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PRODUCTIVITY AND PROFITABILITY OF WHEAT (*TRITICUM AESTIVUM* L.) BASED CROPPING SYSTEM WITH INTEGRATED NUTRIENT MANAGEMENT IN CENTRAL PLATEAU OF UTTAR PRADESH

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ABSTRACT

A field experiment was conducted during *kharif* and *rabi* season of 2015-16 and 2016-17 at the Krishi Vigyan Kendra, Ganiwan, Chitrakoot Uttar Pradesh (UP). The objective was the diversification of wheat-based cropping system with nutrient management in Central plateau of U.P. In *kharif* season, maize, soybean and rice crops were raised under seven fertility levels in randomized block design. In *rabi* season, wheat was grown in the same plots keeping 3 cropping systems in the main-plots and seven fertility levels in sub-plots. Thus, twenty one treatment combinations were tried in split-plot design with four replications. Under the productivity of maize-wheat cropping system, grain yield of maize was 3798 kg ha^{-1} and wheat yield was 3064 q/ha under T_4- 90:45:30 and 100:60:40 kg ha^{-1} NPK (75% NPK+VC 2 t/ha to *kharif* and 100% NPK to wheat). In soybean-wheat system, grain yield of soybean was 3347 kg ha^{-1} and wheat yield was 3231 kg ha^{-1}. In rice, wheat system, grain yield of rice was 3870 kg ha^{-1} and wheat yield was 31.38 q/ha. The wheat equivalent grain yield achieved in maize-wheat cropping system was 6151 kg ha^{-1} whereas in soybean-wheat system 7677 kg ha^{-1} and in rice-wheat system 6081 kg ha^{-1}. The highest total net return was obtained in case of soybean-wheat (Rs 109660/ha), followed by rice-wheat (Rs 82302/ha) and maize-wheat (Rs 79135/ha). Similarly in maize-wheat system, the highest system profitability was recorded under the same treatment T_4 (Rs 276/ ha/day), followed by T_5- 90:45:30 and 75:45:30 kg ha^{-1} NPK (75% NPK+VC 2 t/ha to *kharif* and 75% NPK to wheat) (Rs 237/ha/day). Thus, the best cropping system was soybean-wheat applied with T_4- 90:45:30 and 100:60:40 kg ha^{-1} NPK (75% NPK+VC 2 t/ha to *kharif* and 100% NPK to wheat) for the Central plateau of U.P.

Keywords: nutrient management, profitability, wheat-based cropping, yield

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 (Blanco and Humberto, 2010). 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 (Jat *et al*., 2013). In recent years, the deterioration in soil health associated with global predicament of energy along with escalation in the prices of chemical fertilizers compelled to emphasize on supplementation of chemical fertilizers with low priced nutrient sources such as organics and bio-resources (Anonymous, 2018-19). 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.

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Nitrogen is a key element in plant growth, which is found in hormones, plant proteins, all plant cells and in chlorophyll. Phosphorus helps to transfer of energy from sunlight to plants, stimulates early root and plant growth, and hastens maturity. Potassium increases vigour and disease resistance in plants, helps formation and movement of starch, also increase sugar percentage and oil percentage in plants and can improve fruit quality. Sulphur is a constituent of amino acids in plant proteins and is involved in energy-producing processes in plants. It is important for producing higher crop yield and better quality of produces and also responsible for many flavours in plant such as the aroma of onions and cabbage. Zinc helps in the production of plant hormones which is responsible for stem elongation and leaf expansion. In addition to key nutrients, nitrogen (N) and phosphorus (P), response to potassium (K) fertilization has been increasing with time and it has been considered essential to include in fertilizer recommendation for optimization of crop yield. Further, continuous use of sulphur (S)-free fertilizer in India over the years has widened N: P: K: S ratio which has been accentuated the deficiency of sulphur (S). Sulphur is essential for many growth functions in plants including nitrogen metabolism, enzyme activity and protein and oil synthesis. Generally, sulphur-deficient plants have short and/or spindly stems and yellowing of the young (top) leaves. With nitrogen deficiency, yellowing affects the older, lower leaves first. Micronutrients have attained a great significance in today's intensive and exploitive agriculture aiming at increased productivity of crops. In India, intensive cropping with nutrient exhaustive high yielding varieties coupled with the use of high analyzed fertilizer for enhancing production of food grain have catalyzed the rapid depletion of micronutrients in the soil. Zinc (Zn) deficiency is the most widely spread role among all the micronutrients and has been most widely reported to be deficient in calcareous and low organic matter in soils. Therefore, without application of zinc, sustainable productivity is difficult in each cereal crops. In recent years, zinc (Zn) nutrient in wheat is integral part of balanced nutrition in many areas of the country. Therefore, there is need to work out balanced fertilization recommendations involving combinations of S and Zn with N, P, K to increase production and productivity of wheat based cropping system in many areas of the country. The continuous use of chemical fertilizers in an unbalanced and indiscriminate manner deteriorated the soil health and led to deleterious effect on long term fertility of soil and sustainability of yield.

In recent years, the degradation in soil health related with global predicament of energy along with rise in the prices of chemical fertilizers leads to emphasize on augmentation of chemical fertilizers with low priced nutrient sources such as organics and bio-resources. Although, the higher production can be attained by more addition of inorganic fertilizers alone, but it may lead to upstate of pollution and deterioration in soil characteristics that can only be keep up at sustainable extend by addition of bio-products and organic manures. Amongst the organic manures, vermi-compost, farmyard manures are a traditional source most readily available and widely used by the farmers since time immemorial. Addition of organic material to the soil such as vermi-compost, farmyard manures helps in maintaining soil fertility and productivity. Organic matter is the source of energy to the soil micro flora and organic carbon content is considered to be an index the health of soil and human being also.

MATERIALS AND METHODS

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 $80^0 58'$ to $81^0 34'$ E longitude and $24^0 52'$- $25^0 25'$ N latitude and an elevation of 132.98 meter above mean sea level.

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 minimum temperature of 3.5^oC in December and January month to maximum temperature of 47^oC in the month of May and June. Average numbers of rainy days are 42 days of district Chitrakoot. Approximately 90% of rainfall of this district is falling from June to September. The relative humidity remains minimum 19 to 26% during summer and medium 35 to 45% during winter season, while it attains maximum value 90 to 95% during rainy season.

Weather condition

Data regarding weather conditions prevailing during 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 mean annual rain fall (802 mm) of Chitrakoot. However, this rainfall was fell in 36 and 45 rainy days during two consecutive years. The maximum and minimum temperature was noted in 47 and 46.7^{0}C and 3 and 3^{0}C during June and January month 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 first year. Similarly in second year, it was found maximum in June and 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 maximum in the month of June (18.5 km/h) and minimum in March (0.7 km/h).

Physico-chemical properties of soil

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

Soil samples were taken at the end of crop-cycle in each crop sequence from 0-15 cm depth of soil for chemical analysis. After this, samples were carried in the laboratory of Krishi Vigyan Kendra, Ganiwan, Chitrakoot. The samples were taken plot wise separately and then analysis of soil property 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 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 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 randomize block design with 4 replications. Whereas in *rabi* season, wheat crop was sown under 3 cropping systems with 7 treatment of nutrient levels having 50 to 100 % NPK. Thus, wheat was sown in 21 treatment combinations in 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

Productivity of *kharif* crops

The data in Table 1 revealed that the treatment T_4- 90:45:30 and 100:60:40 kg ha^{-1} NPK (75% NPK+VC 2 t/ha to *kharif* and 100% NPK to wheat) produced significantly maximum grain yield of maize (3790 kg ha^{-1}), soybean (3350 kg ha^{-1}) as compared to the remaining treatments. In treatment T_1- 120:60:40 and 100:60:40 kg ha^{-1} NPK (100% NPK to *kharif* and 100% NPK to wheat) gave the lowest grain yield 3080, 2040 and 2830 kg ha^{-1}, respectively. The effect of other treatments remained under intermediate position. The increased yield under T_4 and other treatments may be ascribed to the application of balanced doses of fertilizer and organic manures which increased the physical activities of crop plants that converted carbohydrate and proteins in the form of grains. Vermicompost is the richest source of micronutrients along with the improvement in the microbial activities of the soil. Such nutrient management practices provided good physico-chemical and biological conditions of the soil to ensure more availability of NPK with reduced nutrient losses. Moreover, synergistic effect of NPK and vermicompost promoted growth parameters and gave maximum grain and straw yields of *kharif* crops. The present results corroborate with the findings of Gupta *et al*. (2006), Meena *et al*. 2007, Singh

et al. (2008) and Singh *et al*. (2015). Nitrogen supplied was properly utilized in inorganic form due to high microbial activities in the soil due to vermicompost application. This brought about to better physical development of plants facilitating the increased formation of chlorophyll and photosynthesis process. Such healthier and better developed plants forced to the higher yield attributes and resulted higher yield of *kharif* crops. These results are in conformity with those of Paramasivan *et al*. (2011) and Vishudhanand (2014).

Profitability of *kharif* crops

The data in Table 1 further indicate that the treatment T_4- 90:45:30 and 100:60:40 kg ha^{-1} NPK (75% NPK+VC 2 t/ha to *kharif* and 100% NPK to wheat) proved the most remunerative treatment. The significantly maximum net income of *kharif* crops maize, soybean and rice was Rs. 36113/-, Rs. 65932/- and Rs 40373/- ha, respectively. Whereas, the treatment T_1- 120:60:40 and 100:60:40 kg ha^{-1} NPK (100% NPK to *kharif* and 100% NPK to wheat) gave the lowest net income from maize (Rs. 28999/-ha), soybean (Rs. 24668 ha^{-1}) rice (Rs. 12205 ha^{-1}). The treatments profitability of *kharif* crops provided gross income after market sale. Billore *et al.* (2009), Verma *et al.* (2006), Kumar and Dhar *et al*. (2010) and Vishudhanand (2014) almost reported similar results on economics of crops.

Table 1. Productivity and profitability from *kharif* crops under integrated nutrient management (pooled for 2 years

Treatment	Maize **(Ganga-11)**		**Soybean (NRC-7)**		**Rice (Sugandha-5)**	
	Grain yield (kg/ha)	**Net income (Rs/ha)**	**Grain yield (kg/ha)**	**Net income (Rs/ha)**	**Grain yield (kg/ha)**	**Net income (Rs/ha)**
T_1 120:60:40 (100% NPK)	3880	28999	2040	24668	2830	12205
T_2 120:60:40:30:5(100%N:P:K:S:Zn/ha)	3490	34133	2670	50604	3020	13599
T_3 120:60:40:30:5(100%N:P:K:S:Zn/ha)	3470	33820	2720	52221	3080	14718
T_4 90:45:30 (75% NPK + VC @ 2 t/ha)	3790	36113	3.350	65932	3870	40373
T_5 90:45:30 (75% NPK + VC @ 2 t/ha)	3550	31844	3050	57606	30730	26176
T_6 90:45:30 (75% NPK + VC @ 2 t/ha)	3490	30928	3040	57368	3750	25443
T_7 60:30:20(50% NPK + VC @ 2 t/ha)	3490	32105	2740	50337	3080	11889
C.D. (*P*=0.05)	1.66	1162	1.77	31.64	20.09	2108

VC= Vermi-compost
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: 120:60:40:20:5 (100 % N: P: K: S: Zn/ha)

Table 2. Residual effect of *kharif* crops and various applied nutrients on grain yield and economics of wheat (pooled for 2 years)

Treatment		**Grain yield (kg ha^{-1})**	**Net income (Rs ha^{-1})**	**B:C ratio**	**Wheat equivalent yield (kg ha^{-1})**	**System profitability (Rs./ha/day)**		
Cropping systems (Main-plot treatments)						**Maize-wheat**	**Soybean-wheat**	**Rice-wheat**
C_1 Maize-wheat		3060	43023	2.89	61510	-	-	-
C_2 Soybean-wheat		3230	43729	2.91	76770	-	-	-
C_3 Rice-wheat		3140	41929	2.92	60810	-	-	-
C.D. (P=0.05)		NS	NS	NS	1.32	-	-	-
Nutrient levels (kg/ha) (Sub-plot treatments)								
Kharif	***Rabi***							
T_1- 120:60:40 (100% NPK)	100:60:40 (100% NPK)	2380	24055	2.19	50430	147	162	97
T_2- 120:60:40:30:5 (100%N:P:K:S:Zn/ha)	75:45:30 (75% NPK)	2750	24907	2.28	59680	188	237	131
T_3- 120:60:40:30:5 (100%N:P:K:S:Zn/ha)	50:30:20 (50% NPK)	2830	36806	2.63	60650	196	241	139
T_4- 90:45:30 (75% NPK + VC @ 2 t/ha)	100:60:40 (100% NPK)	4030	63369	3.18	85130	276	358	277
T_5- 90:45:30 (75% NPK + VC @ 2 t/ha)	75:45:30 (75% NPK)	3540	54529	3.53	75020	237	312	2.16
T_6- 90:45:30 (75% NPK + VC @ 2 t/ha)	50:30:20 (50% NPK)	3630	52759	3.39	73140	227	305	213
T_7- 60:30:20(50% NPK + VC @ 2 t/ha)	100:60:40 (100% NPK)	2.850	33827	3.17	60480	177	232	122
CD (*P*=0.05)		4.58	1956	0.00	2.29	5.67	7.21	4.88

Fertilizer doses VC = Vermi-compost
Wheat : - 120: 60: 40 kg/ha (100 % NPK /ha)

Yield and profit of succeeding wheat

The residual effect of nutrients applied *kharif* crops on yield and economical of succeeding wheat was almost the same (Table 2). However, the residual effect of applied nutrients to *kharif* and *rabi* crops brought about significant changes in the yield and economics of succeeding wheat. Accordingly, the treatment T_4 gave the maximum yield up to 4030 kg ha^{-1} and net income Rs. 63369.00/ha, followed by T_5- 90:45:30 and 75:45:30 kg ha^{-1} NPK (75% NPK+VC 2 t/ha to *kharif* and 75% NPK to wheat) and T_6- 90:45:30 and 50:30:20 kg ha^{-1} NPK (75% NPK+VC 2 t/ha to *kharif* and 50% NPK to wheat) treatments.

Wheat equivalent yield and system profitability

Amongst the cropping systems, significantly highest wheat equivalent grain yield (7680 kg ha^{-1}) was recorded under soybean-wheat system, whereas maize-wheat and rice-wheat cropping systems were at par. In case of fertility levels, maximum wheat equivalent grain yield was secured from treatment T_4 (8510 kg ha^{-1}), followed by T_5 (7500 kg ha^{-1}), T_6 (7310 kg ha^{-1}) and the lowest under T_1 (5040 kg ha^{-1}). The variation in wheat equivalent grain yield was due to yield obtained in the preceding crops and their sale price as well as yield of the succeeding wheat under different fertility treatments.

The highest system profitability was recorded in treatment T_4, followed by T_5 in all the cropping systems. In maize-wheat, it was maximum of (Rs. 276 ha^{-1} per day) in T_4, followed by T_5 (Rs 237 ha^{-1} per day). In case of soybean-wheat, it was Rs 358 ha^{-1} per day in T_4, followed by T_5 (Rs 312 ha^{-1} per day). Similarly in rice-wheat, the system profitability was up to Rs. 277 ha^{-1} per day in T_4, followed by Rs 216 ha^{-1} per day in T_5 treatment. The lowest systems cropping profitability was observed in T_1 (Rs 147, 162 and 97), respectively. Thus, amongst the nutrient levels it was maximum in T_4- 90:45:30 and 100:60:40 kg ha^{-1} NPK (75% NPK+VC 2 t/ha to *kharif* and 100% NPK to wheat) and 100% NPK applied to succeeding wheat crop in all the cropping systems but found highest in soybean-wheat cropping system.

CONCLUSION

In terms of Productivity of *kharif* crops, treatment T_4- 90:45:30 and 100:60:40 kg ha^{-1} NPK (75% NPK+VC 2 t/ha to *kharif* and 100% NPK to wheat) produced significantly maximum grain yield of maize (3790 kg ha^{-1}), soybean (3350 kg ha^{-1}) as compared to the remaining treatments. Whereas, profitability of *kharif* crops, 90:45:30 and 100:60:40 kg ha^{-1} NPK (75% NPK+VC 2 t/ha to *kharif* and 100% NPK to wheat), proved the treatment T_4 is most remunerative treatment. The significantly maximum net income of *kharif* crops maize, soybean and rice was Rs. 36113/-, Rs. 65932/- and Rs 40373/- ha^{-1}, respectively. Yield and profit of succeeding wheat the residual effect of nutrients applied in *kharif* crops on yield and economical of succeeding wheat was almost the same. Wheat equivalent yield and system profitability, amongst the cropping systems, significantly highest wheat equivalent grain yield (7680 kg ha^{-1}) was recorded under soybean-wheat system, whereas maize-wheat and rice-wheat cropping systems were at par. In case of fertility levels, maximum wheat equivalent grain yield was secured from treatment T_4 (8510 kg ha^{-1}), followed by T_5 (7500 kg ha^{-1}), T_6 (7310 kg ha^{-1}).

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AUTHOR'S CONTRIBUTION

A. K. Singh: Designed and conducted the study
H. S. Kushwaha: Data analysis and proof reading

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