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Effect of foliar application of nano urea on wheat crop yield in Himachal Pradesh

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Abstract

A field experiment entitled “Effect of foliar application of nano urea on wheat crop yield in Himachal Pradesh” was conducted at the Research Farm of the School of Agriculture, Abhilashi University, Mandi (H.P.) during Rabi 2024-25. Soil of the experimental field was acidic in reaction, medium in organic carbon, low in available nitrogen, medium in available phosphorus and available potassium. The experiment was laid out in randomized block design with three replications, consisting of eight treatments i.e. T₁ - Recommended N dose (1/3rd basal, 1/3rd CRI and 1/3rd Tillering), T₂ - Recommended N + one spray of nano urea at tillering (4ml L⁻¹), T₃ - Recommended N + two spray of nano urea N at tillering and jointing (4ml L⁻¹), T₄ - 75% N + water spray at tillering and jointing, T₅ - 75% N + one spray of nano urea N at tillering (4ml L⁻¹), T₆ - 75% N + two spray of nano urea N at tillering (4ml L⁻¹) and jointing (4ml L⁻¹), T₇ - 50% N + two spray nano urea N at tillering (4ml L⁻¹) and jointing (4ml L⁻¹) and T₈ - Control (No fertilizer). The investigation revealed that treatment T₃ and T₆ had a significant impact specifically on parameters such as plant height, number of tillers per square meter. Dry matter accumulation and yield attributes including effective tillers, number of spikes per square meter, spike length, number of grains per spike, grain yield. Straw yield and biological yield were also affected.

Keywords: Nano urea, pH, nitrogen, phosphorous and potassium

Introduction

Wheat (*Triticum aestivum*. L) is one of the most important rabi season crop in India, covering about 50% total area under food crops and producing more than 70% of total food grain among rabi season crops (Kumar *et al.* 2018) [5]. Wheat is one of the most nutritive food grain crops, containing 60-68% carbohydrates, 8-15% protein, 1.5-2% fat, 2- 3% sugar, 2-2.5% cellulose and 1.5-2% minerals (Singh *et al.* 2011) [14].

The world production of wheat is 770.4 million tonnes area and productivity. China is the largest producer of wheat in the world and India is the second largest producer of wheat in the world. The other leading producers of wheat include Russia and United States of America. In India, wheat is grown over an area of 31.83 million hectares with total production of 117.50 million tonnes with the average productivity of 3690 kg ha⁻¹ (Anonymous 2024-25) [1].

India's wheat production has seen substantial growth, with the area under cultivation at approximately 31.83 million hectares and production reaching about 113.29 million metric tons. Productivity has also increased, averaging around 3.56 tons per hectare. Key drivers for this success include the "Green Revolution," government support like Minimum Support Price (MSP), and an expansion in area, particularly in states like Uttar Pradesh, Madhya Pradesh, and Punjab (Anonymous 2024-25) [1].

Fertilizers are vital to India's agriculture, which contributes 18% to GDP. The Indian fertilizer industry, valued at ₹982 billion in 2024, is expected to reach ₹1,401 billion by 2033, driven by rising demand and government support. Chemical fertilizers dominate, especially for grains, with North India leading the usage. Despite growth in production and exports, India relies heavily on imports for key nutrients (Anonymous 2025) [2]. India is the world's second-largest consumer of fertilizers with an annual consumption exceeding 55 million tons. Fertilizer consumption, in terms of nutrients (N + P₂O₅ + K₂O) is estimated at 30.64 million metric tonnes (MT) for 2023-24, reflecting a 2.7% increase compared to 2022-23. During this period,

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Nitrogen (N) Consumption is estimated at 20.46 million MT (up 1.2%), Phosphorus ($P_2 O_5$) at 8.31 million MT (up 4.9%), and Potassium ($K_2 O$) at 1.88 million MT (up 9.5%) (Anonymous 2025) [2]. the availability of nutrients to plants, soil fertility, and soil health were all negatively impacted by unbalanced and excessive fertilizer application. Additionally, it resulted in nutrient losses from the fields due to leaching and gas emissions, which are the main causes of environmental degradation. Nanotechnology created nanofertilizers with particles smaller than 100 nm to solve all of these issues. Through bio-fortification, foliar application of nano fertilizers, such as nano urea, improves crop nutritional quality and NUE while reducing soil salt buildup. (Kumar *et al.* 2021) [15].

Liquid nano urea, developed by the Indian Farmers' Fertilizer Cooperative Limited (IFFCO), is an innovative nanotechnology-based fertilizer designed to meet plants' nitrogen requirements, especially during key growth stages. Recognized by the Government of India under the Fertiliser (Inorganic, Organic or Mixed) (Control) Order 1985, this liquid formulation features extremely small particle sizes (20-50 nm, less than 100 nm overall), giving it a much larger surface area compared to conventional urea. With a nitrogen content of 4% and a shelf life of about two years, nano urea is applied as a foliar spray (2-4 ml per liter of water), which allows for efficient absorption and targeted delivery of nitrogen to the plant's most critical areas. Its high zeta potential (greater than 30) provides stability, while its superior solubility and small size enhance uptake, minimize nutrient loss to the environment, and improve physiological properties of crops, especially under drought stress. Overall, nano urea supports metabolic processes that boost yield, improve quality, and reduce overall fertilizer use (Lakshman *et al.* 2022) [6]. Wheat yields increased when nano urea (liquid) was applied topically twice throughout the tillering and jointing stages; however, there were no appreciable changes in wheat grain yield when 5% urea and nano urea were treated with 100% RDN. In terms of productivity and nitrogen consumption efficiency, two applications of nano urea performed better than one. However, the reduction in wheat production under 50% RDN could not be made up for by foliar urea or nano urea application. (Bishwas *et al.* 2024) [16]. When compared to the other treatments, foliar nutrient injection significantly increased yield characteristics such plant height, number of tillers/m row, spike length, and 1000 grain weight.

Materials and Methods

A field experiment was carried out during *Rabi* season of 2024-25 at the Research Farm, Department of Agronomy, School of Agriculture, Abhilashi University, Chail Chowk Distt. Mandi (H.P). This experiment focused on the cultivation of wheat *var.* HPW 360 during the *Rabi* season of 2024-25. Sowing of the seeds was done on November 29, 2024. The design was Randomized Block Design in which the gross plot size was 3m × 2m, totaling 6 square meters, while the net plot size, the actual experimental area was 2.5 m × 1.5m, equivalent to 3.75 square meters. The study included 8 different treatments *i.e.* T₁ - Recommended N dose (1/3rd basal, 1/3rd CRI and 1/3rd Tillering), T₂ - Recommended N + one spray of nano urea at tillering (4ml L⁻¹), T₃ - Recommended N + two spray of nano urea N at tillering and jointing (4ml L⁻¹), T₄ - 75% N + water spray at tillering and jointing, T₅ - 75% N + one spray of nano urea N at tillering (4ml L⁻¹), T₆ - 75% N + two spray of nano urea N at tillering (4ml L⁻¹) and jointing (4ml L⁻¹), T₇ - 50% N + two spray nano urea N at tillering (4ml L⁻¹) and jointing (4ml L⁻¹) and T₈ - Control (No fertilizer) with each treatment replicated three

times, resulting in a total of 24 plots. To maintain separation between replications, a gap of 1 meter was maintained. This experimental setup aimed to explore various aspects of wheat growth and performance under different conditions and treatments. Composite soil sample was collected before to the experiment start from all three replications. It was found that the soil of experimental field was acidic in nature, low in organic carbon content and available phosphorous, medium in potassium and slightly deficient or low in available nitrogen. Harvesting is done when 90% of the grain population has turned yellow and data processing in the study was carried out with the ANOVA test.

Result and discussion

Plant height

An observation of data in table 4.1 and fig. 4.1 indicated that significantly taller height plants of wheat were produced with the application of recommended N + two spray of nano urea N at tillering and jointing (4ml L⁻¹) (T₃) which remained statically at par with the application of 75% N + two spray of nano urea N at tillering (4ml L⁻¹) and jointing (4ml L⁻¹) (T₆). The lowest plant height was measured in the absolute control plot *i.e.* no fertilizer applied. The increased plant height under higher nitrogen level along with nano urea spray was due to improved nitrogen use efficiency and continuous nutrient availability during critical growth stages of the crop. Similar findings were reported by Ojha *et al.* (2023) [8] and Midde *et al.* (2022) [7] who observed the improvement in plant height with 100% recommended dose of nitrogen along with foliar application of nano urea.

Number of tillers (m⁻²)

Data regarding number of tillers per square meter have been presented in table 4.2 and depicted graphically in fig.4.2. The result indicated that treatment T₃ recorded the highest number of tillers per meter square due to the nano urea boosts wheat tillering by providing nitrogen directly to the leaves and promoting higher number of tillers per meter square which remaining at par with treatment T₆ resulted in significantly higher number of tillers per square meter at critical stages of observations. Significantly lowest number of tillers was recorded under the treatment T₈ at all the stages of observations due to absence of the nitrogen supplementation through nano urea, which resulted in limited vegetative growth and reduced the tiller production. This might perhaps be described to be adequate availability of nitrogen during entire growth period of the crop which increased the utilization and absorption of nitrogen by growing plant from the soil as the result of least competition for nitrogen. Increased levels of nitrogen resulted in reduction of mortality of tillers and produced more tillers from the main stem. The similar result was also observed by the Singh and Agarwal (2001) [12] reported that adequate nitrogen supply and foliar application of nano nitrogen fertilizers significantly increased the number of tillers per square meter due to improved nitrogen availability and enhanced vegetative growth.

Dry matter accumulation

The effect of foliar application on nano urea on dry matter accumulation on wheat crop as presented in the table 3 and fig. 3. The application of (T₃) recommended N + two spray of nano urea N at tillering and jointing (4ml L⁻¹) produced significantly higher dry matter accumulation which was statistically at par with treatment (T₆) (75% N + two spray of nano urea N at tillering (4ml L⁻¹) and jointing (4ml L⁻¹)) at critical stages of observations. Significantly lowest dry matter accumulation per

square meter was recorded under treatments T₈ (Absolute control plot) at all the stages of observations. The primary cause of the lowest dry matter accumulation in control plot (T₈) was the developing plant's inability to obtain enough nitrogen, which led to the crop's worse development and lowest dry weight however in treatment T₃ improved nitrogen use efficiency through foliar feeding have supported continuous biomass accumulation. Comparable results were reported by Ojha *et al.* (2023) [8] who reported that the higher levels of nitrogen management and the suggested nano urea led to a greater buildup of dry matter in wheat plants.

Yield attributes

On close scanning of data presented in the table 4 and fig.4 reported that the maximum number of effective tillers, spike length and number of grains per spike was recorded under the treatment T₃ (Recommended N + two spray of nano urea N at tillering and jointing (4 ml L⁻¹) and remained statistically at par with treatment T₆ (75% N + two spray of nano urea N at tillering (4 ml L⁻¹) and jointing (4 ml L⁻¹) application of nano urea which improved nitrogen use efficiency in reproductive stage, which resulting in better grain formation and development in wheat crop. Whereas, the minimum number of effective tillers, spike length and number of grains per spike under treatment T₈ (Control) because of the no fertilizer was applied in this treatment during investigation resulted in lesser number of grains pr spike. But in case of test weight the treatments did not have any significant influence on the test weight of wheat grains. Treatment T₃ recorded the maximum test weight, while where nitrogen was not applied T₈ recorded the minimum test weight. The results indicated that the nitrogen plays a key role in the growth and enhancement of the wheat grain. Sharma *et al.* (2018) observed that lower nitrogen availability in control

treatments resulted in poor grain filling and comparatively lower 1000-grain weight in wheat. Similar result was also observed by the Midde *et al.* (2022) [7] and Prasad *et al.* (2014) [10].

Yield

Data pertaining to yield as influenced by different nitrogen level practices have been presented in table 5 and delineated through fig 5. Among the different nitrogen level management practices, treatment T₃ {Recommended N + two spray of nano urea N at tillering and jointing (4ml L⁻¹)} recorded significantly highest grain yield, straw yield and biological yield and it was at par with the treatment T₆ {75% N + two spray of nano urea N at tillering (4ml L⁻¹) and jointing (4ml L⁻¹)} respectively which was mainly due to higher plant height, dry matter accumulation, number of effective tillers, test weight etc. where all these growths and yield attributing characters contributed to final straw yield of the wheat crop whereas, the control treatment (T₈) in which no fertilizers will be applied recorded lowest grain yield, straw yield and biological yield. Higher grain yield, straw yield and biological yield due to no application of any fertilizer in the control plot which ultimately hinder the crop growth resulting in lesser straw yield. The productivity of wheat (grain) increased with an increasing dose of N fertilizer and nano urea supplied N directly, which led to an increase in the leaf area index, photosynthesis, and translocation of nutrients from the soil to plant. The recommended nitrogen combined with nano-urea sprays was attributed to improved nutrient availability and enhanced physiological growth processes (Dimkpa and Bindraban 2018, Raliya *et al.* 2018) [3, 11]. However, in harvest index there was no significant effect of treatments on the harvest index of the wheat crop. However, the data shows that the maximum harvest index was achieved with T₃ {Recommended N + two spray of nano urea N at tillering and jointing (4ml L⁻¹)} and the minimum harvest index was achieved with T₈ (control). The non-significant effect of treatments on harvest index may be attributed to proportional increases in grain and straw yield under improved nutrient supply, which maintains similar partitioning efficiency among treatments (Fageria *et al.* 2011) [4]. Similar results were also obtained by Singh & Singh (2017) [13].

Table 1: Effect of Nitrogen rates and foliar application of nano-urea on plant height (cm) of wheat crop

Sr. No.	Treatment	Plant height (cm)					
		30 DAS	60 DAS	90 DAS	120 DAS	150 DAS	At Harvest
T ₁	Recommended N dose (1/3 rd basal, 1/3 rd CRI and 1/3 rd Tillering)	12.15	36.11	63.26	79.11	99.73	96.66
T ₂	Recommended N + one spray of nano urea at tillering (4ml L ⁻¹)	11.09	35.85	68.02	85.89	101.73	99.97
T ₃	Recommended N + two spray of nano urea N at tillering and jointing (4ml L ⁻¹)	14.47	42.89	70.44	90.06	106.37	104.07
T ₄	75% N	10.05	31.33	61.85	72.65	94.40	90.90
T ₅	75% N + one spray of nano urea N at tillering (4ml L ⁻¹)	10.60	34.14	60.42	69.45	92.04	91.37
T ₆	75% N + two spray of nano urea N at tillering (4ml L ⁻¹) and jointing (4ml L ⁻¹)	13.37	39.00	58.04	66.56	85.28	82.70
T ₇	50% N + two spray nano urea N at tillering (4ml L ⁻¹) and jointing (4ml L ⁻¹)	12.84	34.70	54.66	64.38	82.63	79.01
T ₈	Control (No fertilizer)	8.46	27.65	44.40	60.09	74.10	70.00
	SEM±	20.55	9.22	5.24	5.44	3.64	4.17
	CD (P=0.05)	NS	5.68	5.52	7.00	5.86	6.52

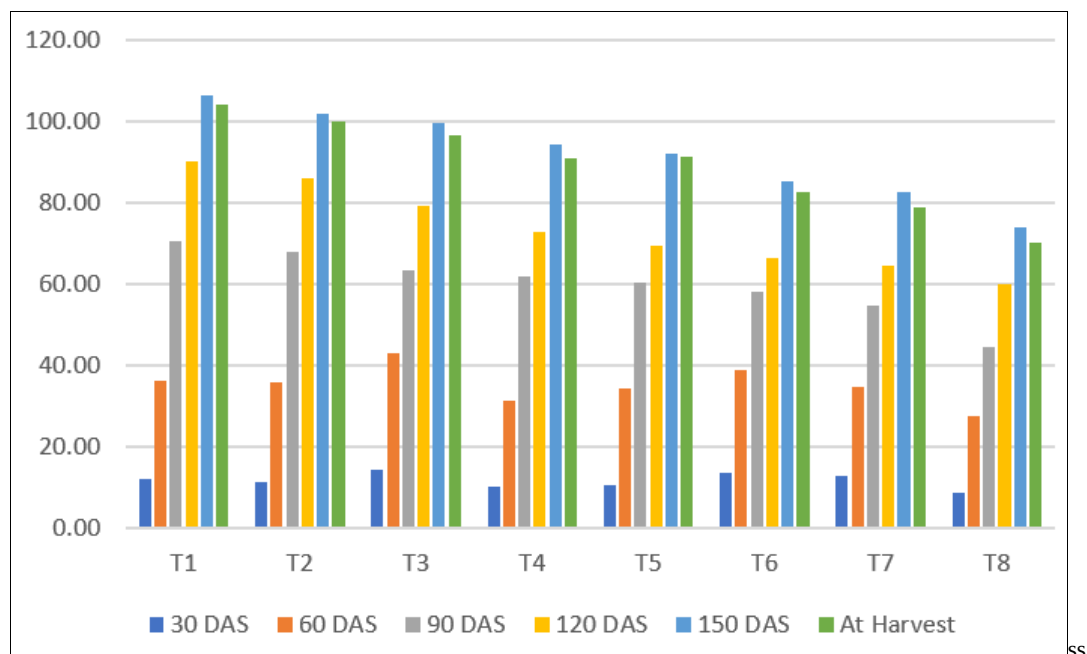


Fig 1: Effect of Nitrogen rates and foliar application of nano-urea on plant height (cm) of wheat crop

Table 2: Effect of Nitrogen rates and foliar application of nano-urea on No. of tillers (m^{-2}) of wheat crop

Sr. No.	Treatment	No. of Tillers (m^{-2})					
		30 DAS	60 DAS	90 DAS	120 DAS	150 DAS	At Harvest
T ₁	Recommended N dose (1/3 rd basal, 1/3 rd CRI and 1/3 rd Tillering)	149.42	187.71	230.78	310.26	302.66	298.19
T ₂	Recommended N + one spray of nano urea at tillering (4ml L ⁻¹)	145.89	196.06	260.55	358.54	350.79	347.72
T ₃	Recommended N + two spray of nano urea N at tillering and jointing (4ml L ⁻¹)	160.50	210.72	290.45	390.17	382.34	378.61
T ₄	75% N	136.28	162.26	180.84	260.11	255.11	245.45
T ₅	75% N + one spray of nano urea N at tillering (4ml L ⁻¹)	140.14	170.76	220.47	330.48	323.17	315.56
T ₆	75% N + two spray of nano urea N at tillering (4ml L ⁻¹) and jointing (4ml L ⁻¹)	156.92	206.33	270.85	365.11	360.71	355.05
T ₇	50% N + two spray nano urea N at tillering (4ml L ⁻¹) and jointing (4ml L ⁻¹)	150.72	198.36	250.88	335.10	322.44	317.43
T ₈	Control (No fertilizer)	130.53	150.74	170.88	200.14	190.84	188.14
	Sem±	11.49	2.80	5.04	5.11	4.48	4.63
	CD (P=0.05)	NS	9.10	20.69	28.51	24.40	24.82

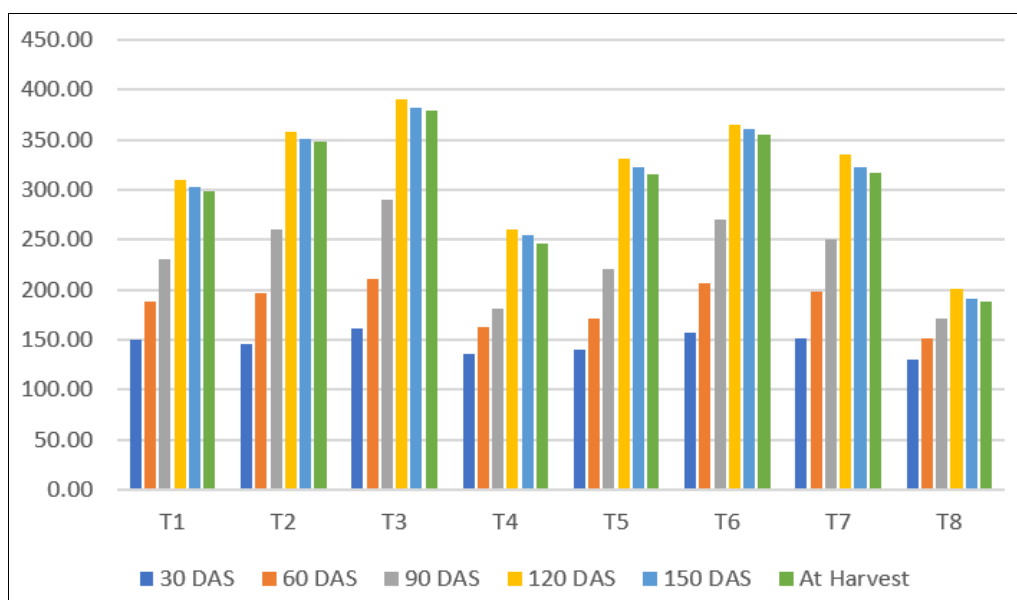
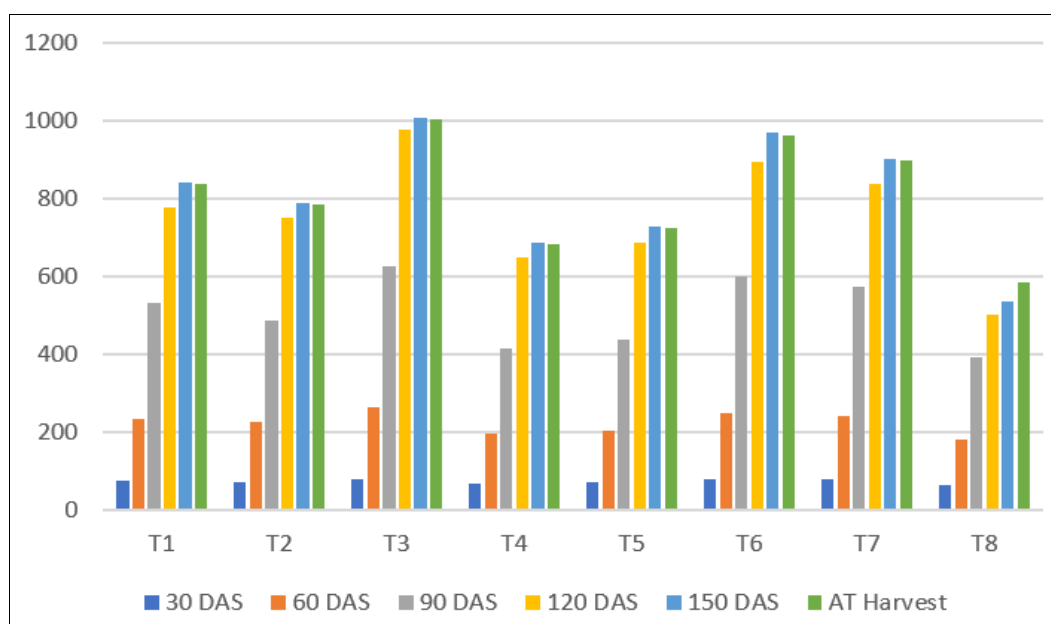


Fig 2: Effect of Nitrogen rates and foliar application of nano-urea on No. of tillers (m^{-2}) of wheat crop

Table 3: Effect of Nitrogen rates and foliar application of nano-urea on dry matter accumulation (gm^{-2}) of wheat crop

Sr. No.	Treatment	Dry matter accumulation (gm^{-2})					
		30 DAS	60 DAS	90 DAS	120 DAS	150 DAS	At Harvest
T ₁	Recommended N dose (1/3 rd basal, 1/3 rd CRI and 1/3 rd Tillering)	72.94	225.25	485.02	750.50	789.01	783.01
T ₂	Recommended N + one spray of nano urea at tillering (4ml L ⁻¹)	74.71	235.27	530.79	775.65	840.92	835.92
T ₃	Recommended N + two spray of nano urea N at tillering and jointing (4ml L ⁻¹)	80.25	262.05	626.63	975.42	1008.95	1003.95
T ₄	75% N	68.14	194.71	415.93	650.27	686.30	681.30
T ₅	75% N + one spray of nano urea N at tillering (4ml L ⁻¹)	70.07	204.91	438.86	687.85	728.47	724.47
T ₆	75% N + two spray of nano urea N at tillering (4ml L ⁻¹) and jointing (4ml L ⁻¹)	78.46	247.59	598.41	892.77	967.98	963.98
T ₇	50% N + two spray nano urea N at tillering (4ml L ⁻¹) and jointing (4ml L ⁻¹)	77.75	240.03	575.03	837.75	902.83	898.83
T ₈	Control (No fertilizer)	65.26	180.88	393.02	500.35	534.35	586.35
	Sem±	9.71	5.30	5.49	6.35	6.41	5.02
	CD (P=0.05)	NS	20.74	48.87	84.36	91.40	71.08

**Fig 3:** Effect of Nitrogen rates and foliar application of nano-urea on dry matter accumulation (gm^{-2}) of wheat crop**Table 4:** Effect of Nitrogen rates and foliar application of nano-urea on yield attributes of wheat crop

Sr. No.	Treatment	No. of effective tillers (m^{-2})	Spike length (cm)	No. of grain per spike	Test weight (g)
T ₁	Recommended N dose (1/3 rd basal, 1/3 rd CRI and 1/3 rd Tillering)	294.19	12.46	35.59	43.52
T ₂	Recommended N + one spray of nano urea at tillering (4ml L ⁻¹)	271.29	11.99	33.44	42.28
T ₃	Recommended N + two spray of nano urea N at tillering and jointing (4ml L ⁻¹)	351.27	15.45	42.80	46.37
T ₄	75% N	238.17	11.28	32.26	44.03
T ₅	75% N + one spray of nano urea N at tillering (4ml L ⁻¹)	252.23	11.65	30.78	45.24
T ₆	75% N + two spray of nano urea N at tillering (4ml L ⁻¹) and jointing (4ml L ⁻¹)	337.41	13.33	40.49	45.62
T ₇	50% N + two spray nano urea N at tillering (4ml L ⁻¹) and jointing (4ml L ⁻¹)	317.04	12.78	36.52	45.39
T ₈	Control (No fertilizer)	186.95	10.32	29.71	40.84
	Sem±	5.36	11.41	6.53	8.59
	CD (P=0.05)	26.36	2.40	4.03	NS

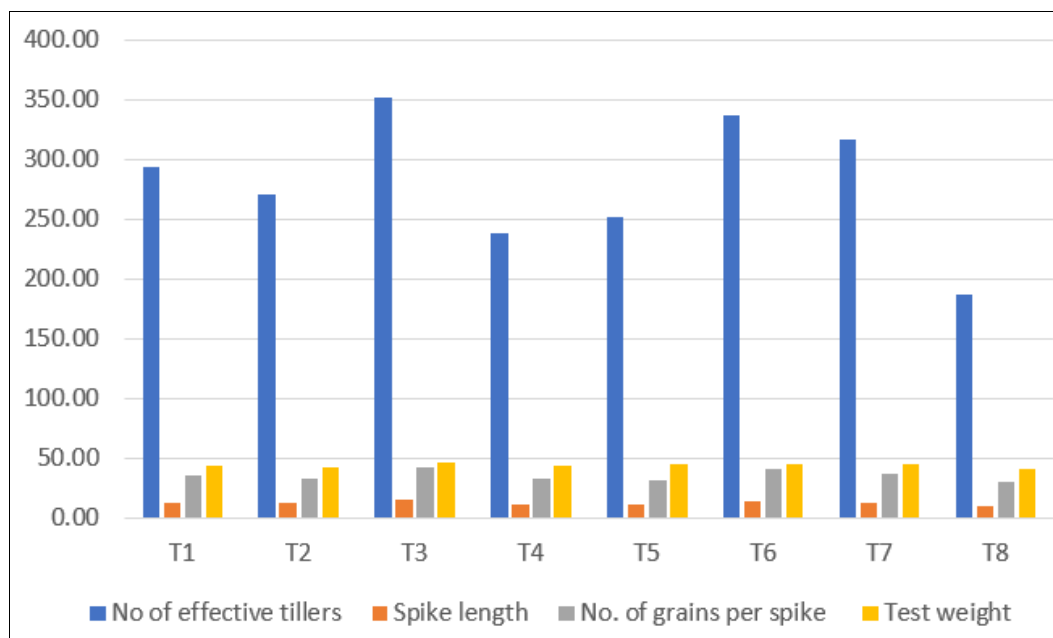


Fig 4: Effect of Nitrogen rates and foliar application of nano-urea on yield attributes of wheat crop

Table 5: Effect of Nitrogen rates and foliar application of nano-urea on yield of wheat crop

Sr. No.	Treatment	Grain yield (q ha ⁻¹)	Straw yield (q ha ⁻¹)	Biological yield (q ha ⁻¹)	Harvest index (%)
T ₁	Recommended N dose (1/3 rd basal, 1/3 rd CRI and 1/3 rd Tillering)	39.32	49.72	89.13	44.15
T ₂	Recommended N + one spray of nano urea at tillering (4ml L ⁻¹)	37.88	46.65	84.53	44.81
T ₃	Recommended N + two spray of nano urea N at tillering and jointing (4ml L ⁻¹)	45.56	58.71	104.27	43.69
T ₄	75% N	33.39	42.54	75.93	43.97
T ₅	75% N + one spray of nano urea N at tillering (4ml L ⁻¹)	35.44	44.87	80.31	44.12
T ₆	75% N + two spray of nano urea N at tillering (4ml L ⁻¹) and jointing (4ml L ⁻¹)	43.87	56.76	100.63	43.59
T ₇	50% N + two spray nano urea N at tillering (4ml L ⁻¹) and jointing (4ml L ⁻¹)	41.13	53.66	94.79	43.39
T ₈	Control (No fertilizer)	30.64	41.28	71.92	42.60
	Sem±	4.99	4.32	4.89	29.73
	CD (P=0.05)	3.35	3.73	7.51	NS

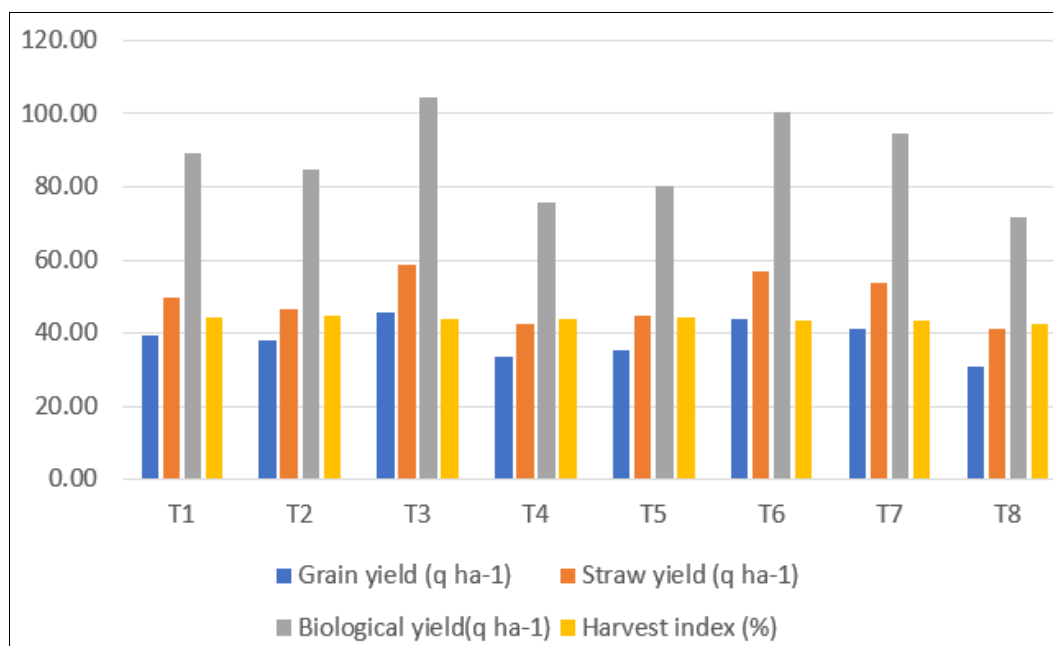


Fig 5: Effect of Nitrogen rates and foliar application of nano-urea on yield of wheat crop

Conclusion

The investigation revealed that application of T₃ (Recommended N + two spray of nano urea N at tillering and jointing (4ml L⁻¹) and T₆ {75% N + two spray of nano urea N at tillering (4ml L⁻¹)

and jointing (4ml L⁻¹)} had a significant impact on the growth and yield attributes of wheat crops. The impact of different nitrogen levels on the availability of nitrogen, Phosphorus, and potassium after the harvest of crop was found to be significant.

Treatment T₃ (Recommended N + two spray of nano urea N at tillering and jointing (4ml L⁻¹) recorded the highest available nitrogen, phosphorous and potassium after harvest. Treatment T₃ (Recommended N + two spray of nano urea N at tillering and jointing (4ml L⁻¹) recorded the higher gross return, net returns (ha¹) and benefit cost.

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