



Effect of Integrated Nutrient Management on Growth and Yield of Wheat (*Triticum aestivum* L.) in Sandy Soil of West Bengal

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Abstract: The influence of nano urea as foliar spray along with split application of potassium was studied on wheat cv. DBW 187 (Karan Vandana) during 2022-2023 at Seacom Skills University, Birbhum, West Bengal. The maximum plant height, more dry matter production, more number of tillers per m² were observed in treatment with Basal dose of 50:60:20 kg NPK/ha and foliar spray with 0.5% Nano Urea and 1% MOP solution at Crown root initiation and Flag Leaf stage. The same treatment showed highest number of spikes/m², spike length, filled grains/spike, test weight, grain yield and straw yield as well. Soil enzymatic activity was maximum in RDF with split potassium doses. The gross returns, net returns and benefit: cost ratio too were maximum in the same treatment. Hence, a basal dose of 50:60:20 kg NPK/ha and foliar spray with 0.5% Nano Urea and 1% MOP solution at CRI and Flag Leaf stage was beneficial for wheat production in the Red and Lateritic soils of West Bengal, keeping soil health in view.

Keywords: Wheat, Nano urea, Enzymatic activity, Potassium

Wheat (*Triticum aestivum* L.) accounts for approximately one-fifth of the total area under food grains and provides roughly one-third (40%) of India's total food grain production, showcasing the significant role of this crop in India's food security (Pyne et al., 2022). India is the second largest producer of wheat, accounting 12 per cent of the global production (Kundu et al., 2020). West Bengal produces only a small fraction of India's total wheat output, accounting for 5.15% of the state's food grain production and 3.1% of the national production. Given the region's population growth and dietary preferences, it is imperative to increase wheat productivity in West Bengal to satisfy the growing food demands (Goswami et al., 2020). Following the introduction of the Green Revolution in India, food production soared, paralleled by a rapid escalation in the use of chemical fertilizers, which in turn has triggered a range of environmental concerns and negative impacts on soil health. While fertilizer is necessary in producing high yields, synthetic fertilizers have environmental consequences, such as altering the global nutrient budget, affecting water and air quality, and ultimately contributing to climate change through greenhouse gas emissions (Lu 2017). Even nutrients applied through the fertilizers at the time of sowing are not fully utilized by the crop and are lost through various ways (leaching, fixation etc.) and the crop may suffer from nutrients deficiency at the later stage (Pratihari et al., 2023). Despite decades of technological advances, the efficiency of N, P, and K fertilizers has remained relatively constant at 30-35, 15-20, and 35-40%, respectively,

with a substantial proportion of the applied fertilizer accumulating in the soil or leaching into aquatic systems, contributing to eutrophication (Yahaya 2023). All these led to major issue through which farmers have been facing two simultaneous challenges i.e., to cater to the ever increasing population and avoiding inorganics on soil. Thus, by decreasing its soil requirement of inorganic could be curtailed to some extent, through foliar application to compensate the nutrient requirement. Foliar spray of one or more nutrients to supplement soil application of fertilizers has been gaining more attention in recent years to overcome the problem of low fertilizer nutrient supply from soil to plant (Verma et al 2023). NPK 19:19:19 fertilizer is available as hundred percent water soluble complete fertilizer containing nitrogen, phosphorus and potassium each with 19% low salt index. Nano fertilizers have distinctive novel characteristics than the bulk materials and also have enormous advantages over the traditional fertilizers and used to improvise the crop production and soil properties in general (Roy et al., 2023). Nano Urea (Nano Nitrogen), developed by Indian Farmers Fertilizer Cooperative Limited (IFFCO), provides a novel alternative to ease farmers away from urea. Foliar fertilizers can provide the plant nutrient at critical stages of plant growth when the nutrient requirement of plant exceeds the normal uptake for certain nutrients (Sarkar et al., 2021). Large amount of potassium is required by wheat, and once the reproduction stage is finished, a constant supply is required until heading (Sharma et al., 2022). The present study was conducted to

find out the best possible application of liquid fertilizers NPK 19:19:19 and nano urea comparing with the conventional soil application of recommended dose of fertilizer.

MATERIAL AND METHODS

Field experiment was undertaken in wheat in *Rabi* season of 2022-23 at the Instructional Farm (23°70' E latitude, 87°67' N longitude and 9.75 m above mean sea level) of Seacom Skills University, Kendradangal, Birbhum, West Bengal, India to observe if substituting soil application of inorganics (either partly or fully) with foliar spray could be possible without sacrificing the production and degradation of soil health. The soil of experimental field was sandy loam soil, with slightly acidic (pH 5.9), available N (186 kg/ha), phosphorus (16.37 kg/ha) and potassium (225.06 kg/ha). The trial was conducted in a randomised block design with 3 replications consisting of 8 different treatments with a plot size of 6.0 X 4.0 m² (Table 1). The biofortified, high yielding variety of wheat [DBW 187 (Karan Vandana)] was line sown on 20th November, 2022 and harvested on 10th March, 2023. The inter row spacing given was 22.5 cm with a depth of 4 cm to get an uniform germination. The growth parameters, yield and yield attributes were recorded at specified stages with standard procedure. After maturity, harvested plant samples were collected, oven dried and ground for analyzed to study the total uptake of N, P and K following the standard procedures (Jackson 1973), soil enzymatic activity like dehydrogenase activity (DHA), acid phosphatase activity (APA) were determined (Sahoo et al 2022). The Cost of cultivation were estimated and gross and net return (as per market price in West Bengal) were worked out for economic analysis. The experimental data were analyzed by SPSS (Version-26.0) package. The comparison of treatments was made with or Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Growth parameters: The treatment comprises of basal

application of 50:60:20 kg NPK/ha and foliar spray with 0.5% Nano Urea and 1% MOP solution at CRI and flag leaf stage attained the highest plant height (76.12 cm) with more number of tillers per m² (370.93) (Table 2). This treatment also showed highest leaf area index (LAI) (4.94) and dry matter production (910.7 g/m²) closely followed by the treatment T₄- Basal dose of 50:60:20 kg NPK/ha + top dressing of 25:20 kg NK/ha at CRI stage and 25 kg N/ha at flag leaf stage (RDF with split application of N and K as well) (4.91) and (891.2 g /m²). It might be due to increased photosynthetic rate and higher leaf area that increased total dry matter production observed by supplementation of nitrogen through foliar spray (Rawate et al 2022). Moreover, foliar nutrient of MOP along with nano urea, produced an optimal nutrient supply and, as a result, enhanced meristematic cell activity and cell elongation, both of which are known to have positive impacts on the metabolic process and improved vegetative development (Patel et al 2022). In addition, the rate of growth was also highest (17.52) in T₆- Basal dose of 50:60:20 kg NPK/ha and foliar spray with 0.5% Nano Urea and 1% MOP solution at CRI and Flag Leaf stage, which is because of ample nitrogen supply as well as availability, generating an optimal environment for root zone growth and development. The results were in conformity to the findings of Choudhary et al. (2023).

Yield attributes and yield: Basal dose of 50:60:20 kg NPK/ha and foliar spray with 0.5% nano urea and 1% MOP solution at CRI and Flag Leaf stage has shown a hike in yield attributes and yield of wheat, compared to control treatment (T₁) as well as only application of RDF (Table 2). The number of spikes/m² varied between 119.56 and 295.67. Highest number of spikes/m² (295.67) was in T₆- Basal dose of 50:60:20 kg NPK/ha and foliar spray with 0.5% Nano Urea and 1% MOP solution at CRI and flag leaf stage. Similar trend was also observed in spike length (14.04 cm). The increase was because of positive response in terms of availability of nutrients through foliar application of nano urea as well as split

Table 1. Treatment details

Sl. no.	Treatment details
T ₁	Absolute control (no NPK)
T ₂	Basal dose of 50:60:40 kg NPK/ha + top dressing of 25 kg N/ha at CRI and Flag Leaf stage {RDF (conventional application)}
T ₃	Basal dose of 25:30:20 kg NPK/ha + top dressing of 12.5 kg N/ha at CRI and Flag Leaf stage (50% RDF)
T ₄	Basal dose of 50:60:20 kg NPK/ha + top dressing of 25:20 kg NK/ha at CRI stage and 25 kg N/ha at Flag Leaf stage (RDF with split application of N and K as well)
T ₅	Only foliar spray with 0.5% solution of 19:19:19 NPK at 10 Days interval, starting from 11 DAS
T ₆	Basal dose of 50:60:20 kg NPK/ha and foliar spray with 0.5% Nano Urea and 1% MOP solution at CRI and Flag Leaf stage
T ₇	Basal dose of 50:60:20 kg NPK/ha and foliar spray with 0.5% solution of 19:19:19 NPK at CRI and Flag Leaf stage
T ₈	Basal dose of 50:60:20 kg NPK/ha and foliar spray with 0.5% solution of Nano Urea at CRI and Flag Leaf stage

doses of potassium through MOP. Similar kind of results were demonstrated by other investigator (Rawate et al 2022). This also led to increased number of filled grains/spike which varied from 8.56 to 27.82 with an average increase of 225% in the treatment T_6 as compared with T_1 (absolute control). Test weight varied from 37.36 to 40.31 g with variation of 7.9% and was highest in treatment T_6 . The grain yield varied between 1660 to 4292 kg/ha and highest value was recorded from T_6 treatment which was statistically at par and closely followed by treatment T_4 and lowest grain yield of wheat was in control treatment. Wheat straw yield also followed the same trend, varied from 3824 to 6262 kg/ha and highest value observed was in T_6 . The synergistic effect of the integrated use of potassium in splits (basal and foliar) along with nano urea might have improved several yield-contributing traits, as well as various vegetative growth characteristics, enhancing the overall performance of the crop. Nano fertilizers have been found to enhance the efficiency of conventional fertilizers by facilitating better absorption of nutrients through plant cells, resulting in optimal growth of plant parts and metabolic processes, such as photosynthesis. This led to increased accumulation and translocation of photosynthate to the economic parts of the plant, thereby enhancing source and sink strength and ultimately resulting in higher yield (Ojha et al., 2023, Patel et al., 2022). The harvest index of wheat increased from 30.89 to 41.30 and the hike was noted up to 33.70%. Highest value was recorded in the treatment (T_6). The foliar application of nitrogen in combination with split doses of potassium led to proper maintenance of leaf nutrients and enhanced photosynthetic capacity, ultimately leading to increased grain and stover yield. The improved photosynthate formation, as a result of the foliar application of nano urea, led to a significant positive impact on the harvest index.

Soil enzymatic activity: Dhydrogenase activity varied from 9.2 to 11.3 ($\mu\text{g TPF/gm/24 hr}$) with a variation of 22.82% and acid phosphatase activity varied from 23.18 to 28.69 ($\mu\text{g PNPP/gm/ hr}$) with an average rise of 23.77% (Table 3). In both cases highest activity was recorded in T_4 treatment. Split doses of nitrogen and potassium led to better availability of nutrients to plants might have resulted in higher uptake of them through which less disturbance occurred on soil biotics elements and in fact application of foliar spray of nano urea in T_6 plot has also shown significant effect on the microbial activity in soil which led to almost equivalent result of dehydrogenase activity as well as acid phosphatase, giving a hike in yield of wheat. This results were also observed on pea by Symanowicz et al. (2018).

Nutrient uptake: After the harvest, nutrient uptake of grain and straw varied significantly with different split nutrient management practices as per treatments (Table 3). The total nitrogen uptake varied from 43.6 to 118.6 kg/ha, with the variation being 172.02%. Phosphorus uptake varied from 5.57 to 16.22 kg/ha, with the variation of 191.20% and the potassium uptake varied from 49.6 to 114.1 kg/ha and the variation was 130.04%. The foliar application of nano-fertilizers might have allowed the rapid absorption of nutrients through the epidermis or stomata, followed by efficient translocation via apoplast or symplast pathways, significantly improving the nitrogen uptake of the plants (Kumar et al., 2023). Furthermore, as only half the dose of urea was applied as basal fertilizer, it was completely absorbed by the plants due to their high nitrogen demand during vegetative growth, thus reducing nitrogen loss. The reduced urea application also allowed beneficial biotic colonies to mobilize nutrients such as phosphorus, resulting in higher uptake of this nutrient. Even the split doses of

Table 2. Effect of integrated nutrient management on growth and yield of wheat

Treatment	Plant height (cm) at harvest	Dry matter production (g/m^2) at harvest	No. of tillers/ m^2 at harvest	LAI (90 DAS)	CGR (61-90)	No. of spikes/ m^2	Length of spikes (cm)	Number of filled grains/spike	Test weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)	Harvest index (%)
T_1	45.59 ^a	443.6 ^d	168.59 ^e	1.86 ^d	7.72 ^c	119.56 ^d	9.55 ^a	8.56 ^c	37.36	1660 ^b	3824 ^b	30.89 ^b
T_2	70.10 ^{a,b}	891.0 ^a	327.02 ^{b,c}	4.55 ^a	17.73 ^a	252.23 ^{b,c}	12.09 ^b	19.35 ^b	39.86	3909 ^{a,b}	5812 ^a	40.22 ^a
T_3	56.43 ^d	551.2 ^c	265.25 ^d	3.50 ^{b,c}	8.73 ^c	222.97 ^c	10.43 ^{c,d,e}	17.95 ^b	39.54	3468 ^{c,d}	5800 ^a	37.48 ^a
T_4	72.05 ^a	891.2 ^a	354.63 ^{a,b}	4.91 ^a	17.59 ^a	284.82 ^a	12.63 ^b	27.6 ^a	40.28	4011 ^{a,b}	5844 ^a	40.66 ^a
T_5	54.32 ^d	518.19 ^c	199.55 ^e	3.43 ^c	9.23 ^{b,c}	147.89 ^d	9.77 ^{d,e}	10.64 ^c	37.70	3231 ^d	5368 ^a	37.76 ^a
T_6	76.12 ^a	910.7 ^a	370.93 ^a	4.94 ^a	17.52 ^a	295.67 ^a	14.04 ^a	27.82 ^a	40.31	4292 ^a	6262 ^a	41.30 ^a
T_7	64.21 ^{b,c}	671.6 ^b	316.44 ^{b,c}	3.94 ^b	11.13 ^b	265.54 ^{a,b}	11.63 ^{b,c}	18.53 ^b	39.61	3867 ^{b,c}	5911 ^a	39.52 ^a
T_8	61.15 ^{c,d}	576.5 ^c	282.41 ^{c,d}	3.54 ^{b,c}	8.96 ^c	236.43 ^{b,c}	11.23 ^{b,c,d}	17.97 ^b	38.09	3704 ^{b,c}	5801 ^a	39.12 ^a

See Table1 for treatment details

Individual values in column with the same letter are not significantly different at $p < 0.05$ according to DMRT

Table 3. Effect of nutrient management on soil enzymatic activity, nutrient uptake and economics of wheat

Treatment	Enzymatic activity		Nutrient uptake			Economic Analysis			
	DHA (μg TPF/gm/24 hr)	AP (μg PNPP/gm/ hr)	N (kg/ha)	P (kg/ha)	K (kg/ha)	Cost of cultivation ($\times 10^3\text{₹/ha}$)	Gross return ($\times 10^3\text{₹/ha}$)	Net return ($\times 10^3\text{₹/ha}$)	B:C
T ₁	9.2 ^{b,c}	23.18 ^e	43.6 ^f	5.57 ^b	49.6 ^c	24.56 ^c	29.88 ^e	5.32 ^f	1.22 ^e
T ₂	11.2 ^a	28.45 ^{a,b}	102.2 ^{c,d}	8.02 ^{a,b}	91.4 ^b	31.80 ^{a,b}	70.36 ^{a,b}	38.57 ^{b,c}	2.21 ^b
T ₃	10.0 ^{a,b,c}	25.29 ^{c,d}	96.2 ^{c,d}	8.1 ^{a,b}	89.4 ^b	30.43 ^{a,b}	62.44 ^{c,d}	32.01 ^d	2.05 ^c
T ₄	11.3 ^a	28.69 ^a	108.3 ^b	9.3 ^{a,b}	104.3 ^{a,b}	31.80 ^{a,b}	72.21 ^{a,b}	40.42 ^{a,b}	2.27 ^b
T ₅	9.2 ^{b,c}	23.18 ^e	86.7 ^e	11.08 ^{a,b}	95.1 ^b	36.06 ^a	58.16 ^d	22.10 ^e	1.61 ^d
T ₆	11.1 ^{a,b}	27.92 ^b	118.6 ^a	16.22 ^a	114.1 ^a	32.78 ^{a,b}	77.27 ^a	44.49 ^a	2.36 ^a
T ₇	10.4 ^{a,b}	26.17 ^c	105.7 ^{b,c}	10.65 ^{a,b}	90.0 ^b	30.93 ^{a,b}	69.62 ^{a,b,c}	38.69 ^{b,c}	2.25 ^b
T ₈	10.3 ^{a,b}	25.06 ^{c,d}	101.6 ^{c,d}	9.67 ^{a,b}	99.4 ^{a,b}	32.31 ^{a,b}	66.68 ^{b,c}	34.37 ^{c,d}	2.06 ^c

See Table 1 for treatment details

Individual values in column with the same letter are not significantly different at $p < 0.05$ according to DMRT

potassium through MOP also made it easy for the plant for its uptake without much loss. This findings was collaborated with the findings of Patel et al. (2022).

Economics: Gross return ($\text{₹}77.27 \times 10^3/\text{ha}$), net return ($\text{₹}44.49 \times 10^3/\text{ha}$) and benefit: cost (B:C) ratio (2.36) were higher in treatment T₆ followed by T₄ (Table 3).

CONCLUSION

Wheat responded very well to the foliar application of nano urea along with split application of MOP. Application of split dose of fertilizer along with nano urea markedly improved the plant growth, yield attributes, and grain yield of wheat as compared to traditional practices. The basal dose of 50:60:20 kg NPK/ha and foliar spray with 0.5% solution of Nano Urea at CRI and flag leaf stage, increased the grain yield to the tune of 236 kg/ha when it was supplemented with 50% RDF. It was further increased to about 584 kg/ha when an additional potash was applied as foliar spray @1% solution along with nano urea as basal dose of 50:60:20 kg NPK/ha and foliar spray with 0.5% Nano Urea and 1% MOP solution at CRI and flag leaf stage. Thus combined application of nano fertilizer as foliar spray and MOP (in split doses) could be more acceptable in the growth, yield and economics of wheat in the red and lateritic soils of West Bengal.

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