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ORIGINAL ARTICLE

Effect of Foliar Application of Nano-Fertilizers on Growth and Yield of Wheat (*Triticum Aestivum* L.)

Sk Gangwar*[1], R P Singh[2], P K Mishra[3], R. Ahmad[4] And A K Singh[5]
[*1]Senior Scientist and Head, Krishi Vigyan Kendra, Madhopur (West Champaran-I)
[2]Senior Scientist and Head, Krishi Vigyan Kendra, Narkatiyaganj (West Champaran-II)
[3, 4]Krishi Vigyan Kendra, Madhopur (West Champaran-I)
[6]Senior Scientist and Head, Krishi Vigyan Kendra, Piparakothi (Eest Champaran-I)
(Dr Rajendra Prasad Central Agricultural University, Pusa (Samastipur), Bihar)
Corresponding Authors email: drskgangwar1@gmail.com

ABSTRACT
A field experiment was carried out in two different places of district West Champaran through farmers participatory mode for evaluating the performance of foliar application of nano-fertilizers on yield and yield attributing traits of wheat variety HD 2967. The experiments included five treatments and using RBD design. A number of growth criteria in plants and yield (quantity) parameters were recorded. Fertilizer application in soil and foliar application of nano-fertilizer combination T_5 i.e., N, P, K, and Zn of 60, 60, 40, 10 kg/ha + nano urea @ 500ml/ha were found effective as in increased plant height (86.71 cm), no. tillers per plant (6.5), no. grains per plant (35.95), grain yield (38.15 qt/ha) and straw yield (63.85 qt/ha) at both the locations followed by T_2, T_3, T_4 and T_1 while, harvest index was received higher (37.48%) in T_5 followed by T_2, T_4, T_3 and T_1. The final result indicated that T_2 and T_5 significantly increased plant height, tillers per plant, grains per plant, grain yield, straw yield and harvest index in comparison to T_1 (control). There are no significant differences were found in T_3 and T_4 against yield attributes and yield component.
Key words: *Foliar spray, Nano fertilizer, Nutrient use efficiency, Wheat.*

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INTRODUCTION

Wheat (*Triticum aestivum* L.) is main staple food grain crop, grown in a range of environments over an area of 221.82 million hectares with an annual production likely to reach more than 775.83 million tons in 2020-21 (Foreign Agricultural Service, USDA, 2021). It is consumed by nearly 36 per cent of the world population with more than half of their calories and nearly half of their protein but also core part of animal feed as straw in most of the countries [21]. India is the second largest producer country in the world occupying about 31.45 million hectares area and producing 107.59 million tons with productivity of 34.21 q/ha in 2019-20 [3]. The area, production and productivity of wheat in the states of Bihar are 2.25 million hectares, 5.90 million tons and 26.26 q/ha, respectively [3]. Despite of this significant growth, the world population in some parts is still facing hunger crisis due to insufficient availability of food grains and also due to poor quality food intake about 50 per cent of the world's population is suffering from micronutrient malnutrition [6]. Health index in developing countries is declining due to low levels of malnutrition in the diet [6]. About 75 percent of world's population suffers from inadequate intake of micronutrients in diet as Zn, problems of anaemia, weakened immune system contributing 40 per cent of women and children all over world [20].

To meet the future food demands imposed by overwhelming increasing population which is expected to reach nine to ten billion in 2050, the world wheat production must continue to increase by 2% annually [10]. This challenge of increasing wheat production is daunting as the wheat cropping system at present is constrained by climatic fluctuations, poor soil health and has increased risk of epidemic outbreak of

diseases and insect-pests. To address these challenges, innovative technologies with a potential of increasing the sustainability of the present-day cropping systems are required to be introduced in modern agriculture. Among these technological advancements, nanotechnology has the potential to contribute to a new technology-based agricultural revolution [12]. Many nanomaterials have been developed for agricultural applications, including new solutions for soil and water remediation, as well as nano-fertilizers and nano-pesticides, designed to reduce the applied amounts of fertilizers and pesticides, while increasing food production and quality [11, 22, 14]. Besides, the use of nano enabled products for crop protection can reduce significantly the impact caused by the agriculture on the environment, in this way being an eco-friendly alternative [7]. Recent research evidences indicated that intervention of nanotechnology in wheat farming is still in its early stages, although have bright prospects for efficient nutrient utilization through nano formulations of fertilizers, breaching yield barriers through bio nanotechnology, surveillance and management of pests and diseases and development of new-generation pesticides etc. Looking of above facts, Krishi Vigyan Kendra Madhopur studies the effect of foliar application of nano-fertilizers on growth and yield attributes of wheat as compare to control (farmers practice) at two locations in the district during 2019-2020.

MATERIAL AND METHODS

Field experiment was conducted in two places of West Champaran district on the wheat variety HD 2967 at village Makota and Sapahi with five treatments *i.e.* (T_1, T_2, T_3, T_4 and T_5) during 2019-20. In control plots, the N, P, K, and Zn were applied with the ratio of 120, 60, 40, 10 kg/ha which was designated as T_1. The Zn was applied in the control as well as other tested plots after 20 days of sowing in all treatments. The N, P, K, and Zn of 60, 60, 40, 5 kg/ha were applied in combination of nano urea in the ratio of 500ml/ha it was designated as T_2. In the treatment three, the N, P, K, and Zn of 50, 60, 40, 5 kg/ha were applied in combination of nano urea in the ratio of 500ml/ha, it was denotated as T_3. As in treatment four, the N, P, K, and Zn of 120, 60 40, 10 kg/ha were applied in combination of nano Cu in the ratio of 500ml/ha and designated as T_4. In the T_5, the N, P, K, and Zn of 60, 60, 40, 10 kg/ha were applied in combination of nano urea in the ratio of 500ml/ha and designated as T_5. The experiment was laid out in a randomized block design (RBD). The first spray of nano fertilizers (@500 ml/ha in 1000 litres of water) was applied at 25 days after sowing and second spraying were followed after 25 days of first application. The wheat sowing date was 8/12/2019. All the recommended practices were applied to raise a good crop. Size of experiment units was 9 m^2 (3m x3m) and a distance of 1.5 m was left between units and replicates to increase the precision of the trial. At the stage of grain maturity some parameters of growth and yield were estimated. Biological yield quintal/ha was also estimated from each experimental unit weighing the entire plants (grains + straw), weight of 1000 grain were measured too after isolation and removing of straw at 12% moisture content. The data were analyzed with simple statistical tools as given below:-

$$\sigma = \sqrt{\frac{\sum (x-\bar{x})^2}{(n-1)}}$$

where,

x= each value in the data set

$\bar{x}$= mean of all values in the data set

n= number of values in the data set

RESULTS AND DISCUSSION

The use of nano-fertilizer significantly enhanced plant growth and yield parameters in wheat at village Makota location. Foliar application of nano urea and soil application of NPK and Zn as desired rate of application, T_2 and T_5 significantly increased plant height (86.90 cm), tillers per plant (no. 6), grains per plant (no. 35.67), grain yield (38.10 qt/ha), straw yield (63.50 qt/ha), harvest index (37.50%) and plant height (86.80 cm), tillers per plant (no. 7), grains per plant (no. 36.57), grain yield (38.90 qt/ha), straw yield (63.80 qt/ha), harvest index 37.88%) respectively as shown in table 1.

Foliar application of nano urea and soil application of NPK and Zn as desired rate of application, at village Sapahi location, T_2 and T_5 significantly increased plant height (86.40 cm), tillers per plant (no. 6), grains per plant (no. 35), grain yield (36.50 qt/ha), straw yield (63.60 qt/ha), harvest index (36.46 %) and plant height (86.60 cm), tillers per plant (no. 6), grains per plant (no. 35.33), grain yield (37.40 qt/ha), straw yield (63.50 qt/ha), harvest index (37.07%) respectively as shown in table 2.

The pooled data analysed which are depicted in table 3 and final results showed that T_5 and T_2 significantly increased plant height (86.71cm), tillers per plant (no.6.5), grains per plant (no. 35.95), grain yield (38.15 qt/ha), straw yield (63.85 qt/ha), harvest index (37.48%) and plant height (86.65 cm), tillers per plant (no. 6), grains per plant (no. 35.34), grain yield (36.72 qt/ha), straw yield (63.55 qt/ha), harvest

index 36.98%) respectively. The data were pooled from both the places of the district were found similar trends as depicted in table 1 and 2. Although fertilizers are very important for plant growth development and yield and other attributes of wheat as shown in our result in table 1, 2 and 3 but most of the applied fertilizers are unavailable to plants due to many factors, such as leaching, degradation by photolysis, hydrolysis and decomposition. Micronutrients exist in very small amounts in both soil and plants, but their role is as important as the primary or secondary nutrients. Important micronutrients include six elements, namely, iron, manganese, zinc, copper, boron and molybdenum [19]. The increase in plant height, total chlorophyll, concentrations of N, P and K in leaves at foliar feeding of nano super micro plus fertilizer, di combination of nano N, P and K fertilizer and commercial fertilizer are attributed to the role of these nutrients in stimulating plant growth. These essential elements are required for optimum growth of the plant to complete its life cycle [5, 3]. Macronutrient's nutrients are nitrogen, phosphorus and potassium are one of the chief importance in improving quality and productivity of wheat [18]. These, functions include the synthesis of chlorophyll and thylakoid and the development of chloroplasts [15]. It also plays a role in the transfer of energy within the plant, and in many enzymatic activities and photosynthesis as well as respiration and synthesis of proteins therefore has a key role in plant growth [4]. Roles of micronutrients in plant can include growth and metabolism associated with photosynthesis, chlorophyll formation, and development of root and respiration cells and the effectiveness of enzymes involved in primary and secondary metabolism [16]. Foliar feeding combination of N, P and K nano fertilizer showed improvements of growth and yield parameters of wheat at lower concentration [2]. Nano-fertilizer are easily absorbed by the epidermis of leaves translocated to stems which facilitated the uptake of active molecules and enhanced growth and productivity of wheat [1]. Nano fertilizer have large surface area and particle size less than the pore size of leaves of the plant which can increase penetration into the plant tissues from applied surface and improve uptake and nutrient use efficiency and uptake of the nutrients [17]. The positive effect of foliar applied nitrogen, phosphorus, and potassium to sustain proper leaf nutrition as well as carbon balance, and improving photosynthetic capacity is well established [13, 8].

Table 1: Effect of nano-fertilizer on yield and other attributes of wheat at village Makota

Treatment	Plant height (cm)	Tillers/plant (no.)	Grains/plant (no.)	Grain yield (qt/ha)	Straw yield (qt/ha)	Harvest index (%)
T_1	84.50	4	33.75	35.10	62.80	35.85
T_2	86.90	6	35.67	38.10	63.50	37.50
T_3	85.20	5	34.00	35.50	63.35	35.91
T_4	85.60	5	34.60	35.60	63.45	35.94
T_5	86.80	7	36.57	38.90	63.80	37.88
Mean	**85.20**	**5.4**	**34.92**	**36.64**	**63.38**	**36.74**

Table 2: Effect of nano-fertilizer on yield and other attributes of wheat at village Sapahi

Treatment	Plant height (cm)	Tillers/plant (no.)	Grains/plant (no.)	Grain yield (qt/ha)	Straw yield (qt/ha)	Harvest index (%)
T_1	81.30	4	33.25	33.80	61.40	35.50
T_2	86.40	6	35.00	36.50	63.60	36.46
T_3	85.00	5	33.80	34.60	63.20	35.38
T_4	83.70	4	34.75	34.90	62.50	35.83
T_5	86.60	6	35.33	37.40	63.50	37.07
Mean	**84.60**	**5**	**34.43**	**35.44**	**62.84**	**36.05**

Table 3: Effect of nano-fertilizer on yield and other attributes of wheat (pooled data)

Treatment	Plant height (cm)	Tillers/ plant (no.)	Grains/plant (no.)	Grain yield (qt/ha)	Straw yield (qt/ha)	Harvest index (%)
T_1	82.90	4.0	33.50	34.45	62.10	35.68
T_2	86.65	6.0	35.34	36.72	63.55	36.98
T_3	85.10	5.0	33.90	35.05	63.28	35.65
T_4	84.65	4.5	34.68	35.25	62.98	35.89
T_5	86.71	6.5	35.95	38.15	63.85	37.48
Mean	**85.20**	**5.2**	**34.67**	**35.93**	**63.15**	**36.34**
SD	**1.499**	**1.0368**	**1.006**	**1.498**	**0.670**	**0.852**

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