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Effect of new generation fertilizers with conventional fertilizer on nutrient use efficiency, growth and development of wheat (*Triticum aestivum* L.)

Shikhar Verma, NS Rana, Vikash Singh, Mausmi Rastogi, Shravan Kumar Maurya and Praveen Kumar Yadav

Shikhar Verma
M.Sc. Scholar, Department of Agronomy, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

NS Rana
Professor, Department of Agronomy, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

Vikash Singh
M.Sc. Scholar, Department of Agronomy, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

Mausmi Rastogi
M.Sc. Scholar, Department of Agronomy, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

Shravan Kumar Maurya
M.Sc. Scholar, Department of Agronomy, Banda University of Agriculture & Technology, Banda, Uttar Pradesh, India

Praveen Kumar Yadav
M.Sc. Scholar, Department of Soil Science and agricultural chemistry, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

Corresponding Author:
Shikhar Verma
M.Sc. Scholar, Department of Agronomy, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India

Abstract
A Field experiment was conducted at crop research centre of SVPUA&T, Meerut (U.P.) during 2020-21. Field was well drained sandy clay loam soil, low in organic carbon and available nitrogen, medium in available phosphorus, potassium and zinc and moderately alkaline in pH. Novel nutrient sources and their modes of applications with 12 treatments consisting of control, basal application of recommended 100% NPK (150:60:40), 75% NPK (112.5:45:30) + NPK Consortia seed treatment (250 ml in 3 litre water 60 kg^{-1} seed) + NPK (18:18:18 @15 g l^{-1}) + Bio-stimulant (625 ml ha^{-1}) + Nano N (4 ml l^{-1}) + Nano Zn (10 ml l^{-1}) in various combinations were attempted on wheat variety HD 2967 in RBD design with three replications. The results of the study revealed that wheat grown with 75% NPK + NPK Consortia + NPK + Bio-stimulant + Nano Zn spray attainted significantly better growth as reflected by, CGR (5.8 g m^{-2} day^{-1}) and RGR (0.0022 g g^{-1} day^{-1}). Nutrient use efficiency i.e. agronomic efficiency for N, P & K (24.5, 61.3 & 92.0 kg of grain in yield increase kg^{-1}of nutrient applied), physiological efficiency for N, P & K (23.4, 156.9 & 37.7 kg of yield increase kg^{-1} of nutrient absorbed) and partial factor productivity for N, P & K (49.7, 124.2 & 186.3 kg of grain kg^{-1} of nutrient applied) was also better under treatment. Thus, the wheat crop grown with application of 100% NPK + Bio-stimulant spray had attained better CGR, RGR, nutrient use efficiency i.e. Agronomic Efficiency (AE), Physiological efficiency (PE), Partial factor productivity (PFP).

Keywords: Nano-fertilizer, new generation fertilizer, NPK-consortia, Sagarika, nano-N, nano-Zn

Introduction

Wheat (*Triticum aestivum* L.) is one of the world's most significant staple food crops, providing 21% of total food calories and 20% of total protein to over 4.5 billion people. Wheat crop acreage worldwide is 216.18 million ha, yielding 763.6 million metric tonnes at an average of 3530 kg ha^{-1} (USDA report, 2020) [12].

With an average productivity of 3530 kg ha^{-1} in India, it covers 29.32 million ha and produces 103.6 million metric tonnes, accounting for one-third of total food grain production (USDA report, 2020) [12]. By 2050, the present global population of 7.7 billion people will have increased to 9.7 billion. India has 1.3 billion people, second only to China (1.41 billion), and is predicted to overtake China's population, reaching 1.7 billion. Wheat, as a result, will likely continue to play an important role in securing global food security. With 9.65 million hectares (36.6%), 26.87 million tonnes (39.3%), and a productivity of 2785 kg ha^{-1}, Uttar Pradesh is India's largest wheat-growing state. (Anonymous, 2019) [1]. Due to late sowing the harvest of long-term rice varieties and sugarcane, poor seed replacement rate, lack of quality seed, imbalanced fertilisation, unscientific water management, and poor mechanisation, among other factors, wheat productivity in the state is significantly lower than in Punjab (4.3 tonnes ha^{-1}) and Haryana (4 tonnes ha^{-1}). Wheat sowing has been postponed till the end of December, and in some cases into the first week of January in western Uttar Pradesh, resulting in significant yield decreases. Farmers try to compensate for late planting by using too much fertiliser, especially nitrogen, and ignoring yield physiology in constrained conditions. Despite the great productivity of the research, the nutrient use efficiency is low. N, P, and K nutrient utilisation efficiency remains at 30-35 percent, 18-20 percent, and 35-40 percent, respectively as reported by Subhramanian *et al*. (2015) [10]. Low fertiliser efficiency not only raises production costs, but it also has serious environmental consequences. Furthermore, the very volatile worldwide market has resulted in an increase in fertiliser prices.

In light of these realities, we must develop a fertiliser management strategy that prioritises efficiency. Various nano-sized fertilisers or smart delivery-based fertilisers with surface coatings of nanoparticles have gotten a lot of attention in recent years. Nanoparticles have special features due to their tiny scale, high specific surface area, high surface energy, and high solubility. Live microorganisms with the potential to mobilise plant nutrients in the soil are known as biofertilizers. They're a low-cost, capital-intensive, non-bulk, and eco-friendly technique to boost output (Kloepper *et al*., 1989) [4]. The application of bio-stimulants fertiliser is critical in order to substitute commercial chemical fertilisers. Seaweed Extract is a new generation, highly effective natural organic fertiliser that stimulates crop growth, yield, and biotic and abiotic stress resistance in a variety of crops. Unlike chemical fertilisers, seaweed extracts are biodegradable, non-toxic, non-polluting, and non-hazardous to humans, animals, and birds, in addition to having minimal production costs. The use of extracts of *Kappaphycus alvarezii* and *Gracilaria edulis* is thought to boost wheat nutritional absorption. This could be due to the presence of organic compounds and a natural chelating component (anitol) that aid the plant in mobilising fixed nutrients in useable form. It's also high in potassium and phosphorus as reported by Shah *et al*. (2013) [9].

Material and Method

The experiment was carried out at the University's crop research centre in the Indo-Gangetic plains of Western Uttar Pradesh. At an elevation of 230 metres above mean sea level, it is located at 290 5′ 34″ N latitude, 770 41′ 58″ E longitudes, and 290 5′ 34″ N latitude. On the national route 58 that connects New Delhi and Dehradun, Meerut is 65 kilometres from Delhi. During 2021, the crop saw the lowest mean weekly minimum temperature (4.90 °C) in the fourth week of December and the highest (38.20 °C) in the second week of April. The second week of January was the most humid (94.9%), while the second week of April was the driest (22.0%) of the crop season. During the growing season, the crop received 39.9 millimetres of rain. Nutrient use efficiency (NUE) shows the ability of crops to absorbs and utilize nutrients in yield i.e. Agronomic Efficiency (AE), Physiological Efficiency (PE) & Partial Factor Productivity (PFP) as classified by Craswell and Godwin (1984) [2] were estimated for the purpose as follows. The Agronomic efficiency (AE) indicates improvement in productivity in response to applied nutrient. It is expressed as kg of gain in yield per kg a particular nutrient applied and was calculated using the appropriate equation. The Physiological efficiency (PE) indicates the ability of crop to transform acquired nutrient into economic yield and expressed as kg of grains produced per kg of nutrient absorbed. Partial factor productivity indicates productions of a crop in comparison to its nutrient input. It is expressed as kg of grains produced per kg of nutrient applied and was worked out. Crop Growth Rate (g m^{-2} day^{-1}) Mean crop growth rate of a plant community for a time "t" is defined as the increase in dry weight of plant material per unit area per unit of time. It was calculated from periodic dry matter recorded at different stages with the help of appropriate formula and Relative Growth Rate (RGR) (g g^{-1} day^{-1}) The relative growth rate of a plant at an instant for a time interval "t" is defined as the increase in dry weight of plant material per unit of material present per unit of time. The mean relative growth rate (RGR) of the crop was calculated by the appropriate formula (Radford, 1967) [8]. Appropriate formulas were used to calculate particular indices are as follows.

1) $AE = (Y_t - Y_0)/A_t$

Where,
AE = Agronomic Efficiency (AE) (kg grain yield increase kg^{-1} nutrient applied)
Y_t = Yield under test treatment (kg ha^{-1})
Y_o = Yield under control (kg ha^{-1})
A_t = Units of nutrient applied in the test treatment (kg ha^{-1})

2) $PE = (Y_t - Y_0)/(U_t - U_0)$

Where,
PE = Physiological efficiency (kg yield increase kg^{-1} nutrient uptake)
Y_t = Yield under test treatment (kg ha^{-1})
Y_o = Yield under control (kg ha^{-1})
U_t = Uptake of nutrient in test treatment (kg ha^{-1})
U_o = Uptake of nutrient in control (kg ha^{-1})

(3) $PFP = Y/N$
Where,
PFP = Partial Factor Productivity (kg of grain $kg^{-1}$of nutrient applied)
Y = Grain yield (kg ha^{-1})
N= Amount of nutrient applied (kg ha^{-1})

(4) $CGR = (W_2 - W_1)/(t_2 - t_1) \times 1/A$

Where,
W_1 = Dry weight of plant (g) per m row length at time t_1
W_2 = Dry weight of plant (g) per m row length at time t_2
A = Land area (m^2)

(5) $RGR = (logeW_2 - logeW_1)/(t_2 - t_1)$

Where
W_1 = Dry weight of plant (g) per m row length at time t_1
W_2 = Dry weight of plant (g) per m row length at time t_2

Result and Discussion

Perusal of data presented in Table 1 revealed that there was significant increase in agronomic use efficiency of NPK under different nutrient management practices in comparison to 100% NPK except treatment having NPK Consortia, NPK spray with 75% RDF. Application of 75% NPK + NPK Consortia + NPK spray + Bio-stimulant spray + Nano Zn spray led to higher agronomic efficiency of 24.5 for N, 61.3 for P and 92.0 for K as against 13.8, 34.6 and 52.0 respectively with 100% NPK. Application of Nano fertilizers, Biofertilizer, Bio-stimulant, and Inorganic fertilizer spray individually or simultaneously with 75% of NPK when compared with 100% NPK indicated significant increase in agronomic efficiency except treatment having NPK consortia, NPK spray with 75% NPK. Similar findings were given by Jhanzab *et al*. (2015) [3]. Application of nutrient, irrespective of doses and sources increased physiological efficiency Table 1. In case of physiological N-use efficiency, the application of NPK- (150:60:40) recorded maximum PE (42.2), while minimum (23.0) with 75% NPK + NPK Consortia + Nano N spray + Nano Zn spray. In case of physiological P-use efficiency, maximum PE (236.0) with 75% NPK + NPK Consortia + Nano N spray and lowest (147.9) with 100% NPK + Nano Zn spray. Subjected to physiological potassium use efficiency, application 75% NPK + NPK Consortia +Nano N spray + Nano Zn spray found maximum PE (46.9) and lowest (36.1) in 75% NPK + NPK Consortia. (Parmar and Sindhu, 2013) [5]. The data on PFP given in Table 1 indicated significant increase with application of nano fertilizers, biofertilizer, bio-stimulant and inorganic fertilizer spray in comparison to 100% NPK, though of the nutrient Combinations of Nano fertilizers, Biofertilizers, Bio-stimulant, and Inorganic fertilizer spray proved more production than these with 100% NPK. Partial factor productivity ranged from 32.7 to 49.7 for Nitrogen, 81.8 to 124.2 for Phosphorus and 122.8 to 186.3 for Potassium, lowest PFP with 100% NPK and highest PFP with 75% NPK + NPK Consortia + NPK spray + Bio-stimulant spray + Nano Zn spray. Similarly, Prasad *et al*. (2010) [7] reported that the seaweed sap also contains a hormone which might be responsible for increasing nutrient uptake by increasing stomata uptake efficiency. The data on crop growth rate (CGR) presented in Table 2 indicated significant variations across the stages being highest during 60-90 days period and lower during initial and later phases. Further perusal of the data showed significant increase in crop growth rate with application of nutrients over control at all the stages during 60-90 days period. The highest crop growth rate during 60-90 DAS period associated with 100% NPK + Nano Zn spray was significantly higher than other treatments except 100% NPK + Bio-stimulant spray, 75% NPK + NPK Consortia + NPK spray + Bio-stimulant spray + Nano Zn spray, 75% NPK + NPK Consortia +Nano N spray + Nano Zn spray. In comparison to 100% NPK, use of Nano fertilizers, Biofertilizer, Bio-stimulant, and Inorganic fertilizer spray with 100 or 75% NPK enhanced crop growth rate remarkably except 75% NPK with Biofertilizer and NPK spray. Similar result was found by Surendar *et al.* (2013) [11]. Perusal of data in Table 2 revealed that RGR attained maximum value between 60-90 days stage and then declined consistently till the crop maturity. Crop fertilized with 100% NPK + Nano Zn spray recorded highest growth rate at 60-90 DAS. Lowest value of RGR was recorded in control over rest of the treatments. In comparison to 100% NPK, use of Nano fertilizers, Biofertilizer, Bio-stimulant, and Inorganic fertilizer spray with 100% or 75% NPK enhanced relative growth rate increase. Such differences were however non-significant. Similar result was also found by Patra *et al.* (2018) [6].

Table 1: Effect New generation fertilizers with conventional fertilizer on Nutrient use efficiency

Treatment	Agronomic use-efficiency (AE)			Physiological use-efficiency (PE)			Partial factor productivity (PPF)		
	Nitrogen (N)	Phosphorus (P)	Potassium (K)	Nitrogen (N)	Phosphorus (P)	Potassium (K)	Nitrogen (N)	Phosphorus (P)	Potassium (K)
Control	--	--	--	--	--	--	--	--	--
NPK- (150:60:40)	13.8	34.6	52.0	42.2	222.1	40.7	32.7	81.8	122.8
100% NPK + Nano Zn spray	18.9	47.3	71.0	23.5	147.9	37.5	37.8	94.5	141.8
100% NPK + Bio-stimulant spray	18.3	45.83	68.7	26.0	175.1	42.2	37.2	93.0	139.5
75% NPK + NPK Consortia	13.5	33.7	50.6	41.8	183.3	36.1	38.7	96.7	145.0
75% NPK + NPK spray	14.9	37.3	56.0	34.6	188.3	37.1	40.1	100.2	150.3
75% NPK + NPK Consortia + Nano N spray	18.7	46.8	70.3	25.3	236.0	40.3	43.9	109.8	164.7
75% NPK + NPK Consortia + NPK spray	21.2	53.1	79.6	26.2	178.0	39.4	46.4	116.0	174.0
75% NPK + NPK Consortia + NPK spray +Bio-stimulant spray	22.4	56.0	84.0	25.3	232.1	40.4	47.6	118.9	178.3
75% NPK + NPK Consortia + NPK spray + Bio-stimulant spray + Nano Zn spray	24.5	61.3	92.0	23.4	156.9	37.7	49.7	124.2	186.3
75% NPK + NPK Consortia + Nano Zn spray	19.8	49.5	74.3	33.2	210.1	37.1	45.0	112.4	168.7
75% NPK + NPK Consortia +Nano N spray + Nano Zn spray	23.5	58.8	88.3	23.0	232.8	46.9	48.7	121.8	182.7
S.Em±	0.7	1.8	2.7	0.9	6.8	1.4	1.5	3.8	5.7
CD (p = 0.05)	2.1	5.3	7.9	2.7	20.1	4.1	4.5	11.3	16.9

Table 2: Effect New generation fertilizers with conventional fertilizer on CGR and RGR at various crop growth stages

Treatments	crop growth rate (g m^{-2} day^{-1})				Relative growth rate (g g^{-1} day^{-1})			
	30-60 DAS	60-90 DAS	90-120 DAS	120-Harvest	30-60 DAS	60-90 DAS	90-120 DAS	120-At Harvest
Control	2.6	8.8	6.2	5.7	0.0151	0.0121	0.0064	0.0039
NPK- (150:60:40)	4.5	16.5	8.6	5.8	0.0221	0.0186	0.0047	0.0024
100% NPK + Nano Zn spray	5.3	19.6	9.6	5.8	0.0238	0.0200	0.0045	0.0021
100% NPK + Bio-stimulant spray	5.2	18.3	9.6	6.3	0.0241	0.0195	0.0048	0.0024
75% NPK + NPK Consortia	3.6	15.5	9.2	6.4	0.0212	0.0210	0.0054	0.0027
75% NPK + NPK spray	4.5	16.4	9.2	5.7	0.0256	0.0201	0.0051	0.0024
75% NPK + NPK Consortia + Nano N spray	4.9	16.8	9.2	6.1	0.0245	0.0192	0.0049	0.0025
75% NPK + NPK Consortia + NPK spray	5.2	16.6	9.6	6.3	0.0253	0.0187	0.0051	0.0025
75% NPK + NPK Consortia + NPK spray +Bio-stimulant spray	5.1	17.4	9.6	6.4	0.0249	0.0192	0.0049	0.0025

75% NPK + NPK Consortia + NPK spray + Bio-stimulant spray + Nano Zn spray	5.4	19.0	9.6	5.8	0.0250	0.0198	0.0046	0.0022
75% NPK + NPK Consortia + Nano Zn spray	5.1	16.9	9.2	6.1	0.0245	0.0190	0.0048	0.0024
75% NPK + NPK Consortia +Nano N spray + Nano Zn spray	5.1	18.1	9.6	6.2	0.0250	0.0197	0.0048	0.0024
S.Em±	0.2	0.6	0.3	0.3	0.001	0.001	0.0001	0.002
CD (p = 0.05)	0.5	1.8	1.0	0.6	NS	NS	NS	NS

Conclusion

Nutrient use efficiency is dependent upon grain yield, uptake of nutrient and the amount of nutrient applied. Application of 75% NPK + NPK Consortia + NPK spray + Bio-stimulant Spray + Nano Zn spray increased nutrient use efficiency significantly in comparison to 100% NPK, control and some other treatments. Where 100% NPK + Nano Zn spray recorded highest Crop growth rate and relative growth rate at 60-90 DAS.

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