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**Kapil Kumar**

Department of Crop Physiology,  
Chandra Shekhar Azad  
University of Agriculture and  
Technology Kanpur,  
Uttar Pradesh, India

**SN Singh**

Department of Crop Physiology,  
Chandra Shekhar Azad  
University of Agriculture and  
Technology Kanpur,  
Uttar Pradesh, India

**MA Khan**

Department of Crop Physiology,  
Chandra Shekhar Azad  
University of Agriculture and  
Technology Kanpur,  
Uttar Pradesh, India

## Response of morpho-physiological traits and grain yield of wheat varieties to foliar applied different doses of boron and thiourea under two sowing dates

**Kapil Kumar, SN Singh and MA Khan**

### Abstract

A field experiment conducted at Experimental Research Farm, Nawabganj of Chandra Shekhar Azad University of Agriculture and Technology Kanpur, India, in timely and late sowing conditions during Rabi season *i.e.*, 2013-14 and 2014-15. In this experiment use split-split plot design in which, two sowing dates (D<sub>1</sub>- Timely sowing, D<sub>2</sub>- Late sowing) in main plot, four varieties (V<sub>1</sub>: K- 607, V<sub>2</sub>: K-402, V<sub>3</sub>: K-7903, V<sub>4</sub>: K-9533) in subplot and five treatments (T<sub>0</sub>- Control, T<sub>1</sub>- Boron 0.2%, T<sub>2</sub>- Boron 0.5%, T<sub>3</sub>- Thiourea 500ppm, T<sub>4</sub>- Thiourea 1000ppm). The response of morpho-physiological traits such as plant height (D<sub>1</sub>- 24.6, 23.3 and 81.6, 79.8; V<sub>2</sub>- 24.5, 23.5cm and 82.0, 80.2; T<sub>3</sub>- 26.1,24.6 and 79.5, 78.0; D<sub>1</sub>V<sub>2</sub>- 25.8, 24.8 and 87.3, 85.2; D<sub>1</sub>T<sub>3</sub>- 27.5, 25.4 and 83.3, 82.4 cm; V<sub>1</sub>T<sub>3</sub>- 26.9, 25.7 and 83.8, 81.8cm; D<sub>1</sub>V<sub>2</sub>T<sub>3</sub>- 27.9, 216.7 and 89.1, 86.8 at 45 DAS and 85 DAS, respectively), grain yield, these were D<sub>1</sub>- 433.4 g m<sup>-2</sup>; V<sub>2</sub>- 409.2 g m<sup>-2</sup>; T<sub>3</sub>- 401.5 g m<sup>-2</sup>; D<sub>1</sub>V<sub>2</sub>- 462.2 g m<sup>-2</sup>; D<sub>1</sub>T<sub>3</sub>- 445.7 g m<sup>-2</sup>; V<sub>2</sub>T<sub>3</sub>- 419.0 g m<sup>-2</sup>; D<sub>1</sub>V<sub>2</sub>T<sub>3</sub>- 475.0 g m<sup>-2</sup>, were found mostly significantly in sowing year 2013-14 than 2014-15. CTD was obtained more in D<sub>1</sub>- 5.45 °C, V<sub>3</sub>- 5.15 °C, T<sub>3</sub>- 5.17 °C, D<sub>1</sub>V<sub>3</sub>-5.62 °C, D<sub>1</sub>T<sub>3</sub>- 5.65 °C, V<sub>3</sub>T<sub>3</sub>- 5.30 °C, and MII was observed low in D<sub>1</sub>- 25.58, V<sub>2</sub>-24.88, T<sub>2</sub>- 25.09, D<sub>1</sub>V<sub>1</sub>-23.82, D<sub>1</sub>T<sub>2</sub>- 24.83, V<sub>2</sub>T<sub>3</sub>- 24.32, D<sub>1</sub>V<sub>1</sub>T<sub>2</sub>- 24.32 at flowering stage.

**Keywords:** Plant height (cm), CTD (°C), MII, grain yield (g m<sup>-2</sup>), date of sowing, boron (0.2% and 0.5%) and thio-urea (500ppm and 1000ppm)

### Introduction

Wheat is the major source of plant based human nutrition and a part of daily dietary need in one form or the other. Wheat is the world's most outstanding crop that excels all other cereals both in area and production, known as king of cereals. The use of micronutrients is also important because of increasing economic and environmental concerns (Nadim *et al.*, 2012). Boron (B) is a unique non-metal micronutrient required for normal growth and development of plants. Boron is absorbed by roots as un-dissociated boric acid [B(OH)<sub>3</sub> or H<sub>3</sub>BO<sub>3</sub>], among the elements required by plants that are taken up from the soil, Boron is the only element that is taken up by plants not as an ion, but as an uncharged molecule (Marschner, 1995). In 1923, it was first time reported that Boron is essential for cell structure of plants (Warrington, 1923). Thiourea is an organo sulphur compound with the formula SC(NH<sub>2</sub>)<sub>2</sub>. It is structurally similar to urea, except that the oxygen atom is replaced by a sulphur atom, but the properties of urea and thiourea differ significantly. A number of thiourea derivatives have been reported to form complexes with copper and cobalt (Dominguez *et al.*, 2002). More to the points, awareness of seed quality, nutrients managements, poor irrigation, low farmer's educations, not use micronutrients and organic matters are limiting factors towards the wheat production. It is perceived that micronutrients play a key role in the improvements of wheat yield (Nadim M.A. 2011). Besides, boron can be involved in many processes as membrane potential, plasmalemma-bound enzymes and ion fluxes across membranes (Goldbach H.E. and Wimmer M. 2007) <sup>[10]</sup>.

### Materials and Methods

A field experiments was conducted on the effect of foliar application boron and thio-urea doses at different growth stages on morpho-physiological and yield performance of four wheat varieties under timely (D<sub>1</sub>) and late (D<sub>2</sub>) sowing dates against control (T<sub>0</sub>) at experimental

### Correspondence

**Kapil Kumar**

Department of Crop Physiology,  
Chandra Shekhar Azad  
University of Agriculture and  
Technology Kanpur,  
Uttar Pradesh, India

Research Farm, Nawabganj of Chandra Shekhar Azad University of Agriculture and Technology Kanpur during Rabi season *i.e.*, 2013-14 and 2014-15. This experiment was designed in split-split plot design in which sowing dates (D) putted in main plot, variety (V) in sub plot and treatments (T) in sub-sub plot, so total treatments were 40. The combinations of treatment in this experiment were two sowing dates (D<sub>1</sub>- Timely sowing: 21 November and D<sub>2</sub>- Late sowing: 23 December), four varieties (V<sub>1</sub>: K-607, V<sub>2</sub>: K402, V<sub>3</sub>: K-7903 and V<sub>4</sub>: K-9533), foliar spray of boron (T<sub>1</sub>- 0.2% and T<sub>2</sub>- 0.5%) and thiourea (T<sub>3</sub>-500ppm and T<sub>4</sub>- 1000ppm) with T<sub>0</sub>-control and their combinations were sowing dates and variety (DxV), sowing dates and treatment (DxT), variety and treatment (VxT), sowing date and variety and treatment (DxVxT) in both experiment years under plot size 3x1.8 m<sup>2</sup>. The soil of experimental plot was sandy loam of medium fertility and neutral pH. The plant height measured from base (soil level) of plant to the auricle of the top leaf of the tagged main shoot in early stage of growth and upto base of the panicle after ear emergence. Canopy Temperature Depression (CTD) °C: It was measured by Infra Red Thermo-meter. (Tele temp AG-42 USA). The difference between ambient and canopy temperature has to be entered in the data book. Care should be taken to see that the angle and the distance between the canopy and the Infra-red Thermo-meter remain constant for each plot. Observation should be recorded between 11.00 a.m. to 01.00 p.m. (mid day). Membrane Injury Index (MII %): Leaf membrane injury index is determined by recording the electrical conductivity of leaf lichgates in double distilled

water at 40 °C and 100 °C. Leaf samples (0.1g) were cut in to dish of uniform size and taken in test tubes containing 10ml of double distilled water in two sets. One set was kept at 40 °C for 30 minutes and their respective electric conductivities C<sub>1</sub> and C<sub>2</sub> were measured by electric conductivity meter (ESICO, Model 1601) using protocol. Membrane injury index was recorded at different determine growth stages and calculated by using formula given as under  $MII (\%) = \{[1 - (T_1/T_2)]/[1 - (C_1/C_2)]\} \times 100$  Where, MII – Membrane Injury Index, T<sub>1</sub> – Initial conductivity reading in heat treated tissue, T<sub>2</sub> – Final Conductivity reading in heat treated tissue, C<sub>1</sub> – Electrical Conductivity before autoclaving tissue, C<sub>2</sub> – Electrical Conductivity after autoclaving tissue. The grain yield per plot was recorded separately for each variety and expressed as per square meter.

## Results and Discussion

### Plant Height (cm)

The data showed on the effect of foliar spray of boron and thio-urea on sowing dates, varieties, treatments and their interaction to plant height (cm) at 45 and 85 DAS in Table 1 (A) & (B).

**Effect of sowing dates:** The mean value of sowing dates to plant height in cm was recorded statistically maximum in the timely sowing date (D<sub>1</sub>) with 24.6 and 23.3 cm at 45 DAS, 81.6 and 79.8 cm at 85 DAS while minimum in late sowing date (D<sub>2</sub>) with 22.2 and 21.1 cm at 45 DAS, 73.8 and 72.7 cm at 85 DAS for both concerning years.

**Table 1 (A):** Effect of foliar applied boron and thio-urea on Plant Height (cm) at 45 DAS of wheat cultivars under timely and late sown condition:

Treat.	2013-14						2014-15							
	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>		V <sub>4</sub>	Mean	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>		V <sub>4</sub>	Mean		
D <sub>1</sub>	25.0	25.8	23.8		23.9	24.6	23.8	24.8	22.0		22.5	23.3		
D <sub>2</sub>	22.5	23.2	20.9		22.2	22.2	21.5	22.1	19.6		21.2	21.1		
Mean	23.7	24.5	22.3		23.0		22.6	23.5	20.8		21.9			
Treat.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	Mean	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	Mean		
D <sub>1</sub>	22.0	23.4	25.4	27.5	24.7	24.6	20.9	22.3	24.3	25.6	23.3	23.3		
D <sub>2</sub>	19.3	21.1	23.6	24.8	22.2	22.2	18.3	19.9	22.6	23.6	21.4	21.1		
Mean	20.7	22.2	24.5	26.1	23.5		19.6	21.1	23.4	24.6	22.3			
V <sub>1</sub>	21.0	22.9	25.0	26.1	23.8	23.7	19.9	21.7	23.9	25.2	22.6	22.6		
V <sub>2</sub>	22.1	23.4	25.5	26.9	24.6	24.5	21.1	22.3	24.6	25.7	23.6	23.5		
V <sub>3</sub>	19.2	20.9	23.2	26.0	22.3	22.3	18.2	19.7	22.0	23.0	21.2	20.8		
V <sub>4</sub>	20.4	21.8	24.4	25.5	23.2	23.0	19.2	20.6	23.2	24.3	22.0	21.9		
Mean	20.7	22.2	24.5	26.1	23.5		19.6	21.1	23.4	24.6	22.3			
Treat.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>		T <sub>3</sub>	T <sub>4</sub>	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>		T <sub>3</sub>	T <sub>4</sub>		
D <sub>1</sub>	V <sub>1</sub>	22.5	24.3	26.0		27.2	25.1	21.5	22.9	24.6		26.4	23.6	
	V <sub>2</sub>	23.7	24.7	26.6		27.9	26.0	22.8	23.9	26.0		26.7	24.8	
	V <sub>3</sub>	20.3	21.7	24.4		24.9	23.6	19.1	20.9	23.3		24.5	22.5	
	V <sub>4</sub>	21.7	22.8	24.9		26.0	24.1	20.4	21.5	23.4		24.9	22.6	
D <sub>2</sub>	V <sub>1</sub>	19.5	21.5	24.1		25.1	22.5	18.4	20.6	23.2		24.1	21.6	
	V <sub>2</sub>	20.6	22.0	24.6		25.9	23.2	19.4	20.7	23.3		24.8	22.5	
	V <sub>3</sub>	18.1	20.2	22.2		23.1	21.1	17.3	18.5	20.8		21.7	19.9	
	V <sub>4</sub>	19.2	20.8	23.8		25.0	22.4	18.0	19.8	23.1		23.8	21.5	
Factors	D	V	D*V	T	D*T	V*T	D*V*T	D	V	D*V	T	D*T	V*T	D*V*T
SE(d)	0.2	0.2	0.3	0.3	0.4	0.5	0.8	0.1	0.1	0.1	0.1	0.1	0.1	0.2
C.D. at 5%	0.7	0.5	NS	0.5	NS	NS	NS	0.2	0.2	0.2	0.1	0.2	0.3	0.4

**Effect of varieties:** The mean value of varieties observed significantly higher to plant height for both stages with variety V<sub>2</sub> *i.e.*, 24.5 and 23.5 cm at 45 DAS, 82.0 and 80.2 cm at 85 DAS followed by variety V<sub>1</sub> with 23.7 and 22.6; 79.6 and 78.0 cm meanwhile, minimum in variety V<sub>3</sub> with 22.3 and 20.8; 69.6 and 68.3 for both years of experimentation, respectively.

**Effect of treatments:** The statistically maximum mean value of treatments on plant height (cm) was measured in treatment T<sub>3</sub> followed by T<sub>2</sub> than T<sub>4</sub> these were 26.1 and 24.6; 79.5 and 78.0; 24.5 and 23.4; 78.5 and 77.1 than 23.5 and 22.3; 77.7 and 76.3 cm while T<sub>0</sub> with 20.7 and 19.6; 76.0 and 74.3 cm was minimum than T<sub>1</sub> with 22.2 and 21.1; 77.1 and 75.6 cm

for years *i.e.*, 2013-14 and 2014-15 at 45 DAS; 85 DAS, respectively.

**Interaction effect of sowing dates and varieties:** It is evolved that the interaction effect of sowing dates with varieties that significantly higher interaction value of plant

height was in combination  $D_1V_2$  *i.e.*, 25.8 and 24.8; 87.3 and 85.2 cm followed by  $D_1V_1$  *i.e.*, 25.0 and 23.8; 85.0 and 82.8 cm while lowest in combination  $D_2V_3$  *i.e.*, 20.9 and 19.6 cm; 67.2 and 66.4 cm at both stages during year 2013-14 and 2014-15, respectively.

**Table 1 (B):** Effect of foliar applied boron and thio-urea on Plant Height (cm) at 85 DAS of wheat cultivars under timely and late sown condition:

Treat.	2013-14					2014-15								
	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>		V <sub>4</sub>	Mean	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>		V <sub>4</sub>	Mean		
D <sub>1</sub>	85.0	87.3	71.9		82.3	81.6	82.8	85.2	70.2		80.9	79.8		
D <sub>2</sub>	74.3	76.7	67.2		77.2	73.8	73.2	75.2	66.4		76.2	72.7		
Mean	79.6	82.0	69.6		79.7		78.0	80.2	68.3		78.6			
Treat.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	Mean	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	Mean		
D <sub>1</sub>	79.9	80.9	82.4	83.3	81.7	81.6	77.8	79.0	80.6	81.6	79.9	79.8		
D <sub>2</sub>	72.1	73.3	74.6	75.6	73.7	73.8	70.9	72.1	73.6	74.4	72.7	72.7		
Mean	76.0	77.1	78.5	79.5	77.7		74.3	75.6	77.1	78.0	76.3			
V <sub>1</sub>	77.8	79.0	80.4	81.5	79.5	79.6	75.7	77.2	79.0	79.9	78.3	78.0		
V <sub>2</sub>	80.0	81.1	82.8	83.8	82.2	82.0	78.4	79.6	80.9	81.8	80.1	80.2		
V <sub>3</sub>	68.0	69.1	70.3	71.1	69.5	69.6	66.5	67.7	69.0	70.0	68.1	68.3		
V <sub>4</sub>	78.1	79.1	80.5	81.5	79.5	79.7	76.8	77.7	79.4	80.3	78.6	78.6		
Mean	76.0	77.1	78.5	79.5	77.7		74.3	75.6	77.1	78.0	76.3			
Treat.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>		T <sub>3</sub>	T <sub>4</sub>	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>		T <sub>3</sub>	T <sub>4</sub>		
D <sub>1</sub>	V <sub>1</sub>	83.0	84.4	86.1		87.0	84.8	80.3	81.8	83.7		84.9	83.4	
	V <sub>2</sub>	85.4	86.3	88.2		89.1	87.7	83.5	84.8	86.0		86.8	84.9	
	V <sub>3</sub>	70.0	71.46	72.5		73.2	72.1	68.5	69.6	70.9		71.9	70.0	
	V <sub>4</sub>	80.8	81.5	83.1		84.0	82.1	78.9	80.0	81.8		82.8	81.3	
D <sub>2</sub>	V <sub>1</sub>	72.76	73.6	74.9		76.1	74.1	71.2	72.7	74.4		74.9	73.3	
	V <sub>2</sub>	74.7	75.9	77.5		78.5	76.8	73.5	74.5	75.9		76.9	75.4	
	V <sub>3</sub>	65.5	66.8	68.1		69.0	66.9	64.7	66.0	67.1		68.2	66.2	
	V <sub>4</sub>	75.5	76.8	77.9		79.0	76.9	74.7	75.5	77.1		77.7	76.0	
Factors	D	V	D*V	T	D*T	V*T	D*V*T	D	V	D*V	T	D*T	V*T	D*V*T
SE(d)	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.2	0.1	0.1	0.1	0.2
C.D. at 5%	0.5	0.2	0.2	0.2	NS	0.3	0.4	0.3	0.3	0.4	0.1	0.2	0.2	NS

**Interaction effect between sowing dates and treatments:** In the first year of experimentation, the mean value of interaction effect of sowing dates and treatments did not show significant effect on plant height (cm) at both stage but numerically higher interaction value was found in combination  $D_1T_3$  than  $D_1T_2$  (27.5; 83.3 cm and 25.4; 82.4 cm) while lowest in combination  $D_2T_0$  than  $D_2T_1$  (19.3; 72.1 cm and 21.1; 73.3 cm). The statistically maximum plant height recorded from combination  $D_1T_3$  followed by  $D_1T_2$  (25.6; 81.6 cm and 24.3; 80.6 cm) meanwhile minimum in combination  $D_2T_0$  (18.3; 70.9 cm) for second year of experimentation.

**Interaction effect of varieties with treatments:** It is visualized from interaction effect between varieties and treatments that data on plant height in cm at 45 DAS was not significant in year 2013-14 but numerically highest interaction value noted from combination  $V_2T_3$  than  $V_1T_3$  (26.9 and 26.1 cm) and lowest from combination  $V_3T_0$  and  $V_4T_0$  (19.2 and 20.4 cm) while statistically maximum

interaction value was in combination  $V_2T_3$  (25.7) followed by  $V_1T_3$  (25.2) and minimum in combination  $V_3T_0$  (18.2) and  $V_4T_0$  (19.2) in year 2014-2015. At 85 DAS, significantly higher interaction value observed from combination  $V_2T_3$  (83.8 and 81.8cm) followed by  $V_2T_2$  (82.8 and 80.9cm) but lower from combination  $V_3T_0$  (68.0 and 66.5 cm) in both year of experimentation, respectively.

**Interaction effect of sowing dates, varieties and treatments:** The data on interaction effect among sowing dates, varieties and treatments to plant height (cm) did not indicate significant at 45 DAS but significant at 85 DAS with 2013-14. So, maximum non-significant and significant interaction value noted from combination  $D_1V_2T_3$  *i.e.*, 27.9 and 89.1 but minimum from combination  $D_2V_3T_0$  *i.e.*, 18.1 and 65.5 cm, respectively. During 2014-15, statistically more value of interaction effect to plant height (cm) observed from combination  $D_1V_2T_3$  *i.e.*, 26.7 and 86.8 cm (non-significant) at par with  $D_1V_1T_3$  *i.e.*, 26.4 (at 45 DAS) followed by  $D_1V_2T_2$  *i.e.*, 26.0 and 86.0 cm at both stages, respectively.

## Canopy Temperature Depression (CTD) in °C

**Table 2:** Effect of foliar applied boron and thio-urea on Canopy Temperature Depression (°C) at flowering stage of wheat cultivars under timely and late sown condition:

Treat.	2013-14						2014-15							
	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	Mean	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>	V <sub>4</sub>	Mean				
D <sub>1</sub>	5.34	5.28	5.62	5.57	5.45	4.32	4.22	4.58	4.56	4.42				
D <sub>2</sub>	4.33	4.48	4.68	4.42	4.48	3.33	3.51	3.68	3.44	3.49				
Mean	4.83	4.88	5.15	5.00		3.83	3.86	4.13	4.00					
Treat.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	Mean	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	Mean		
D <sub>1</sub>	5.14	5.40	5.54	5.65	5.52	5.45	4.1	4.35	4.49	4.61	4.51	4.42		
D <sub>2</sub>	4.17	4.43	4.55	4.68	4.55	4.48	3.18	3.44	3.57	3.68	3.59	3.49		
Mean	4.65	4.91	5.05	5.17	5.04		3.65	3.89	4.03	4.15	4.05			
V <sub>1</sub>	4.61	4.75	4.88	5.03	4.90	4.83	3.61	3.71	3.90	4.01	3.91	3.83		
V <sub>2</sub>	4.43	4.85	5.00	5.15	4.98	4.88	3.43	3.86	3.96	4.08	3.98	3.86		
V <sub>3</sub>	4.91	5.11	5.21	5.30	5.20	5.15	3.90	4.10	4.16	4.26	4.21	4.13		
V <sub>4</sub>	4.66	4.95	5.10	5.20	5.08	5.00	3.66	3.90	4.10	4.23	4.10	4.00		
Mean	4.65	4.91	5.05	5.17	5.04		3.65	3.89	4.03	4.15	4.05			
Treat.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>				
D <sub>1</sub>	V <sub>1</sub>	5.13	5.26	5.36	5.53	5.40	4.13	4.20	4.33	4.50	4.43			
	V <sub>2</sub>	4.90	5.20	5.40	5.53	5.70	3.83	4.10	4.33	4.46	4.33			
	V <sub>3</sub>	5.33	5.60	5.70	5.76	5.70	4.30	4.57	4.67	4.70	4.67			
	V <sub>4</sub>	5.20	5.53	5.70	5.80	5.63	4.23	4.50	4.63	4.80	4.63			
D <sub>2</sub>	V <sub>1</sub>	4.10	4.23	4.40	4.53	4.40	3.10	3.23	3.46	3.53	3.40			
	V <sub>2</sub>	3.96	4.50	4.60	4.76	4.60	3.03	3.60	3.60	3.70	3.63			
	V <sub>3</sub>	4.50	4.63	4.73	4.83	4.70	3.50	3.63	3.67	3.83	3.77			
	V <sub>4</sub>	4.13	4.36	4.50	4.60	4.53	3.10	3.30	3.57	3.67	3.57			
Factors	D	V	D*V	T	D*T	V*T	D*V*T	D	V	D*V	T	D*T	V*T	D*V*T
SE(d)	0.01	0.04	0.05	0.03	0.04	0.05	0.07	0.02	0.04	0.06	0.03	0.05	0.07	0.09
C.D. at 5%	0.01	0.08	0.12	0.05	NS	0.10	NS	0.08	0.10	0.04	0.01	NS	0.13	NS

The data on CTD at flowering stage is revealed from Table 2, which affected due to sowing dates, varieties, foliar spray of boron, thio-urea and their interaction.

**Effect of sowing dates:** The statistically maximum mean value of sowing dates to CTD was recorded in timely sown date *i.e.*, D<sub>1</sub> (5.45 and 4.42 °C) and minimum in late sown date *i.e.*, D<sub>2</sub> (4.48 and 3.49 °C) during both years of experimentation.

**Effect of varieties:** For both experimental year, the significantly higher mean value of varieties to CTD in °C was measured in variety V<sub>3</sub> *i.e.*, 5.15 and 4.13 followed by V<sub>4</sub> *i.e.*, 5.00 and 4.00 and V<sub>2</sub> *i.e.*, 4.88 and 3.86 but lower in variety V<sub>1</sub> *i.e.*, 4.83 and 3.83, respectively.

**Effect of treatments:** Among the treatments, treatment T<sub>3</sub> gave better performance with 5.17 and 4.15 °C in both years but in first year at par treatment T<sub>4</sub> with 5.04 and 4.05 °C (higher in second year). Next to this were, treatment T<sub>2</sub> with 5.05 and 4.03 than T<sub>1</sub> with 4.91 and 3.89 °C, while T<sub>0</sub> gave lower performance with 4.65 and 3.65 °C during both experimental years.

**Interaction effect of sowing dates and varieties:** The value sowing dates and varieties recorded significantly superior for CTD in combination D<sub>1</sub>V<sub>3</sub> (5.62 and 4.58 °C) at par with combination D<sub>1</sub>V<sub>4</sub> (5.57 and 4.56 °C) followed by combination D<sub>1</sub>V<sub>1</sub> (5.34 and 4.32 °C) and combination D<sub>2</sub>V<sub>1</sub> (4.33 and 3.33 °C) gave inferior performance during both years of experimentation.

**Interaction effect between sowing dates and treatments:** Although, the effect of sowing dates with treatments did not show significant but numerically maximum value was in combination D<sub>1</sub>T<sub>3</sub> *i.e.*, 5.65 and 4.61 °C followed by other combinations as well as minimum was in combination D<sub>2</sub>T<sub>0</sub> *i.e.*, 4.17 and 3.18 °C for years 2013-14 and 2014-15, respectively.

**Interaction effect of varieties and treatments:** It is visualized that the value of both experimental years significantly maximum value of CTD recorded in combination V<sub>3</sub>T<sub>3</sub> (5.30 and 4.26 °C) at par with combination V<sub>3</sub>T<sub>2</sub>; V<sub>3</sub>T<sub>4</sub> and V<sub>4</sub>T<sub>3</sub> (5.21 and 4.16; 5.20 and 4.21; 5.20 and 4.23) and minimum in combination V<sub>2</sub>T<sub>0</sub> (4.43 and 3.43 °C), respectively.

**Interaction effect among sowing dates, varieties and treatments:** Though, the value of sowing dates, varieties and treatments for CTD in °C noted non-significant but numerically maximum value of CTD measured in combination D<sub>1</sub>V<sub>4</sub>T<sub>3</sub> with 5.80 and 4.80 °C as compared to other combinations as minimum in combination D<sub>2</sub>V<sub>2</sub>T<sub>0</sub> 3.96 and 3.03 °C for both concerning years, respectively.

**Membrane Injury Index (%):** The data regarding on membrane injury index (in percent) at flowering as presented in Table 3, affected due to sowing dates, varieties, foliar applied boron & thio-urea treatments and their interaction.

**Table 3:** Effect of foliar applied boron and thio-urea on Membrane Injury Index (%) at flowering stage of wheat cultivars under timely and late sown condition:

Treat.	2013-14						2014-15							
	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>		V <sub>4</sub>	Mean	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>		V <sub>4</sub>	Mean		
D <sub>1</sub>	24.96	25.43	27.83		28.49	26.68	23.82	24.38	26.83		27.28	25.58		
D <sub>2</sub>	27.26	26.39	26.46		27.89	27.00	26.31	25.37	25.60		26.87	26.04		
Mean	26.11	25.91	27.14		28.19		25.07	24.88	26.22		27.07			
Treat.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	Mean	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	Mean		
D <sub>1</sub>	27.88	26.65	25.95	26.30	26.61	26.68	26.72	25.54	24.83	25.29	25.50	25.58		
D <sub>2</sub>	27.82	26.93	26.39	26.84	27.00	27.00	26.93	25.97	25.35	25.93	26.00	26.04		
Mean	27.85	26.79	26.17	26.57	26.81		26.83	25.76	25.09	25.61	25.75			
V <sub>1</sub>	27.52	25.94	25.51	25.84	25.73	26.11	26.26	24.80	24.40	25.25	24.62	25.07		
V <sub>2</sub>	26.82	26.00	25.50	25.35	25.86	25.91	25.88	24.99	24.40	24.32	24.80	24.88		
V <sub>3</sub>	27.80	27.02	26.20	27.19	27.50	27.14	26.94	26.22	25.19	26.15	26.53	26.22		
V <sub>4</sub>	29.27	28.19	27.45	27.91	28.13	28.19	28.24	27.03	26.39	26.69	27.03	27.07		
Mean	27.85	26.79	26.17	26.57	26.81		26.83	25.76	25.09	25.61	25.75			
Treat.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>		T <sub>3</sub>	T <sub>4</sub>	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>		T <sub>3</sub>	T <sub>4</sub>		
D <sub>1</sub>	V <sub>1</sub>	26.79	24.89	24.26		24.52	24.34	23.76	23.10		23.74	23.14		
	V <sub>2</sub>	26.19	25.44	25.19		24.81	25.53	25.31	24.06		23.81	24.34		
	V <sub>3</sub>	28.64	27.64	26.83		27.69	28.33	27.57	26.66		26.78	27.43		
	V <sub>4</sub>	29.91	28.63	27.51		28.18	28.24	28.65	27.35		26.82	27.11		
D <sub>2</sub>	V <sub>1</sub>	28.25	26.99	26.77		27.15	27.13	27.16	25.85		26.76	26.11		
	V <sub>2</sub>	27.45	26.57	25.82		25.89	26.20	26.45	25.57		24.83	25.27		
	V <sub>3</sub>	26.97	26.41	25.58		26.69	26.66	26.32	25.78		25.58	25.67		
	V <sub>4</sub>	28.63	27.75	27.39		27.64	28.02	27.83	26.70		26.57	26.97		
Factors	D	V	D*V	T	D*T	V*T	D*V*T	D	V	D*V	T	D*T	V*T	D*V*T
SE(d)	0.12	0.27	0.38	0.14	0.20	0.30	0.40	0.18	0.20	0.28	0.20	0.28	0.40	0.57
C.D. at 5%	NS	0.58	0.82	0.27	NS	0.56	NS	NS	0.43	0.61	0.40	NS	NS	NS

**Effect of sowing dates:** Although, sowing dates was not significant on MII during both the year of experimentation while, numerically maximum mean value was noted in late sown date *i.e.*, D<sub>2</sub> (27.00 and 26.04 %) and minimum in timely sown date *i.e.*, D<sub>1</sub> (26.68 and 25.58 %).

**Effect of varieties:** The statistically higher mean value of MII tested from variety V<sub>4</sub> with 28.19 and 27.07 followed by V<sub>3</sub> with 27.14 & 26.22 and V<sub>1</sub> occupy the III<sup>rd</sup> rank with 26.11 & 25.07 however least in V<sub>2</sub> with 25.91 and 24.88 during both experimental years, respectively.

**Effect of treatments:** The significant effect of treatments were found for MII (%) high mean value from treatment T<sub>0</sub> (27.85 and 26.83) followed by T<sub>4</sub> (26.81 and 25.75) at par T<sub>1</sub> (26.79 and 25.76), T<sub>3</sub> (26.57 and 25.61) while lower in treatment T<sub>2</sub> (26.17 and 25.09) for years 2013-14 and 2014-15, respectively.

**Interaction effect between sowing dates and varieties:** It is revealed that significantly higher value of MII tested from combination D<sub>1</sub>V<sub>4</sub> *i.e.*, 28.49 and 27.28 at par with combination D<sub>2</sub>V<sub>4</sub> *i.e.*, 27.89 and 26.87, D<sub>1</sub>V<sub>3</sub> *i.e.*, 27.83 and 26.83 but least this value was in combination D<sub>1</sub>V<sub>1</sub> *i.e.*, 24.96 and 23.82 for both concerning years.

**Interaction effect of sowing dates with treatments:** Although, interaction effect between sowing dates and treatments did not statistically significant for MII however, numerically maximum value was recorded in combination D<sub>1</sub>T<sub>0</sub> with 27.88 in year 2013-14 and D<sub>2</sub>T<sub>0</sub> with 26.93 in year 2014-15 as well as minimum in combination D<sub>1</sub>T<sub>2</sub> with 25.95 and 24.83 during both years of experimentation.

**Interaction effect of varieties and treatments:** For the first year of experimentation significantly more value of MII (%) observed in combination V<sub>4</sub>T<sub>0</sub>, V<sub>4</sub>T<sub>1</sub> and V<sub>4</sub>T<sub>4</sub> (29.27, 28.19

and 28.13), respectively and less in combination V<sub>2</sub>T<sub>3</sub> (25.35). On the other hands, the value of MII did not show significant with second year while, numerically highest was in combination V<sub>4</sub>T<sub>0</sub> (28.24) and lowest in combination V<sub>2</sub>T<sub>3</sub> (24.32).

**Interaction effect of sowing dates, varieties and treatments:** Although, value of interaction effect among sowing dates, varieties and treatments was not significant for both corresponding years but numerically lowest value of MII was in combination D<sub>1</sub>V<sub>1</sub>T<sub>2</sub> *i.e.*, 24.26; 23.10 and highest in combination D<sub>1</sub>V<sub>4</sub>T<sub>0</sub> *i.e.*, 29.91; 28.65 respectively.

#### Grain yield (g m<sup>-2</sup>)

The data with respect to the effect of sowing dates, varieties, foliar applied boron, thio-urea and their interaction on grain yield (g m<sup>-2</sup>) after harvesting have been presented in Table No. 4.

**Effect of sowing dates:** The statistically higher mean value of sowing dates for grain yield (g m<sup>-2</sup>) in D<sub>1</sub> (433.4 and 424.3) as compared to D<sub>2</sub> (350.4 and 343.3) in both experimental year, respectively.

**Effect of varieties:** The mean value of grain yield in g m<sup>-2</sup> was significantly influenced by varieties for both concerning years. Among the varieties, V<sub>2</sub> *i.e.*, 409.2 and 401.6 was statistically superior from V<sub>1</sub> *i.e.*, 401.6 and 393.1, V<sub>4</sub> *i.e.*, 380.4 and 373.7 but inferior in V<sub>3</sub> *i.e.*, 376.0 and 366.8, respectively.

**Effect of treatments:** It is visualised from the mean value of grain yield (g m<sup>-2</sup>) weighed significantly maximum in treatment T<sub>3</sub> with 401.5 and 394.6 at par treatment T<sub>2</sub> with 397.4 and 389.1, treatment T<sub>4</sub> at III<sup>rd</sup> position with 393.1 and 386.2, T<sub>1</sub> at IV<sup>th</sup> rank with 389.0 and 380.7 but minimum in

treatment T<sub>0</sub> with 378.5 and 368.2, during both years of experimentation.

**Interaction effect of sowing dates and varieties:** The value of interaction effect of sowing dates with varieties was significant effect on grain yield. The statistically D<sub>1</sub>V<sub>2</sub> (462.2 and 453.2 g m<sup>-2</sup>) gave good performance against other combination and very low performance was given by combination D<sub>2</sub>V<sub>3</sub> (346.1 and 336.7 g m<sup>-2</sup>) during both concerning years, respectively.

**Interaction effect between sowing dates and treatments:** The interaction value of sowing dates and treatments was significant for year 2013-14 and 2014-15. The combination D<sub>1</sub>T<sub>3</sub> (445.7 and 437.9 g m<sup>-2</sup>) and D<sub>1</sub>T<sub>2</sub> (440.8 and 432.4 g m<sup>-2</sup>) was recorded maximum grain yield (g m<sup>-2</sup>) while minimum in combination D<sub>2</sub>T<sub>0</sub> (341.6 and 333.0 g m<sup>-2</sup>), respectively.

**Interaction effect of varieties and treatments:** During both years of experimentation, the interaction effect of varieties and treatments was significant on grain yield (g m<sup>-2</sup>). The statistically maximum value for grain yield was in combination V<sub>2</sub>T<sub>3</sub> i.e., 419.0 and 410.1 followed by V<sub>2</sub>T<sub>2</sub> i.e., 414.5 and 406.8 while minimum in V<sub>3</sub>T<sub>0</sub> i.e., 360.0 and 350.6.

**Interaction effect among sowing dates, varieties and treatments:** In the first year, the value of grain yield (g m<sup>-2</sup>) for sowing dates, varieties and treatments was not significant, but numerically maximum in combination D<sub>1</sub>V<sub>2</sub>T<sub>3</sub> and D<sub>1</sub>V<sub>2</sub>T<sub>2</sub> (475.0 and 468.7 g m<sup>-2</sup>) respectively. During second year, value of these interaction found significantly higher grain yield g m<sup>-2</sup> in combination D<sub>1</sub>V<sub>2</sub>T<sub>3</sub> (463.3) at par with D<sub>1</sub>V<sub>2</sub>T<sub>2</sub> (459.7 g m<sup>-2</sup>). The combination D<sub>2</sub>V<sub>3</sub>T<sub>0</sub> gave lower performance during both years, i.e., 335.0 and 325.3, respectively.

**Table 4:** Effect of foliar applied boron and thio-urea on Grain Yield (g m<sup>-2</sup>) of wheat cultivars after harvesting under timely and late sown condition:

Treat.	2013-14						2014-15							
	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>		V <sub>4</sub>	Mean	V <sub>1</sub>	V <sub>2</sub>	V <sub>3</sub>		V <sub>4</sub>	Mean		
D <sub>1</sub>	451.3	462.2	405.8		414.4	433.4	439.4	453.2	396.8		407.7	424.3		
D <sub>2</sub>	351.9	356.2	346.1		347.3	350.4	346.8	350.0	336.7		339.6	343.3		
Mean	401.6	409.2	376.0		380.9		393.1	401.6	366.8		373.7			
Treat.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	Mean	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	Mean		
D <sub>1</sub>	415.4	430.2	440.8	445.7	435.1	433.4	403.5	420.8	432.4	437.9	426.8	424.3		
D <sub>2</sub>	341.6	347.9	354.0	357.3	351.1	350.4	333.0	340.5	345.9	351.4	345.6	343.3		
Mean	378.5	389.0	397.4	401.5	393.1		368.2	380.7	389.1	394.6	386.2			
V <sub>1</sub>	390.0	398.8	406.5	410.3	402.5	401.6	378.5	390.6	397.5	403.6	395.3	393.1		
V <sub>2</sub>	396.3	405.5	414.5	419.0	411.0	409.2	387.3	400.1	406.8	410.1	403.6	401.6		
V <sub>3</sub>	360.0	373.1	382.5	386.8	377.5	376.0	350.6	359.5	374.1	379.5	370.1	366.8		
V <sub>4</sub>	367.8	378.8	386.1	390.0	381.6	380.9	356.6	372.5	378.1	385.3	375.8	373.7		
Mean	378.5	389.0	397.4	401.5	393.1		368.2	380.7	389.1	394.6	386.2			
Treat.	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>		T <sub>3</sub>	T <sub>4</sub>	T <sub>0</sub>	T <sub>1</sub>	T <sub>2</sub>		T <sub>3</sub>	T <sub>4</sub>		
D <sub>1</sub>	V <sub>1</sub>	435.0	447.7	458.3		462.7	453.0	421.6	436.0	446.0		453.0	440.6	
	V <sub>2</sub>	445.0	458.3	468.7		475.0	464.3	435.0	453.0	459.7		463.3	455.0	
	V <sub>3</sub>	385.0	401.7	414.7		419.6	408.3	376.0	384.3	408.3		413.6	402.0	
	V <sub>4</sub>	396.6	413.3	421.6		425.7	415.0	381.6	410.0	415.7		421.6	409.7	
D <sub>2</sub>	V <sub>1</sub>	345.0	350.0	354.6		358.0	352.0	335.3	345.3	349.0		354.3	350.0	
	V <sub>2</sub>	347.6	352.7	360.3		363.0	357.6	339.7	347.3	354.0		357.0	352.3	
	V <sub>3</sub>	335.0	344.7	350.3		354.0	346.7	325.3	334.7	340.0		345.3	338.3	
	V <sub>4</sub>	339.0	344.3	350.7		354.3	348.3	331.7	335.0	340.6		349.0	342.0	
Factors	D	V	D*V	T	D*T	V*T	D*V*T	D	V	D*V	T	D*T	V*T	D*V*T
SE(d)	1.5	0.6	0.8	0.3	0.5	0.7	1.0	1.6	0.5	0.6	0.6	0.9	1.3	1.8
C.D. at 5%	6.4	1.3	1.8	0.7	1.0	1.4	NS	7.2	1.0	1.4	1.3	1.8	2.6	3.7

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