond to the recurrent heat stress, is expected to provide an opportunity in managing yield losses due to heat stress and getting the relatively stable yield.

In view of this the present study was under taken with the objective of to access the effect of heat stress on growth and seed yield of wheat and its management through different chemical sprays of growth regulators.

Materials and Methods

A field experiment was conducted at Instructional Farm of Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri, (19° 48' N latitude and 74° 32' E longitude and 495 meter above mean sea level), in factorial randomized block design with three replications during kharif season of 2015. Climatologically, this area falls in the semi-arid tract characterized by scarcity zone. The daily minimum and maximum temperature ranged from 14.5 to 23.7 oC and 30.1 to 36.0 oC, respectively and the total rainfall of 285.4 mm was received during crop growth period. The soil of the experimental field was silty clay loam, having pH 7.72, medium in organic C (0.47%), low in available N (144.57 kg ha-1) and medium in available P (17.24 kg ha-1) and available K (388.20 kg ha-1) and Moderate in organic carbon, pH and EC were 0.47 %, 7.72 and 0.25 dS/m of soil, respectively. The experiment consisted of 28 treatments with two sowing dates*viz*.,S1-21st Dec. and S2- 16thJan, two varieties*viz*.,V1-Trimbak (NIAW-301) and V2-Phule Samadhan (NIAW-1994)and seven chemical spray treatments *viz*., Control, Water spray, Spraying of Salicylic acid @50 ppm, Spraying of Salicylic acid @ 100 ppm, Spraying of potassium chloride @ 3%, Spraying of ascorbic acid @50 ppm, Spraying of humic acid @ 3%.Wheat was sown at 22.5 cm line and fertilizer dose of 60 kg N and 60 kgP2O5 and 60 kg K2O ha-1 were applied at the time of sowing through urea, single super phosphate and muriate of potash and 60 kg N ha-1was applied at 30 days after sowing. Chemical sprays were applied as per treatment wise to wheat crop. The intercultural operations, protective irrigation are given as per critical growth stages and plant protection measures were carried out as per the recommendations of respective crops.

The plant stand and crop conditions were good during the experimental period. The data on growth and yield attributing characters recorded from randomly selected five plants at from each plot. The crop was harvested at physiological maturity and threshed after sun dried. Seed and stover yield was obtained treatment wise from net plot and converted into tons per ha

Table 1: Effect of sowing dates, varieties and chemical sprays on Physiological and biochemical parameters of wheat

Treatment	Plant height (cm)	50% flowering	Canopy temperature (°C)	Chlorophyll mg g^{-1} FW	Proline content (µ moles g^{-1} FW)	Lipid peroxidation rate (nmol g^{-1} FW)	Seed yield Plant^{-1} (g)	Seed yield (q ha^{-1})
A. Sowing dates								
S_1:21st Dec.	86.00	63.60	23.48	2.36	1.54	34.16	7.01	43.41
S_2:16thJan	78.45	58.62	34.07	1.75	1.95	50.94	5.65	38.83
SEm ±	0.49	0.21	0.21	0.01	0.01	0.33	0.08	0.45
CD at 5%	1.40	0.61	0.62	0.03	0.03	0.94	0.23	1.28
B. Varieties								
V_1: Trimbak	84.31	60.43	29.38	2.04	1.62	41.33	5.80	39.59
V_2: P. Samadhan	80.14	61.79	28.17	2.07	1.88	43.77	6.86	42.65
SEm ±	0.49	0.21	0.21	0.01	0.01	0.33	0.08	0.45
CD at 5%	1.40	0.61	0.60	NS	0.04	0.94	0.23	1.28
C. Chemical sprays								
T_1: Control	78.58	61.75	30.42	1.65	1.97	45.31	5.21	35.01
T_2: Water spray	80.42	61.42	29.83	1.83	1.85	44.24	5.70	39.00
T_3: Spraying of salicylic acid @ 50 ppm.	81.08	61.42	29.33	1.92	1.71	41.21	6.34	40.32
T_4: Spraying of salicylic acid @ 100 ppm.	81.42	60.92	28.92	2.03	1.77	42.75	6.27	41.38
T_5:Spraying of potassium chloride @ 3 %	82.92	61.33	28.17	2.03	1.81	43.95	6.80	42.51
T_6: Spraying of ascorbic acid @ 50 ppm.	84.58	60.42	27.67	2.35	1.61	40.25	6.87	44.29
T_7:Spraying of humic acid@ 3 %	86.58	60.50	27.08	2.58	1.52	40.18	7.12	45.35
SEm. ±	0.92	0.41	0.40	0.02	0.03	0.620	0.14	0.85
CD at 5%	2.62	NS	1.13	0.06	0.07	1.756	0.42	2.41
D. Interaction effects								
SXV	NS	NS	NS	N.S	NS	Sig.	NS	NS
SXT	NS	NS	NS	Sig.	NS	Sig.	NS	NS
VXT	NS	NS	NS	Sig.	NS	Sig.	Sig.	NS
SXVXT	NS	NS	NS	Sig.	NS	Sig.	NS	NS
General Mean	82.23	61.11	28.77	2.06	1.748	42.55	6.331	35.01

Table 1a: Interaction effect between sowing dates and varieties on Physiological and biochemical parameters of wheat

Treatments (S x V)	Proline content (µ moles g^{-1} FW)	Seed yield plant $^{-1}$(g)
S_1V_1	1.43	6.352
S_1V_2	1.65	7.671
S_2V_1	1.80	5.248
S_2V_2	2.11	6.052
SEm.±	0.02	0.11
CD at 5%	0.05	0.32

Table 1b: Interaction effect of sowing dates and chemical sprays on Physiological and biochemical parameters of wheat

Treatments (S x T)	Chlorophyll content (mg g^{-1} FW)	Proline content (µ moles g^{-1} FW)
S_1T_1	1.92	1.40
S_1T_2	2.17	1.46
S_1T_3	2.31	1.47
S_1T_4	2.40	1.52
S_1T_5	2.22	1.57
S_1T_6	2.63	1.63
S_1T_7	2.92	1.35
S_2T_1	1.39	2.15
S_2T_2	1.50	1.75
S_2T_3	1.54	1.95
S_2T_4	1.67	2.03
S_2T_5	1.84	2.05
S_2T_6	2.08	2.07
S_2T_7	2.24	1.38
SE (m) ±	0.03	0.04
CD at 5%	0.09	0.10

Table 1c: Interaction effect of varieties and chemical sprays on Physiological and biochemical parameters of Wheat

Treatments (V x T)	Chlorophyll content (mg g^{-1} FW)	Proline content (µ moles g^{-1} FW)	Seed yield plant^{-1} (g)
V_1T_1	1.68	1.93	4.050
V_1T_2	1.82	1.39	4.667
V_1T_3	1.93	1.57	6.100
V_1T_4	1.99	1.67	6.117
V_1T_5	2.15	1.71	6.500
V_1T_6	2.33	1.76	6.417
V_1T_7	2.42	1.27	6.750
V_2T_1	1.63	2.19	6.367
V_2T_2	1.84	1.82	6.733
V_2T_3	1.91	1.84	6.583
V_2T_4	2.08	1.87	6.433
V_2T_5	1.91	1.89	7.100
V_2T_6	2.38	1.94	7.333
V_2T_7	2.74	1.76	7.483
SEm.±	0.03	0.04	0.21
CD at 5%	0.09	0.10	0.60

Table 1d: Interaction effect of sowing dates, varieties and chemical sprays on Physiological andbiochemical parameters of wheat

Treatments (S x V x T)	Chlorophyll content (mg g^{-1} FW)	Proline content (µ moles g^{-1} FW)	Seed yield plant^{-1} (g)	Seed yield (q ha^{-1})
$S_1V_1T_1$	1.90	1.75	4.933	39.69
$S_1V_1T_2$	2.12	1.34	5.800	40.98
$S_1V_1T_3$	2.28	1.32	6.467	41.58
$S_1V_1T_4$	2.34	1.42	6.467	42.04
$S_1V_1T_5$	2.39	1.48	6.833	42.42
$S_1V_1T_6$	2.70	1.54	6.633	45.09
$S_1V_1T_7$	2.73	1.17	7.333	45.42
$S_1V_2T_1$	1.93	1.82	7.333	40.22
$S_1V_2T_2$	2.21	1.58	7.233	41.42
$S_1V_2T_3$	2.33	1.61	7.500	42.33
$S_1V_2T_4$	2.45	1.62	7.500	43.64
$S_1V_2T_5$	2.04	1.65	7.900	45.11
$S_1V_2T_6$	2.56	1.72	8.000	47.80
$S_1V_2T_7$	3.10	1.53	8.233	49.04
$S_2V_1T_1$	1.46	2.12	3.167	21.78
$S_2V_1T_2$	1.52	1.45	3.533	34.56
$S_2V_1T_3$	1.58	1.82	5.733	36.98
$S_2V_1T_4$	1.63	1.92	5.767	38.76
$S_2V_1T_5$	1.90	1.95	6.167	40.62
$S_2V_1T_6$	1.96	1.97	6.200	42.13
$S_2V_1T_7$	2.10	1.37	6.167	42.27
$S_2V_2T_1$	1.32	2.19	5.400	38.36
$S_2V_2T_2$	1.47	2.05	6.233	39.04
$S_2V_2T_3$	1.49	2.07	5.667	40.40
$S_2V_2T_4$	1.71	2.12	5.367	41.07
$S_2V_2T_5$	1.77	2.13	6.300	41.87
$S_2V_2T_6$	2.20	2.16	6.667	42.16

$S_2V_2T_7$	2.37	1.99	6.733	43.67
SEm. ±	0.05	0.05	0.29	1.69
CD at 5%	0.13	0.14	0.84	4.81

Results and Discussion

Effect of heat stressand its management on plant height and days to 50% flowering

The effect of heat stress on growth attributes of wheat were influenced significantly due to different sowing dates, varieties, chemical sprays at harvest (Table 1).The data regarding the effect of sowing dates, varieties, chemical sprays onplant heightand days to 50 % flowering of wheat are presented in Table 1. From the data it was observed that the growth characters like days to 50 % flowering differed significantly due to sowing dates and varieties. It is also revealed that the plant height was significantly differed due sowing dates, varieties and chemical sprays and their interaction. The days to 50 % was significantly influenced by the date of sowing. From the data it was revealed that the days to 50 % flowering was significantly lowest (59 days) in 16th January sowing which was 5 days earlier than 21stDecember sowing irrespective of varieties and chemical sprays. The varieties also showed significant influence on the days to 50 % flowering. The days to 50 % flowering was differed significantly among both the varieties. Trimbak variety recorded the lowest 60 days for 50 % flowering whereas 62 days were required in the wheat var. Phule Samadhan. The heat stress mitigating chemical sprays were sprayed at 50 % flowering hence did not differ significant effect on days to 50 % flowering.

The interaction effect of sowing dates and variety recorded significant difference in days to 50 % flowering. The variety Trimbak sown on 16th January showed the lowest days for 50% flowering (58 days) which whereas the highest days were recorded in Phule Samadhan sown on 21st December (64 days). The interaction effect of varieties and chemical spraying recorded significant difference in days to 50 % flowering. The interaction combination of variety Trimbak and chemical spray of humic acid @ 3 % recorded significantly lowest days (59 days) for 50 % flowering whereas highest days (63 days) were found in the interaction of in Phule Samadhan variety and chemical spray of humic acid @ 3%.The combine dinteraction effect of sowing dates, varieties and chemical sprays was not significant for days to 50 % flowering in wheat.

Effect of sowing dates, varieties, chemical sprays and their interaction effect on plant height of wheat

The plant height was significantly influenced by the date of sowing. From the data it was revealed that the plant height was significantly highest in 21st December (86 cm) sowing which was higher than 16th January sowing irrespective of varieties and chemical sprays. The plant height was differed significantly among both the varieties. Trimbak are recorded the highest plant height (84.31cm) as compared to Phule Samadhan(80.14 cm) irrespective of sowing dates and chemical sprays (Table No.1).The heat stress mitigating chemical sprays showed significant effect on plant height. The plant height was differed significantly among the chemical treatments. The spraying of humic acid @ 3% recorded the significantly highest plant height (86.58 cm) than rest of all treatments but it was at par with spraying of ascorbic acid @ 50 ppm (Table No.1).The interaction effect of sowing dates and varietiesdid not differ significant difference on plant height. The interaction effect of varieties and chemical spraying treatment also recorded non-significant difference on plant height The interaction effect of sowing dates and chemical spray and the combine effect of sowing dates, varieties and chemical sprays was not significant for plant height in wheat. These results are conformed with Viswanathan *et al*., (2001) [17] Mohammadi *et al*., (2006) [12] and Tewlode *et al*., (2006) [16]

Effect of heat stress and its management on seed yield per plant (g) of wheat

The seed yield per plant (g)was significantly influenced by the date of sowing of wheat. From the data it was revealed that the seed yield per plant of 21st December (7.01 g)was significantly higher than the 16th January sowing (5.65gm). Among the varieties seed yield per plantshowed significant difference between them. The variety Phule Samadhan was found significantly higher seed yield per plant (6.86 g) than the variety Trimbak (5.80gm). The seed yield per plant showed significant effect due to the heat stress mitigating chemical sprays. The highest seed yield per plant (7.11g) was recorded in spraying with humic acid @3% treatment where as the lowest (5.21g) was found in control (Table No.1).

The difference in seed yield per plant was found significant due to interaction effect of sowing dates and varieties. The highest seed yield per plant (7.67g) was recorded in interaction combination of variety Phule Samadhan and 21st December than rest of all treatments. Whereas the lowest seed yield per plant (5.25g) was found in variety Trimbak sown on 16th January in Table 1a.

The seed yield per plant was found significant due to interaction effect between varieties and chemical treatments. The highest seed yield per plant (7.48g) was recorded in variety Phule Samadhan spraying with humic acid @3%, whereas the lowest seed yield (4.05g) was found combination of control with variety Trimbak in Table 1c. The combined interaction effect of sowing dates, varieties and chemical sprays were found to be significant in seed yield per plant at harvest. The highest seed yield per plant (8.23g) was recorded in variety Phule Samadhan which wassownon21tst December spraying of humic acid@1 % and lowest seed yield per plant (3.17g) was recorded in variety Trimbak which was sown on 16th January incontrol (Table No.1d). Sebastino *et al*., (2005) [8] studied that, the foliar application of Humic acid recorded higher grain yield, spike fertility and protein content in grain of durum wheat crops. Tufail *et al*. (2014) [15] revealed that the significant effects of humic substances on plant growth and yield of wheat.

Effect of heat stress on physiological and biochemical parameters of wheat

The data regarding the effect of sowing dates, varieties, chemical sprays on canopy temperature, chlorophyll content, proline content and lipid peroxidation of wheat are presented in the Table 1. From the data it was observed that the physiological and biochemical parameters *viz*., canopy temperature, chlorophyll content andlipid peroxidation did not differed significantly but proline content differed significantly due to sowing dates and varieties. However, it is revealed that the proline content and chlorophyll content was significantly differed by sowing dates, varieties and chemical sprays and their interaction.

Effect of sowing dates, varieties, chemical sprays and their interaction on canopy temperature of wheat

From the data, it is revealed that the canopy temperature of 21st December sown wheat crop recorded significantly lower (23.48oC) than crop sown at 16th January (34.07oC). Among the varieties, Phule Samadhan recorded significantly lowest canopy temperature (28.17oC) as compare to other variety Trimbak (29.38oC)irrespective of sowing dates and chemical sprays. The canopy temperature was differed significantly due to the heat stress mitigating chemical sprays. The lowest Canopy temperature (27.08oC) was recorded in spraying of humic acid @3% (T7) treatment whereas the highest (30.42oC) was recorded in the control treatment with irrespective of sowing dates and varieties. The two way interaction effect of sowing dates and variety, sowing dates and chemical sprays, varieties and the combine effect of sowing dates varieties and chemical sprays was not significant forcanopy temperature of wheat. The cool canopy during grain filling period in wheat is an important physiological principle for high temperature stress tolerance and high temperature can inhibit photosynthetic enzymes as well as loss of permeability of cellular membranes. These above results are in agreement with Munjal and Rena (2003) [11] and Levitt (1980) [10].

Effect of sowing dates, varieties, chemical sprays and their interaction on Chlorophyll content (mg g-1FW) of wheat

From the data it is revealed that the chlorophyll content of 21st December sowing was significantly higher (2.36mg g-1FW) than the 16th January sowing (1.75 mg g-1FW) irrespective of varieties and chemical sprays. Among the varieties Chlorophyll content recorded non-significant difference in chlorophyll content irrespective of sowing dates and chemical sprays. The Chlorophyll content was differed significantly due to the heat stress mitigating chemical sprays. The highest chlorophyll content (2.58 mg g-1FW) was recorded with spraying of humic acid @ 3 % treatment whereas the lowest(1.65 mg g-1FW) was found in control (without any spray treatment) irrespective of sowing dates and varieties. The two way interaction effect of sowing dates and variety showed non-significant effect on chlorophyll content. The interaction of sowing dates and chemical sprays showed significant effect on chlorophyll content. The combined interaction of variety Phule Samadhan and spraying of humic acid @ 3% recorded the highest chlorophyll content (2.74mg g-1FW) whereas the lowest (1.68mg g-1FW) was found in the interaction combination of variety Trimbak and control treatment. The combine effect of sowing dates, varieties and chemical sprays wassignificant forchlorophyll content. The combined interaction of variety Phule Samadhan and spraying of humic acid @3% sown on 21st December recorded the highest (3.10mg g-1FW) chlorophyll content whereas the lowest (1.32 mg g-1FW) was found in the interaction of variety Trimbak and control sown on 16th January.The above results are in close confirmation with Darvishan *et al*. (2013) [7] who reported the effects were positive with humic acid 3% with foliar application on physiological and biochemical change in corn. Chen *et al*. (1990) [6] observed that the use of humic substances on foliar sprays can promote greater root and shoot growth, root branching, leaf chlorophyll content, rates of nutrient uptake, photosynthesis and respiration.

Effect of sowing dates, varieties, chemical sprays and their interaction effect on proline content (µ moles g-1FW) of wheat

From the data it is revealed that the proline content of 16th January sowing was significantly higher (1.95 µ moles g-1 FW) than the 21stDecembersowing (1.54 µ moles g-1FW) irrespective of varieties and chemical sprays. Among the varieties, proline content differed significant effect between them. The variety Phule Samadhan recorded the highest (1.88 µ moles g-1 FW) proline content than the variety Trimbak (1.62 µ moles g-1FW). The proline content was differed significantly due to the heat stress mitigating chemical sprays. The highest proline content (1.97 µ moles g-1 FW) was recorded in control treatment, where as the lowest (1.52 µ moles g-1 FW) was found in humic acid @3% treatment irrespective of sowing dates and varieties. The two way interaction effect of sowing dates and variety showed significant effect on proline content irrespective of chemical treatment. The interaction of variety Phule Samadhan sown on 16th January recorded the highest proline content (2.11 µ moles g-1FW) whereas the variety Trimbak sown on 21st December recorded the lowest (1.43µ moles g-1FW) proline content. The difference in proline content was found significant due to interaction effect of sowing dates and chemical sprays irrespective of variety. The highest proline content (2.15 µ moles g-1FW) was recorded in control treatment sown on 16th January whereas the lowest(1.35 µ moles g-1FW) was found in 21st December humic acid@ 3%.The difference in proline content was found significant due to interaction effect of varieties and chemical treatments. The highest proline content (2.19 µmolesg-1FW) was recorded in variety Phule Samadhan in control whereas the lowest was found (1.27 µmoles g-1FW) in variety Trimbak inhumic acid@3%. The difference in proline content was found significant due to combined interaction effect of sowing dates, varieties and chemical spray. The highest proline content was recorded (2.19 µ moles g-1 FW) in the interaction of variety Phule Samadhan sown on16thJanuary in control treatment whereas the lowest (1.17 µ moles g-1FW) was found in variety Trimbak sown on 21st December humic acid@3 %.Above results are in close conformity with findings of Mumtaz *et al*. (1995) [13] reported the proline enhances the stability of protein and membrane under high temperature or moisture stress. Ahmed and Hasan (2011) [1] grown the seedling of wheat genotypes in Phytotron and investigated the seedling of proline content and screening criteria against heat stress. Akhbari *et al*. (2016) [3] studied the large number of plant species accumulate proline in response to salinity stress and that accumulation may play a role in defense against salinity stress. Proline content under salt stress is increased in sensitive cultivar than resistance.

Effect of heat stress and its management on seed yield of wheat

The date of the sowing of 21st December of variety Phule Samadhan recorded highest seed yield per plant and its significant results to increase the seed yield (q/ha) as compared to 16 January, late sowing indicating that there was heat stress on growth and grain filling effect on wheat. Among the chemical treatments, the spraying of humic acid @ 3% were recorded the highest seed yield (45.35 q/ ha) for the variety Phule Samadhan. The variety Phule Samadhan sown under heat stress condition recorded lowest yield (38.36 q ha-1). It clearly showed that humic acid spraying @ 3% plays significant role in mitigating the effect of heat stress in wheat. And it was also reflected in improvement of growth parameters, physiological, biochemical parameters and yield contributing characters and seed yield. The highest chlorophyll content was recorded in the variety Phule Samadhan with the spray of humic acid @ 3 %.

Effect of sowing dates, varieties, chemical sprays and their interaction effect onseed yield per ha (q) of wheat

The seed yield per ha was significantly influenced by the date of sowing of wheat. From the data it was revealed that the

seed yield (43.41 q/ha) of 21st December was significantly higherthanthe 16th January sowing. Among the varieties, the variety Phule Samadhan recorded significantly higher seed yield (42.65 q/ha) than other variety Trimbak (39.59 q/ha). The seed yield in wheat showed significant effect due to the heat stress mitigating chemical sprays. The highest seed yield (45.35q/ha) was recorded in spraying with humic acid @3% treatment whereas the lowest was found (35.01q/ha) in control treatment. The combined interaction effect between sowing dates, varieties and chemical sprays were found to be significant differences (Table 1d).The highest seed yield (49.04 q/ha) was recorded in interaction combination of variety Phule Samadhan which wassownon21st December and spraying with humic acid@3% treatment and the lowest seed yield (21.78q/ha) was recorded in variety Trimbak which was sown on 16th January in control treatment (Table No.1d).Similar results were reported by Delfine *et al*.(2005) [8] and Tufai l*et al*. (2014) [15] The results indicated that, the wheat crop sown on 21st December along with the variety Phule Samadhan and spraying of humic acid @ 3 % tomitigating the heat stress to reducing proline content and significantly increase the growth and yield attributes, yield and quality parameters in wheat.

On the basis of experiment, it could be concluded that thewheat crop sown on 21st December along with the variety Phule Samadhan and spraying of humic acid @3% is recommended for enhancement of growth, seed yield and quality parameters in wheat (*Triticum aestivum* L.).

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