Original Research Article

Effect of Nano and Non-nano Nutrients on Content, uptake and NUE of Wheat (*Triticum aestivum* L.)

Abstract

The study was carried out in the winter (rabi) season to determine whether " **Effect of Nano and Non-nano nutrient on content, uptake and NUE of wheat (*Triticum aestivum* L.)**." *The study's findings revealed that wheat grown with 100% NPK + nano nutrients (N + P + K + Zn) had significantly higher uptake, namely N (143.1 kg ha-1), P (28.9 kg ha^{-1}), K (109.0 kg ha^{-1}), and Zn (519.5 g ha^{-1}).* Applications of nano nutrients—N, P, K, and Zn, and N + P + K + Zn + 75% NPK—worked synergistically and increased content and uptake over 100% NPK. Similarly, the agronomic efficiency (kg of grain kg^{-1} of nutrient applied) of N (22.4), P (56.0), and K (84.0) was greatest when 75% NPK + nano N + bio nano P, K, and Zn were applied. In a similar manner, physiological efficiency and partial factor productivity were also found to be significantly higher with the same treatment. Thus, the wheat crop grown with the application of Nano-N + 75 and 100 percent NPK led to higher nutrient content, accumulation, and efficiency.

Keywords: Nano Nutrient, Efficiency, Content, Uptake, Wheat

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the world's most significant food crop in terms of production and acreage. It was grown on 216.94 million hectares around the world, yielding 734.03 million metric tonnes of grain with an average productivity of 3.39 t/ha (USDA report, 2018–

19). Wheat also accounts for about a third of India's total food grain production. (Tandon, 2000), and it covered an area of 30.750 million ha with a production of 101.20 million tonnes in 2018–19 (Kumar *et al., 2019)*. With a total area of 9.65 million hectares (36.6 percent), a yield of 29.67 million metric tonnes (30.9 percent), and a productivity of 27,955 kg per ha, Uttar Pradesh is India's biggest wheat-growing state (Anonymous, 2019).

When compared to the United Kingdom (8.5 t ha-1), Germany (7.9 t ha-1), France (7.8 t ha-1), and China (6.10 t ha-1) wheat productivity in India is very low. The situation is further grim in the state of Uttar Pradesh (2.7 t ha1), even though Punjab and Haryana had been harvesting 4.36 t ha1 and 4.0 t ha^{-1} (Anonymous, 2018). In Punjab, a major factor behind higher productivity is that almost 100% of the wheat area is irrigated and receives a very high level of fertilizer. The application of urea, diammonium phosphate, and muriate of potash have been found to have lower fertilizer-use efficiency (Yuvaraj *et al.*, 2018). The nutrient-use efficiencies range from 20–50% for N, 10–25% for P, 70–80% for K, and 2% for micronutrients, owing to various losses that contribute to greenhouse gas emissions, certain health hazards, and an increase in the cost of cultivation, but also result in sub-optimal productivity levels and low-quality produce (Singh *et al*., 2017). However, there are some health risks, such as the blue baby syndrome and an increase in cultivation costs (Nader and Shahraki, 2013). Nanotechnology (Nano/Bio nano fertilizers) holds promise in this context, and nano-fertilizers can help preserve soil health and crop productivity.

Nanoparticles (eco-friendly fertilisers like Nano/Bio-Nano NPK and Zn liquid) have the potential to transform the agriculture and food industries by, among other things, enhancing plant nutrient uptake, disease molecular treatment, disease detection, maintaining soil fertility, and ensuring good output without causing environmental damage. Bio-based nanomaterials (BBNM) are micron-sized minerals that are brought to a scale of 10–100 nm using a system and technique. They are naturally occurring inorganic solids with a well-defined chemical composition and an organised interior structure.

MATERIALS AND METHODS

An investigation was conducted at the crop research station of the Sardar Vallabhbhai Patel University of Agriculture and Technology, found in the Indo-Gangetic plains of western Uttar Pradesh. Meerut has a semi-arid and sub-tropical climate with extremely hot summers and freezing winters. The crop received 190 mm during this period. The soil texture at the test site was sandy loam with low available nitrogen and organic carbon, medium accessible phosphorus and potassium, and a somewhat alkaline reaction. The experiment was laid out in a randomised block design with three replications and 14 treatments. Wheat variety DBW 17 was grown as a test crop. The recommended NPK dose was 150:60:40 kg ha-1 of N, P2O5, and K2O, applied repeatedly as needed. The total amount of DAP, MOP and half of the nitrogen was delivered at the time of sowing, and the other half was applied in two equal splits at the CRI and tillering stages. Nano-nitrogen (4 ml per litre), bio-nano-phosphorus (40 ml per litre), bio-nano-potash (40 ml per litre), and bio-nano-zinc (40 ml per litre) at spray 28 and 45 DAS were applied by mixing in 500 litres of water ha^{-1}.

The modified micro-Kjeldahl method was used to determine the nitrogen content of samples (Jackson, 1973). Using the vanadium-phosphorus acid yellow colour method in an acid system, the amount of phosphorus is measured at a wavelength of 470 nm. According to Cavell, A. J.'s description, the intensity of the yellow colour was measured using a spectrophotometer (1954). The flame photometer was used to estimate the amount of potassium present in the digested material (Cavell, A. J., 1954). The amount of potassium in the seed and straw was given as a percentage. Nutrient use efficiency (NUE) shows the ability of crops to absorb and utilise nutrients in their yield. It develops nutrient uptake, assimilation, and utilisation strategies. Nutrient use efficiency is classified by **Craswell and Godwin (1984).**

The total nutrient uptake was calculated as:

Total nutrient uptake (kg ha^{-1}) = Nutrient uptake in seed + Nutrient uptake in straw

$$\text{Uptake (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content in seed/straw (\%) x Seed/straw yield as dry weight (kg ha}^{-1}\text{)}}{100}$$

The SPSS technique was used for the analysis of variance to define the statistical significance of treatment effects at a 5% probability level. Further, the F-test and the significance of the difference between treatments were examined by the critical difference (CD) as described by **Gomez and Gomez (1984).**

RESULT AND DISCUSSION

Nutrient content (%) and uptake (kg ha^{-1})

Nitrogen, Phosphorus and Potassium content and uptake in grain and straw

The analysis of variance pertaining to the nitrogen, phosphorus, and potassium content (%) in grain and straw revealed a significant effect of nutrient management practises and the data presented in Table 1. The crop fertilised with 100 % NPK + nano-N, P, K, and Zn had significantly higher nitrogen, phosphorus, and potassium contents in its components, *i.e.*, grain and straw. The lowest nitrogen, phosphorus, and potassium content in grain and straw were recorded in crops receiving no fertilizers. It was closely followed by one receiving 75% of NPK along with nano-N, P, K, and Zn in respect to nitrogen content in grain and straw.

Application of 100 or 75 % of NPK with added nano-nutrients resulted in a significant increase in nutrient uptake in grain and straw, total accumulation, and component parts compared with 100% NPK (Figure 1). The crop grown with 100 % NPK + Nano N, P, K, and Zn accumulated the significantly highest amount of nitrogen (143.1% kg ha^{-1}) whereas the lowest (40.1 kg ha^{-1}) was in a crop grown without fertilizer in its grain, straw, and total as well. In the case of phosphorus, the crop accumulated a larger amount of phosphorus in grains than in straw, irrespective of the treatments (Table 2). The respective share of grain and straw towards total uptake was 59.5 & 40.5 % in 100% NPK with nano-N + P + K+ Zn. In the case of potassium, the crop accumulated a larger amount of potassium in straw than in grain, irrespective of the treatments (Table 3). Respective share of grain and straw towards total uptake was 18.1 & 81.9 % with 100% NPK + nano nutrients and 20.9 & 79.1 % without fertilizer.

It may be due to higher-absorption rates, utilisation efficacy, and minimum losses of nanonutrients. A reduction in volatilization, denitrification, leaching, and fixation losses of NPK has been observed by Yuvaraj et al. (2020) and Abdel et al. (2018). According to Rajonee *et al*. (2016) and Al-Juthery *et al*. (2019), nanofertilizer has a large surface area but a smaller particle size than what passes through plasmodesmata, which results in the effective delivery of nutrients to sink sites. Poor content in control plots was mainly due to a lack of application and widespread deficiency of such nutrients (Abdel *et al.*, 2016).

Nutrient Use Efficiency

Agronomic Efficiency (AE) (kg grain yield increase kg^{-1} nutrient applied):

The data analysis in Table -4 revealed a significant increase in the agronomic use efficiency of NPK under different nutrient management practices compared to 100% NPK. The use of 75% NPK + nano N + bio nano P, K, and Zn resulted in higher agronomic efficiency of 22.4 for N, 56.0 for P, and 84.4 for K compared to 9.4, 23.5, and 35.3 for 100% NPK.

Physiological Efficiency (PE) (kg yield increase kg^{-1} nutrient uptake): The physiological efficiency of N was reduced by 15.2 and 13.6 kg grain yield kg1 nitrogen uptake, respectively, when 100 and 75% NPK with nano N, P, K, and Zn were applied (Table -5). The maximum physiological P-use efficiency was 247.9 with 75% NPK + water spray and the lowest was 109.4 with 100% NPK + bio-nano P. The physiological efficiency of phosphorus was reduced by 102.2 and 98 kg of grain yield per nutrient absorbed, respectively, when 100 and 75% NPK with nano-N, P, K, and Zn were applied. In terms of physiological potassium use efficiency, 75% NPK + water spray had the highest PE (54.8) and 100% NPK + bio nano K had the lowest (36.0).

Partial Factor Productivity (PFP) (kg of grain kg^{-1} of nutrient applied):

Application of nanonutrients in addition to 75% NPK + nano-N + P + K + Zn increased PFP by 190 units of N, 47.0 units of P, and 72.0 units of K compared to 100% NPK. The magnitude of increase in PFP with nanonutrient application was in ascending order of Nano K, Nano P, Nano Zn, and Nano N over the recommended dose of fertilizer, whether 100%.

Nutrient use efficiency (agronomic, partial factor productivity, and physiological efficiency) is reported in Tables 4-6. We observed significant results with the use of nanonutrients. Nutrient use efficiency is dependent upon grain yield, the uptake of nutrients, and the amount of nutrients applied. Application of 75% NPK with nanonutrients (N, P, K, and Zn) increased nutrient use efficiency significantly in comparison to 100% NPK, control, and other treatments. The large surface area and small particle size of nano-fertilizers, which are smaller than the pore size of the plant's roots and leaves, may be the reasons for this. This may boost the nano-penetration of fertilisers into the plant from the applied surface and increase absorption and nutrient usage efficiency. A fertilizer's specific surface area and particle count per unit area rise as particle size decreases, giving nano fertilizers greater surface area and opportunities for interaction (Duhan *et al*., 2017 and Lowry *et al*., 2019). This increases nutrient penetration and absorption, resulting in high nutrient utilisation efficiency. According to Yuvaraj *et al.* (2018) and Liu *et al.* (2015) nanonutrients with a size of less than 100 nm boost plant metabolism by increasing its usage of fertilisers more effectively, reducing pollution, and being more ecologically friendly. Similar findings were given by Qureshi *et al*. (2018), Singh *et al*. (2017), and Hagab *et al.* (2018).

CONCLUSION:

The aforementioned information eliminates any doubt regarding the effect of nutrition management systems on wheat production characteristics, yield, nutrient consumption efficiency, protein content and yield, and returns. When applied singly or in combination, N, P, K, and Zn nanonutrients promoted crop development and markedly boosted content, absorption, and NUE. Additionally, nano/bio nano sources of N, P, K, and Zn may promote the growth and absorption of wheat. Sowing irrigated wheat at 30 and 45 DAS in a timely manner with a 75 percent NPK + nanonutrient spray was found to be both technically and financially feasible.

Data Availability: Data generated or analyzed during this study are available from the corresponding author upon reasonable request.

REFERENCES

1. Abdel-Aziz, H.; Hasaneen, M.N.; and Omar, A. (2018). Effect of Foliar Application of Nanochitosan NPK Fertilizer on the Chemical Composition of Wheat Grains *Egyptian Journal of Botany, vol. 58, no. 1, pp. 87-95.*
2. Abdel-Aziz, H.M.; Hasaneen, M.N.; and Omer, A.M. (2016). Nanochitosan-NPK fertiliser enhances the growth and productivity of wheat plants grown in sandy soil. *Spanish Journal of Agricultural Research,* 14(1): 902,
3. Cavell, A. J. (1954). A rapid method for the determination of nitrogen, phosphorus, and potassium in plant materials *Journal of Food Science and Technology, 5(4), pp. 195-200.*
4. Duhan, J. S., Kumar, R., Kumar, N., Kaur, P., Nehra, K., and Duhan, S. (2017). Nanotechnology: the new perspective in precision agriculture. *Biotechnol. Rep.* 15, 11–23. doi:10.1016/j.btre.2017.03.002
5. Gomez, K.A., and Gomez, A.A. 1984. Statistical Procedure for Agriculture Research, 2nd Edition Jon Wielly and Sons, New York
6. Hagab, R. H., Kotp, Y. H., & Eissa, D. (2018). Using nanotechnology to improve the efficiency of phosphorus fertiliser use in peanut beans grown in sandy soils*Journal of Advanced Pharmacy Education and Research, Jul-Sep, 8* (3), 59-67.
7. Liu, R., and R. Lal. 2015. "Potentials of Engineered Nanoparticles as Fertilizers for Increasing Agronomic Productions." A Review. Science of the Total Environment 514: 131–139 doi:10.1016/j.scitotenv.2015.01.104
8. Lowry, G. V., Avellan, A., and Gilbertson, L. M. (2019). Opportunities and challenges for nanotechnology in the agri-tech revolution. *Nat. Nanotechnol.* 14, 517–522. doi:10.1038/s41565-019-0461-7

9. M.L. Jackson, "Soil Chemical Analysis," Prentice Hall of India Private Limited, New Delhi, 1973.
10. Naderi, M., and Shahraki, A. (2013). Nano-fertilizers and their roles in sustainable agriculture. *International Journal of Agriculture and Crop Science*, **5**(19): 2229-2232.
11. Qureshi, A.; Singh, D.K.; and Dwivedi, S. (2018). Nanofertilizers: A Novel Way for Enhancing Nutrient Use Efficiency and Crop Productivity., 7(2): 3325-3335.
12. Rajonee, A. A., Niger, F., Ahmed, S., & Huq, S. I. (2016). Synthesis of nitrogen nanofertilizer and its efficacy Canadian J. Pure Appl. Sci., 10(2), 3913:3919.
13. Singh M D (2017). Nano-fertilisers are a new way to increase the efficiency with which nutrients are used in crop production. international journal of agriculture, review article *International Journal of Agriculture Sciences.* 9(7) 3831-3833.
14. Yuvaraj, M., & Subramanian, K. S. (2020). Novel slow-release nanocomposite fertilizers in *nanotechnology and the environment*. Intech Open.

Tables

Table 1. Effect of nano-nutrient on nitrogen content (%), nitrogen uptake and total uptake (kg ha^{-1}) in grain and straw

Treatment	Nitrogen content (%)		Nitrogen uptake(kg ha^{-1})		Total uptake (kg ha^{-1})
	Grain	Straw	Grain	Straw	
Control	1.2	0.18	32.6	7.8	40.1
RDF (150:60:40)	1.4	0.28	57.8	16.9	74.7
100 % RDF + water spray at 28 and 45 DAS	1.4	0.29	58.4	17.8	76.0
100 % RDF + Nano N spray at 28 and 45 DAS	1.7	0.57	85.3	37.4	122.8
100 % RDF + Bio Nano P spray at 28 and 45 DAS	1.6	0.35	77.1	22.6	99.8
100 % RDF + Bio Nano K spray at 28 and 45 DAS	1.5	0.31	71.8	19.8	91.6
100 % RDF + Bio Nano Zn spray at 28 and 45	1.6	0.37	78.7	24.2	102.9

DAS					
100 % RDF + Nano N + Bio Nano P + Bio Nano K + Bio Nano Zn spray at 28 and 45 DAS	1.9	0.60	101.8	41.2	143.1
75 % RDF + water spray at 28 and 45 DAS	1.3	0.30	50.8	17.6	68.3
75 % RDF + Nano N spray at 28 and 45 DAS	1.8	0.55	89.5	35.5	125.0
75 % RDF + Bio Nano spray P at 28 and 45 DAS	1.5	0.32	71.7	20.5	92.2
75 % RDF + Bio Nano spray K at 28 and 45 DAS	1.4	0.28	66.2	17.8	84.0
75 % RDF + Bio Nano Zn spray at 28 and 45 DAS	1.5	0.30	72.1	19.3	91.5
75 % RDF + Nano N + Bio Nano P + Bio Nano K + Bio Nano Zn spray at 28 and 45 DAS	1.8	0.58	94.3	38.5	132.8
SEm±	**0.03**	**0.01**	**2.6**	**1.0**	**3.8**
CD (P = 0.05)	**0.10**	**0.02**	**7.7**	**2.9**	**11.1**

Table 2. Effect of nano-nutrients on phosphorus content (%), phosphorus uptake and total uptake (kg ha^{-1}) in grain and straw

Treatment	**Phosphorus content (%)**		**Phosphorus uptake (kg ha^{-1})**		**Total uptake (kg ha^{-1})**
	Grain	**Straw**	**Grain**	**Straw**	
Control	0.10	0.06	2.7	2.5	5.2
NPK (150:60:40)	0.17	0.08	7.0	4.8	11.8
100 %NPK + water spray at 28 and 45 DAS	0.18	0.09	7.5	5.5	13.0
100 % NPK + Nano N spray at 28 and 45 DAS	0.27	0.12	13.6	7.9	21.5
100 % NPK + Bio Nano P spray at 28 and 45 DAS	0.31	0.15	14.7	9.7	24.4
100 % NPK + Bio Nano K spray at 28 and 45 DAS	0.21	0.12	9.8	7.7	17.5
100 % NPK + Bio Nano Zn spray at 28 and 45 DAS	0.20	0.11	9.8	7.2	17.0
100 % NPK + Nano N + Bio Nano P + Bio Nano K + Bio Nano Zn spray at 28 and 45 DAS	0.32	0.17	17.2	11.7	28.9
75 % NPK + water spray at 28 and 45 DAS	0.15	0.07	5.9	4.1	10.0
75 % NPK + Nano N spray at 28 and 45 DAS	0.24	0.13	11.7	8.4	20.1
75 % NPK + Bio Nano spray P at 28 and 45 DAS	0.29	0.14	13.7	9.0	22.7
75 % NPK + Bio Nano spray K at 28 and 45 DAS	0.18	0.11	8.2	7.0	15.2
75 % NPK + Bio Nano Zn spray at 28 and 45 DAS	0.17	0.10	8.2	6.4	14.6

75 % NPK + Nano N + Bio Nano P + Bio Nano K + Bio Nano Zn spray at 28 and 45 DAS	0.30	0.16	15.7	11.3	27.0
SEm±	**0.01**	**0.01**	**0.5**	**0.4**	**0.9**
CD (P = 0.05)	**0.03**	**0.02**	**1.5**	**1.1**	**2.6**

Table 3. Effect of nano-nutrients on potassium content (%), potassium uptake and total uptake (kg ha^{-1}) in grain and straw

Treatment	**Potassium content (%)**		**Potassium uptake (Kg ha^{-1})**		**Total uptake (Kg ha^{-1})**
	Grain	**Straw**	**Grain**	**Straw**	
Control	0.24	0.7	7.7	29.2	36.9
NPK (150:60:40)	0.49	1.0	15.5	60.4	75.9
100 %NPK + water spray at 28 and 45 DAS	0.50	1.0	15.4	61.3	76.7
100 % NPK + Nano N spray at 28 and 45 DAS	0.56	1.1	17.0	72.3	89.3
100 % NPK + Bio Nano P spray at 28 and 45 DAS	0.52	1.0	18.4	64.7	83.1
100 % NPK + Bio Nano K spray at 28 and 45 DAS	0.63	1.2	17.7	76.7	94.4
100 % NPK + Bio Nano Zn spray at 28 and 45 DAS	0.54	1.1	16.8	71.9	88.7
100 % NPK + Nano N + Bio Nano P + Bio Nano K + Bio Nano Zn spray at 28 and 45 DAS	0.65	1.3	19.7	89.3	109.0
75 % NPK + water spray at 28 and 45 DAS	0.36	0.8	11.9	46.7	58.6
75 % NPK + Nano N spray at 28 and 45 DAS	0.52	1.1	14.4	71.1	85.5
75 % NPK + Bio Nano spray P at 28 and 45 DAS	0.50	1.0	15.0	64.0	79.0
75 % NPK + Bio Nano spray K at 28 and 45 DAS	0.64	1.2	15.3	76.1	91.4
75 % NPK + Bio Nano Zn spray at 28 and 45 DAS	0.51	1.0	15.7	64.4	80.1
75 % NPK + Nano N + Bio Nano P + Bio Nano K + Bio Nano Zn spray at 28 and 45 DAS	0.65	1.3	16.1	86.2	102.3
SEm±	**0.01**	**0.02**	**0.7**	**3.2**	**3.10**
CD (P = 0.05)	**0.08**	**0.06**	**2.1**	**9.3**	**11.5**

Table 4. Effect of nano-nutrients on agronomic use efficiency

Treatment	**Agronomic use-efficiency (AE)**		
	Nitrogen(N)	**Phosphorus(P)**	**Potassium(K)**
Control	--	--	--
NPK (150:60:40)	9.4	23.5	35.3
100 %NPK + water spray at 28 and 45 DAS	9.7	24.2	36.3
100 % NPK + Nano N spray at 28 and 45 DAS	15.3	38.3	57.5

100 % NPK + Bio Nano P spray at 28 and 45 DAS	14.0	35.0	52.5
100 % NPK + Bio Nano K spray at 28 and 45 DAS	13.8	34.5	51.8
100 % NPK + Bio Nano Zn spray at 28 and 45 DAS	14.7	36.7	55.0
100 % NPK + Nano N + Bio Nano P + Bio Nano K + Bio Nano Zn spray at 28 and 45 DAS	17.6	44.0	66.0
75 % NPK + water spray at 28 and 45 DAS	10.6	26.4	39.7
75 % NPK + Nano N spray at 28 and 45 DAS	20.0	50.0	75.0
75 % NPK + Bio Nano spray P at 28 and 45 DAS	18.3	45.8	68.7
75 % NPK + Bio Nano spray K at 28 and 45 DAS	17.9	44.7	67.0
75 % NPK + Bio Nano Zn spray at 28 and 45 DAS	18.6	46.4	69.7
75 % NPK + Nano N + Bio Nano P + Bio Nano K + Bio Nano Zn spray at 28 and 45 DAS	22.4	56.0	84.0
SEm±	**0.4**	**1.1**	**1.6**
CD (P = 0.05)	**1.3**	**3.2**	**4.7**

Table 5. Effect of nano-nutrients on physiological use efficiency

Treatment	**Physiological use-efficiency (PE)**		
	Nitrogen (N)	**Phosphorus (P)**	**Potassium (K)**
Control	--	--	--
NPK (150:60:40)	40.8	213.6	36.2
100 %NPK + water spray at 28 and 45 DAS	40.4	185.9	36.4
100 % NPK + Nano N spray at 28 and 45 DAS	27.8	141.1	43.9
100 % NPK + Bio Nano P spray at 28 and 45 DAS	35.2	109.4	45.5
100 % NPK + Bio Nano K spray at 28 and 45 DAS	40.2	168.3	36.0
100 % NPK + Bio Nano Zn spray at 28 and 45 DAS	35.0	186.4	42.5
100 % NPK + Nano N + Bio Nano P + Bio Nano K + Bio Nano Zn spray at 28 and 45 DAS	25.6	111.4	36.6
75 % NPK + water spray at 28 and 45 DAS	42.2	247.9	54.8
75 % NPK + Nano N spray at 28 and 45 DAS	26.5	151.0	46.3
75 % NPK + Bio Nano spray P at 28 and 45 DAS	39.5	117.7	48.9
75 % NPK + Bio Nano spray K at 28 and 45 DAS	45.8	201.0	36.9
75 % NPK + Bio Nano Zn spray at 28 and 45 DAS	40.7	222.3	48.4

75 % NPK + Nano N + Bio Nano P + Bio Nano K + Bio Nano Zn spray at 28 and 45 DAS	27.2	115.6	38.5
SEm±	**1.1**	**4.8**	**1.1**
CD (P = 0.05)	**3.2**	**14.1**	**3.3**

Table 6. Effect of nano-nutrients on partial factor productivity

Treatment	**Partial factor productivity**		
	Nitrogen (N)	**Phosphorus (P)**	**Potassium (K)**
Control	--	--	--
NPK (150:60:40)	27.5	69	103
100 %NPK + water spray at 28 and 45 DAS	27.8	70	104
100 % NPK + Nano N spray at 28 and 45 DAS	33.5	84	126
100 % NPK + Bio Nano P spray at 28 and 45 DAS	32.1	80	121
100 % NPK + Bio Nano K spray at 28 and 45 DAS	31.9	80	120
100 % NPK + Bio Nano Zn spray at 28 and 45 DAS	32.8	82	123
100 % NPK + Nano N + Bio Nano P + Bio Nano K + Bio Nano Zn spray at 28 and 45 DAS	35.7	89	134
75 % NPK + water spray at 28 and 45 DAS	34.8	87	130
75 % NPK + Nano N spray at 28 and 45 DAS	44.2	110	166
75 % NPK + Bio Nano spray P at 28 and 45 DAS	42.5	106	159
75 % NPK + Bio Nano spray K at 28 and 45 DAS	42.0	105	158
75 % NPK + Bio Nano Zn spray at 28 and 45 DAS	42.8	107	160
75 % NPK + Nano N + Bio Nano P + Bio Nano K + Bio Nano Zn spray at 28 and 45 DAS	46.6	116	175
SEm±	**0.01**	**0.02**	**0.03**
CD (P = 0.05)	**0.02**	**0.05**	**0.1**

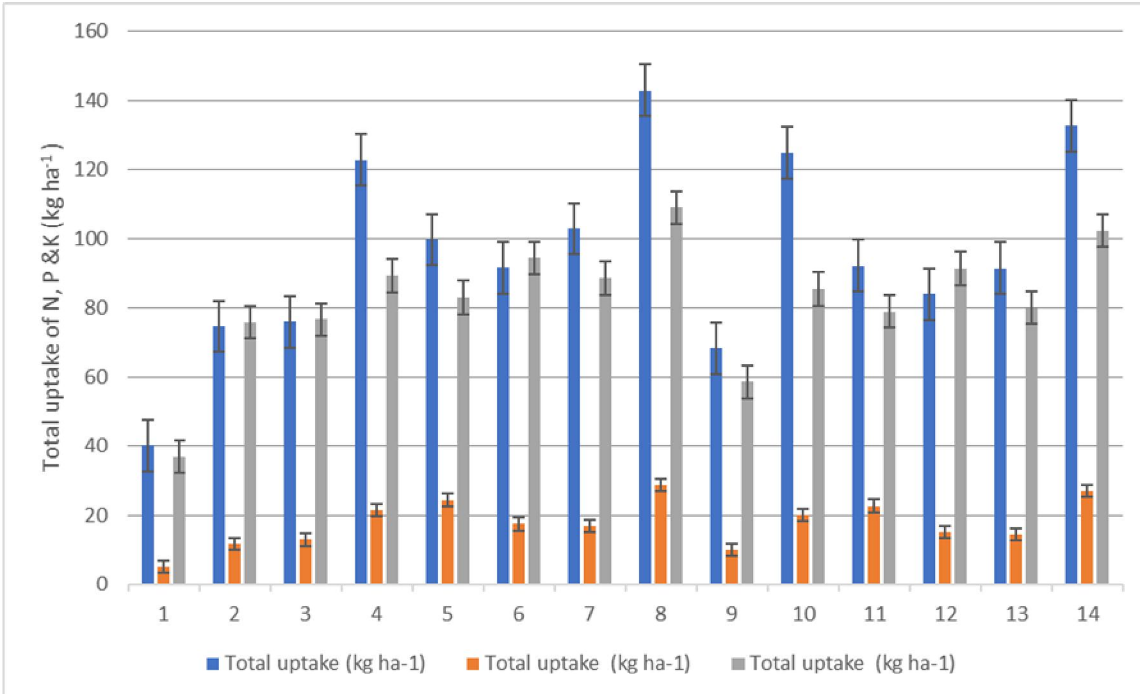

Fig.1. Effect of nano-nutrients on Total uptake of N, P &K (kg ha^{-1})