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Research Article

EFFECT OF NUTRIENT MANAGEMENT OPTIONS ON PERFORMANCE AND NUTRIENT USE EFFICIENCY OF WHEAT (*Triticum aestivum* L.) IN LIGHT TEXTURE SOIL

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Abstract- The field experiment was conducted at CRC, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut during *rabi* 2013-14 and 2014-15. Influence of organic and inorganic sources on nutrient uptake and yield of wheat (*Triticum aestivum* L.) in Western Uttar Pradesh. Addition of 100% NPK (2% Urea spray at tillering and jointing stage) (RDF-recommended dose of fertilizer i.e 150: 75: 60 kg NPK ha^{-1} was recorded significantly higher value of nutrient uptake and grain yield (49.51 and 47.23 q ha^{-1}) was recorded yield, which was at par with 75% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering and jointing stage) (48.93 and 46.83 q ha^{-1}) grain was recorded yield. Nitrogen, phosphorous and potash content and uptake as well as agronomic efficiency was also increased with the application of 100% NPK (2% Urea spray at tillering and jointing stage). Which was at par with the 75% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering and jointing stage). Highest organic carbon % in soil was recorded in 75% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering and jointing stage).The integrating of 75% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering and jointing stage)found more productive by maintain or improving the soil health.

Keywords- Nutrient Management, Vermicompost, Urea Spray, Agronomic efficiency of NPK

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Introduction

In India wheat is the second most important food crop next to rice and it contributes nearly 35% to the national food basket. Among winter crops, it contributes about 49% of the food grains. India is the second largest wheat producer 86.53 million tonnes next only to China 121.72 million tonnes and covers the largest area under wheat cultivation (29.65 m ha), which is about 13.77 % of the world wheat area 217 million hectare [1]. Minimum, optimum and maximum (cardinal) temperature for germination of wheat crop are 2°C to 4 °C, 24 °C to 25 °C and 36.6 ° C to 38.7 °C respectively, for growth and development. In western Uttar Pradesh, it is grown under rice-wheat and sugarcane cropping. Enhancement of wheat production from limited land area is great challenge for Indian agriculturist. Apart from developing high yielding wheat varieties, integrated nutrient management will be required to boost wheat production.

Plant nutrient plays an important role in growth, development and productivity of crop. Wheat crop is highly responsive to applied nutrient through various sources, a proper fertility management is an important parameter for optimizing the productivity while, generally grown in intensive cropping system with higher use of inorganic especially nitrogenous fertilizers. This condition is adversely affected and therefore it is needed to supply the nutrient to the crop in combination with organic sources. Indian soil are generally deficient in nutrient particularly nitrogen. Nitrogen fertilization always results in an increase in above ground dry matter and root biomass production, which results into higher productivity as well as higher residue left in soil after the harvest of the crop which helps in improving the fertility of soil. The nutrient use efficiency value becomes high with combination vermicompost. Keeping this in view, an attempt was made to Effect of nutrient management option on crop yield and nutrient uptake by wheat (*Triticum aestivum* L.) in western Uttar Pradesh.

Materials and Method

The field experiment was conducted during the *rabi* season of 2013-14 and 2014-15 at CRC, Sardar Vallabhbhai Patel University of Agriculture and Technology, Modipuram, (29^0 13' N, 77^0 68' 43 E, 237 m above mean sea level) Meerut, India. Climate is semi arid sub tropical with extremes of hot weather in summer and cold in winter season. There is gradual decrease in mean daily temperature from October reaching as low as 2-4 °C in January and further a gradual increase is registered from February reaching as high as 43-45°C in May. The rains are predominantly caused by south-west monsoon, which sets in the last week of June, reaches its peak in July-August and withdraws by the end of September. The area receives 862 mm of rains annually on an average, of which 90% is confined to rainy season (July-September). Soil of experimental field was sandy loam with pH of 7.2, Electric Conductivity (EC) 0.61.5 dSm^{-1}, low in organic C (0.41%), available N (247.65 kg ha^{-1}), medium in available P (18.9 kg ha^{-1}) and K (197.7 kg ha^{-1}). A range of mean weekly maximum temperature varied from 14.1°C to 36.6°C, and the mean weekly minimum temperature ranged from 5.6 °C to 19.4 °C during 2013-14. During next season i.e. 2013-14, mean weekly maximum temperature varied from 11.°C to 38.7°C, and the mean weekly minimum temperature ranged from 1.2°C to 19.4 °Cwere recorded in the cropping season. The total of 177.0 mm rainfall was received during 2013-14 and 203.3mm during 2014-15. The experiment was laid out in 3 replicates in a RBD (Randomized Block design). Studies were conducted with eleven treatments *viz.,* Control, 100% NPK,100% NPK (2% Urea spray at tillering stage),100% NPK (2% Urea spray at jointing stage),100% NPK (2% Urea spray at tillering and jointing stage),100%

NPK (2% Urea spray at the time of herbicide application), 75% NPK + Vermicompost 2 t/ha, 75% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering stage), 75% NPK + Vermicompost 2 t/ha (2% Urea spray at jointing stage), 75% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering and jointing stage),75% NPK + Vermicompost 2 t/ha (2% Urea spray at the time of herbicide application)

The experiment was carried out in the same field during both the years. Wheat crop (PBW 550) was sown with the row spacing of 22.5 cm as per treatments. Five irrigations were applied at four critical phenological stages. In regards to fertilizer application of the crop, 150 kg N, 75 kg P_2O_5 and 60 kg K_2O were applied. Out of which, 1/2 N and full dose of P_2O_5 and K_2O were applied as basal dose at the time of sowing by broadcasting method. The remaining 1/2 dose of N were applied in two splits at CRI and late tillering stages, 2% urea spray was done at tillering, jointing stage and both stage organic manure was applied through vermicompost 2% urea spray was used from 100% NPK and 75% NPK treatment.plant height Five spike were randomly selected and threshed manually, grains counted and data presented as grains per spikes. The sample of 1000-grains collected from each plot, weighed and presented as gram. Total bundle weight was recorded from each plot at the time of harvesting. The crop was threshed and grain were weighed and presented as quintal per hectare. Meteorological data, *viz.,* rainfall, relative humidity, maximum and minimum temperature, were recorded from Agrometeorological observatory, IIFSR, Meerut. Data on yield attributes, biological yield, and harvest index were recorded at crop maturity. Standard procedures were used for chemical analysis of soil and plant sample. The data were analyzed by using the 'Analysis of Variance Technique' as per the procedures described by Panse and Sukhatme [2]. The treatment means were compared at 5% level of significance

Result and Discussion

Yield and yield attributes

The yield of a crop depends upon the source sink relationship and is the cumulative function of various growth parameters *viz;* plant height, dry matter accumulation and yield attributing components *viz;* number of grains per spike, grain yield and biological yield. Applications of vermicompost with inorganic sources of fertilizer at any level were found to improve the growth and yield attributing character [Table-1] and nutrient content and uptake in grain [Table-2] in comparison to control. Nutrient had significant effect on plant height during both the year of investigation. In general, the crop attained more plant height during 2013-14 than in 2014-15. Further, the plant height picked up with advancement in crop age irrespective of the treatment during both the year investigation. Plant height increased as the crop growth advanced and reached to maximum at maturity. Application of different nutrient management practices influenced the plant height significantly over the control. Each successive nutrient dose from 100% NPK to control plot resulted in significant reduction in plant height during both the years. The application of 100% NPK (2% Urea spray at tillering and jointing stage) produced maximum plant height which was at par with 100% NPK (2% Urea spray at tillering stage), 75% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering and jointing stage)during 2013-14 and 2014-15. The control plots resulted significant reduction in plant height compared to other treatments at harvest. Such a higher plant height in 100% NPK (2% Urea spray at tillering and jointing stage) can be associated with sufficient nutrient supply at the active growth stage. Similar results of increased plant height were also reported by Yadav *et al.* [3] and Agarwal *et al.* [4].

Table-1 *Effect of nutrient management options on Grain, biological yield (q ha^{-1}) and harvest index (%) of wheat.*

Treatment	Plant height at harvest in (cm)		Dry matter at harvest (g) m^{-1}		Number of grains/spike		Grain Yield (q ha^{-1})		Biological yield (q ha^{-1})		Harvest Index (%)	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Control	59.2	57.2	149.7	145.77	30.82	27.47	31.80	29.43	79.83	74.36	39.83	39.57
100% NPK	86.8	85.7	229.0	221.34	37.23	35.84	46.53	44.12	111.59	106.38	42.59	42.41
100% NPK (2% Urea spray at tillering stage)	87.9	86.2	242.6	230.46	42.22	40.13	48.41	46.59	113.43	109.56	42.85	42.52
100% NPK (2% Urea spray at jointing stage)	86.2	85.5	225.4	216.12	39.12	38.56	46.51	44.47	109.98	105.35	42.44	42.21
100% NPK (2% Urea spray at tillering and jointing stage)	88.9	88.2	247.7	235.98	45.71	43.68	49.51	47.23	115.09	110.79	43.01	42.63
100% NPK (2% Urea spray at the time of herbicide application)	85.2	83.7	224.1	215.63	39.44	34.91	46.30	43.87	109.25	103.99	42.37	42.18
75% NPK + Vermicompost 2 t/ha	84.6	83.3	214.4	208.32	36.10	34.42	46.00	43.30	108.72	102.97	42.31	41.81
75% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering stage)	86.5	85.2	235.2	227.15	40.84	39.45	47.63	45.32	111.77	106.82	42.61	42.42
75% NPK + Vermicompost 2 t/ha (2% Urea spray at jointing stage)	84.2	82.2	215.2	213.78	34.56	34.13	45.50	42.50	107.86	101.88	42.18	41.71
75% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering and jointing stage)	88.5	86.6	244.2	232.56	43.10	41.86	48.93	46.83	113.99	110.14	42.92	42.59
75% NPK + Vermicompost 2 t/ha (2% Urea spray at the time of herbicide application)	85.8	84.2	220.2	215.43	35.35	35.14	46.40	44.21	109.63	104.77	42.32	42.19
SEm(±)	0.79	0.74	1.77	2.11	0.39	0.42	0.46	0.55	1.15	1.21	0.44	0.14
C.D. (P=0.05)	2.36	2.21	7.16	6.60	1.16	1.25	1.39	1.63	3.42	3.95	0.131	0.048

In general, dry matter accumulation (g m^{-1}) followed an increasing trend with advancement in crop age and reached its peak at maturity. Nutrient management option was significant effect on dry matter accumulation during both years. Further, perusal of the data revealed that dry matter accumulation (gm^{-1}) decreased significantly with nutrient doses from 100% NPK to control irrespective of the crop stages and years. At harvest, 100% NPK (2% Urea spray at tillering and jointing stage) crop accumulated more dry matter than other nutrient options during both the years. In general, the increase in dry matter accumulation was more up to at harvest stage. At harvest highest dry matter accumulation was recorded in 100% NPK (2% Urea spray at tillering and jointing stage) during both years but which was significantly at par with 75% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering and jointing stage) and 100% NPK (2% Urea spray at tillering stage) during both the years was significantly better than the remaining treatments. Minimum dry matter accumulation was recorded in control plots. Dry matter production in crop is a function of current photosynthesis. Balanced nutrition helps in achieving higher dry matter accumulation through enhanced canopy cover which ultimately increased higher amount of assimilated through higher rate of current photosynthesis. Dry matter accumulation is a function of total

plant stand, plant height, number of tillers per meter row length hence all these characters will ultimately affect dry matter accumulation by crop. The beneficial impact of organic manures on physical, biological and chemical properties of soils is widely known but the full appreciation for the some remains largely ignored in commercial chemical agriculture. Organic manures also increase the nutrient holding capacity of soil and minimize the effect of toxicants. Organic manures make the soil biologically active as these are good source of food and energy for soil micro-organisms and increase the activity of microbes which bring non-available plant nutrients into available from [5] thus improving the growth character. The contributions of organic and inorganic sources of nutrients also produced better growth parameters *viz*., plant height and dry matter. Similar results were also reported by Chaplot and Sumeriya [6].

Table-2 *Effect of nutrient management option on N, P, and K content and uptake in grain of wheat.*

Treatment	N content (%)		P content (%)		K content (%)		N uptake (kg ha^{-1})		P uptake (kg ha^{-1})		K uptake (kg ha^{-1})		Organic carbon(%)	
	Grain						Grain							
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Control	1.43	1.39	0.28	0.25	0.16	0.14	45.47	40.91	8.90	7.36	4.96	4.21	0.42	0.40
100% NPK	1.71	1.68	0.32	0.28	0.23	0.21	79.53	74.12	14.88	12.35	10.58	9.46	0.45	0.46
100% NPK (2% Urea spray at tillering stage)	1.77	1.73	0.31	0.29	0.25	0.25	86.04	80.60	15.07	13.51	12.32	11.51	0.44	0.46
100% NPK (2% Urea spray at jointing stage)	1.68	1.64	0.30	0.28	0.21	0.20	78.67	72.93	14.05	12.45	10.05	8.96	0.46	0.47
100% NPK (2% Urea spray at tillering and jointing stage)	1.82	1.79	0.32	0.30	0.28	0.27	90.11	84.54	15.84	14.17	13.84	12.89	0.45	0.46
100% NPK (2% Urea spray at the time of herbicide application)	1.64	1.61	0.3	0.28	0.20	0.18	75.93	70.63	13.89	12.28	9.03	7.98	0.43	0.45
75% NPK + Vermicompost 2 t/ha	1.61	1.59	0.29	0.27	0.18	0.16	74.06	68.85	13.34	11.69	8.07	7.04	0.50	0.53
75% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering stage)	1.76	1.74	0.31	0.28	0.25	0.23	83.83	78.86	14.77	12.69	11.76	10.60	0.51	0.54
75% NPK + Vermicompost 2 t/ha (2% Urea spray at jointing stage)	1.58	1.55	0.30	0.29	0.17	0.16	71.89	65.88	13.65	12.33	7.69	6.91	0.54	0.56
75% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering and jointing stage)	1.79	1.73	0.31	0.3	0.26	0.25	87.58	81.02	15.17	14.05	12.72	11.87	0.55	0.57
75% NPK + Vermicompost 2 t/ha (2% Urea spray at the time of herbicide application)	1.65	1.6	0.32	0.30	0.20	0.20	76.56	70.74	14.85	13.26	9.65	8.62	0.54	0.55
SEm(±)	0.005	0.006	0.002	0.002	0.01	0.01	1.65	1.94	0.287	0.507	0.55	0.50	0.01	0.006
C.D. (P=0.05)	0.014	0.017	0.005	0.006	0.03	0.04	4.90	4.76	0.887	1.507	1.64	1.49	0.03	0.018

Table-3 *Effect of nutrient management practices on agronomic efficiency of N P K*

Treatment	Agronomic efficiency (Kg grain yield /Kg applied N)					
	N		P		K	
	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
Control	-	-	-	-	-	-
100% NPK	9.82	9.79	44.98	44.85	29.46	29.38
100% NPK (2% Urea spray at tillering stage)	11.07	11.41	50.72	50.27	33.22	34.24
100% NPK (2% Urea spray at jointing stage)	9.81	10.03	44.92	45.92	29.42	30.08
100% NPK (2% Urea spray at tillering and jointing stage)	11.81	11.87	54.08	54.35	35.42	35.6
100% NPK (2% Urea spray at the time of herbicide application)	9.67	9.63	44.27	44.09	29	28.88
75% NPK + Vermicompost 2 t/ha	9.96	9.73	31.87	31.13	24.70	24.12
75% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering stage)	11.11	11.15	35.53	35.66	27.53	27.63
75% NPK + Vermicompost 2 t/ha (2% Urea spray at jointing stage)	9.61	9.17	30.75	29.33	23.83	22.73
75% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering and jointing stage)	12.02	12.21	38.44	39.05	29.79	30.26
75% NPK + Vermicompost 2 t/ha (2% Urea spray at the time of herbicide application)	10.25	10.37	32.76	33.17	25.39	25.70
SEm(±)	0.53	0.55	0.58	0.56	0.45	0.42
C.D. (P=0.05)	1.60	1.66	1.73	1.67	1.36	1.27

In general, higher number of grains spike^{-1} was noticed in 2013-14 than 2014-15. Further, perusal of data indicated that number of grains spike^{-1} differs with nutrient management option during both the years. Among nutrient management, practices significantly higher number of grains (45.71 and 43.68) per spike was

observed under 100% NPK (2% Urea spray at tillering and jointing stage) were significantly higher than remaining treatments during both the year. The minimum number of grains per spike was recorded in control treatments during both years.

More yield attributes were found in the treatment where organic and inorganic sources of plant nutrients were applied over control. This may be due to effect of organic and inorganic sources on the adequate nutrient supply for longer period, which will affect crop growth and photosynthetic activity. Similar results were reported byAgrawal *et al.* [4], Gowda *et al*. [7]. Stimulated vegetative growth of wheat on account of adequate and prolonged supply of essential nutrients in treatment receiving vermicompost and in addition to 75% NPK manifested itself in increase number of grain/spike similar beneficial effect of INM on yield attributes of wheat has been reported by Dahiya *et al* [8]. Such improved yield attributes can be linked with balanced nutrition particularly nitrogen with play a vital role in cell division and cell elongation as well as increase in sink size which provide a feedback to sources for production of higher amount of photo-synthate. Higher level of nutrients improved the fertility level of soil and creates congenial condition for better growth and development thus improved the yield attributes. These results are in conformity with those reported by Gupta and Sharma [9].

Application of nutrient management treatments significantly increased the grain and biological yield of wheat during the years of experimentation. The maximum grain yield (49.51. and 47.23 q ha^{-1}) observed in 100% NPK (2% Urea spray at tillering and jointing stage) T_5 was statistically at par with 75% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering and jointing stage), 100% NPK (2% urea spray at tillering stage), and significantly higher than the remaining treatments during both the year. The lowest grain yield (31.80 and 29.43 qha^{1}) was recorded in control. The maximum biological yield (115.09 and 110.79 q ha^{-1}) observed with the application of 100% NPK (2% Urea spray at tillering and at jointing stage) was statistically at par with 75% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering and at jointing stage), and 75% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering stage) and 100% NPK (2% urea spray at tillering stage) during 2013-14 and treatment 75% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering and at jointing stage) and 100% NPK (2% urea spray at tillering stage) during 2014-15 remained significantly superior over to rest of the treatments during both the years. The lowest biological yield of (79.83 and 74.36 q ha^{-1}) was recorded in the control plot.Foliar application of 2% urea at tillering stage increased the grain yield of wheat significantly over 100% NPK, while other single foliar application could not result any significant influence. Two foliar application of 2% urea (tillering + jointing stage) either with 100% or with 75% NPK resulted significantly higher grain yield than recommended practice 100% NPK. The mean grain and biological yield increased (3.05 and 4.00 qha^{-1}) due to foliar application of 2% urea in 100% NPK (2% Urea spray at tillering and at jointing stage) over prevailing recommended nitrogen application 100% NPK during 2013-14 and during 2014-15, respectively.

Different nutrient management treatment significantly influenced harvest index of wheat during both the crop seasons. The highest harvest index 43.01 and 42.63 during 2013-14and 2014-15 respectively recorded under 100% NPK (2% Urea spray at tillering and jointing stage) the treatment was found at par with 75% NPK + Vermicompost 2 t/ha (2% Urea spray tillering and jointing stage) T_{10} and significantly higher than remaining treatment during both the year. The lowest harvest index of 39.83 and 39.57 was recorded in control. Harvest index increased significantly over 100% NPK due to foliar application of 2% urea at tillering stage. Two foliar application of 2% (tillering + jointing stage) either with 100% or 75% NPK resulted in significantly higher harvest index than recommended practice 100% NPK. The harvest index increased by 0.42 and 0.33 over due to foliar application of 2% urea in 100% NPK (2% Urea spray at tillering and jointing stage) and 75% NPK + Vermicompost 2 t/ha (2% Urea spray tillering and jointing stage) during 2013-14 and 0.22 and 0.18 during 2014-15.

The beneficial effect of organic manures on grain, biological yield harvest index characters might be assigned to the fact that after proper decomposition and mineralization, these manures supplied available plant nutrients directly to the plants and also had solubilizing effect on fixed forms of nutrients in soil. Similar findings were also reported by Gul *et al.* [10]. The combination use of organic manures and chemical fertilizers enhanced the inherent capacity of soil as reported by Vasanthi and Kumar Swamy [11] Bhardwaj *et al.* [12], Meena *et al.*[13]. The organic manures also increase the adsorptive power of soil for cations and anion particularly phosphates and nitrates and these adsorbed ions are released slowly for the benefit of crop during entire crop growth period leading to higher yields reported by Singh and Singh [14].

Effect on nutrient management on N, P, and K content and uptake in grain of wheat

Application of different nutrient management option increased nitrogen, phosphorus and potassium content and their uptake by wheat grain significantly over control during both years with few exceptions. Among different nutrient management option, highest value for NPK content and uptake was recorded with 100% NPK (2% Urea spray at tillering and jointing stage)Followed by 75% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering and at jointing stage)Similarly higher nitrogen content treatment where INM was followed may be more translocation of photosynthesis to gain. Similar results are in confirmation with the finding of Fattah *et al.* [15], and Rathor and Sharma [16]. NPK contents increase might be due to the solubilisation effect of organic manures on native nutrients solubilisation and releasing of nutrients for a longer duration might be the reason for greater availability. Mahapatra *et al.* [17] reported that organic sources had a longer and greater efficiency as compared to inorganic source that might be responsible for higher uptake by building material.

Application of different nutrient management option increased significantly the uptake of NPK in grain. The uptake of these nutrients was more in 2013-14 as compared to 2014-15 because the yield was more during the first year of experiment. Among nutrient management option 100% NPK (2% Urea spray at tillering and jointing stage) and control recorded maximum and minimum NPK uptake in grain, respectively. Organic carbon in soil varied significantly among different nutrient treatment. Maximum carbon content was recorded in 75% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering and jointing stage) (0.55 and 0.57) was statistically at par with 75% NPK + Vermicompost 2 t/ha (2% Urea spray at jointing stage) and 75% NPK + Vermicompost 2 t/ha (2% Urea spray at the time of herbicide application) during both the year which was significantly higher to control.

More uptake of nitrogen in the when fertilizer was applied alone and with combination over control may be due to better availability of nutrient to plant owing to improved physical condition of soil. Similarly higher nitrogen content in when nutrient management option was followed may be more translocation of photosynthesis to gain. Removal of potassium is very high by cereal crops. Unfortunately, application of K did not receive due attention for most of Indian soil which were considered adequate in native K supply. But intensive agriculture led to occurrence of K deficiency in soil and thereby low uptake of K by the crop. Applications of organic manures are also found to increase the exchangeable K status of the soil. Higher N, P and K contents and their uptake by wheat have also been reported by Gupta and Sharma [18], Singh *et al.*[19], Pandey *et al.*[20], Sepat *et al.*[21], and Mahapatra *et al.* [17].

Application of 75% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering and jointing stage) significantly improves the soil health along with enhanced organic carbon in soil that the application of fertilizer alone. Similar, result was also reported by Pandey *et al.* [20].

The highest grain yield of wheat with the application of 100% NPK was found at par with 75% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering and jointing stage). In view the sustainability of soil health 75% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering and jointing stage) seems better. Thus 75% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering and jointing stage) may be suggested for good performance of wheat crop and sustainability of soil health and crop yields in future.

Effect of nutrient management practices on agronomic efficiency of N P K

Agronomic efficiency was found to be affected significantly by different treatments. The highest nitrogen use efficiency 12.02 and 12.21 kg grain/kg N applied was recorded with the application 75% NPK + Vermicompost + 2 t ha^{-1} (2% urea spray at tillering stage and jointing stage) T_{10} was at par with 100% NPK (2% Urea

spray at tillering stage) T_3, 100% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering and jointing stage) T_5 75% NPK + Vermicompost 2 t/ha (2% urea spray at tillering stage) T_8 and significantly higher than the rest the treatment during both the years. Lowest Nitrogen use efficiency 9.61 and 9.17 kg grain/kg N applied was recorded with 75% NPK + Vermicompost 2 t/ha (2% Urea spray at jointing stage) T_9 during 2013-14 and 2014-15 respectively.

Phosphorus use efficiency was found to differ significantly among different nutrient treatments management. The highest phosphorus use efficiency 54.08 and 52.27 kg grain yield/kg P applied was recorded with 100% NPK + Vermicompost 2 t/ha (2% Urea spray at tillering and jointing stage) T_5 was significantly higher than rest of the treatments during both the years. Lowest phosphorus use efficiency 30.75 and 29.33kg grain yield/kg P applied was recorded in 75% NPK + Vermicompost 2 t/ha (2% Urea spray at jointing stage) T_9 during 2013-14 and 2014-15 respectively.

Agronomic efficiency of potassium was found to vary significantly among different nutrient management treatments. It the highest Potassium use efficiency 35.42 and 35.6 kg grain yield/kg K applied was recorded with the application of 100 % NPK + Vermicompost 2 t/ha (2% Urea spray at tillering and jointing stage) which was significantly higher than to rest of the treatments during both the years. Lowest Potassium use efficiency 23.83 and 22.73 Kg grain yield/Kg K applied was recorded in 75% NPK + Vermicompost 2 t/ha (2% Urea spray at jointing stage) T_9 during 2013-14 and 2014-15 respectively. Based on two years results remaining the effect of different nutrient options on nitrogen, phosphorus and potassium use efficiency it can be stated that enhanced application can be linked with maximum N, P and K use efficiency. Similar results were also reported by Singh and Yadav [22]. N, P and K use efficiency is directly correlated with yield. Increased yield ultimately resulted in higher fertilizer use efficiency. Similar results were also reported by Laxminarayana and Patiram [23]. Gao*et al.* [24] Iqbal *et al.* [25] Ganajax *et al.* [26]

Conflict of Interest: None declared

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