# *Original Research Article*

**Effect of nano-nutrient on growth attributes, yield, Zn Content, and uptake in wheat (*Triticum aestivum* L.)**

**Abstract**

Considering the food and nutritional security concerns, and post green revolution second generation problems *i.e.* increasing input use with declining efficiency trends, deteriorating soil health, depleting water resources, pollution, and narrowing profits at the end of farmers, an investigation was carried out on Wheat (*Triticum aestivum*) crop during 2019-20 at the crop research centre of SVPUA&T, Meerut (U.P.) to overcome these problems. Novel nutrient sources and their modes of applications with 14 treatments consisting of control, basal applications of recommended 100% NPK (150:60:40) , 75% NPK (112.5:45:30) + water spray + nano N (4 ml $l^{-1}$) + bio nano P (40 ml $l^{-1}$) + bio nano K (40 ml $l^{-1}$) + bio nano Zn (10 ml $l^{-1}$) in various combinations were attempted on wheat variety DBW17 in randomized complete block design (RCBD) with three replications. The results of the study revealed that wheat grown with 75% NPK + nano nutrients (N + P + K + Zn) attainted significantly better growth as reflected by taller plants (91.7 cm), more no. of tillers $m^{-1}$ row length (61.8), and higher dry matter accumulation $m^{-1}$ row length (239.2), recorded at harvest with grain yield of (52.4 q $ha^{-1}$). The crop contained 53.2 ppm Zn in grain and 31.8 ppm Zn in straw. Applications of nano nutrients – N, P, K, Zn and N +P + K + Zn +75% NPK worked synergistically and increased grain yields by 17.9, 15.7 14.5, 16.5 and 26.9% over 100% NPK. Thus, the wheat crop grown with the application of Nano-N + 75% NPK followed Nano-Zn + 75% NPK by had attained better growth (plant height, no. of the tiller, dry matter accumulation, yield (grain), nutrient content, and nutrient uptake.

***Keywords**: Bio Nano Zn, Nano N, Bio Nano P, Bio Nano K, Wheat*

## 1. INTRODUCTION

Wheat (*Triticum aestivum* L.*)* is the most important food crop in the world in terms of area and production. It was grown over an area of 216.94 million ha across the globe and produced 734.03 million metric tonnes of grains with an average productivity of 3.39 tonnes $ha^{-1}$ (USDA report, 2018-19). For more than 4.5 billion people globally, wheat offers 20% of the protein and 21% of the food calories. Wheat was grown on 30.750 million ha with a production of 101.20 million tonnes in 2018–19 in India as well (Tandon, 2000). Uttar Pradesh is the country's top wheat-producing state with an area of 9.65 million ha (36.6%), a production of 29.67 million tonnes (39.9%), and a productivity of 2795 kg $ha^{-1}$ (Anonymous, 2019). In 2050, the 7.6 billion people on the planet now are probably going to number 9.8 billion. India, which has 1.3 billion people and is predicted to exceed China in around seven years to reach a peak population of 1.7 billion by 2050, is the second most populous country after China (1.41 billion) (The UN World Population Prospects: The 2017 Revision). Thus, it is anticipated that the role of wheat in ensuring global food security would continue. The significant growth in food grain production in India from 52 million tonnes in 1551-52 to 284.83 million tonnes in 2018-19 as well as the rise in wheat production from 11.4 to 101.20 mt in 1966-67 have both been largely attributed to efficient fertilizer applications. However, India's wheat production is quite poor when compared to the UK (8.5 t $ha^{-1}$), Germany (7.9 t $ha^{-1}$), France (7.8 t $ha^{-1}$), and China (6.10 t $ha^{-1}$). Significantly though Punjab and Haryana had been harvesting 4.36 t $ha^{-1}$ and 4.0 t $ha^{-1}$, the situation in Uttar Pradesh (2.7 t $ha^{-1}$) is even worse (Anonymous, 2018). In Punjab, major factor behind higher productivity is that almost 100% area of wheat is irrigated, and it receives very high level of fertilizer. The major constraints in realizing the yield potential of HYV's are delayed sowings, declining nutrient use efficiency, weed infestation, narrowing profit margins, escalating fertilizer prices, declining factor productivity, suboptimal and imbalanced fertilization. Furthermore, the rising environmental concerns accounted to green revolution technologies have been necessitating scientific crop and soil management. The green revolution of the 1970's paved the way for food security in India attributed to introduction of high yielding dwarf and fertilizer responsive genotypes of wheat and rice. Contribution of fertilizer inputs towards crop yield has been represented to be about 30-40 %. However, use of conventional blanket fertilizer recommendations and skewed dependence on high analysis fertilizer has led to numerous deficiencies of macro and micro-nutrients, especially phosphorus, potassium and zinc. Nitrogen, Phosphorus, Potassium application ratio under the pre-dominant cropping systems rice-wheat (15:06:01), sugarcane-ratoon–wheat (10:04:01), rice-wheat-gram (13:06:01) and maize-wheat (34:17:01) happened to be drastically abnormal (Singh, 2014). Ironically, this has negatively affected the soil health, human prosperity aside diminishing crop response ratio and about 8-10 million tonnes of NPK mining in India (Tandon, 2004). The application of urea, DAP and MOP have been found to have lower fertilizer efficiency which ranges from 20 - 50 % for nitrogen, 10-25 % for phosphorus, 70-80 % for potassium and 2% for micronutrient owing to various losses which not only contribute to the greenhouse gases emission, certain health hazards such as blue baby syndrome and increase in cost of cultivation. Shortage of arable land, limited water and nutrient resources, necessitates an increase in resource use efficiency without sacrificing production through effective use of modern technologies (Naderi and Shahraki, 2013). In this regard, nanotechnology (Nano/Bio nano fertilizers) shows promise and can significantly contribute to crop productivity and soil health. Nanoparticles are extremely small, with at least one dimension being less than 100 nm (on the order of magnitude 10-9). They have the potential to transform the agriculture and food industries by improving plant nutrient uptake, disease molecular therapy, quick disease diagnosis, etc (Anonymous, 2015). Nano-fertilizers provide the crop with the primary nutrients as required in a phased manner since they contain nutrients and growth promoters enclosed in Nano scale polymers. Due to their enormous surface area, these nanoparticles can retain a large number of nutrient ions and release them gradually and consistently in response to crop demand, resulting in higher nutrient use efficiency (Subramanian *et al.*, 2015). Additionally, by increasing carbon uptake, enhancing soil aggregation, and enhancing water holding capacity, these could more precisely release their active ingredients in response to environmental cues and biological demands and contribute to the health of the soil. Micron-sized minerals that are brought to a scale of 10-100 nm by a system and method are known as bio-based nanomaterials (BBNM). They are inorganic solids that naturally arise that have a particular chemical make-up and a well-organized internal structure. These are artificial nanomaterials made by grinding minerals with bio agents like parthenium, neem, clay, FYM, and vegetable peels with a mortar and pestle. Due to their small size and mobility, nanoparticles often have a higher intracellular uptake than micro particles and are accessible to a wider spectrum of biological targets. The cutting-edge dietary agricultural inputs, such as eco-friendly fertilizers like Nano/Bio-Nano NPK and Zn liquid formulations with organic & chelated micronutrients, are known to secure high output while preserving soil fertility. Nanoparticles can be created using trace elements, vitamins, probiotics, seaweed extract, and humic acid to give all crops complete nutrition.)" Was conducted with the following objectives - to assess the effect of nutrient sources and doses on growth, yield and quality of wheat, to study the effect of nutrient sources and doses on nutrient content and uptake by crop and on residual soil fertility, and to work out economic feasibility of various treatments.

## 2. MATERIALS AND METHODS

### 2.1 Research location

The experiment was carried out at the university's crop research centre in the Indo-Gangetic plains of western Uttar Pradesh. The farm is situated 230 metres above mean sea level at coordinates 290 5′ 34″ N latitude, 770 41′ 58″ E longitude. The national route 58 connecting New Delhi and Dehradun, which is 65 kilometres from Delhi, passes through Meerut.

### 2.2 Crop Metrology

The crop experienced lowest (7.6$^0$C) mean weekly minimum temperature in 2$^{nd}$ week of January and highest (36.3$^0$C) in 4$^{th}$ week of April during 2020. First week of March was most humid (95.3%), however the driest (22.0 %) crop season was the 2$^{nd}$ week of April. Accordingly, the evaporation demand of the atmosphere during was maximum (86.50 mm) during last week of April and minimum (1.3 mm) during 1$^{st}$ week of January. The crop received 190 mm during its period. The soil of the experimental site was sandy loam in texture, low in available nitrogen and organic carbon, medium in available phosphorus, available potassium and slightly alkaline in reaction. Soil samples were collected from each plot after crop harvest as to determine their chemical properties.

### 2.3 Wheat variety

DBW-17 was developed by DWR Karnal and made available by CVRC in 2006 for use in the north-western plain zone for timely sown irrigation circumstances. The plant grows to a height of 80–90 cm on average and is semi-dwarf. Protein content is 11–12%, and the yield potential is 55–60 q ha$^{-1}$.

### 2.4 Fertilizer application

The recommended dose of NPK was taken as 150: 60: 40 kg ha$^{-1}$ of N, $P_2O_5$ and $K_2O$ repetitively where ever required. Nitrogen, phosphorus and potassium were given through urea (46% N), DAP (18 % N & 46% $P_2O_5$) and MOP (60% $K_2O$) respectively. Total amount of DAP, MOP and 50% of nitrogen were applied at time of sowing and remaining half of nitrogen was top dressed in two equal splits at CRI and tillering stages. Nano Nitrogen (4 ml per litre), Bio nano phosphorus (40ml per litre), Bio nano potash (40ml per litre) and Bio nano zinc (40ml per litre) were applied by mixing in 500 litre of water ha$^{-1}$. The sprays were given at 28 and 45 days after sowing as per_treatments. Where ever, more than one nutrient was required they all were mixed in some 500 litre of water and sprayed in a single run. Hand pressure sprayer fitted with flat fan nozzle. The nano materials were supplied by Indian Farmer's Fertilizer Cooperative Ltd (IFFCO), New Delhi.

**2.5 Plant population (No. of population $m^{-2}$)**

The number of plants at three marked places from each plot were recorded at harvest on row length basis and presented on number per $m^{-2}$ basis.

**2.6 Growth**

As to find out the effect of treatments on growth of the crop, observations on plant height, number of tillers and dry matter accumulation were recorded at harvest as under:

**2.6.1 Plant height (cm)**

Five plants were tagged randomly in sampling area for recording height. The height was measured in centimeters with the help of meter scale from the ground surface to the tip of fully expanded leaves. Height of all the five plants were summed and averaged to express plant height in centimeters.

**2.6.2 Number of tillers $m^{-1}$ row length**

Number of tillers were recorded on row length basis from three places in each plot, averaged and expressed as number $m^{-1}$ row length.

**2.6.3 Dry matter accumulation (g $m^{-1}$)**

Row length, measuring 0.25 m, was measured at two places randomly and all the plants falling in the range were cut close to the ground and sun dried. The sun dried sample was kept in oven at $70 \pm 2$ $^0$C temperature till the constant weight was achieved. The oven dried weight was recorded and expressed as dry matter accumulation per metre row length (g $m^{-1}$).

**2.7 Grain yield (q $ha^{-1}$)**

The grains obtained after threshing and winnowing of each of the net -plot were weighed in kilograms. The grain yield was further converted on hectare basis and expressed quintals.

$$Grain\ yield\ (q\ ha^{-1}) = \frac{Net\ plot\ grain\ weight}{Net\ plot\ area\ (m^2)} \times 10000$$

**2.8 Zinc content and uptake**

Zinc content of the digested material was estimated by Atomic Absorption Spectro-photometer (AAS) Lindsay and Norvell (1978). Ground plant sample weighing 0.5 gram was taking in a 100 ml conical flask. After adding 10 ml of di-acid mixture, the flask was heated on hot plot until the residue become colourless. Thereafter, the mixture was allowed to cool, diluted with distilled water and filtered through Whatman No.1 filter paper. The volume of filtrate was made to 50 ml by adding distill water. Zinc content of the solution was expressed with help of Atomic Absorption Spectrophotometer using hallow cathode lamp (HCL). The zinc content (ppm) as indicated by the AAS based on computed standard curve was recorded as used to work out uptake as under:

$$\text{Zn uptake in seed (g ha}^{-1}) = \frac{\text{Zn content in seed (ppm) x Seed yield as dry weight (g ha}^{-1})}{10^6}$$

$$\text{Zn uptake in straw (g ha}^{-1}) = \frac{\text{Zn content in straw (ppm) x Straw yield as dry weight (g ha}^{-1})}{10^6}$$

$$Total\ zinc\ uptake\ (g\ ha^{-1}) = \text{Zinc uptake in seed (g ha}^{-1}) + \text{Zinc uptake in straw (g ha}^{-1})$$

**2.9 Statistical Analysis**

Statistical analysis was done with the help of window-based SPSS (Statistical Product and Service Solutions) Version 10.0, SPSS, Chicago, IL. The SPSS technique was used for the analysis of variance to define the statistical significance of treatment effect at 5 % probability level. Further, F- test and significance of difference between treatments was examined by critical difference (CD) as described by Gomez and Gomez (1984).

**3. RESULTS AND DISCUSSION**

**3.1 Plant population**

At later stages (harvest) where it exhibited significant variations. Crop fertilized with 100 % NPK + Nano N + Bio Nano P + Bio Nano K + Bio Nano Zn was having highest plant population at harvest stage being significantly superior over control, 75% NPK+ water spray, 100% NPK and 100% NPK + water spray but remained at par with other nutrient management practices. Reducing NPK doses by 25 % coupled with spray of nano / bio nano fertilizer increased plant population significantly in comparison to control and 100% NPK even though it remained at par with 100% NPK + nano / bio nano fertilizers. Similar result was also obtained by Rizwan *et al.* (2019).

**3.2 Plant height (cm)**

At later stages (60, 90 days and at harvest), application of either of nano nutrient or their simultaneous use with 100% or 75% NPK increased plant height remarkably over 100% NPK. Further reduction of NPK dose from 100% to 75% along with application of nano nutrients reduced plant height, though it was not significant. Crop fertilized with 100 % NPK + Nano N + Bio Nano P + Bio Nano K + Bio Nano Zn registered higher plant height at all the stages (except 30 DAS) being significantly superior over control, 100% NPK + water spray and 75% NPK +water spray but remained at par with those receiving any combination with 75% NPK and 100% NPK with all other nano nutrient inputs (Nano N + Bio Nano P + Bio Nano K + Bio Nano Zn). Magnitude of increase in plant height with application of nano nutrients was in descending order of nano nitrogen > nano zinc> nano phosphorus > nano potash over recommended dose of fertilizer whether 100% or 75%, though such the differences were non-significant. Similar, an increase in plant height with application of NPK with nano-nutrient (NPK) by Mehta S. (2017), with nano-Zn by Munir *et al.* (2020) and Rizwan *et al.* (2019) has also been reported. Significant increase in plant height with application of nano-nutrients might be explained on the basis that Nano N and Bio-nano-P stimulates root and shoot growth, the effect being prominent in case of roots.

**3.3 Number of tillers**

At harvest, application of either of nano nutrient or their simultaneous use with 100%/75 % NPK increased plant height over 100% NPK. Further reducing NPK doses by 25% coupled with application of nano nutrients reduced number of tillers, though it was not significant. Crop fertilized with 100 % NPK + Nano N + Bio Nano P + Bio Nano K + Bio Nano Zn had highest number of tillers at all the stages (except 30 DAS) being significantly superior over control, 100 % NPK + water spray and 75% NPK + water spray but remained at par with those receiving any combination with 75% NPK and 100% NPK with all other nano nutrient inputs ( Nano N + Bio Nano P + Bio Nano K + Bio Nano Zn). The profuse tillering was due to the fact that nano fertilizer enhanced emergence, more efficient nutrient utilization satisfying nutrient requirement of the crop and increased activity of chloroplast (Hong *et al.*,2005).

### 3.4 Dry matter accumulation

At later stages (60, 90 days and at harvest), application of either of nano nutrient or their simultaneous use with 100 % or 75 % NPK increased plant dry matter significantly over 100% NPK**.** Further reducing NPK doses by 25% coupled with application of nano nutrients reduced number of tillers, however it was not significant. Application of 100 % NPK + Nano N + Bio Nano P + Bio Nano K + Bio Nano Zn resulted in maximum accumulation of dry matter at all growth stages (excluding 30 DAS) in compare to 100 % and 75 % recommended NPK and control, while it remained at par with all other nutrient inputs practice. Application of nano-nutrients in addition to 100% NPK resulted in an increase in dry matter accumulation by 13.2, 9.8, 9.3, 8.2 & 18.7% at harvest with nano -N, P, K & Zn and N + P + K + Zn over 100% NPK. Respective increase along with 75% of NPK was 10.6, 8.8, 8.1, 10.3 & 15.8% over 100% NPK. Among the treatments, 100 % NPK + Nano N + Bio Nano P + Bio Nano K + Bio Nano Zn accumulated 73.7% and 18.7% more dry matter over control and 100% NPK at harvest. The lowest dry matter accumulation (141.2 g $m^{-1}$) was recorded in unfertilized plot and showed inferiority to rest of the treatments at harvest. Apart from, increase plant height, and no. of tillers might have also attributed to it. Besides, the increase in dry matter might be due to cumulative vigorous growth which in turn put forth more photosynthesis surface, chlorophyll formation, biomass and nutrient uptake. These results were in corroboration with the findings of Armin *et al*. (2014), Aziz *et al*. (2016), Hafeez *et al*. (2015), and Benzon *et al*. (2015).

### 3.5 Yield

Fertilizer application, irrespective of nutrients doses and their sources, increased grain yield significantly over no nutrient application as indicated by data given in (Table 2) and depicted in Application of 100% NPK coupled with spray of Nano Zn and bio-stimulant increased grain yield by 8.9 q $ha^{-1}$ (21.5%), 6.9 q $ha^{-1}$ (16.7%), 6.6 q $ha^{-1}$ (16.0%), 7.9 q $ha^{-1}$ (19.1%) and 12.3 q $ha^{-1}$ (29.8%) over 100% NPK. Respective increase with 75% of NPK was 7.4 q $ha^{-1}$ (17.9%), 6.5 q $ha^{-1}$ (15.7%), 6 q $ha^{-1}$ (14.5%), 6.8 q $ha^{-1}$ (16.5%) and 11.1 q $ha^{-1}$ (26.9%). Further, application Nano nutrients with 75% NPK reduced grain yield comparison to that with 100% NPK, though the reduction was not significant. Crop fertilized with 75% NPK + Nano N + P + K and Zn gave significantly higher yield than control & 100% NPK. Increase in grain yield with application of Nano nutrients was significant and in descending order of Nano-N > Nano Zn > Nano > Nano K over NPK alone whether 100% or 75%. This might be due to the fact that nano-fertilizers have large surface area and less particle size than the pore size of root and leaves of the plant which can increase penetration into the plant from applied surface and improve nutrient uptake and increase yield of wheat. Further, nano-NPK is considered the biological pump for the plants to absorb nutrients and water. As mentioned earlier, nano- fertilizers may have affected these processes through its nutrient transportation capability in terms of penetration and movement of a wide range of nutrients, from roots uptake to foliage penetration and movements within the plant. Significant increase in crop yields with foliar application of Nano-fertilizers has been advocated by Tarafdar *et al.* (2012) and Benzon *et al.* (2015).

### 3.6 Zinc content in grain and straw

The zinc content in wheat grains ranged from 32.2 to 54.5 ppm and in straw from 25.1 to 33.1 ppm under various treatments (Table 2). The highest zinc content in grain (54.5 ppm) and straw (33.41ppm) were recorded with the application of 100% NPK with nano- nano N + P + K + Zn, being significantly superior over all other treatments except 75% NPK with nano- N + P + K + Zn, 100% & 75% NPK with nano Zn. All the other treatments where 100 or 75% NPK was supplemented with nano Zinc resulted in significant increase in Zinc content over 100% NPK. Application of nano nutrients with (100/75%) increased nutrient concentration in comparison to 100% of NPK. Application of fertilizers readily increases the availability of nutrient concerned in the soil solution thereby enhancing its absorption by the plant roots and further translocation to the site of action. Application of nano-nutrient increased contents in grains or straw. Favorable effect of Zn on nutrient content of wheat has also been noted by Gupta and Sharma (2006), Aziz *et al*. (2016), Jhanzab *et al.* (2015). The beneficial effect of nano-nutrient when applied in conjunction with inorganic might have helped in increasing and balancing the availability of essential plant nutrients.

### 3.7 Zinc uptake in grain and straw

In general, the crop accumulated larger amount of zinc in grains then in straw irrespective of the treatments (Table 2). The crop fed with 100% NPK with nano- N + P + K + Zn (519.5 g $ha^{-1}$) accumulated significantly highest amount of zinc whereas the lowest (192.3 g $ha^{-1}$) being in crop grown without fertilizers in grain, straw and total as well. Respective share of grain and straw towards total uptake was 56.2 & 43.8 % in 100% NPK with nano- N + P + K + Zn and 48.1 & 51.9 % in control plot. Application of 100 or 75 % of NPK with added nano nutrient resulted significant increase in total zinc accumulation and also in component parts when compared with 100% NPK. Nano- N, P, K & Zn and N + P + K + Zn with 75% NPK increased total zinc uptake by 56.6, 46.5, 41.8 115.4 & 144 g $ha^{-1}$ over 100% NPK alone. Differences between treatments having 100 and 75% of NPK with nano nutrients were non-significant though the former resulted in higher uptake. These results are in conformity with the findings of Kumar *et al.* (2014), Jhanzab *et al*. (2015), and Adhikari *et al*. (2014). The slow release pattern as a responsible factor for enhanced nutrient uptake has been advocated by Manikandan and Subramanian (2016).

**Table. 1 Effect of nano-nutrient on growth attributes of wheat at harvest**

| Treatments | Growth attributes | | | |
|---|---|---|---|---|
| | Plant population (No $m^{-2}$) | Plant height (cm) | Number of tillers $m^{-1}$ row length | Dry matter accumulation (g $m^{-1}$) |
| Control | 228 | 65.4 | 45.6 | 141.2 |
| NPK (150:60:40) | 274 | 76.1 | 54.8 | 206.6 |
| 100 %NPK + water spray at 28 and 45 DAS | 276 | 76.8 | 55.2 | 207.4 |
| 100 % NPK + Nano N spray at 28 and 45 DAS | 305 | 89.0 | 61 | 233.8 |
| 100 % NPK + Bio Nano P spray at 28 and 45 DAS | 296 | 87.0 | 59.2 | 226.9 |
| 100 % NPK + Bio Nano K spray at 28 and 45 DAS | 292 | 85.3 | 58.4 | 225.8 |
| 100 % NPK + Bio Nano Zn spray at 28 and 45 DAS | 301 | 87.2 | 60.2 | 223.6 |
| 100 % NPK + Nano N + Bio Nano P + Bio Nano K + Bio Nano Zn spray at 28 and 45 DAS | 310 | 92.1 | 63.2 | 245.3 |
| 75 % NPK + water spray at 28 and 45 DAS | 259 | 71.1 | 51.8 | 204.6 |
| 75 % NPK + Nano N spray at 28 and 45 DAS | 303 | 86.7 | 60.6 | 228.6 |
| 75 % NPK + Bio Nano spray P at 28 and 45 DAS | 291 | 85.4 | 58.2 | 224.8 |
| 75 % NPK + Bio Nano spray K at 28 and 45 DAS | 290 | 85.0 | 58 | 223.4 |
| 75 % NPK + Bio Nano Zn spray at 28 and 45 DAS | 297 | 86.0 | 59.4 | 227.8 |
| 75 % NPK + Nano N + Bio Nano P + Bio Nano K + Bio Nano Zn spray at 28 and 45 DAS | 309 | 91.7 | 61.8 | 239.2 |
| **SEm±** | **10.7** | **2.9** | **2.5** | **9.2** |
| **CD (P = 0.05)** | **31.5** | **8.5** | **7.4** | **24.4** |

**Table: 2 Effect of nano-nutrient on grain yield, Zn content, uptake and total uptake of wheat**

| Treatments | Grain yield (q ha$^{-1}$) | Zinc content (ppm) | | Zinc uptake (g ha$^{-1}$) | | Total uptake (g ha$^{-1}$) |
|---|---|---|---|---|---|---|
| | | Grain | Straw | Grain | Straw | |
| Control | 27.2 | 32.2 | 25.1 | 87.6 | 104.7 | 192.3 |
| NPK (150:60:40) | 41.3 | 42.6 | 28.1 | 175.9 | 169.7 | 345.6 |
| 100 %NPK + water spray at 28 and 45 DAS | 41.7 | 43.4 | 28.4 | 181.0 | 173.0 | 354 |
| 100 % NPK + Nano N spray at 28 and 45 DAS | 50.2 | 45.4 | 30.9 | 227.9 | 203.0 | 430.9 |
| 100 % NPK + Bio Nano P spray at 28 and 45 DAS | 48.2 | 44.2 | 28.8 | 213.0 | 186.3 | 399.3 |
| 100 % NPK + Bio Nano K spray at 28 and 45 DAS | 47.9 | 44.3 | 29.1 | 212.2 | 185.9 | 398.1 |
| 100 % NPK + Bio Nano Zn spray at 28 and 45 DAS | 49.2 | 52.3 | 32.7 | 257.3 | 213.9 | 471.2 |
| 100 % NPK + Nano N + Bio Nano P + Bio Nano K + Bio Nano Zn spray at 28 and 45 DAS | 53.6 | 54.5 | 33.1 | 292.1 | 227.4 | 519.5 |
| 75 % NPK + water spray at 28 and 45 DAS | 39.1 | 36.1 | 26.2 | 141.2 | 153.0 | 294.2 |
| 75 % NPK + Nano N spray at 28 and 45 DAS | 49.7 | 44.4 | 28.1 | 220.7 | 181.5 | 402.2 |
| 75 % NPK + Bio Nano spray P at 28 and 45 DAS | 47.8 | 43.6 | 28.7 | 208.4 | 183.7 | 392.1 |
| 75 % NPK + Bio Nano spray K at 28 and 45 DAS | 47.3 | 43.7 | 28.5 | 206.7 | 180.7 | 387.4 |
| 75 % NPK + Bio Nano Zn spray at 28 and 45 DAS | 48.1 | 53.8 | 31.4 | 258.8 | 202.2 | 461 |
| 75 % NPK + Nano N + Bio Nano P + Bio Nano K + Bio Nano Zn spray at 28 and 45 DAS | 52.4 | 53.2 | 31.8 | 278.8 | 210.8 | 489.6 |
| **SEm±** | **1.8** | **0.9** | **1.0** | **6.6** | **3.5** | **11.8** |
| **CD (P = 0.05)** | **5.2** | **2.7** | **2.92** | **19.3** | **10.3** | **29.6** |

## 4. CONCLUSION

As per the discussed above problem increasing input use with declining efficiency trends, deteriorating soil health, depleting water resources, pollution, and narrowing profits at the end of farmers it can be concluded that application of Nano-N + 75% NPK followed Nano-Zn + 75% NPK can be a good approach to overcome these problems and get a higher yield with better nutrient uptake which ultimately helps in improving quality of grain.

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