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Effect of foliar spray of Nano DAP on growth of wheat (*Triticum aestivum* L.)

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Abstract

A field experiment was conducted during *rabi* 2022-23 at Palampur to study the effects of foliar spray of nano DAP on the growth of wheat. The experiment was conducted in Randomized Complete Block Design with twelve treatments, replicated thrice. Application of 75 % NP along with seed treatment with nano – DAP and two foliar sprays of nano – DAP @ 0.4 % increased plant height by 60.49%, 38.33%, 43.79%, 40.99% and 42.59% at 30, 60, 90 DAS and at harvest compared to the control. Statistically similar results were observed with treatment 100 % NPK as well as all other treatments where either 50 or 75 % recommended NP was applied along with seed treatment and foliar application of nano – DAP. Application of 75 % NP along with seed treatment and two foliar sprays of nano DAP enhanced crop growth rate, relative growth rate, yield attributes and ultimately increased grain yield.

Keywords: CGR, growth, nano DAP, RGR, wheat

Wheat (*Triticum aestivum* L.) is an important food grain crop of the world including India (Farooq *et al*. 2015). In India, wheat occupies an area of 29.3 million hectares, with a total production of 103.6 million tonnes and 3,533 kg/ha productivity (Anonymous 2021a). In Himachal Pradesh, total area under wheat cultivation is 319 thousand hectares with total production of 564.63 thousand tonnes (Anonymous 2021b). Indian agriculture production systems are mainly rely on chemical fertilizers but during the past few decades, use efficiencies of N, P, and K fertilizers have remained constant as 30-35%, 15-20% and 35-40%, respectively, attributed to variety of factors *viz*., leaching, degradation by photolysis, hydrolysis and volatilization etc (Tarafdar *et al*. 2016).

Most importantly, India currently imports significant quantities of fertilizer to meet domestic demand. The fertilizer market in India experienced a significant increase in imports during the year 2023, with a remarkable overall growth of 25% compared to the previous year (Anonymous 2023). Among the imported fertilizers, DAP, showed impressive growth rates of 52%, surpassing the imports recorded in the year 2022 (Anonymous 2023). In order to address issues of low fertilizer use efficiency, imbalanced fertilization, multi-nutrient deficiencies and decline of soil organic matter, it is indeed need of the day to evolve the nano-based fertilizer formulations with multiple functions.

The newly created nano-fertilizer will reduce chemical fertilizer consumption, saving significant foreign exchange on fertilizer imports (Poudel *et al*. 2023). In India, nano-DAP (Diammonium Phosphate) with size ranges from 10 to 30 nanometers was recently introduced by Indian Farmers Fertilizer Cooperative Limited (IFFCO) to meet the demands of farmers. It contains 8 per cent nitrogen and 16 per cent phosphorus by weight in its nano form. The finance minister in the Interim Budget 2024-25 has announced the expansion of the application of Nano DAP as a fertilizer on various crops in all agro-climatic zones. As a part of the Union Government Aatma Nirbhar Bharat's initiative to promote self-sufficiency in fertilizers, it is advising and supporting the Indian fertilizer companies to strengthen their backend supply chain.

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Materials and Methods

The experiment was carried out at the Research Farm of Fodder Section, College of Agriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur during *rabi* 2022-23, to study the effect of foliar spray of nano DAP on growth of wheat (*Triticum aestivum* L.). The experimental site was at 32° 06' N latitude, 76° 542 E longitude and at an altitude of 1290 m above mean sea level. Experimental site falls under sub-temperate mid hill zone of Himachal Pradesh. It lies in North-West Himalaya in the Palam Valley of Kangra district of Himachal Pradesh, India. Soil of the experimental site was silty clay loam in texture, acidic in reaction, low in available nitrogen and medium in available phosphorus and available potassium content. The experiment was conducted in a Randomized Block Design (RBD) with twelve treatments and three replications. The treatments included; T_1: N_0P_0, T_2: $N_{100}P_{100}$, T_3: $N_{75}P_{75}$, T_4: $N_{50}P_{50}$, T_5: T_3 + Seed Treatment (ST) with nano DAP @ 5ml/kg seed + 1 spray Nano DAP @ 0.2 %, T_6: T_3 + ST + 1 spray Nano DAP @ 0.4 %, T_7: T_3 + ST + 2 spray Nano DAP @ 0.2 %, T_8: T_3 + ST + 2 spray Nano DAP @ 0.4 %,T_9: T_4 + ST + 1 spray Nano DAP @ 0.2 %,T_{10}:T_4 + ST + 1 spray Nano DAP @ 0.4 %, T_{11}: T_4 + ST + 2 spray Nano DAP @ 0.2 %,T_{12}: T_4 + ST + 2 spray Nano DAP @ 0.4 %. First spray was done 40-45 DAS and second spray was done 85 DAS. The RDF for wheat was 120:60:30 kg/ha with HPW 368 as variety. During the experimental period, the mean weekly maximum temperature ranged between 13.7°C in the 3rd standard week and 29.2°C in the 20th standard week. Furthermore, the total rainfall received during the cropping season was 483.1 mm.

The plant height of wheat was measured from the ground level to tip of the terminal growing point and expressed in cm. Crop growth rate (g/m^2/day) was computed between 30-60 DAS, 60-90 DAS and 90-120 DAS. Number of effective tillers per square meter was counted from two randomly selected meter row lengths from each net plot at the time of harvesting and the mean was calculated. This mean value was used to calculate the number of effective tillers per square meter bymultiplying it with factor 5. A representative sample of grains was taken from the produce of each net plot and1000—grains were counted by digital seed counter. Moisture content in grains was recorded and the weight of 1000 grains adjusted at 14 % moisture and expressed as 1000 grain weight in grams. Ten spikes were randomly selected from each plot and threshed. The grains were cleaned and weighed; the mean weight of ten spikes was given as grain weight per spike in grams.

Crop growth rate was calculated from the dry weight taken at different time intervals. It denotes overall growth rate of crop plant and it is measured after fix period of the time, irrespective of the previous growth rate. The value was calculated by using the formula suggested by Radford (1967).

$$CGR = \frac{W_2 - W_1}{T_2 - T_1}$$

Where,

W_1& W_2: Total dry weight (g) of plant at time T_1 and T_2

$T_2 - T_1$: Time interval (days) between two dates of observation

Relative growth rate (mg/g /day) indicate rate of growth per unit dry matter. It was computed by using formula as suggested by Blackman (1919).

$$RGR = \frac{Log_e W_2 - Log_e W_1}{T_2 - T_1}$$

Where,

W_1& W_2 : Total dry weight (g) of plant at time T_1 and T_2

$T_2 - T_1$: Time interval (days) between two dates of observation

Grain yield (q/ha) were measured by the total biomass harvested from each net plot was threshed, winnowed, cleaned and dried. Grains thus obtained were weighed in terms of kg/net plot and then converted in terms of q/ha.Data on various parameters were statistically analyzed using the method proposed by Gomez and Gomez (1984). The critical difference (CD) was calculated for parameters whose effects were significant at the 5% confidence level.

Results and Discussion

The application of nano DAP significantly affects the plant height at all stages of observation (Table 1). At 30 DAS, significantly taller wheat plants were recorded with the application of 100% NPK (T_2) though this treatment was at par with all other treatments in which 75 % recommended NP alone or along with seed treatment and foliar application of nano – DAP was applied. Nano spray effects were observed at later stages *i.e.*, at 60 DAS, 90 DAS, 120

Table1.Effect of different fertilizer treatments on plant height (cm), crop growth rate ($g/m^2/day$) and relative growth rate (mg/g/day) of wheat

	Treatment	Plant height					CGR_1	CGR_2	CGR_3	RGR_1	RGR_2	RGR_3
		30 DAS	60 DAS	90 DAS	120 DAS	At harvest	30-60 DAS	60-90 DAS	90-120 DAS	30-60 DAS	60-90 DAS	90-120 DAS
T_1	N_0P_0	8.1	18.0	39.5	60.5	61.8	0.73	3.46	5.45	45.99	42.96	23.20
T_2	$N_{100}P_{100}$	13.2	24.7	56.4	84.3	88.5	1.55	6.84	10.35	48.91	47.59	27.56
T_3	$N_{75\%}P_{75\%}$	12.6	23.8	53.9	81.5	84.9	1.36	6.00	9.91	49.00	46.84	26.69
T_4	$N_{50\%}P_{50\%}$	11.8	21.8	49.6	75.7	78.0	1.15	5.12	8.65	46.18	43.83	25.14
T_5	T_3 + Seed treatment (ST) + one spray of nano DAP @ 0.2 %of water at 40 days after sowing (DAS)	12.8	24.5	55.7	84.5	87.9	1.47	6.58	10.05	49.85	47.22	27.03
T_6	T_3 + ST + one spray of nano DAP @ 0.4 % of water at 40 DAS	12.9	24.7	56.2	84.8	88.4	1.52	6.58	10.14	49.75	48.37	27.13
T_7	T_3 + ST + Two spray of nano DAP @ 0.2 %of water (40 DAS and 85 DAS)	12.8	24.3	56.6	85.0	89.0	1.48	6.88	10.18	50.14	47.37	27.51
T_8	T_3+ ST + Two sprays of nano DAP @ 0.4 % of water (40 and 85 DAS)	13.0	24.9	56.8	85.3	89.4	1.53	6.90	10.53	50.17	49.13	27.64
T_9	T_4+ ST + one spray of nano DAP @ 0.2 %of water at 40 DAS	12.2	22.2	52.2	79.5	82.0	1.26	5.56	9.16	47.62	45.79	25.35
T_{10}	T_4+ ST + one spray of nano DAP @ 0.4 % of water at 40 DAS	12.3	22.6	52.4	80.1	82.8	1.35	5.58	9.34	47.82	46.01	25.81
T_{11}	T_4+ ST + Two spray of nano DAP @ 0.2 %of water (40 DAS and 85 DAS)	12.2	22.4	54.0	82.0	85.0	1.28	5.74	9.62	48.47	45.94	25.86
T_{12}	T_4+ ST + Two spray of nano DAP @ 0.4 % of water (40 DAS and 85 DAS)	12.4	22.8	54.2	82.1	85.3	1.35	5.79	9.84	49.08	46.19	26.14
	SEm±	0.2	0.8	1.4	1.6	1.7	0.07	0.31	0.50	1.31	1.14	0.86

DAS and at harvest (Table 1), because sprays were done at tillering and pre-flowering stages. Significantly taller plants were recorded at 60, 90,120 DAS and at harvest with the application of T_8 i.e. 75 % NP along with seeds treated with nano – DAP and two foliar sprays of nano – DAP @ 0.4 % at 40-45 DAS and 85 DAS though this treatment was at par with the application of 100 % recommended NPK (T_2) as well as all other treatments where either 50 or 75 % recommended NP was applied along with seed treatment and foliar application of nano – DAP. Further, significantly lower plant height was recorded in control treatment at all stages of observations.

The increase in plant height at 60 and 90, 120 DAS and at harvest could be a result of higher availability of nutrients with the combined application of chemical and nano fertilizers, high reactivity and surface area of nano particles aided in meeting up the immediate requirement of nitrogen and phosphorus throughout the crop period, enhancement in the enzymatic activity of photosynthesis, carbohydrate metabolism, synthesis of protein and cell division and cell elongation which in turn increased the plant height. These findings were in corroboration with the findings of Yasser *et al*. (2020) and Singh *et al*. (2021).

The CGR values were higher between 60-90 DAS and 90-120 DAS than between 30 and 60 DAS (Table 1), indicating that greater dry matter build-up occurred between 60-120 DAS. Significantly higher CGR_1 was recorded in T_2 (100% NP) which was at par with all other treatments except T_9, T_{11}, T_4, (50% NP) and control. Significantly higher CGR_2 and CGR_3 was recorded with the application of T_8 (75 % NP + seed treatment + 2 foliar sprays @ 4 ml/l water) though this treatment was at par with the application of 100 % recommended NP as well as all other treatments where either 50 or 75 % recommended NP was applied along with seed treatment and foliar application of nano – DAP. The observed increase in crop growth rate might be on account of beneficial effect of nano fertilizer in improving the availability of nutrients at different stage during crop growth period, enhancement of photosynthetic efficiency, as nano-fertilizers have been shown to improve chlorophyll content and photosynthetic rate. Moreover, nano DAP provided both the nutrients (nitrogen and phosphorus), nitrogen increased enzymatic activity, which may lead to the synthesis and transportation of photosynthetic material, resulting in an increase in plant biomass, whereas, phosphorus also contributes significantly to a number of other biological functions, such as production of high energy molecules through biomolecule synthesis, cell division, the activation and inactivation of enzymes, and the metabolism of carbohydrates, which promotes plant growth. Similar results were obtained by Sahithi *et al*. (2023) and Sahu (2023).

The application of nano DAP significantly affects the relative growth rate from 30 to 60 DAS (RGR_1) but thereafter, the effect was not significant from 60 to 90 DAS and 90 to 120 DAS (Table 1). Higher value of RGR was obtained with T_8 (75 % NP + seed treatment + 2 foliar sprays @ 4 ml/l water) which was at par with all other treatments where either 50 or 75 % recommended NP was applied along with seed treatment and foliar application of nano – DAP. The reason for this increase could be the enhancement of photosynthetic efficiency, as nano fertilizer have been shown to improve chlorophyll content and photosynthetic rate (Poudel *et al*. 2023).

A close perusal of the data revealed that significantly higher number of effective tillers/m^2 were recorded with the application of 100 % NP (T_2), remaining with at par with T_8, T_7, T_6, T_5, T_3, T_{12}, T_{11}, T_{10} and T_9 (Table 2). Significantly, lower effective tillers/m^2 were observed in control treatment. Adequate supply of nitrogen and phosphorus from conventional fertilizers along with foliar application of nano DAP might have increased the number of tillers and also reduced the number of barren tillers, hence ultimately increasing number of effective tillers / m^2 (Chinnappa *et al*. 2023).

Application of 75 % NP or 50 % NP along with seed treatment and two foliar sprays of nano – DAP @ 0.4 % resulted in significantly higher weight of grains/spike as compared to sole application of 75% NP or 50% NP through conventional fertilizers. Significantly, lower weight of grains per spike was recorded in treatment where only potassium was used through conventional fertilizer *i.e.* control. Higher grain weight per spike was attributed to the increased availability of nitrogen and phosphorus along with timely application of nano nitrogen and nano phosphorus through foliar sprays at critical stages, which might have increased the overall machinery and efficiency of photosynthesis. Nitrogen

Table 2. Effect of different fertilizer treatments on yield attributes and grain yield (q/ha) of wheat

Treatment		Effective tillers/m^2	Grain weight/ spike (g)	1000 grain weight (g)	Grain yield (q/ha)
T_1	N_0P_0	195.8	1.28	40.78	17.82
T_2	$N_{100}P_{100}$	278.9	2.15	43.56	37.15
T_3	$N_{75\%}P_{75\%}$	263.2	2.07	43.06	33.94
T_4	$N_{50\%}P_{50\%}$	242.7	1.86	42.28	29.70
T_5	T_3 + Seed treatment (ST) + one spray of nano DAP @ 0.2 %of water at 40 days after sowing (DAS)	269.0	2.12	43.38	35.03
T_6	T_3 + ST + one spray of nano DAP @ 0.4 % of water at 40 DAS	273.0	2.15	43.52	35.70
T_7	T_3 + ST + Two spray of nano DAP @ 0.2 %of water (40 DAS and 85 DAS)	268.4	2.22	43.72	36.97
T_8	T_3+ ST + Two sprays of nano DAP @ 0.4 % of water (40 and 85 DAS)	273.7	2.29	43.88	38.12
T_9	T_4+ ST + one spray of nano DAP @ 0.2 %of water at 40 DAS	251.7	1.97	42.60	30.91
T_{10}	T_4+ ST + one spray of nano DAP @ 0.4 % of water at 40 DAS	255.5	1.99	42.73	31.52
T_{11}	T_4+ ST + Two spray of nano DAP @ 0.2 %of water (40 DAS and 85 DAS)	253.0	2.05	42.98	32.67
T_{12}	T_4+ ST + Two spray of nano DAP @ 0.4 % of water (40 DAS and 85 DAS)	258.4	2.08	43.16	33.45
	SEm±	9.4	0.07	0.24	1.24
	CD (P = 0.05)	27.7	0.20	0.70	3.65

and phosphorus play important role in the process of photosynthesis, nitrogen being a constituent of chlorophyll and phosphorus being co factor of several enzymatic reactions of photo synthesis, they played their respective contribution in higher grain weight (Poudel *et al*. 2023).

The application of 75 % NP or 50 % NP along with seed treatment and two foliar sprays of nano – DAP @ 0.4 % proved beneficial for 1000 grain weight as compared to its single spray though the differences between the two were not found to be significant. Higher test weight observed in this investigation could be attributed to the adequate supply of nitrogen and phosphorus, which increased test weight of grains because of their efficient remobilization of photosynthates to the grain thereby producing more bold grains and ultimately higher 1000-grain weight. Adequate nutrition from starting helped in good vegetative growth, higher photo synthesis, and more accumulation of photo synthates leading to formation of good-quality grains of bigger size. Further, foliar spray of nano DAP aids in keeping the foliage of crop green and its photosynthetic machinery active which helps in increasing leaf area duration and ultimately accumulation of more photosynthates insink for longer duration of crop growth and ultimately increasing test weight whereas, inadequate nutrition during initial growth stage in control treatment resulted in reduced vegetative growth, less photosynthesis, lesser accumulation of photosynthates leading to formation of smaller grains of small size and hence, lower test weight (Parmar *et al*. 2024).

The grain yield of wheat was significantly impacted by various treatments (Table 2) with significantly higher yield (38.12 q / ha) recorded in T_8 (75 % NP + seed treatment + 2 foliar sprays @ 0.4 %) though this treatment was at par with T_2 (100 % NP), T_7 (75 % NP + seed treatment + 2 foliar sprays @ 0.2 %), T_6 (75 % NP + seed treatment + 1 foliar sprays @ 0.4 %) and T_5 (75 % NP + seed treatment + 1 foliar sprays @ 0.2 %). Significantly lower grain yield was recorded in the control plot (17.82 q / ha). A close perusal of the data revealed that simultaneous use of seed treatment along with two sprays of nano – DAP @ 0.4 % at 40-45 and 85 days after sowing resulted in significant increase in grain yield as compared to when only fertilizers were used. The increased yield components may be responsible for higher grain yield. The optimum and balanced nutrient availability was ensured throughout the crop period, particularly during the critical stages of the crop, by applying conventional and nano fertilizer (nano DAP) in combination. This is because nanoparticles have a greater surface area and are smaller size, allowing them to more readily enter plants and improve nitrogen and phosphorus uptake. Increased uptake leads to optimal growth of plant parts and metabolic processes, such as photosynthesis, which increases the accumulation of photosynthates and their translocation to the economically productive parts of the plant. This process increase biomass, yield-attributing characters, and yield by enhancing the translocation of assimilates to seeds – all of which contribute to increased yield. Significant improvement in grain and stover/straw yield of maize and wheat with the application of 100 percent RDF through conventional sources along with two foliar applications of bio nano P and K over treatments comprised of natural farming practices and sole application of conventional fertilizers were reported by Baghla and Sharma (2023). Similar results were reported by Rajput *et al*. (2022) and Bhargavi and Sundari (2023).

Conclusion

The field experiment demonstrated that the combined application of chemical fertilizers along with nano DAP, particularly the 75 % NP + seed treatment + 2 foliar sprays @ 4 ml/l water significantly improved yield attributes, crop growth rate (CGR), relative growth rate (RGR) and grain yield of wheat. To maximize its incorporation into agricultural practices and guarantee sustainable crop production systems, more research is needed into the long-term impacts, economic viability, and environmental sustainability of Nano DAP.

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References

Anonymous 2021a. Agricultural area food crops. https://www.indiastat.com/data/agriculture/agricultural-area-foodcrops

Anonymous 2023.https://fertiliserindia.com/india-fertilizer-report-card-for-q1fy23-24-record-production-imports-and-sales

Baghla D and Sharma VK 2023. Impact of foliar application of bio nano P and K and their conventional sources on yield of maize and wheat in an acid *Alfisol*. Himachal Journal of Agricultural Research **49 (1):** 55-61.

Bhargavi G and Sundari A 2023. Effect of nano urea on the growth and yield of rice (*Oryzasativa*) under SRI in the Cauvery delta zone of Tamil Nadu. Crop Research **58 (2):** 12-17.

Blackman VH 1919. The compound interest law and plant growth. Annals of Botany**33:** 169-175.

Chinnappa SA, Krishnamurthy D, Ajayakumar MY, Ramesha YM and Ravi S 2023. Effect of Nano Fertilizers on Growth, Yield, Nutrient Uptake and Soil Microbiology of *Kharif* Sorghum. International Journal of Environment and Climate Change **13:** 2339-2348.

Farooq M, Naeem M, Abdul S, Ijaz M and Iqbal MM 2015. Impact of sowing time andplanting method on the quality traits of wheat. Journalof Global Innovations Agricultural and Social Sciences3 **(1):** 8"11.

Gomez KA and Gomez AA 1984. Statistical Procedure for Agricultural Research. WileyInter Science, NewYork, USA. p 680.

Parmar GS, Viradiya MB and Patel JA 2024. Response of nano dap on yield and nutrient content of wheat grown in loamy sand soil. International Journal of Plant & Soil Science **36:** 374-383.

Poudel A, Singh SK, Jimenez-Ballesta R, Jatav SS, Patra A and Pandey A 2023. Effect of nano-phosphorus formulation on growth, yield and nutritional quality of wheat under semi-arid climate. Agronomy **13:** 768.

Radford PJ 1967. Growth analysis formulae their use and abuse. Crop Science **7:** 71-175.

Rajput JS, Thakur AK, Nag NK, Chandrakar T and Singh DP 2022. Effect of nano fertilizer in relation to growth, yield and economics of little millet (*Panicum sumatrense* Roth) under rainfed conditions. Pharma Innovation Journal**11 (7):** 153-156.

Sahithi B, Babu KK, Prasanth P, Lakshminarayana D and Gouthami P 2023.Studies on effect of nano urea and nano dap alone and in combination with different levels of nitrogen and phosphorus on growth and yield of marigold (*Tagetes erecta* L.) Cv. Superball. The Pharma Innovation Journal **12 (11):** 901-906.

Sahu D 2023. Performance of nano-DAP under rice-wheat cropping system in vertisol of Chhattisgarh. The Pharma Innovation Journal **12 (7):** 1565-1569.

Singh NR, Sarma SS, Rao TN, Pant H, Vadali VSS, Srikanth VV and Kumar R 2021. Cryo-milled nano-DAP for enhanced growth of monocot and dicot plants. Nanoscale Advances **4 (3):** 4834–4842.

Tarafdar JC, Raliya R, Mahawar H and Rathore I 2016. Development of zinc nano fertilizer stoenhance crop production in pearlmillet (*Pennisetum americanum* L.). Agricultural Research3 **(3):** 257–262.

Yasser EE, El-Ghobashy, Elmehy KA and El-Douby KA 2020. Influence of Intercropping Cowpea with some maize hybrids and N nano mineral fertilization on productivity in salinity soil. Egyptian Journal of Agronomy 42 (1): 63-78.

Anonymous 2021b. Statistical year book of Himachal Pradesh2019-20.DirectorateofEconomicsand Statistics, Himachal Pradesh.