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Influence of integrated nutrient management using nano phosphatic fertilizer on nutrient use efficiency and yield of wheat (*Triticum aestivum* L.) in Vertisols

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Abstract
The experiment was conducted during *rabi* 2019 to know the effect of integrated nutrient management using nano phosphatic fertilizer on yield, uptake by wheat, soil fertility status and nutrient use efficiency after harvest of wheat. The field trial study showed that, the highest grain yield (3546 kg ha^{-1}) was obtained by application of Green manuring of sun hemp + 50% RD of NP through inorganic fertilizers + spraying of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage of Wheat, which is an increase by 6% over Green manuring of sun hemp + 100% RDF. Phosphorus use efficiency is recorded in between 13.43 to 35.83 % under the application of RDF alone or in combination of nano P suspension.

Keywords: Nano phosphatic fertilizer, wheat, tillering, flowering, ghanjivamrut, jivamrut, vermicompost

Introduction
Wheat (*Triticum aestivum* L.) is one of the oldest and most important cereal crops in India. Wheat plays an important role in total cereal production and global food security. India is the second largest producer of wheat in the world next to China. Wheat is the second most important crop in India after rice and contributes nearly 35% to the national food basket. India will require 109 million tons of wheat to feed the population of 1.25 billion by 2020, which can be achieved by growth rate of 2.2% but the current growth rate is only 1.0%. Wheat cultivation in India occupies 30.42 million-hectare area with the production of 99.87 million tons and productivity of 32.83 q ha^{-1}. Wheat production of India is 99.87 million tons during 2017-18 which is higher by 1.26 million tons than the production of 98.61 million tons achieved during 2016-17 [1]. The average wheat productivity of India is 3283 kg ha^{-1}. Productivity of wheat can only be enhanced by application of scientific tools and techniques in agriculture. Modern science basically deals with three areas i.e. information technology, biotechnology and nanotechnology.

The crop production and global food security are greatly dependent on fertilizer input constituting nitrogen, Phosphorus and potassium, as it supplements soil nutrients, promotes plant growth and increase crop productivity. Response of P fertilizer in Vertisols of India has been reported to be unpredictable and this has been ascribed to high P fixation due to high clay content and high content of smectite. Soil of Vidarbha region of Maharashtra are dominated in smectite and varied from 40 to 78%. At present 5% of the Indian soils have adequate available P, 49.3% under low category, 48.8% under medium and only 1.9% under high category [9]. The primary goal of integrated nutrient management (INM) is to combine old and new methods of nutrient management into ecologically sound and economically viable farming systems that utilize available organic and inorganic sources of nutrients in a judicial and efficient way [5]. Chemical fertilizers like urea, diammonium phosphate (DAP) and single superphosphate (SSP) are used in agriculture to meet the shortage of N, P and K in the soil. But most part of these fertilizers are lost as run-off or volatilized. It is estimated that about 40–70% of nitrogen, 80–90% of phosphorus, and 50 to 70% of potassium of the applied fertilizers is lost to the environment and can't be absorbed by plant applied causing exchequer loss to the nation and environmental pollution as well [12].

Nano fertilizers are synthesized or modified form of traditional fertilizers, fertilizers bulk materials or extracted from different vegetative or reproductive parts of the plant by different physical, chemical or biological methods with the help of nanotechnology used to improve soil fertility, productivity and quality of agriculture produce [10]. Particle size of P-fertilizers greatly influences their agronomic effectiveness. Decreased particle size increases the specific surface area of a fertilizer, which increase the dissolution rate of fertilizers with low solubility in water [8]. Nanoparticles are expected to be the ideal candidates for use as a P-fertilizer for plants. Nano-fertilizers are highly effective for precise nutrient management in precision agriculture with matching the crop growth stage for nutrient and may provide nutrient throughout the crop growth period. To increase phosphorus use efficiency and minimize the losses of phosphatic fertilizers, nano phosphatic fertilizer is the best alternative to increase phosphorus use efficiency as well as nutrient uptake and yield of various crops. Nano fertilizer increases fertilizer use efficiency by targeted release of nutrient in adequate proportion without any harmful effect on soil as well as plant [13].

Materials and Methods

The Hydroxyapatite (HA) source of Phosphorus is used for synthesis of nano phosphatic fertilizer which is prepared by using Chemical precipitation method as demonstrated by Mateus *et* al., 2007 [7] in the laboratory of Department of Nanotechnology and Centre for Advanced Research in Plant Tissue Culture, Anand Agricultural University, Anand (Gujarat). A field experiment was conducted during *rabi* 2019 at Botany Research Farm, College of Agriculture, Nagpur (MH). After the preparation of hydroxyapatite nanoparticles different characterization techniques were used to investigate their particle size (nm), poly dispersive index (PDI) and count rate (Kcps), zeta potential and morphological characteristics at same place where nano P is synthesized. Dynamic light scattering measurements for particle size (nm) and Polydispersity Index showed that the particle size was in the range of 145- 172 nm with Polydispersity Index of 0.274 to 0.328, it is the mid-range value and indicating that the particles were in disperse form in aqueous suspension. From the analysis, the zeta potential value was found to be (-47.13 and -47.23 mV) respectively for two sprayings, revealing the better stability of synthesized HAP nanoparticles in aqueous suspension [16].

The soil used for the experiment was alkaline in reaction with low in available nitrogen, medium in available phosphorus and high in available potassium. With respect to DTPA-micronutrients, Zn, Mn and Fe was in medium and Cu present in sufficient range. The experiment is laid down in randomized block design which had nine treatments and three replications. The treatments were T1 [Absolute control], T2 [GM* + 100% RDF], T3 [GM* + Ghanajivamrut 5 t ha^{-1} + Azophos seed treatment + 50% RD of NP through fertilizer + Jivamru], T4 [GM* + Vermicompost 5 t ha^{-1} + Azophos seed treatment + 50% RD of NP through fertilizer + Jivamrut], T5 [GM* + 50% RD of NP through fertilizer + Foliar spray of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage of wheat], T6 [T3 + Foliar spray of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage of wheat], T7 [T4 + Foliar spray of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage of wheat], T8 [GM* + Ghanajivamrut 5 t ha^{-1}] and T9 [GM* + Vermicompost 5 t ha^{-1} + Azophos seed treatment + Jivamrut] in which GM* means green manuring of Sunhemp (*Crotolaria juncea*). Sunhemp were harvested after 30 days of sowing and incorporated into field by tractor-drawn rotavetor on 3rd November. Wheat (AKW-1071) was sown on 15th November using 100 kg seed ha^{-1}. Fertilizers used were urea, DAP, muriate of potash and 1000 ppm nano P fertilizer. Wheat crop was harvested at physiological maturity and yields (Grain and Straw) were recorded.

Grain and straw samples were analysed for nitrogen content by Kjeldahl method (Piper, 1966). Phosphorus and potassium in di-acid (HNO_3: $HClO_4$) digest were determined by vanadomolybdate yellow colour method and flame photometer. The soil pH was determined in 1:2.5 soil water ratio in suspensions using digital pH meter [4]. Electrical conductivity was determined by in 1:2.5 soil water ratio using Conductivity meter [4].Organic carbon from soil was determined by Wet oxidation method [15]. The available nitrogen was estimated by alkaline permanganate method described by Subbiah and Asija (1956) [14]. Available Phosphorus was determined by Olsen's method using 0.5 M sodium bicarbonate (pH 8.5) as extractant and Darco G-60 free from soluble Phosphorus to absorb the dispersed organic matter and make the filtrate colourless for further spectrophotometric analysis. Available potassium was determined by flame photometer using neutral normal ammonium acetate extractant [4]. The available sulphur estimated turbidimetrically ($CaCl_2$) extract using spectrophotometer described by Chesnin and Yien (1951) [2]. DTPA extractable Zn, Fe, Cu and Mn was estimated by the method described by Lindsay and Norvell (1978) [6] for this log soil was shaken in 20 mL 0.005 M DTPA buffer solution (Diethylene triamine penta acetic acid containing 0.1 M calcium chloride adjusted to pH 7.3 with HCl) for two hours and then filtered and filtrate was subjected to measurement on Atomic Absorption Spectrophotometer (AAS). The nutrient use efficiency (%) is estimated by following formula:

$$\text{NUE (\%)} = \frac{\text{Nutrient uptake in fertilized plot (kg ha}^{-1}\text{)} - \text{Nutrient uptake in unfertilized plot (kg ha}^{-1}\text{)}}{\text{Nutrient Applied (kg ha}^{-1}\text{)}} \times 100$$

Results and discussion

Effect of INM with nano phosphatic fertilizer on yield attributes and yield of wheat

The data pertaining to effect of INM with nano phosphatic fertilizer on yield attributes and yield of wheat is given in table 1.

Table 1: Effect of INM with nano phosphatic fertilizer on yield attributes and yield of wheat

Treat. No.	Treatment Details	Test weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
T_1	Absolute control	38.43	1657.40	2006.00
T_2	GM* + 100% RDF	42.32	3340.21	4175.10
T_3	GM* + Ghanajivamrut 5 t ha^{-1} + Azophos seed treatment + 50% RD of NP through fertilizer + Jivamrut	39.53	3218.00	4019.00
T_4	GM* + Vermicompost 5 t ha^{-1} + Azophos seed treatment + 50% RD of NP through fertilizer + Jivamrut	41.12	3230.00	4076.35
T_5	GM* + 50% RD of NP through fertilizer + Foliar spray of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage of wheat	42.62	3546.00	4481.43
T_6	T_3 + Foliar spray of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage of wheat	42.20	3542.00	4454.00
T_7	T_4 + Foliar spray of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage of wheat	42.06	3217.00	4096.55
T_8	GM* + Ghanajivamrut 5 t ha^{-1}	39.76	1902.37	2415.33
T_9	GM* + Vermicompost 5 t ha^{-1} + Azophos seed treatment + Jivamrut	39.15	1966.00	2443.49
SEm ±		2.65	126.23	170.57
CD at 5%		NS	378.45	511.38

The data on test weight of wheat grain as influenced due to different treatments are presented in result revealed that, treatment GM* + 50% RD of NP through fertilizer + Foliar spray of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage recorded significantly higher test weight (42.62 g) of wheat followed by T_2 (42.32 g) T_6 (42.20 g) and T_7 (42.06 g). However, the treatment effects were not significant.

Among different treatments, T_5 (GM* + 50% RD of NP through fertilizer + Foliar spray of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage of wheat) resulted in highest grain yield (3545.76 kg ha^{-1}) and straw yield (4481.43 kg ha^{-1}). T_5 treatment is followed by treatment T_6 which comprises of T_3 + Foliar spray of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage of wheat under which grain yield (3541.97 kg ha^{-1}) and straw yield recorded (4453.65 kg ha^{-1}). Similar results were reported by Dhansil *et al.* (2018) [3], yield of wheat increased by 6% with application of GM* + 50% RD of NP through fertilizer + Foliar spray of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage of wheat, over GM* + 100% RDF.

Nutrient uptake by Wheat

Table 2: Influence of INM with nano phosphatic fertilizer on nutrient uptake by Wheat

Treat. No.	Treatment Details	N uptake (kg ha^{-1})		P uptake (kg ha^{-1})		K uptake (kg ha^{-1})	
		Grain	Straw	Grain	Straw	Grain	Straw
T_1	Absolute control	30.37	12.14	4.25	3.09	3.84	36.31
T_2	GM* + 100% RDF	65.60	27.96	12.91	8.06	11.13	91.99
T_3	GM* + Ghanajivamrut 5 t ha^{-1} + Azophos seed treatment + 50% RD of NP through fertilizer +Jivamrut	60.45	25.35	11.53	6.96	9.56	82.99
T_4	GM* + Vermicompost 5 t ha^{-1} + Azophos seed treatment + 50% RD of NP through fertilizer +Jivamrut	60.35	25.77	11.49	7.32	9.96	80.26
T_5	GM* + 50% RD of NP through fertilizer + Foliar spray of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage of wheat	68.09	27.81	15.35	9.01	10.99	96.21
T_6	T_3 + Foliar spray of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage of wheat	68.68	30.41	14.87	8.62	11.57	98.42
T_7	T_4 + Foliar spray of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage of wheat	63.12	28.32	12.64	7.88	10.83	89.29
T_8	GM* + Ghanajivamrut 5 t ha^{-1}	35.96	15.22	6.59	3.52	5.44	47.17
T_9	GM* + Vermicompost 5 t ha^{-1} + Azophos seed treatment + Jivamrut	36.78	15.22	6.55	3.61	5.57	47.16
SEm ±		4.44	1.92	0.49	0.32	0.52	3.40
CD at 5%		13.30	5.75	1.48	0.96	1.54	10.19

Nitrogen and potassium uptake in grain and straw recorded highest in the treatment T_6 which is comprised of T_3 + Foliar spray of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage of wheat *i.e.* 68.68 kg ha^{-1}, 28.32 kg ha^{-1} and 11.57 kg ha^{-1}, 98.42 kg ha^{-1} respectively as shown in table 2. Nitrogen and potassium uptake recoded high in T_6 might be due to application of ghanjivamrut (0.91% N, 0.49% P and 1.16% K) and green manuring of sunhemp (2.11% N, 0.31% P and 1.47% K). Phosphorus uptake recorded highest in treatment T_5 (GM* + 50% RD of NP through fertilizer + Foliar spray of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage of wheat) *i.e.* 15.35 kg ha^{-1} and 9.01 kg ha^{-1} in grain and straw of wheat respectively. Phosphorus uptake in grain and straw is influenced due to nano P fertilizer spraying at tillering and flowering stages of wheat. This results were compatible with studies done by Dhansil *et al.* (2017) [3].

Nutrient use efficiency influenced by INM with nano phosphatic fertilizer

Table 3: Influence of INM with nano P fertilizer on nutrient use efficiency (%)

Treat. No.	Treatment Details	Nitrogen Use Efficiency (%)	Phosphorus Use Efficiency (%)	Potassium Use Efficiency (%)
T_1	Absolute control	-	-	-
T_2	GM* + 100% RDF	27.61	21.79	57.51
T_3	GM* + Ghanajivamrut 5 t ha^{-1} + Azophos seed treatment + 50% RD of NP through fertilizer + Jivamrut	20.31	13.43	31.27
T_4	GM* + Vermicompost 5 t ha^{-1} + Azophos seed treatment + 50% RD of NP through fertilizer + Jivamrut	18.78	13.74	27.88
T_5	GM* + 50% RD of NP through fertilizer + Foliar spray of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage of wheat	36.76	35.82	61.24
T_6	T_3 + Foliar spray of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage of wheat	26.50	17.38	41.98
T_7	T_4 + Foliar spray of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage of wheat	21.07	14.10	33.25
T_8	GM* + Ghanajivamrut 5 t ha^{-1}	6.60	7.52	7.44
T_9	GM* + Vermicompost 5 t ha^{-1} + Azophos seed treatment + Jivamrut	5.45	4.57	6.99
SEm ±		2.87	0.92	2.34
CD at 5%		8.61	2.75	7.03

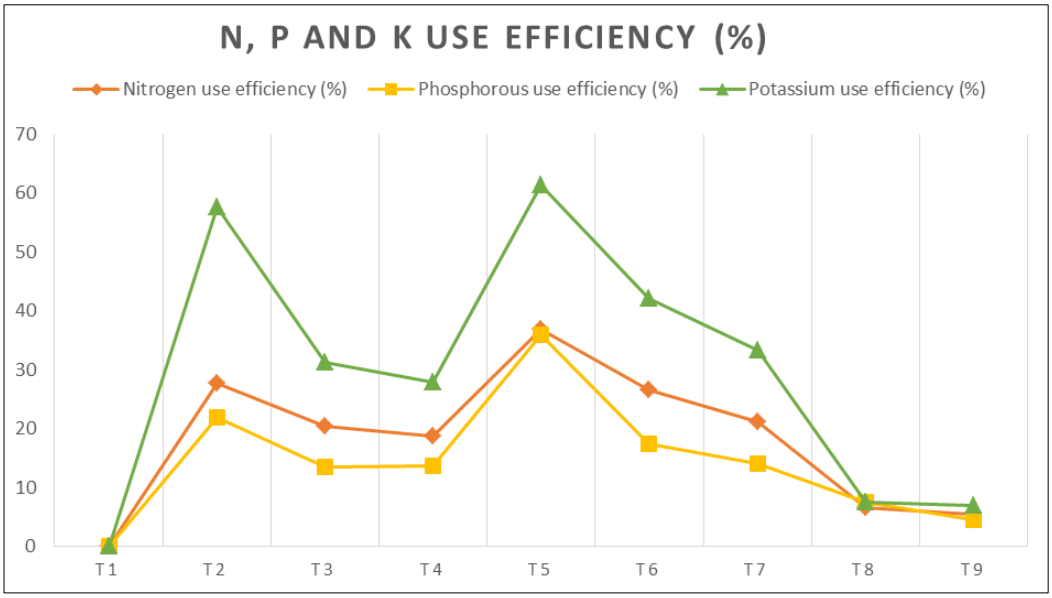

Fig 1: NPK use efficiency

As shown in table 3. and fig. 1., Nitrogen use efficiency recorded highest in treatment T_5 (GM* + 50% RD of NP through fertilizer + Foliar spray of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage of wheat) *i.e.* 36.76% which is statistically superior over other treatments. Tarafdar *et al.* (2015) [11] compared P use efficiency of SSP, Soluble P (KH_2PO_4) and nano phosphorus and reported highest value of 57.8% of P use efficiency in case of nano P. Phosphorus use efficiency recorded highest in treatment T_5 (GM* + 50% RD of NP through fertilizer + Foliar spray of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage of wheat) *i.e.* 35.82% which is statistically superior over all other treatments. The maximum NPK content and uptake as well as protein content and uptake were observed with the application of 2.5-time reduction of RDF through nano phosphatic fertilizer [3]. Potassium use efficiency recorded highest in treatment T_5 (GM* + 50% RD of NP through fertilizer + Foliar spray of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage of wheat) *i.e.* 61.24% which is statistically at par with T_2 (GM* + 100% RDF) treatment which has 57.51% Potassium use efficiency. Although, potassium as a basal dose was not applied higher use efficiency might be due to balance use of nutrients by crop.

Effect of INM and nano phosphatic fertilizer on fertility status of soil after harvest of crop

The data pertaining to effect of INM and nano phosphatic fertilizer on fertility status of soil after harvest of the crop is given table 4.

The result revealed that the effect of different treatments found statistically non-significant on soil pH and EC after harvest of crop. Soil pH was recorded in between 7.60 to 7.74 and EC ranges between 0.27- 0.33 dS m^{-1}. The experiment resulted that the effect of INM with nano phosphatic fertilizer comprises of different treatments showed that higher organic carbon found in T_7 treatment (4.21g kg^{-1}).

Table 4: Effect of INM and nano phosphatic fertilizer on fertility status of soil after harvest of the crop

Treat. No.	Treatment Details	pH	EC (dS m^{-1})	OC (g/kg)	Avail. N (kg/ha)	Avail. P_2O_5 (kg/ha)	Avail.K_2O (kg/ha)	Avail. S (mg/kg)
T_1	Absolute control	7.68	0.30	3.97	192.80	13.95	425.03	8.11
T_2	GM* + 100% RDF	7.71	0.32	4.08	239.60	16.27	475.67	9.41
T_3	GM* + Ghanajivamrut 5 t ha^{-1} + Azophos seed treatment + 50% RD of NP through fertilizer + Jivamrut	7.63	0.31	4.15	230.40	14.28	474.00	8.63
T_4	GM* + Vermicompost 5 t ha^{-1} + Azophos seed treatment + 50% RD of NP through fertilizer + Jivamrut	7.60	0.31	4.19	233.13	14.64	482.00	8.73
T_5	GM* + 50% RD of NP through fertilizer + Foliar spray of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage of wheat	7.74	0.32	4.08	221.87	14.99	472.60	8.93
T_6	T_3 + Foliar spray of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage of wheat	7.61	0.31	4.17	212.70	15.32	480.30	9.12
T_7	T_4 + Foliar spray of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage of wheat	7.62	0.33	4.21	216.70	15.27	482.35	9.15
T_8	GM* + Ghanajivamrut 5 t ha^{-1}	7.65	0.30	4.12	216.40	14.11	456.00	8.63
T_9	GM* + Vermicompost 5 t ha^{-1} + Azophos seed treatment + Jivamrut	7.65	0.30	4.16	214.73	14.03	462.00	8.54
SEm ±		0.05	0.01	0.04	14.05	0.05	8.63	0.23
CD at 5%		NS	NS	0.13	NS	0.14	25.88	0.70

Data pertaining to fertility status of soil after harvest of crop is presented in table 4 and fig. 2, available nitrogen of soil was observed between 192.80 to 239.60 kg ha^{-1} with the different treatments consist of INM with nano phosphatic fertilizer but it was found statistically non-significant. The maximum available nitrogen in soil was observed 239.60 kg ha^{-1} with the application of 100% RDF (100:50:50 kg NPK ha^{-1}). Available phosphorus of soil was observed between 13.95 to 16.27 kg ha^{-1}. The maximum available Phosphorus was observed 16.27 kg ha^{-1} with the application of GM* + 100% RDF which remained significant over all other treatments. Available potassium of soil was found significant under different INM practices. The maximum available potassium in soil was observed 510.98 kg ha^{-1} with the treatment of T_4 + Foliar spray of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage of wheat which is at par with T_2, T_3, T_4, T_5, T_6 and T_9 treatment. The value of available potassium comes under high in range. In the present study, available sulphur of soil was observed between 8.11 to 9.41 mg kg^{-1} with the different treatments consist of INM with nano P fertilizer. The maximum available sulphur in soil was observed 9.41 mg kg^{-1} with the application of 100% RDF (100: 50: 50 kg NPK ha^{-1}) which is at par with T_4, T_5, T_6 and T_7 treatments.

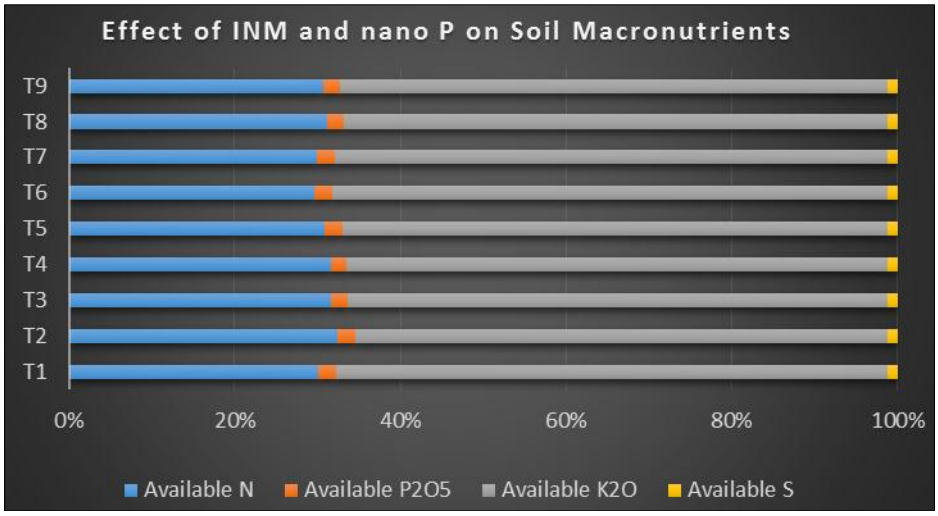

Fig 2: Effect of INM and nano P on fertility status of soil

Influence of INM and nano phosphatic fertilizer on soil micronutrients after harvest of wheat

The result related to DTPA extractable micronutrients status in soil after harvest of wheat is given in table 5.

In the present study, DTPA extractable iron of soil was observed in between 5.23 to 6.12 mg kg^{-1} with the different treatments consist of INM with nano P fertilizer but it was found statistically non-significant. The maximum DTPA extractable iron in soil was observed 6.12 mg kg^{-1} with the treatment T_7 (T_4 + Foliar spray of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage of wheat). DTPA extractable Mn of soil was observed between 2.52 to 2.87 mg kg^{-1} with the different treatments consist of INM with nano P fertilizer. The maximum DTPA extractable manganese in soil was observed 2.87 mg kg^{-1} with the treatment T_2 (GM* + 100% RDF) which found significant over all other treatment. The maximum DTPA extractable zinc in soil was observed 0.77 mg kg^{-1} with the treatment T_7 (T_4 + Foliar spray of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage of wheat) which found at par with treatment T_3, T_4 and T_6. DTPA extractable Cu of soil was observed between 1.27 to 1.72 mg kg^{-1} with the different treatments consist of INM with nano P fertilizer. The maximum DTPA extractable copper in soil was observed 1.72 mg kg^{-1} with the treatment T_2 (GM* + 100% RDF) which found at par with treatment T_7 (1.66 mg kg^{-1}).

Table 5: DTPA extractable micronutrients status in soil after harvest of wheat

Treat. No.	Treatment Details	Fe (mg/kg)	Mn (mg/kg)	Zn (mg/kg)	Cu (mg/kg)
T_1	Absolute control	5.83	2.52	0.60	1.27
T_2	GM* + 100% RDF	5.23	2.87	0.67	1.72
T_3	GM* + Ghanajivamrut 5 t ha^{-1} + Azophos seed treatment + 50% RD of NP through fertilizer + Jivamrut	5.92	2.62	0.71	1.37
T_4	GM* + Vermicompost 5 t ha^{-1} + Azophos seed treatment + 50% RD of NP through fertilizer + Jivamrut	5.91	2.64	0.73	1.44
T_5	GM* + 50% RD of NP through fertilizer + Foliar spray of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage of wheat	6.06	2.80	0.69	1.56
T_6	T_3 + Foliar spray of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage of wheat	6.10	2.76	0.72	1.64
T_7	T_4 + Foliar spray of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage of wheat	6.12	2.78	0.77	1.66
T_8	GM* + Ghanajivamrut 5 t ha^{-1}	5.82	2.59	0.69	1.41
T_9	GM* + Vermicompost 5 t ha^{-1} + Azophos seed treatment + Jivamrut	5.87	2.64	0.70	1.45
SEm ±		0.37	0.02	0.02	0.02
CD at 5%		NS	0.05	0.06	0.07

Conclusion

The study revealed that maximum yield of wheat, P uptake and NPK use efficiency recorded under GM* + 50% RD of NP through fertilizer + Foliar spray of 0.5% of 1000 ppm nano P suspension at tillering and flowering stage of wheat treatment. N and K uptake recorded highest. Available N and P (kg/ha), available S (mg kg^{-1}) and DTPA extractable Mn and Zn (mg/kg) recorded higher in treatment comprises of GM* + 100% RDF. INM with nano P fertilizer found comparable with Phosphorus application through conventional sources which indicated that chemical load and fertilizer cost may be reduced without affecting the yield of wheat.

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References

1. Anonymous. Agricultural stat at glance 2018. Government of India, 2019.
2. Chesnin L, Yien CH. Turbidimetric determination of available Sulphates. Soil Sci. Soc. America proceedings. 1951; 15:149-151.
3. Dhansil A, Zalawadia NM, Prajapati BS, Yadav K. Effect of nano phosphatic fertilizer on nutrient content and uptake by Pearl millet (*Pennisetum glaucum* L.) crop. Int. J. Curr. Micrbiol. App. Sci. 2018; 7(12):2327-2337.
4. Jackson ML. Soil Chemical Analysis prentice hall of India. Private Limited New Delhi, 1973, 151-153.
5. Javaria S, Khan MQ. Impact of integrated nutrient management on tomato yield, quality and soil environment. J. Plant Nutri. 2010; 34(1):140-149.
6. Lindsay WL, Norvell WA. Development of DTPA soil test for Fe, Mn, Zn and Cu. Soil Sci. Soc. of American J. 1978; 42:421-427.
7. Mateus AYP, Ferraz MP, Monterio FJ. Comparative study of nanohydroxyapatite microspheres for medical applications. Inc. J. Biomed. Mater. Res. 2007; 86A:483-493.
8. Mortvedt JJ. Crop response to level of water soluble zinc in granular zinc fertilizer. Fertilizer research. 1992; 33(3):249-255.
9. Pattnyak SK, Sureshkumar P, Tarafdar JC. New vista in Phosphorus research. J. Indian. Soc. Soil Sci. 2009; 57(4):536-545.
10. Singh MD, Gautam Chirag, Patidar Om Prakash, Prakasha G, Vishwajith. Nanoferilizer is a New Way to Increase Nutrient Use Efficiency in Crop Production. Int. J. of Agril. Sci. 2017; 9(7):3831-3833.
11. Tarafdar JC, Rathor I, Thomas E. Enhancing nutrient use efficiency through nano technological interventions. Indian J. Fert. 2015; 11(12):46-51.
12. Trenkel ME. Controlled-release and stabilized fertilizers in agriculture. Int. Ferti. Industry Asso. 1997; 11:1-157.
13. Rameshaiah GN, Pallavi J, Shabnam S. Nano fertilizers and nano sensors - an attempt for developing smart agriculture. Int. J. Engi. Res. Gen. Sci. 2015; 3(1):314-320.
14. Subbaiah BV, Assija GL. A rapid procedure for the estimation of available nitrogen in soils. Current Sci. 1956; 25:259-260.
15. Walkley NM, Black AI. Estimation of organic carbon by chromic acid titration method Soil Science. 1934; 25:259-263.
16. Zak AK, Razali R, Majid W, Darroundi M. Synthesis and characterization of a narrow size distribution of ZnO nanoparticles. Int. J. of Nanomedicine. 2011; 6:1399-140.