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Utilization of nutrients in wheat *(Triticum aestivum L.)* - based cropping system in the Central Plateau of Uttar Pradesh, India

Aditya Kumar Singh[1]*, H.S. Kushwaha[1], Narendra Singh[2]

[1]Department of Natural Resource Management, Faculty of Agriculture, Mahatma Gandhi, Chitrakoot Gramodaya Vishwavidyalaya Chitrakoot, Satna 485331 (M.P.), India
[2]Banda University of Agriculture and Technology, Banda (U.P.), India

ABSTRACT

A field experiment was conducted during the kharif and rabi sessions of 2015-16 and 2016-17 at the Krishi Vigyan Kendra, Ganiwan, and Chitrakoot (U.P.). Bundelkhand region of Uttar Pradesh and Madhya Pradesh is drought affected and the farmers adopt different cropping system with imbalance fertilizer uses. Cereals and pulses both are known to respond well to balance fertilizer applications. If balance fertilizer can be included in the fertilizer schedule for maize, soybean, rice-wheat cropping system, not only productivity of the system can be optimized with increased cereals and pulses productivity but also improve quality of produce. The fertilizer consumption of India has increased from 0.78 million tonnes nutrients in 1965-66 to about 27.22 million tonnes nutrients in 20018-19 [17]. But in this period the cultivated crops depleted more mineral nutrients than replenishment through fertilizers, thus leaving the deficit of about 7 million tonnes of nitrogen, phosphorus and potassium. These types of trends to nutrient deficit are still counting because of profit motivated cultivation with imbalanced uses of fertilizers and this is the major factor which has been recently observed as a decline in growth rate of food grain production and factor productivity. In spite of the use of recommended dose of fertilizers, enhance in yield is not encouraging, which exhibits that there is need to supply secondary and micronutrient in addition to major nutrient. At least five essential nutrients are of wide spread practical importance. These are nitrogen (N), phosphorus (P), potassium (K), sulphur (S), and zinc (Zn).

The objective was the diversification of a wheat-based cropping system with nutrient management in the Central Plateau of U.P. In the kharif season, maize, soybean, and rice crops were raised under 7 fertility levels in a randomized block design. In rabi season, wheat was grown in the same plots keeping 3 cropping systems in the main plots and 7 fertility levels in sub-plots. These 21 treatment combinations were tried in a split-plot design with 4 replications. The treatment T4: 75% NPK+VC 2 t/ha to kharif and 100% NPK to wheat recorded significantly higher total N, P and K uptake by maize (79.84, 19.85, and 144 kg/ha, respectively). The maximum NPK uptake by soybean was 340.37, 17.27, and 147.32 kg/ha, respectively. Similarly, the same treatment T4 brought about the highest NPK uptake by rice (102.02, 28.64 and 94.63 kg/ha, respectively). Thereafter T5: 75% NPK+VC 2 t/ha to kharif and 75% NPK to wheat and T6: 75% NPK+VC 2 t/ha to kharif and 50% NPK to wheat having the same dose 75% NPK+VC 2 t/ha to kharif and 50% NPK to wheat/ha performed almost equally better with respect to NPK uptake by all the kharif crops grown under wheat-based cropping system. The total biomass (grain + straw) produced by maize, soybean, and rice in T4 treatment was 101.68, 81.66, and 95.97 q/ha, respectively. The different cropping systems had no significant changes in the NPK uptake by the succeeding wheat. But amongst the residual nutrient levels, T4 recorded total N, P, and K uptake by wheat (110.37, 21.84 and 139.62 kg/ha, respectively. In this treatment, the total biomass of wheat was 103.08 q/ha. The second and third-best treatments were T5 and T6, respectively. On the other hand, treatment, T1-100% NPK to kharif and 100% NPK to wheat-producing total biomass (58.29 q/ha) was recorded the lowest NPK uptake (60.29, and 11.96 and 76.96 kg/ha, respectively).

Keywords: *Growth, Cropping system, Nutrient uptake, organic manure, Inorganic fertilizer*

INTRODUCTION

The term cropping system refers to the crops, sequences of crops and management techniques used on a particular agricultural field over a period of years. Maintaining long-term soil productivity, conserving soil and water depends on the management of cropping system, which influences the magnitude of soil organic matter and soil erosion [3]. The success of wheat-based cropping system, which took the country to near self-sufficiency in early nineties is subsequently fading and called for enhanced production of cereals and pulses to the import bill on cereals and pulses. In India, the major cropping systems are maize-wheat rice-wheat and soybean-wheat cropping systems under irrigated and rainfed conditions [4]. In recent years, the

**Corresponding Author: Aditya Kumar Singh*
Email Address: adityakumarsinghupc@gmail.com

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deterioration in soil health associated with global predicament of energy along with escalation in the prices of chemical fertilizers compelled to emphasis on the supplementation of chemical fertilizers with low priced nutrient sources such as organics and bio-resources [1]. Keeping these facts in view the study was undertaken to optimize balanced fertilizer requirement for maize-wheat, soybean-wheat and rice-wheat cropping systems in clay-loam soil under prevailing climatic conditions of Bundelkhand region of U.P.

The continuous use of chemical fertilizers without organic manures in an imbalanced and indiscriminate manner deteriorated the soil health and led to deleterious effects on the long-term fertility of soil and sustainability of yield [10]. Therefore, in order to safeguard soil health and the climatic environment it is now essential to adopt suitable cropping systems along with balanced fertilizer application including organic manures like vermicompost. The Bundelkhand region of the U.P. is drought affected. Therefore, farmers adopt different cropping systems with imbalanced fertilizers application without adding organic manures. Cereals and pulses both are known to respond well to integrated nutrient management. If balanced fertilizers through organic and inorganic fertilizers are included in the fertilization schedule for maize, soybean, and rice-wheat cropping systems not only the productivity of the system is optimized but also improve the nutritional quality of produce. Despite the application of the recommended dose of fertilizers, the increase in yield is not encouraging, which indicates that in addition to major nutrients, there is a need to apply secondary and micronutrients also widespread which are deficient in soils. The main reason is that the total removal of nutrients by the crops is never replenished under the fertilizer scheduling program. In recent years, zinc and sulphur nutrients in wheat are considered to be an integral part of balanced nutrition in many areas of the country. Therefore, there is a need to work out balanced fertilization recommendations involving combinations of organic manures sulphur and zinc with N, P, and K to increase the productivity of wheat-based cropping systems in many areas of the country. There is a need to assess strategies for balanced fertilization combined with organic and inorganic sources of nutrients to correlate in maize, soybean, and rice-wheat cropping systems. The addition of organic manures like vermicompost improves the physico-chemical and biological properties of the soil with sustainable crop productivity. Looking at these facts the present research was taken up.

MATERIALS AND METHODS MATERIALS AND METHODS

1. Site selection experimental area

The experiments were carried out at Tulsi Krishi Vigyan Kendra, Ganiwan, Chitrakoot, Uttar Pradesh on clay loam soil during the cropping season of 2015-2016 and 2016-2017. The farm is situated in agro-climatic zone – 8: Central Plateau and hill zone (Bundelkhand region of Uttar Pradesh) at 80058′ to 81034′ E longitude and 24052′ – 25025′ N latitude and an elevation of 132.98 meters above mean sea level.

2. Climate

Agro-ecologically Chitrakoot is characterized by semi-arid and subtropical with hot dry summer and cool winter. The average annual rainfall of the district Chitrakoot is 802 mm. Temperature extremes vary between a minimum temperature of 3.5oC in December and January month to a maximum temperature of 47oC in the month of May and June.

The average numbers of rainy days are 42 days of district Chitrakoot. Approximately 90% of the rainfall in this district is falling from June to September. The relative humidity remains a minimum 19 to 26% during the summer and medium 35 to 45% during the winter season, while it attains a maximum value of 90 to 95% during the rainy season.

3. Weather condition

Data regarding weather conditions prevailing during the experimental period was recorded from the Meteorological Observatory of Tulsi Krishi Vigyan Kendra, Ganiwan, Chitrakoot (U.P.). The total rain-fall was received 761 and 834.75 mm during the 2015-2016 and 2016-2017 which is very similar to the mean annual rain-fall (802 mm) of Chitrakoot. However, this rainfall fell in 36 and 45 rainy days during two consecutive years. The maximum and minimum temperature was noted at 47 & 46.70C and 3 & 30C during June and January months of 2015-16 and 2016-17, respectively. However, maximum relative humidity was observed in October (93%) and July (92%), and minimum in March (20%) and April (19%) during the first year. Similarly in second year, it was found maximum in June & July (99%) and minimum in June (10%). The maximum wind speed was recorded in the month of December (10.4 km/h) and minimum in July (0.1 km/h) during 2015-16, however, in 2016-17 it was recorded as maximum in the month of June (18.5 km/h) and minimum in March (0.7 km/h).

4. Physico-chemical properties of soil

The data pertaining to the initial status of various physico-chemical properties of soil and changes in physico-chemical properties due to the effect of treatments after the end of the first crop cycle during the year 2015-16 were recorded. However, in 2016-17, the initial soil status at the start of the experiment and at end of the experiment was also recorded for studies of the physico-chemical properties of soil.

Soil samples were taken at the end of the crop cycle in each crop sequence from 0-15 cm depth of soil for chemical analysis. After this, samples were carried out in the laboratory of Krishi Vigyan Kendra, Ganiwan, Chitrakoot (UP). The samples were taken plot-wise separately and then analysis of soil properties of pH, EC, OC, N, P, K, S and Zn were made as per standard procedure after this, changes in these soil properties over their initial status were determined. The soil of the experimental field was clay loam in texture and slightly alkaline in reaction (pH 7.8 and 7.9), low in organic carbon (0.58 and 0.71%) and available zinc (9.37 and 8.44 kg/ha), medium in available potassium (145 and 190 kg/ha) and high in available phosphorus (65 and 81 kg/ha) during two respective years. However, available nitrogen was noted as medium (340.50 kg/ha) and low (268 kg/ha) in 2015-16 and 2016-17, respectively. Similarly, available sulphur was estimated low (6.6 kg/ha) and medium (23 kg/ha) during two consecutive years.

The treatments comprised 3 cropping systems (maize-wheat, soybean-wheat, and rice-wheat) under main plots, and 7 nutrient levels of NPK with or without vermicompost in sub-plots. In kharif season, maize, soybean and rice crops were raised under 7 nutrient treatments in randomized block design with 4 replications. Whereas in rabi season, the wheat crop was sown under 3 cropping systems with 7 treatments of nutrient levels having 50 to 100 % NPK. Thus wheat was sown in 21 treatment combinations in a split-plot design with 4 replications. Maize (Ganga-11), soybean (NRC-7) and rice (Sugandha-5), and wheat (HD-2967) were grown under irrigated conditions. Sowing of all the kharif crops was done on 2nd July, 2015 and 5th July 2016, whereas wheat was sown on November 21st, 2015, and November 25th, 2016. Kharif crops were harvested on October 27-28th, 2015 and November 02-03rd, 2016 and wheat crop was harvested on March 28th, 2016, and March 30th, 2017. The remaining nutrient management and cultural practices of all the crops were done as per recommended package of practices.

RESULTS AND DISCUSSION

Nutrient uptake by maize

The data in Table 1 revealed that the maximum total uptake by (grain + straw) maize was recorded under treatment T4 having T4: 75% NPK+VC 2 t/ha to kharif and 100% NPK to wheat (79.84 kg N, 19.85 kg P and 144 kg K/ha), followed by having T5: 75% NPK+VC 2 t/ha to kharif and 75% NPK to wheat (74.41 kg N, 18.16 kg P and 136.11 kg K/ha). It was attributed to the grain and straw yield of maize as uptake was estimated by yield (grain and straw yield) and nutrient content in it. The increased nutrient uptake was in accordance with the total biomass yield of maize (101.68 q/ha). It was higher in T2 and T3 due to the additional supply of sulphur and zinc in T4 to T7 due to the additional supply of vermicompost which supported the root and shoot development and increased uptake of nutrients. It also increased the cation exchange capacity in the roots of the plant yield [3]. These results were supported in [1], [2], [15], and [16].

Nutrient Uptake by soybean

The total NPK uptake by grain + straw of soybean was found highest under treatment T4 (340.3 kg N, 17.27 kg P and 147.32 kg K/ha respectively, followed by T5: 75% NPK+VC 2 t/ha to kharif and 75% NPK to wheat. It was on account of the higher total biomass yield of soybean in T4 treatment (81.66 q/ha). It might be due to the application of vermicompost which played important role in the solubilization of phosphorus and potassium for higher availability of plant nutrients. The availability of nitrogen, phosphorus and potassium increased due to the application of vermicompost thus total uptake of NPK increased. Further integrated nutrient management ensured higher uptake of NPK because of increased cation exchange capacity in the roots of the plants [3]. The present findings were supported in [11] and [12].

Nutrients uptake by rice

The total uptake by grain + straw (102.02 kg N, 28.64 kg P, and 94.63 kg K /ha) was observed under treatment T4: 75% NPK+VC 2 t/ha to kharif and 100% NPK to wheat, followed by T5: 75% NPK+VC 2 t/ha to kharif and 75% NPK to wheat and T6: 75% NPK+VC 2 t/ha to kharif and 50% NPK to wheat. The trend of NPK uptake was in accordance with the total biomass yield (95.57 q/ha) in these treatments. This might be due to the increased and slow supply of nutrients by vermicompost for longer periods of crop growth. It may be well supported by the grain and straw yield of rice. Besides, more availability of nutrients in the soil at higher rates of their application may also be responsible for more uptakes of nutrients. The higher uptake of nutrients under increased fertilizer application might be due to better plant growth and yield. The similar results were supported in [7] and [8].

Nutrients uptake by wheat

The perusal of data in Table 2 indicates that the total NPK uptake by wheat crop was recorded under treatment T4: 75% NPK+VC 2 t/ha to kharif and 100% NPK to wheat, (110.37, 21.84 and 139.62 kg/ha, respectively), followed by T5: 75% NPK+VC 2 t/ha to kharif and 75% NPK to wheat. The trend of uptake was in accordance to the total biomass yield of wheat (103.08 q/ha). Hence these uptake values may be attributed to increased grain and straw yields which also behaved in a similar manner under vermicompost indicating that mineralized nutrients from these sources satisfied the sufficiently nutritional requirements of the crop. The similar effect of organics on succeeding wheat was supported in [4], [10], and [14].

CONCLUSION

Total maximum nitrogen uptake in the soil recorded highest with the application of 75% NPK+VC 2 t/ha to kharif and 100% NPK to wheat (T4) in soybean-wheat system during 2016-17. Treatment T17: 100% NPK+VC 2 t/ha to kharif and 50% NPK to wheat was obtained minimum nitrogen uptake in maize-wheat system at end of the experiment. Highest phosphorus uptake in the soil recorded with the application of T4: 75% NPK+VC 2 t/ha to kharif and 100% NPK to wheat in soybean-wheat system during 2016-17, while, treatment T3: 100% NPK+VC 2 t/ha to kharif and 50% NPK to wheat in rice-wheat system was recorded minimum phosphorus uptake at end of the experiment. Maximum potassium uptake in the soil was analyzed with the application of 75% NPK to kharif and 100% NPK to wheat (T4) in soybean-wheat system during 2016-17. However, Treatment T1: 100% NPK to kharif and 100% NPK to wheat exhibited minimum potassium uptake in rice-wheat system at end of the experiment.

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AUTHOR'S CONTRIBUTION

Aditya Kumar Singh: Designed, Data analysis, writing, and conducted the study.

H. S. Kushwaha and Narendra Singh: Proof reading.

Table 1: Total nutrients uptake (grain + straw) by *kharif* crops applied with different nutrient levels (Pooled for 2 years)

Treatments		Total maize biomass (grain + straw) (q/ha)	Total uptake by maize (kg/ha)			Total soybean biomass (grain + straw) (q/ha)	Total uptake by soybean (kg/ha)			Total rice biomass (grain + straw) (q/ha)	Total uptake by rice (kg/ha)		
			N	P	K		N	P	K		N	P	K
T_1	100 % NPK	83.59	65.75	15.49	117.79	49.73	205.82	11.02	90.66	68.76	56.14	16.03	50.72
T_2	100 % NPKS Zn	94.55	76.12	19.16	133.34	64.98	274.63	16.23	123.64	73.09	60.51	17.81	55.27
T_3	100 % NPKS Zn	94.01	76.05	18.45	133.49	66.45	280.12	15.72	123.86	74.54	60.83	17.59	55.09
T_4	75 % NPK + 2 t VC/ha	101.68	79.84	19.85	144.00	81.66	340.37	17.27	147.32	95.57	102.02	28.64	94.63
T_5	75 % NPK + 2 t VC/ha	96.11	74.41	18.16	136.11	75.02	310.83	16.71	133.67	90.68	80.64	23.22	76.14
T_6	75 % NPK + 2 t VC/ha	94.63	73.97	18.23	132.89	74.24	308.94	15.67	133.09	90.91	79.51	22.18	73.35
T_7	50 % NPK + 2 t VC/ha	94.38	70.65	16.54	131.35	66.20	276.04	12.79	118.00	74.73	55.08	16.55	52.06
C.D. (P=0.05)		**4.14**	**3.04**	**1.09**	**4.45**	**4.00**	**14.33**	**0.88**	**5.98**	**4.50**	**3.50**	**1.29**	**3.64**

V C = Vermicompost
Fertilizer Doses -

Maize : 120:60:40:30:5 (100 % N:P: K: S: Zn/ha)
Soybean : 20:60:40:20:5 (100 % N:P: K: S: Zn/ha)
Rice : 120:60:30:20:5 (100 % N:P:K:S: Zn/ha)

Table 2: Total nutrients uptake by succeeding wheat as influenced by cropping systems and nutrient levels applied in kharif and rabi seasons (Pooled for 2 years)

Treatments **Cropping systems (Main-plot treatments)**			**Total biomass (q/ha)**	**Total N-uptake (kg/ha)**	**Total P-uptake (kg/ha)**	**Total K-uptake (kg/ha)**
C_1 Maize-wheat			77.53	75.71	15.75	98.64
C_2 Soybean-wheat			80.53	77.89	16.49	91.12
C_3 Rice-wheat			77.89	75.88	15.56	97.78
C.D. (P=0.05)			**NS**	**NS**	**NS**	**NS**
Nutrient levels (kg/ha) (Sub-plot treatments)						
Kharif Season	**Rabi** Season	Total NPK (%)				
T_1 100 % NPK	100 %	200 %	58.29	60.29	11.96	76.96
T_2 100 % NPKS Zn	75 % NPK	175 %	68.80	69.00	13.75	85.00
T_3 100 % NPKS Zn	50 % NPK	150 %	69.97	65.38	13.45	81.93
T_4 75 % NPK + 2 t VC/ha	100 % NPK	175 % + vc /ha	103.08	110.37	21.84	139.62
T_5 75 % NPK + 2 t VC/ha	75 % NPK	150 % + vc /ha	90.85	91.68	18.22	113.79
T_6 50 % NPK + 2 t VC/ha	50 % NPK	125 % + vc /ha	89.58	82.51	16.87	103.68
T_7 50 % NPK + 2 t VC/ha	100 % NPK	150 % + vc/ha	69.97	73.15	14.28	93.26
C.D. (P=0.05)			**8.05**	**4.31**	**1.08**	**7.07**

Total Biomass = grain + straw yield. *VC = Vermicompost*

Fertilizer doses
Maize: 120:60:40: 30:5 (100 % N:P: K: S: Zn/ha), *Soybean: 20:60:40:20:5 (100 % N:P: K: S: Zn/ha)*
Rice: 120:60:30:20:5 (100 % N:P:K:S: Zn/ha), *Wheat : 120: 60: 40 kg/ha (100 % NPK /ha)*

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