



# The Effect of Mannitol and Nano Urea on Terminal Heat Stress on Wheat (*Triticum aestivum* L.)

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## Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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## ABSTRACT

The present investigation was conducted during Rabi season, 2022-23 & 2023-24 at the student instructional farm (SIF) of Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya- 224229 (U.P.). The experiment was conducted in randomized block design with three replications, seven treatments and wheat variety (HD 2967). The treatment was comprised of control distilled water spray, Mannitol 25, 50, 100 ppm and Nano urea 25, 50, 100 ppm respectively, which was foliar sprayed at 30 DAS. The observations have been studied on growth, bio-chemical, yield and yield attributes of wheat. Observations were recorded at 60, 90 DAS

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and at maturity stages for timely sowing (15 November) and late sowing (15 December). However, yield and yield parameters were taken at the time of harvesting of the crop. Foliar spray of mannitol and nano urea were performed well at 60, 90 DAS and at maturity parameters. Foliar application of nano urea with 25 ppm was recorded superior on plant height (cm), dry weight plant<sup>-1</sup> (g), chlorophyll content in leaves (SPAD value), Catalase activity (g<sup>-1</sup> fresh weight min<sup>-1</sup>), Peroxidase activity (mg g<sup>-1</sup> fresh weight min<sup>-1</sup>), Super oxide dismutase activity (mg g<sup>-1</sup> fresh weight min<sup>-1</sup>) However, yield and yield attributes viz length of spike, number of tillers plant<sup>-1</sup>, number of grains spike<sup>-1</sup>, grain yield plant<sup>-1</sup> It is concluded from the result that foliar spray of nano urea 25 ppm was found most effective to increasing all characters and yield parameters of wheat.

**Keywords:** Yield parameters; cereal crop; foliar spray; mannitol.

## 1. INTRODUCTION

Wheat (*Triticum aestivum* L.) is the most important cereal crop. Wheat is a member of the poaceae family and placed under genus *Triticum*. It is an annual, long day and self-pollinated plant. Wheat is the most important food cultivar at the global level than any other crop. 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. About 36% of the world population depends directly on wheat to fulfill its calories requirements. It provides 21% caloric and 10-12% protein requirements to about 4.5 billion peoples of the world. Most of them belong to developing countries. In 2021, wheat was cultivated on an area of 215.9 million hectares in the world, and 765.8 million tonnes production was obtained with an average yield of 35.4 qha<sup>-1</sup>, respectively. India has about 31.61 mha area with the production of 109.52 mt and productivity of 34.64 qha<sup>-1</sup>. Uttar Pradesh has about 9.85 mha area, 31.16 mt production and productivity are 32.42 qha<sup>-1</sup>, respectively. Uttar Pradesh ranks first in area (32.89%) and production (31.88 %) of wheat in the country (Agricultural Statistics at a Glance 2021). The production and other yield attributing characters of wheat are greatly affected by hyperthermal conditions (Gupta et al., 2013). The optimum temperatures during the anthesis and grain filling were determined to be 23 °C and 21.3 °C respectively, crop exposure to temperatures above the optimum causes a yield reduction [1]. The optimum temperature for photosynthesis in wheat is around 20 to 30°C, and the rate of photosynthesis declines rapidly at temperatures above 30°C [2]. The heat labile cell components are thylakoid membrane and PS-II. The damage to thylakoid by heat leads to chlorophyll loss (Ni et al., 2018). High temperature stress is a major cause of yield loss in cereal crops throughout many of the world's cereal growing areas, including India. High temperature causes

dehydration in plant tissue which ceases the growth and development of plants. Heat stress increases the soil water content threshold *i.e.*, the amount of water that the plant can extract (Haworth et al., 2018). High temperature stress often favours accumulation of reactive oxygen species (ROS) such as hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>), superoxide radical (O<sup>2-</sup>), hydroxyl ion (OH<sup>-</sup>) and oxygen (O<sup>-1</sup>) in plant tissues (Lai and He, 2016). The reactive oxygen species generated due to stress in chloroplast, mitochondria and peroxisome can disrupt the normal metabolism through oxidative damage of proteins, lipids and nucleic acid leading to damage of cell structure (Qaseem et al., 2019). Osmoprotectants or compatible solutes are small molecules having low molecular weight, electrically neutral, highly soluble and non-toxic at molar concentrations [3]. They help plants to survive in extreme osmotic environment [4]. Plant stress tolerance has been widely reported to be improved with the exogenous application of mannitol. Mannitol, an important osmolyte, is normally synthesized in large amount in many plant species [5], (Mitoi et al., 2009). Nano Urea (Liquid) contains nano scale nitrogen particles which have more surface area Nano urea prepared by nanotechnology contains nano scale particles of Nano Urea. One nano urea liquid particle is 30 nano meters in diameter, with 10,000 times higher surface area to volume size than normal granular urea (Deepika et al., 2022). Average physical size of Nano Urea particles is in the range of 20 -50 nm. Nano Urea contains 4 % nitrogen by weight in its nano form. Nitrogen present in Nano Urea effectively meets the crop nitrogen requirement. It has better use efficiency than conventional urea.

## 2. MATERIALS AND METHODS

During the *Rabi* season of 2022-23 & 2023-24, the inquiry was conducted at the Acharya Narendra Deva University of Agriculture and

Technology's Student Instructional Farm, Narendra Nagar, Kumarganj, Ayodhya (U.P.). Kumarganj is located at 26.47° north latitude and 81.12° east longitude, at an elevation of 113 meters, in the gangetic alluvium of eastern Uttar Pradesh. The experimental site is located in the Indo-Gangatic plains, in a sub-tropical climate with scorching summers and freezing winters. The monsoon season, which runs from July to September, receives over 80% of the total rainfall, with only a few showers in the winter. The design is Randomised Block Design (R.B.D.) with seven treatments, three replications and variety HD 2967. Concentrations of Mannitol (25, 50, 100 ppm) and nano urea (25, 50, 100 ppm) foliar spray along with untreated control. Osmoprotectant and nano urea was sprayed at 52 DAS. The significance of various treatments was judged by The Fisher method of analysis of variance was used to analyze data collected on various growth and yield parameters (Fisher and Yates 1949).

### 3. RESULTS AND DISCUSSION

#### 3.1 Growth Parameters

##### 3.1.1 Plant height (cm)

Data pertaining to plant height as affected by various plants growth nutrients recorded at different growth stages have been presented in table. all the treatments showed statistically significant increase in plant height was recorded with foliar spray of Nano Urea 25ppm timely sowing (75.22, 97.83 and 100.44 cm), late sowing (69.96, 93.64 and 96.32 cm) at 60 DAS, 90 DAS and at maturity stage respectively over rest of the treatments. The minimum plant height

was found with foliar spray of Mannitol 25 ppm timely sowing (63.56, 88.32 and 90.71 cm), late sowing (60.52, 86.46 and 87.38 cm) respectively at 60, 90 DAS and at maturity stages of observation over control. The data conclude that the application of mannitol and nano urea significantly shows positive response to plant height of wheat, because of nitrogen and mannitol provide mechanical strength to the stem and increase their elongation. This result is similar to Sharmy and Ansari (2022), the height of wheat crop is influenced by nutrient applications and nano fertilizers.

##### 3.1.2 Dry weight plant-1 (g)

Observations were recorded on dry weight plant<sup>1</sup> as effected by various foliar spray of plant nutrient at different growth stages have been presented in table. All the foliar applications showed statistically significant increase in dry matter at all the stages of crop over control. The maximum increased in plant dry weight was recorded with foliar spray of nano urea 25ppm timely sowing (27.54g, 37.05g and 35.71g), late sowing (27.37, 37.31 and 35.68 g) at 30, 90 and at maturity stage. Whereas, minimum plant dry biomass was found with foliar spray of mannitol timely sowing (25.32g, 34.55g and 32.66g), late sowing (24.26, 33.73 and 31.62 g) respectively at all the stages of observation over the control. According to the observed result, dry weight of plant was increases continuously till 90 DAS but decreases about 8-10 % at maturity stage (Kumar et al., 2018). With the increase the dose of nitrogen the dry weight of plant will also increases. These similar results were also reported by Ahmed and Abdul (2022).

**Table 1. Variability in plant height in different treatments**

Treatments	Plant Height (cm)					
	Timely sown			Late sown		
	60DAS	90DAS	Maturity	60DAS	90DAS	Maturity
T1 – Control	58.14	83.81	85.55	56.21	81.24	82.43
T2 – Manitol (25ppm)	63.56	88.32	90.71	60.52	86.46	87.38
T3 - Mannitol (50ppm)	69.24	90.80	92.88	63.62	89.45	90.13
T4 - Mannitol (100ppm)	62.81	88.73	91.72	62.11	85.23	90.76
T5 - Nano urea (25ppm)	75.22	97.83	100.44	69.96	93.64	96.32
T6 - Nano urea (50ppm)	67.92	87.78	90.09	67.34	82.87	93.65
T7 - Nano urea (100ppm)	65.21	85.94	88.03	68.71	82.21	87.14
S.Em ±	0.16	0.53	0.28	0.13	0.51	0.25
C.D. 5%	0.48	1.65	0.85	0.43	1.59	0.83

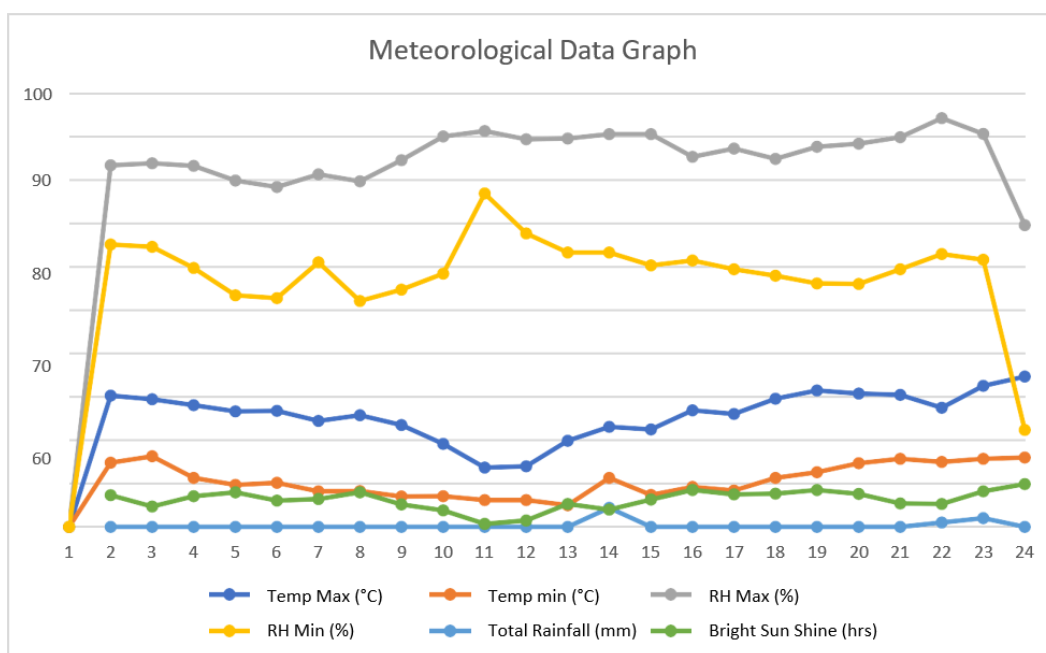


Fig. 1. Meteorological chart during crop period 2022 - 23 & 2023 - 24

Table 2. Variability in Dry weight plant in different treatments

Treatments	Dry weight plant-1 (g)					
	Timely sown			Late sown		
	60 DAS	90 DAS	Maturity	60 DAS	90 DAS	Maturity
T1 – Control	24.88	32.30	31.30	22.45	30.26	30.19
T2 – Manitol (25ppm)	25.32	34.55	32.66	24.26	33.73	31.62
T3 - Mannitol (50ppm)	26.94	35.95	34.65	25.71	34.49	33.35
T4 - Mannitol (100ppm)	26.21	35.25	33.74	25.98	35.85	33.92
T5 - Nano urea (25ppm)	27.54	37.05	35.71	27.37	37.31	35.68
T6 - Nano urea (50ppm)	25.71	34.71	33.87	26.53	35.22	32.11
T7 - Nano urea (100ppm)	25.11	34.19	33.68	25.62	33.67	33.42
S.Em±	0.33	0.09	0.12	0.31	0.06	0.11
C.D. 5%	1.03	0.28	0.37	1.01	0.26	0.33

**3.1.3 Total chlorophyll content in leaves (SPAD value):**

The critical analysis of data presented in the table. clearly indicate that all the foliar spray of different plant nutrients increase chlorophyll content in leaves up to 60, 90 DAS. The maximum increase of chlorophyll was observed with foliar application of nano urea 25ppm timely sowing (23.65, 20.15 SPAD value), late sowing (22.85, 21.03 SPAD value) at 60 and 90 DAS, respectively over rest of the treatments. However, minimum chlorophyll was found with foliar spray of mannitol 25 ppm timely sowing (19.12 and 15.29 SPAD value), late sowing (16.51, 14.74 SPAD value) respectively among all the treatments over control. Chlorophyll content in leaf is positively influenced by the

plant nutrients and nano fertilizers, due to increase in nitrogen content the plant chlorophyll content will also increases. The similar findings were also reported by Muhammad et al. (2022).

**3.1.4 Catalase activity (g-1 fresh weight min-1) in leaves**

The critical analysis of data presented in the Table. clearly indicate that all the foliar spray of different plant nutrients increase catalase activity in leaves up to 60, 90 DAS. The maximum increase of catalase activity was observed with foliar application of nano urea 25ppm timely sowing (155.08 and 171.23), late sowing (136.41 and 141.29) at 60 and 90 DAS, respectively over rest of the treatments. However, minimum catalase activity was found with foliar spray of

Mannitol 25 ppm timely sowing (152.36 and 164.52), late sowing (132.17 and 136.12) respectively among all the treatments over control. The activities of enzymes viz, catalase, nitrate reductase etc. gradually increase with the age of crop up to 90 DAS under different foliar application of plant nutrients. In order to limit oxidative damage under stress condition plants have developed a series of detoxification system that break down highly toxic reactive oxygen species (Ezzat-Ollah Esfandiari et al. 2007).

### 3.1.5 Peroxidase activity (mg g<sup>-1</sup> fresh weight min<sup>-1</sup>) in leaves

The critical analysis of data presented in the Table. clearly indicate that all the foliar spray of different plant nutrients increase Peroxidase activity in leaves up to 60, 90 DAS. The maximum increase of Peroxidase activity was observed with foliar application of nano urea 25ppm timely sowing (145.87 and 225.83), late sowing (200.36 and 250.21) at 60 and 90 DAS, respectively over rest of the treatments. However, minimum catalase activity was found

with foliar spray of Mannitol 25 ppm timely sowing (152.36 and 164.52), late sowing (196.15 and 246.08) respectively among all the treatments over control. The similar findings were also reported by Sharma et al. [6].

### 3.1.6 Super oxide dismutase activity (mg g<sup>-1</sup> fresh weight min<sup>-1</sup>) in leaves

The critical analysis of data presented in the Table. clearly indicate that all the foliar spray of different plant nutrients increase Super oxide dismutase in leaves up to 60, 90 DAS. The maximum increase of Super oxide dismutase activity was observed with foliar application of nano urea 25ppm timely sowing (226.87 and 275.23) late sowing (291.08 and 371.16) at 60 and 90 DAS, respectively over rest of the treatments. However, minimum catalase activity was found with foliar spray of Mannitol 25 ppm timely sowing (152.36 and 164.52), late sowing (286.11 and 367.10) respectively among all the treatments over control. The similar findings were also reported by Karki et al. [7].

**Table 3. Total chlorophyll content in leaves**

Treatments	Total chlorophyll (SPAD Value)			
	Timely sown		Late sown	
	60 DAS	90 DAS	60 DAS	90 DAS
T1 – Control	16.19	10.84	14.63	10.22
T2 – Manitol (25ppm)	19.12	15.29	16.51	14.74
T3 - Mannitol (50ppm)	20.70	16.09	19.36	15.97
T4 - Mannitol (100ppm)	20.25	12.85	20.26	13.61
T5 - Nano urea (25ppm)	23.65	20.15	22.85	21.03
T6 - Nano urea (50ppm)	20.14	14.59	20.47	13.86
T7 - Nano urea (100ppm)	19.91	13.32	18.53	12.17
S.Em±	0.70	1.15	0.67	1.12
C.D. 5%	2.17	3.55	2.03	3.49

**Table 4. Catalase activity (g<sup>-1</sup> fresh weight min<sup>-1</sup>) in leaves**

Treatments	Catalase activity (g <sup>-1</sup> fresh weight min <sup>-1</sup> )			
	Timely sown		Late sown	
	60 DAS	90 DAS	60 DAS	90 DAS
T1 - Control	151.12	162.35	131.58	135.58
T2 – Manitol (25ppm)	152.36	164.52	132.17	136.12
T3 - Mannitol (50ppm)	154.80	167.12	132.95	136.67
T4 - Mannitol (100ppm)	153.35	165.36	133.87	137.87
T5 - Nano urea (25ppm)	155.08	171.23	136.41	141.29
T6 - Nano urea (50ppm)	154.53	167.30	134.10	139.70
T7 - Nano urea (100ppm)	153.76	165.24	135.11	138.85
S.Em±	0.82	1.08	0.97	1.12
C.D. 5%	2.36	3.11	2.77	3.21

**Table 5. Peroxidase activity (mg g<sup>-1</sup> fresh weight min<sup>-1</sup>) in leaves**

Treatments	Peroxidase activity (mg g <sup>-1</sup> fresh weight min <sup>-1</sup> )			
	Timely sown		Late sown	
	60 DAS	90 DAS	60 DAS	90 DAS
T1 - Control	144.12	219.35	195.74	245.50
T2 – Manitol (25ppm)	144.36	220.52	196.15	246.08
T3 - Mannitol (50ppm)	143.80	220.12	196.87	246.95
T4 - Mannitol (100ppm)	144.35	219.36	197.89	247.33
T5 - Nano urea (25ppm)	145.87	225.23	200.36	250.21
T6 - Nano urea (50ppm)	143.53	221.30	199.88	249.58
T7 - Nano urea (100ppm)	144.76	223.24	198.89	248.87
S.Em±	1.38	1.74	1.39	1.68
C.D. 5%	3.97	4.78	4.02	4.83

**Table 6. Super oxide dismutase activity (mg g<sup>-1</sup> fresh weight min<sup>-1</sup>) in leaves**

Treatments	Super oxide dismutase activity (mg g <sup>-1</sup> fresh weight min <sup>-1</sup> )			
	Timely sown		Late sown	
	60 DAS	90 DAS	60 DAS	90 DAS
T1 - Control	224.45	270.35	285.10	366.11
T2 – Manitol (25ppm)	226.11	271.52	286.11	367.10
T3 - Mannitol (50ppm)	225.80	271.12	286.67	367.89
T4 - Mannitol (100ppm)	226.35	273.36	287.65	368.96
T5 - Nano urea (25ppm)	226.87	275.23	291.08	371.16
T6 - Nano urea (50ppm)	226.53	274.30	289.50	370.37
T7 - Nano urea (100ppm)	225.76	275.14	288.15	369.20
S.Em±	1.61	1.86	1.68	2.07
C.D. 5%	4.60	5.33	4.83	5.92

### 3.1.7 Length of spike (cm)

It is evident from the data presented in table clearly indicate that all the foliar spray of different plant nutrients enhances the length of spike as compare to control. The maximum length of spike was measured with foliar spray of nano urea 25ppm timely sowing (11.47cm), late sowing (10.73) over rest of the treatments. However, minimum length of spike was measured with foliar spray of mannitol 25ppm timely sowing (10.33), late sowing (9.54) among all the treatments and also control. Due to positive inflation different plant nutrients, that directly affect the yield growth of crops like length of spikes etc [8-12]. The similar result was reported by Satish et al. (2022).

### 3.1.8 Number of effective tillers plant<sup>-1</sup>

It is evident from the data presented in table. clearly indicate that all the foliar spray of different plant nutrients increases the number of effective tillers plant<sup>-1</sup> as compare to control. The maximum number of effective tillers plant<sup>-1</sup> was recorded with foliar spray of nano urea 25ppm timely sowing (9.33), late sowing (8.73) over rest of the treatments. However, minimum number of

effective tillers plant<sup>-1</sup> was recorded with foliar spray of mannitol 25ppm timely sowing (8.33), late sowing (7.83) among all the treatments over control. The number of tillers were also affected by plant nutrients but the greater number of tillers plants<sup>-1</sup> was found in nano urea application because of accumulation nitrogen increase number of tillers [13-16]. These results are accordance with Arif et al (2017).

### 3.1.9 Number of grains spike<sup>-1</sup>

It is evident from the data presented in table. clearly indicate that all the foliar spray of different plant nutrients significantly increases the number of grains spike<sup>-1</sup> as compare to control. The maximum number of grains spike<sup>-1</sup> was recorded with foliar spray of nano urea 25ppm timely sowing (47.67), late sowing (45.83) over rest of the treatments. However, minimum number of grains spike<sup>-1</sup> was recorded with foliar spray of mannitol 25ppm timely sowing (37.67), late sowing (36.79) among all the treatments over control. Number of grains spike<sup>-1</sup> was also positively influenced by plant nutrients; it enhances the number of grains in spikes due to their biochemical activities. The similar data was reported by Ahmed and Abdul (2022).

**Table 7. Effective tillers and grains spike measurements**

Treatments	length of spike (cm)		Number of effective tillers plant-1		Number of grains spike-1	
	Timely sown	Late sown	Timely sown	Late sown	Timely sown	Late sown
T1 – Control	8.57	7.12	7.00	6.19	33.33	32.33
T2 – Manitol (25ppm)	10.33	9.54	8.33	7.83	37.67	36.79
T3 - Mannitol (50ppm)	11.50	10.29	9.00	8.70	41.67	39.91
T4 - Mannitol (100ppm)	10.93	9.04	8.33	6.99	41.00	40.64
T5 - Nano urea (25ppm)	11.47	10.73	9.33	8.73	47.67	45.83
T6 - Nano urea (50ppm)	10.57	8.65	8.66	7.89	43.67	42.74
T7 - Nano urea (100ppm)	10.17	9.28	8.33	7.13	39.67	38.36
S.Em±	0.15	0.13	0.31	0.29	1.01	0.98
C.D. 5%	0.47	0.42	1.02	1.01	3.13	3.11

### 3.1.9 Grain yield plant-1 (g)

The result presented in Table. clearly indicate that all the foliar spray of different plant nutrients significantly increases the grain yield plant<sup>-1</sup> as compare to control [18-20]. The maximum grain yield plant<sup>-1</sup> was recorded with foliar spray of nano urea 25ppm timely sowing (9.23g), late sowing (8.48g) over rest of the treatments. However, minimum grain yield plant<sup>-1</sup> was recorded with foliar spray of mannitol 25 ppm timely sowing (6.94g), late sowing (5.31g) among all the treatments over control. Due to accumulation of nitrogen and osmoprotectant, grain yield plant<sup>-1</sup> positively influenced and show positive results *i.e.* increase in weight of grains plant<sup>-1</sup>. These results are accordance with Jat at al. (2013).

### 3.1.10 Test weight (g)

Data collected on 1000 seed weight in each foliar spray are presented in Table. The foliar spray of different plant nutrients reveal that increment in seed weight over the control. The maximum seed weight was registered with foliar spray of nano urea 25ppm timely sowing (44.53g), late sowing

(43.39g) over rest of the treatments. However, the minimum seed weight was registered with foliar spray of mannitol 25 ppm timely sowing (40.92g), late sowing (40.23g) over rest of the treatments including control. The weight of seed is also increased due to bio- chemical activities of osmoprotectant and nitrogen. The similar findings were also given by Satish et al. (2022).

### 3.1.11 Grain yield (q h-1)

Grain yield quintals per hectare have been presented in table. all the foliar spray of different plant nutrients significantly increases the grain yield q h<sup>-1</sup> over the control. Significantly, the maximum grain yield q h<sup>-1</sup> was recorded with foliar spray of nano urea 25ppm timely sowing (55.85q h<sup>-1</sup>), late sowing (54.99 q h<sup>-1</sup>) over rest of the treatments. However, the minimum grain yield q h<sup>-1</sup> was recorded with foliar spray of mannitol 25 ppm timely sowing (50.97q h<sup>-1</sup>), late sowing (49.63 q h<sup>-1</sup>) among all the treatments over control. Due to increment in grain yield plant<sup>-1</sup> thereby, increment in grain yield (q h<sup>-1</sup>). The similar result was also found by Partha et al. (2017).

**Table 8. Grain yield and test weight analysis**

Treatments	Grain yield plant-1 (g)		Test weight (g)	
	Timely sown	Late sown	Timely sown	Late sown
T1 – Control	5.71	4.49	40.92	39.38
T2 – Manitol (25ppm)	6.94	5.31	41.72	40.23
T3 - Mannitol (50ppm)	8.73	7.82	43.93	42.94
T4 - Mannitol (100ppm)	7.79	6.99	43.07	43.15
T5 - Nano urea (25ppm)	9.23	8.48	44.53	43.39
T6 - Nano urea (50ppm)	8.30	7.73	41.13	40.02
T7 - Nano urea (100ppm)	8.08	7.94	42.43	41.74
S.Em±	0.14	0.12	0.56	0.48
C.D. 5%	0.44	0.40	NS	NS

**Table 9. Grain yield and harvest index**

Treatments	Grain yield (q h-1)		Harvest index (%)	
	Timely sown	Late sown	Timely sown	Late sown
T1 – Control	48.68	47.39	39.15	37.84
T2 – Mannitol (25ppm)	50.97	49.63	39.25	38.57
T3 - Mannitol (50ppm)	53.84	51.19	41.34	40.29
T4 - Mannitol (100ppm)	52.51	52.08	39.95	38.05
T5 - Nano urea (25ppm)	55.85	54.99	42.58	42.14
T6 - Nano urea (50ppm)	54.66	53.26	41.55	40.82
T7 - Nano urea (100ppm)	53.27	52.74	39.38	38.94
S.Em±	0.04	0.03	NS	NS
C.D. 5%	0.14	0.12	NS	NS

### 3.1.12 Harvest index (%)

The data presented in table. clearly indicate that non-significant variables were found due to foliar spray of plant nutrients. Maximum harvest index (41.88%) was observed with foliar treatment of nano urea 25ppm over the all other treatment including control. Harvest index was also influenced by the foliar applications of plant nutrients. Nutrient-use efficiency refers to the ability of plants to transport and utilize nutrients effectively for growth and yield. Thereby they can allocate resources more efficiently towards grain production, leading to an increased harvest index. The similar findings were observed by Mohd. Arif et al. (2019).

## 5. CONCLUSION

Present investigation clearly indicate that Foliar spray of mannitol and nano urea were performed well at 60, 90 DAS and at maturity parameters. Foliar application of nano urea with 25 ppm was recorded superior on Plant height (cm), dry weight plant<sup>-1</sup> (g), chlorophyll content in leaves (SPAD value), Catalase activity (g-1 fresh weight min-1), Peroxidase activity (mg g-1 fresh weight min-1), Super oxide dismutase activity (mg g-1 fresh weight min-1) However, yield and yield attributes viz length of spike, number of tillers plant<sup>-1</sup>, number of grains spike<sup>-1</sup>, grain yield plant<sup>-1</sup> It is concluded from the result that foliar spray of nano urea 25 ppm was found most effective to increasing all characters and yield parameters of wheat. Present finding needs further validation.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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