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Effect of nutrient management on growth and yield of wheat (*Triticum aestivum* L.) in Chhattisgarh Plain

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Abstract
The present experiment was conducted at Indira Gandhi Krishi Vishwavidyalaya, Barrister Thakur Chhedilal College of Agriculture and Research station, Bilaspur Chhattisgarh during *rabi* season of 2023-24 with a view to study the "Effect of nutrient management on growth and yield of wheat (*Triticum aestivum* L.) in Chhattisgarh Plain" The experiment was conducted in randomized block design and the treatments were consisted of seven levels of nutrient combination and three replications. Results revealed that treatment T_4 (100% RDN + 2 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering and panicle initiation stages) recorded the highest plant height, number of total tillers, dry matter accumulation (g plant-^{l}), effective tillers (388.53 m^{-2}) ear length (12.15 cm), number of grains ear^{-1} head (28.80), test weight (42.38 g), grain yield (41.50 q ha^{-1}) and straw yield (43.12 q ha^{-1}) which was significantly superior over other treatments but was at par with T_2, T_3 and T_7 treatments.

Keywords: Nitrogen, phosphorus and nano-DAP, wheat, yield, yield attributes

Introduction
Wheat (*Triticum aestivum* L.) is a significant food grain crop that feeds around 36 percent of the world's population and is responsible for the green revolution in the Indian subcontinent. Compared to other cereal crops, wheat is primarily utilized as a staple food and higher in protein. It can be consumed in various kinds of foods including bread, cakes, biscuits, bakery goods and sweets. Due to its high nutritional composition (65-75% carbohydrate, 8-13% protein, 0.8-1.5% oil and fat, 0.3-0.5% mineral elements and 0.2% cellulose), wheat has become a more significant crop for human consumption (Sultana and Sheikh, 2022).
Across the world, wheat has occupied 224.05 M ha of land, producing 793.37 Mt of grain and 3.52 t ha^{-1} of productivity (Anonymous, 2023 a.) [2, 3]. A approximately 13.54 percent of global wheat production, India is the world's second-largest producer behind China and the crop has given Indian agriculture the quickest rate of development. In India, wheat cultivated 31.82 M ha during 2021-2022 and produced 112.74 Mt with an average productivity of 3.4 t ha^{-1} (Anonymous, 2023 b.) [2, 3]. In Chhattisgarh, wheat is a significant crop and cultivated on an area of 0.22 M ha with an average productivity of 1.6 t ha^{-1} during 2020-21 (Anonymous, 2022) [1].
Nitrogen is one of the major essential nutrients applied to the crop for higher vegetative growth, productivity and quality (Iqbal *et al.*, 2012) [5]. One of the most vital elements for plant growth and development is phosphorus. It contributes in several of essential plant functions, such as the transmission of energy, photosynthesis, the transformation of carbohydrates and starches, the movement of nutrients throughout the plant. It uses a potassium ion to control the stomata's opening and shutting. The most significant increase in leaf and stem length must be obtained by protecting turgor pressure with potassium.
Materials with a single unit size in at least one dimension between 1 and 100 nm are referred to as nanomaterials (Liu and Lal, 2015) [8]. Scientists created nano-fertilizers by utilising nanotechnology. The term "nano-fertilizer" describes a structure that is between 1 and 100 nm in size and is intended to provide nutrients to crops. Furthermore, this term should be expanded to include bulk materials that are combined with nanoscale structure to produce new products (for example-fertilizer molecules coated in metal nanoparticles). In respect to better nutrient use efficiency, less fertilizer waste and lower cultivation costs, nano fertilizer is a valuable tool in agriculture for enhancing crop growth, yield and quality parameters (Mahil and Kumar, 2019) [9].

Nano-fertilizers have been shown to increase productivity through target delivery or slow release of nutrients, thereby limiting the rate of fertilizer application (Kah *at al*., 2019) [6].

The Indian Farmers Fertilizer Co-operative (IFFCO) recently introduced nano DAP fertilizer in India for demonstration and experimentation in agriculture field. The same amount of N (9kg) and P_2O_5 (23kg) obtained from 50 kg of DAP fertilizer is contained in 500 ml of liquid nano-DAP fertilizer. Its formulation contains nitrogen (8.0% N w/v) and phosphorus (16% P_2O_5 w/v).

Materials and Methods

A field experiment was conducted during *rabi* season of 2023-24 at the Research Farm, Barrister Thakur Chhedilal College of Agriculture and Research station, Bilaspur Chhattisgarh. The wheat variety 'C.G.1044 was sown on 24th December 2023 and harvested 31st march 2024. The soil of the experimental plot was sandy clay loam in texture, low organic carbon (0.50%), low in available nitrogen (213.38 kg ha^{-1}), medium in available phosphorus (10.77 kg ha^{-1}) and medium in available potassium (265.45 kg ha^{-1}). The experiment was laid out in randomized block design (RBD) with seven treatments and three replications. The treatment comprised of T_1: 100% RDN, T_2: 100% RDN + 1 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at tillering stage, T_3: 100% RDN + 1 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at panicle initiation stage, T_4: 100% RDN + 2 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at tillering and panicle initiation stages, T_5: 75% NP + 100% K + 1 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at tillering stage, T_6: 75% NP +100% K + 1 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at panicle initiation stage, T_7: 75% NP +100% K + 2 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at tillering and panicle initiation stages.

To evaluate the treatment effect, the various morphological observations, growth analysis and yields were recorded in the experiment at 30, 60, 90 days after sowing and at harvest. The recommended dose of nutrient for wheat are 100:60:40 kg of N, P_2O_5 and K_2O kg ha^{-1} respectively. Full dose of P_2O_5, K_2O kg ha^{-1} were applied as basal in all the plots through single superphosphate and muriate of potash, respectively. As per the treatment nitrogen was applied in three splits *viz.* half as basal and the remaining half was top dressed equally after 1st and 2nd irrigation. Foliar spray of nano-DAP at tillering and panicle initiation stages. Growth parameters were recorded before harvesting of crop. Harvesting was done when the ear head matured and plant was dried up. The threshing of the crop was done by manually by plot wise and grain, straw were collected separately.

Results and Discussion

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads.

Plant height (cm)

Among the different treatments has significantly effect of plant height of wheat under the investigation. Treatment T_4 (100% RDN + 2 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at tillering and panicle initiation stages) at 30 (38.01 cm), 60 (82.12 cm), 90 DAS (98.29 cm) and at harvest (96.77 cm) recorded significantly maximum plant height. However, it was at par with T_2 (100% RDN + 1 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at tillering stage), T_3 (100% RDN + 1 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at panicle initiation stage) and T_7 (75% NP +100% K + 2 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at tillering and panicle initiation stages) treatments. Further, treatment T_2 (100% RDN + 1 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at tillering stage) sturd in 2nd position but at par with T_3, T_7 and T_1 treatments. Similarly, T_6 (75% NP +100% K + 1 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at panicle initiation stage) at 30 (31.62 cm), 60 (71.75 cm), 90 DAS (87.29 cm) and at harvest (85.52 cm) recorded significantly minimum plant height and at par with T_5 and T_1 treatments.

Table 1: Effect of nutrient management on plant height at different growth stages of wheat

Treatments		Plant height (cm)			
		30 DAS	**60 DAS**	**90 DAS**	**At harvest**
T_1	100% RDN	34.28	75.30	90.90	89.79
T_2	100% RDN + 1 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at tillering stage	36.61	79.51	95.59	93.82
T_3	100% RDN + 1 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at panicle initiation stage	36.40	78.32	95.16	93.22
T_4	100% RDN + 2 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at tillering and panicle initiation stages	38.01	82.12	98.29	96.77
T_5	75% NP + 100% K + 1 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at tillering stage	32.41	73.14	88.34	87.67
T_6	75% NP +100% K + 1 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at panicle initiation stage	31.62	71.75	87.29	85.52
T_7	75% NP +100% K + 2 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at tillering and panicle initiation stages	35.65	77.89	93.96	92.71
	S.E.M. (±)	0.76	1.39	1.54	1.44
	CD (5%)	2.37	4.29	4.75	4.44

Number of total tillers (m^{-2})

The maximum number of tillers (m^{-2}) at 30 (219.20), 60 (326.05), 90 DAS (395.68) and at harvest (388.53) were recorded in treatment T_4 (100% RDN + 2 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at tillering and panicle initiation stages) which was significantly higher as compare to other treatment (Table 2), which was at par with T_2, T_3, and T_7 treatments. Similarly, T_6 (75% NP +100% K + 1 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at panicle initiation stage) at 30 (194.85), 60 (296.05), 90 DAS (376.85) and at harvest (369.80) recorded significantly minimum number of total tillers and at par with T_5 and T_1 treatments.

Table 2: Effect of nutrient management on number of total tillers at different growth stages of wheat

Treatments		Number of total tillers (m^{-2})			
		30 DAS	60 DAS	90 DAS	At harvest
T_1	100% RDN	203.20	309.18	381.43	375.75
T_2	100% RDN + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering stage	214.39	321.15	392.71	386.57
T_3	100% RDN + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at panicle initiation stage	211.07	317.00	387.54	383.33
T_4	100% RDN + 2 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering and panicle initiation stages	219.20	326.05	395.68	388.53
T_5	75% NP + 100% K + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering stage	196.56	300.54	378.64	373.55
T_6	75% NP +100% K + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at panicle initiation stage	194.85	296.05	376.85	369.80
T_7	75% NP +100% K + 2 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering and panicle initiation stages	208.11	315.88	384.41	380.45
	S.E.M. (±)	3.63	3.93	4.03	4.01
	CD (5%)	11.31	12.11	12.43	12.38

Dry matter accumulation (g plant^{-1})

As shown in the table 3 dry matter accumulation did not become statistically significant at 30 DAS. However, significant variances were observed in 60, 90 DAS and at harvest. The highest dry matter accumulation was (*viz.*, 0.65, 8.45, 19.60 and 25.31) in treatment T_4 (100% RDN + 2 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering and panicle initiation stages). However, it was at par with T_2 (100% RDN + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering stage), T_3 (100% RDN + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at panicle initiation stage) and T_7 (75% NP +100% K + 2 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering and panicle initiation stages). Further, treatment T_2 (100% RDN + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering stage) sturd in 2nd position but at par with T_3, T_7 and T_1 treatments. Similarly, T_6 (75% NP +100% K + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at panicle initiation stage) recorded significantly minimum dry matter accumulation was (*viz.*, *s*0.60, 6,91, 14.74 and 20. 35) and at par with T_5 and T_1 treatments. This result was confirmative with Rahman *et al.* (2014) [11].

Table 4: Effect of nutrient management on dry matter accumulation at different growth stages of wheat

Treatments		Dry matter accumulation (g plant^{-1})			
		30 DAS	60 DAS	90 DAS	At harvest
T_1	100% RDN	0.62	7.67	16.25	22.01
T_2	100% RDN + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering stage	0.64	8.28	18.38	24.08
T_3	100% RDN + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at panicle initiation stage	0.64	8.13	18.16	23.50
T_4	100% RDN + 2 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering and panicle initiation stages	0.65	8.45	19.60	25.31
T_5	75% NP + 100% K + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering stage	0.61	7.12	15.59	20.49
T_6	75% NP +100% K + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at panicle initiation stage	0.60	6.91	14.74	20.35
T_7	75% NP +100% K + 2 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering and panicle initiation stages	0.63	7.80	17.48	23.37
	S.E.M (±)	0.01	0.25	0.71	0.68
	CD (5%)	NS	0.77	2.2	2.11

Effective tillers (m^{-2}) at harvest

Table 5 indicated that the different treatments has significantly effect of effective tillers of wheat under the investigation. Treatment T_4 (100% RDN + 2 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering and panicle initiation stages) at 30 (219.20), 60 (326.05), 90 DAS (395.68) and at harvest (388.53) significantly maximum number of effective tillers m^{-2} (388.53). However, it was at par with T_2 (100% RDN + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering stage), T_3 (100% RDN + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at panicle initiation stage) and T_7 (75% NP +100% K + 2 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering and panicle initiation stages) treatments. Further, treatment T_2 (100% RDN + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering stage) sturdy in 2nd position but at par with T_3, T_7 and T_1 treatments. Similarly, T_6 (75% NP +100% K + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at panicle initiation stage) at 30 (194.85), 60 (296.05), 90 DAS (376.85) and at harvest (369.80) recorded significantly minimum number of effective tillers m^{-2} (369.80) and at par with T_5 and T_1 treatments.

Ear length (cm): Among the different treatments has significantly effect of ear length of wheat under the investigation. Treatment T_4 (100% RDN + 2 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering and panicle initiation stages) significantly higher ear length (12.15 cm). However, it was at par with T_2 (100% RDN + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering stage), T_3 (100% RDN + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at panicle initiation stage) and T_7 (75% NP +100% K + 2 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering and panicle initiation stages). Further, treatment T_2 (100% RDN + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering stage) sturd in 2nd position but at par with T_3, T_7 and T_1 treatments. Similarly, T_6 (75% NP +100% K + 1foliar spray of nano-DAP @ 3 ml liter^{-1} of water at panicle initiation stage) recorded significantly lower ear length (10.02 cm) and at par with T_5 and T_1 treatments (Table 5).

Number of grains ear^{-1} head

Table 5 indicated that the different treatments has significantly effect of number of grains ear^{-1} head of wheat under the investigation. Treatment T_4 (100% RDN + 2 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering and panicle initiation stages) significantly higher number of grains ear^{-1} head (28.80). However, it was at par with T_2 (100% RDN + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering stage), T_3 (100% RDN + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at panicle initiation stage) T_7 (75% NP +100% K + 2 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering and panicle initiation stages) treatments. Similarly, T_6 (75% NP +100% K + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at panicle initiation stage) recorded significantly lower number of grains ear^{-1} head (26.25) and at par with T_5 and T_1 treatments. This result was confirmative with Patel *et al*. (2021) [10].

Test weight (g): Among the different treatments has significantly effect of test weight of wheat under investigation (Table 5). Treatment T_4 (100% RDN + 2 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering and panicle initiation stages) produced significantly higher test weight (42.38 g). However, it was at par with T_2 (100% RDN + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering stage), T_3 (100% RDN + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at panicle initiation stage) and T_7 (75% NP +100% K + 2 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering and panicle initiation stages) treatments. Further, treatment T_2 (100% RDN + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering stage) sturd in 2nd position but at par with T_3, T_7 and T_1 treatments. Similarly, T_6 (75% NP +100% K + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at panicle initiation stage) recorded significantly lower test weight (41.03 g) and at par with T_5 and T_1 treatments. This result was confirmative with Rawate *et al*. (2022) [12].

Table 5: Effect of nutrient management on yield attributes of wheat

	Treatments	Effective tillers (m^{-2})	Ear length (cm)	Number of grains ear^{-1} head	Test weight (g)
T_1	100% RDN	375.75	10.62	27.32	41.44
T_2	100% RDN + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering stage	386.57	11.80	28.38	42.24
T_3	100% RDN + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at panicle initiation stage	383.33	11.02	28.34	42.11
T_4	100% RDN + 2 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering and panicle initiation stages	388.53	12.15	28.80	42.38
T_5	75% NP + 100% K + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering stage	373.55	10.32	26.93	41.17
T_6	75% NP +100% K + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at panicle initiation stage	369.80	10.02	26.32	41.03
T_7	75% NP +100% K + 2 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering and panicle initiation stages	380.45	11.11	27.84	41.73
	S.E.M (±)	4.01	0.42	0.5	0.28
	CD (5%)	12.38	1.31	1.56	0.86

Grain yield (q ha^{-1})

Table 6 indicated that the different treatments has significantly effect of grain yield of wheat under the investigation. Treatment T_4 (100% RDN + 2 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering and panicle initiation stages) produced significantly higher grain yield (41.50 q ha^{-1}). However, it was at par with T_2 (100% RDN + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering stage), T_3 (100% RDN + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at panicle initiation stage) and T_7 (75% NP +100% K + 2 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering and panicle initiation stages) treatments. Further, treatment T_2 (100% RDN + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering stage) sturd in 2nd position but at par with T_3, T_7 and T_1 treatments. Similarly, T_6 (75% NP +100% K + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at panicle initiation stage) recorded significantly lower grain yield (31.76 q ha^{-1}) and at par with T_5 and T_1 treatments. This result was confirmative with Kushare *et al*. (2009) [7], Patel *et al*. (2021) [10] and Dhaker *et al*. (2022) [4].

Straw yield (q ha^{-1}): Table 6 indicated that the different treatments has significantly effect of straw yield of wheat under the investigation. Treatment T_4 (100% RDN + 2 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering and panicle initiation stages) produced significantly higher straw yield (43.12 q ha^{-1}). However, it was at par with T_2 (100% RDN + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering stage), T_3 (100% RDN + 1 foliar spray on nano-DAP @ 3 ml liter^{-1} of water at panicle initiation stage) and T_7 (75% NP +100% K + 2 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering and panicle initiation stages) treatments. Further, treatment T_2 (100% RDN + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering stage) sturdy in 2nd position but at par with T_3, T_7 and T_1 treatments. Similarly, T_6 (75% NP +100% K + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at panicle initiation stage) recorded significantly lower straw yield (35.80 q ha^{-1}) and at par with T_5 and T_1 treatments.

Harvest index (%)

The data on harvest index was recorded at the harvest is presented in Table 6. The treatments did not show a significant effect of harvest index as recorded at harvest. Among the treatments, highest harvest index of (49.04) at harvest was recorded with the application of T_4 (100% RDN + 2 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at tillering and panicle initiation stages) and the minimum harvest index (35.80) at harvest was recorded in T_6 (75% NP +100% K + 1 foliar spray of nano-DAP @ 3 ml liter^{-1} of water at panicle initiation stage).

Table 6: Effect of nutrient management on grain yield, straw yield and harvest index of wheat

	Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)
T_1	100% RDN	36.01	38.43	48.37
T_2	100% RDN + 1 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at tillering stage	40.12	41.86	48.93
T_3	100% RDN + 1 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at panicle initiation stage	39.56	41.57	48.76
T_4	100% RDN + 2 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at tillering and panicle initiation stages	41.50	43.12	49.04
T_5	75% NP + 100% K + 1 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at tillering stage	33.90	37.18	47.69
T_6	75% NP + 100% K + 1 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at panicle initiation stage	31.76	35.80	47.01
T_7	75% RDN + 2 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at tillering and panicle initiation stages	38.05	40.58	48.39
	S.E.M. (±)	1.74	1.48	0.49
	CD (5%)	5.38	4.58	NS

Cost of cultivation (₹ ha^{-1})

The cost of cultivation for each treatment has been calculated through including up all the expenditure incurred (ha^{-1}) from sowing to bagging, including field preparation. Among nutrient management, the highest cost of cultivation (₹ 39030.00 ha^{-1}) was recorded in treatment T_4 (100% RDN + 2 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at tillering and panicle initiation stages). However, the lowest cost of cultivation of (₹ 35588.00 ha^{-1}) was recorded under treatment T_6 (75% NP +100% K + 1 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at panicle initiation stage) and T_5 presented in Table 7.

Gross return (₹ ha^{-1})

The data gross return (₹ ha^{-1}) was computed and presented in table 7. The highest gross return (₹ 101123.50 ha^{-1}) was recorded under treatment T_4 (100% RDN + 2 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at tillering and panicle initiation stages). However, the lowest gross return of (₹ 78230.00 ha^{-1}) was recorded under treatment T_6 (75% NP +100% K + 1 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at panicle initiation stage).

Net return (₹ ha^{-1}): The data net return (₹ ha^{-1}) was computed and presented in table 7. The highest net return (₹ 62093.50 ha^{-1}) was recorded in treatment T_4 (100% RDN + 2 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at tillering and panicle initiation stages). However, the lowest net return of (₹ 42642.00 ha^{-1}) was recorded under treatment T_6 (75% NP +100% K + 1 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at panicle initiation stage).

Benefit: Cost ratio

The data benefit: Cost ratio was computed and presented in table 7. The highest benefit: cost ratio (1.68) was recorded under treatment T_2 (100% RDN + 1 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at tillering stage). However, the lowest benefit: cost ratio of (1.20) was recorded under treatment T_6 (75% NP +100% K + 1 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at panicle initiation stage).

Table 7: Effect of nutrient management on economics of wheat cultivation

	Treatments	Cost of cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	Benefit: Cost ratio
T_1	100% RDN	34063.00	88040.72	53977.72	1.58
T_2	100% RDN + 1 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at tillering stage	36546.00	97813.00	61267.00	1.68
T_3	100% RDN + 1 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at panicle initiation stage	36546.00	96536.00	59990.00	1.64
T_4	100% RDN + 2 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at tillering and panicle initiation stages	39030.00	101123.50	62093.50	1.59
T_5	75% NP + 100% K + 1 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at tillering stage	35588.00	83191.50	47603.50	1.34
T_6	75% NP +100% K + 1 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at panicle initiation stage	35588.00	78230.00	42642.00	1.20
T_7	75% NP +100% K + 2 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at tillering and panicle initiation stages	38072.00	93030.25	54958.25	1.44

Conclusion

Application of T_4 (100% RDN + 2 foliar spray of nano-DAP @ 3 ml $liter^{-1}$ of water at tillering and panicle initiation stages) indicated significantly highest grain (41.50 q ha^{-1}) and straw (43.12 q ha^{-1}) yield of wheat.

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