

## Study the response of Mannitol and Nano Urea to mitigate the adverse effect of terminal heat stress on wheat (*Triticum aestivum* L.)

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### Abstract

The present investigation entitled “physiological study of wheat (*Triticum aestivum* L.) with foliar application of mannitol and nano urea under sodic soil condition” was conducted during Rabi season, 2022-23 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, 100ppm and Nano urea 25, 50, 100 ppm respectively, which was foliar sprayed at 30 DAS. The observations have been studied on growth, biochemical, yield and yield attributes of wheat. Observations were recorded at 60, 90DAS 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>freshweightmin<sup>-1</sup>), Peroxidase activity (mg g<sup>-1</sup>freshweightmin<sup>-1</sup>), Super oxide dismutase activity (mg g<sup>-1</sup>freshweightmin<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.

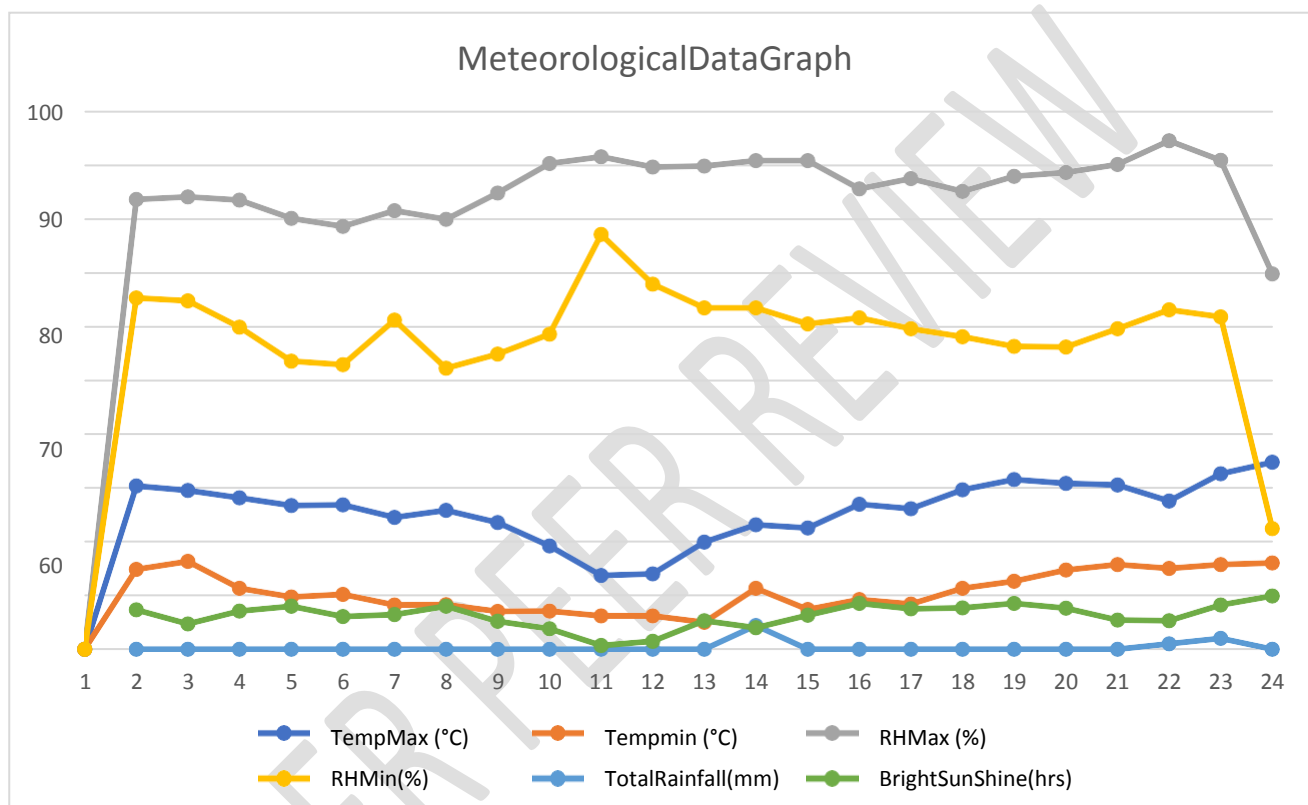
### Introduction

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 (Farooq *et al.*, 2011). 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 (Narayanan, 2018). 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 (Ahn *et al.*, 2011). They help plants to survive in extreme osmotic environment (Lang 2007). 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 (Su *et al.*, 1999 and Mittoiet *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.

## Materials and Methods

During the *Rabi* season of 2022-23, 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).



**Fig1 :- Meteorological chart during crop period 2021 - 22**

## Result and Discussion

### Growth Parameters

#### 4.1.2 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 25ppm timely sowing (63.56, 88.32 and 90.71cm), 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 Shamary and Ansari (2022), the height of wheat crop is influenced by nutrient applications and nano fertilizers.

Table 1 :Variability in plant height in different treatments

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

#### 4.1.4 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 2 :Variability in Dry weight plant in different treatments

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

#### 4.2.1 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 mannitol25ppm 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)

Table 3 :Total chlorophyll content in leaves

Treatments	Totalchlorophyll(SPADValue)			
	Timely sown		Late sown	
	60DAS	90DAS	60DAS	90DAS
<b>T1– Control</b>	16.19	10.84	14.63	10.22
<b>T2–Manitol (25ppm)</b>	19.12	15.29	16.51	14.74
<b>T3 -Mannitol(50ppm)</b>	20.70	16.09	19.36	15.97
<b>T4-Mannitol(100ppm)</b>	20.25	12.85	20.26	13.61

<b>T5 -Nano urea(25ppm)</b>	23.65	20.15	22.85	21.03
<b>T6-Nanourea (50ppm)</b>	20.14	14.59	20.47	13.86
<b>T7-Nanourea (100ppm)</b>	19.91	13.32	18.53	12.17
<b>S.Em±</b>	0.70	1.15	0.67	1.12
<b>C.D.5%</b>	2.17	3.55	2.03	3.49

#### 4.1.1 Catalase activity ( $\text{g}^{-1}\text{fresh weight min}^{-1}$ ) in leaves:

The critical analysis of data presented in the Table clearly indicates 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 25 ppm 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).

Table 4 : Catalase activity ( $\text{g}^{-1}\text{ fresh weight min}^{-1}$ ) in leaves

Treatments	Catalase activity ( $\text{g}^{-1}\text{fresh weight min}^{-1}$ )			
	Timely sown		Late sown	
	60 DAS	90 DAS	60 DAS	90 DAS
<b>T1-Control</b>	151.12	162.35	131.58	135.58
<b>T2-Mannitol (25ppm)</b>	152.36	164.52	132.17	136.12
<b>T3 -Mannitol(50ppm)</b>	154.80	167.12	132.95	136.67
<b>T4-Mannitol(100ppm)</b>	153.35	165.36	133.87	137.87
<b>T5 -Nano urea(25ppm)</b>	155.08	171.23	136.41	141.29
<b>T6-Nanourea (50ppm)</b>	154.53	167.30	134.10	139.70

<b>T7-Nanourea (100ppm)</b>	153.76	165.24	135.11	138.85
<b>S.Em±</b>	0.82	1.08	0.97	1.12
<b>C.D.5%</b>	2.36	3.11	2.77	3.21

#### 4.1.2 Peroxidase activity ( $\text{mg g}^{-1}\text{fresh weight min}^{-1}$ ) in leaves:

The critical analysis of data presented in the Table clearly indicates 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 25 ppm 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 (2021).

Table 5 : Peroxidase activity ( $\text{mg g}^{-1}$  fresh weight  $\text{min}^{-1}$ ) in leaves

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

#### 4.1.3 Super oxide dismutase activity ( $\text{mg g}^{-1}\text{fresh weight min}^{-1}$ ) in leaves:

The critical analysis of data presented in the Table clearly indicates 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 25 ppm 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. (2021).

Table 6 : Super oxide dismutase activity ( $\text{mg g}^{-1}$  fresh weight  $\text{min}^{-1}$ ) in leaves

Treatments	Super oxide dismutase activity ( $\text{mg g}^{-1}$ fresh weight $\text{min}^{-1}$ )			
	Timely sown		Late sown	
	60DAS	90DAS	60DAS	90DAS
T1-Control	224.45	270.35	285.10	366.11
T2-Mannitol (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-Nanourea (50ppm)	226.53	274.30	289.50	370.37
T7-Nanourea (100ppm)	225.76	275.14	288.15	369.20
S.Em $\pm$	1.61	1.86	1.68	2.07
C.D.5%	4.60	5.33	4.83	5.92

#### 4.1.1 Length of spike (cm)

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

#### 4.1.2 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  $\text{plant}^{-1}$  as compare to control. The maximum number of effective tillers  $\text{plant}^{-1}$  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  $\text{plant}^{-1}$  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  $\text{plants}^{-1}$  was found in nano urea application because of accumulation of nitrogen increases number of tillers. These results are in accordance with **Arif et al (2017)**.

#### 4.1.3 Number of grain spike $^{-1}$ :

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 $^{-1}$  as compare to control. The maximum number of grains spike $^{-1}$  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 $^{-1}$  was recorded with foliar spray of mannitol 25ppm timely sowing (37.67), late sowing (36.79) among all the treatments over control. Number of grain spike $^{-1}$  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 $\text{plant}^{-1}$		Number of grain 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-Nanourea (50ppm)	10.57	8.65	8.66	7.89	43.67	42.74
T7-Nanourea (100ppm)	10.17	9.28	8.33	7.13	39.67	38.36
S.E.m±	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

#### 4.1.4 Grain yield plant<sup>-1</sup>(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. 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 **Jatat *et al.* (2013)**.

#### 4.1.5 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 nanourea 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)**.

Table 8 : Grain yield and test weight analysis

	Grain yield plant <sup>-1</sup> (g)	Test weight(g)

Treatments	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-Nanourea (50ppm)	8.30	7.73	41.13	40.02
T7-Nanourea (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

#### 4.1.1 Grainyield(q h<sup>-1</sup>):

Grain yield quintals per hectare have been presented in table. allthe foliar spray of different plant nutrients significantly increases the grain yield q h<sup>-1</sup> overthecontrol. Significantly, the maximum grain yield qh<sup>-1</sup> was recorded with foliar spray of nano urea 25ppm timely sowing (55.85q h<sup>-1</sup>), late sowing (54.99q 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 (49.63q 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).

#### 4.1.2 Harvestindex(%):

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 application 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. al. (2019).

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**Table 9 : Grain yield and Harvest index**

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

### 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<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. Present finding needs further validation.

### Reference

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