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Nutrient use efficiency of maize (*Zea mays*) as influenced by target yield based nutrient management in maize-chickpea cropping sequence

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Abstract
A field experiment was undertaken during the kharif and Rabi season of the years 2021-22 and 2022-23 to study the nutrient use efficiency of maize (*Zea mays*) as influenced by target yield based nutrient management in maize-chickpea cropping sequence. The treatment consists of five nutrient management treatments such as T_1-100 % RDF + FYM @ 10 t ha^{-1}, T_2- As per soil test, T_3- Target yield of 60 q ha^{-1} as per STCR equation with FYM @ 10 t ha^{-1}, T_4- Target yield of 70 q ha^{-1} as per STCR equation with FYM @ 10 t ha^{-1} and T_5 -Control. The maximum nutrient use efficiency of maize was recorded in target yield of 60 q ha^{-1} as per STCR equation with FYM @ 10 t ha^{-1} followed by target yield of 70 q ha^{-1} as per STCR equation with FYM @ 10 t ha^{-1} and minimum nutrient use efficiency was recorded in control.

Keywords: Nutrient use efficiency, Soil test crop response, target yield, maize

Introduction

Since maize is such a valuable crop, no portion of it is wasted and is utilized in some capacity. Since its hybrids are nutrient-exhaustive and absorb a lot of nutrients from the soil, nutrient management is crucial in continuous maize-based cereal cropping systems. This cropping system's low fertilizer efficiency, the shortcomings of the existing fertilizer recommendations, the lack of knowledge about nutrients other than N, P, and K, and the steadily declining soil quality all contribute to its low yield (Joshi *et al*., 2016) [6]. Chemical fertilizers have been the key to raising crop yields, and they will remain a critical component in reaching the nation's food production goals. A balanced nutrient supply must be assured while taking into account the soil's inherent capacity to give nutrients in order to attain desired crop yield levels, as soil reserves alone are insufficient to meet the nutrient uptake needs of these crops (Dass *et al*., 2014) [3]. Higher usage efficiencies of applied inputs, as well as increased crop productivity and profitability, are largely dependent on the appropriate match and balance between applied nutrients, soil sources, and plant demands. According to Xu *et al*. (2009) [8], there are enormous opportunities to further increase the productivity of maize and chickpea by implementing site-specific, integrated nutrient and crop management that takes into consideration the crop requirements, soil-test values, and yield targets. Soil test based application of plant nutrient helps to understand higher comeback ratio and benefit: cost ratio as the nutrients are applied in proportion to the amount of the deficiency of a particular nutrient and the correction of the nutrients imbalance in soil helps to harness the synergistic effects of balanced fertilization (Rao and Srivastava, 2000). The present investigation aimed to study the relationship between the nutrient supplied by the soil and added fertilizers, their uptake and yield of maize and to develop a guideline for judicious application of fertilizer for maximum production of maize under maize-chickpea cropping sequence.

Material and methods

The field experiment was carried out during 2021-22 and 2022-23 at Post Graduate Research Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri to study the nutrient use efficiency of maize (*Zea mays*) as influenced by target yield based nutrient management in maize-chickpea cropping sequence. The experiment was laid out in randomized block design during *kharif* season with four replications. The treatments comprised of five nutrient management *viz*., T_1-100 % RDF + FYM @ 10 t ha^{-1}, T_2- As per soil test, T_3- Target yield of 60 q ha^{-1} as per STCR equation with FYM @ 10 t ha^{-1}, T_4- Target yield of 70 q ha^{-1} as per STCR equation with FYM @ 10 t ha^{-1} and T_5 -Control. During two years of the study, Rajarshi variety of maize were used. The estimated values of partial factor productivity (PFP), agronomic efficiency (AE), apparent recovery (AR), physiological efficiency (PE) and harvest index (HI) of applied N, P and K were computed as suggested by Fageria and Baligar (2003) [5] and Dobermann (2005) [4] which are given as below:

Partial factor productivity (kg grain kg^{-1} NPK)

Partial factor productivity (kg grain kg^{-1} NPK)	=	Crop yield with nutrient applied (kg) / Amount of nutrient applied (kg)

Agronomic efficiency (kg grain kg^{-1} nutrient NPK)

Agronomic efficiency (kg grain kg^{-1} nutrient NPK)	=	Crop yield with nutrient applied (kg)	-	Crop yield without nutrient (kg)
		Amount of nutrient applied (kg)		

Partial nutrient balance (kg nutrient kg^{-1} NPK)

Partial nutrient balance (kg nutrient kg^{-1} NPK)	=	Nutrient content of harvested portion of crop (kg) / Amount of nutrient applied (kg)

Apparent recovery efficiency (kg uptake kg^{-1} nutrient NPK)

Apparent recovery efficiency (kg uptake kg^{-1} nutrient NPK)	=	Total nutrient uptake from nutrient applied plot (kg) - Nutrient uptake from without nutrient plot (kg)
		Amount of nutrient applied (kg)

Results and discussion

The nutrient use efficiency were evaluated in terms of partial factor productivity, agronomic efficiency, partial nutrient balance, apparent recovery efficiency and physiological efficiency of maize are presented in Table 1.

Partial factor productivity (kg grain kg^{-1} NPK)

The partial factor productivity in maize as influenced by different treatment are presented in Table 1. The partial factor productivity was increases with decrease in fertilizer quantity. The target yield of 60 q ha^{-1} as per STCR equation with FYM @ 10 t ha^{-1} (T_3) treatment recorded significantly higher partial factor productivity of maize was 22.69 and 28.95 kg grain kg^{-1} NPK than rest of the treatments during both the years. This might be because of higher nutrient use efficiency of applied nutrients. Significantly minimum partial factor productivity of maize observed in 100 % RDF + FYM @ 10 t ha^{-1} (T_1) treatment was 19.91 and 20.74 kg grain kg^{-1} NPK during both years. Partial factor productivity is an important indicator used to reflect the productivity of N, P and K fertilizers. Maintaining a large crop yield with relatively high partial factor productivity of nutrient is vital for both production and environmental protection. The NPK fertilizer's productivity usually decreases with increased rates of fertilization indicating relatively lower economic returns under high NPK supply conditions. But partial factor productivity of nutrient was increased significantly with increasing rates of fertilizers application under waterlogging because of efficient use of NPK by stressed plants. Similar results were postulated by Chaudhari *et al.* (2021) [2].

Table 1: Nutrient use efficiency of maize as influenced by different nutrient management treatments

Treatment	Nutrient use efficiencies (kg ha^{-1})							
	Partial Factor Productivity (kg grain kg^{-1} NPK)		Agronomic Use Efficiency (kg grain kg^{-1} NPK)		Partial Nutrient Balance (kg nutrient in plant kg^{-1} NPK)		Apparent Recovery Efficiency (kg uptake kg^{-1} NPK)	
	2021	2022	2021	2022	2021	2022	2021	2022
T_1: 100 % RDF + FYM @ 10 t ha^{-1}	19.91	20.74	6.66	7.84	0.954	1.00	0.295	0.358
T_2: As per soil test	22.32	22.92	9.65	10.58	1.07	1.12	0.440	0.500
T_3: Target yield of 60 q ha^{-1} as per STCR equation with FYM @ 10 t ha^{-1}	22.69	28.95	11.40	15.38	1.10	1.43	0.538	0.751
T_4: Target yield of 70 q ha^{-1} as per STCR equation with FYM @ 10 t ha^{-1}	19.33	23.95	10.68	13.80	0.938	1.18	0.508	0.675
T_5: Control	-	-	-	-	-	-	-	-
S.Em. ±	0.74	0.81	0.88	1.01	0.03	0.04	0.035	0.046
C.D. at 5 %	2.28	2.51	2.72	3.12	0.10	0.13	0.108	0.143
General mean	16.85	19.31	7.68	9.52	0.812	0.945	0.356	0.457

Agronomic use efficiency (kg grain kg^{-1} NPK)

The agronomic efficiency in maize as influence by different nutrient management treatments are presented Table 1. Significantly higher agronomic efficiency of was registered in target yield of 60 q ha^{-1} as per STCR equation with FYM @ 10 t ha^{-1} (T_3) treatment was 11.40 and 15.38 kg grain kg^{-1} NPK than rest of the treatment during both the years. Significantly minimum agronomic efficiency of maize (6.66 and 7.84 kg grain kg^{-1} NPK) was observed in 100 % RDF + FYM @ 10 t ha^{-1} (T_1) treatment during both years. Higher agronomic efficiency might be because of higher use efficiency of applied nutrients obtain maximum grain yield with balanced quantity of nutrients. These results are in accordance with Chaudhari *et al.* (2021) [2] and Bhavya *et al.* (2021) [1].

Partial nutrient balance (kg nutrient in plant kg^{-1} NPK)

The partial nutrient balance of maize was influenced significantly due to different nutrient management treatments during both the years are presented in Table 1. The target yield of 60 q ha^{-1} as per STCR equation with FYM @ 10 t ha^{-1} (T_3) treatment recorded significantly higher partial nutrient balance of maize was 1.10 and 1.43 kg grain kg^{-1} NPK than rest of the treatment during both the years. Significantly minimum partial nutrient balance of maize (0.954 and 1.00 kg grain kg^{-1} NPK) was observed in 100 % RDF + FYM @ 10 t ha^{-1} (T_1) treatment during both years. It may be due to higher grain yield that is direct relation to higher uptake of the entire nutrient in significantly uptake of N, P and K. Similar findings were also reported by Kumar *et al.* (2015) [7].

Apparent recovery efficiency (kg uptake kg^{-1} NPK)

The apparent recovery efficiency in maize was influenced significantly due to different nutrient management treatments during both the years are presented in Table 1. The target yield of 60 q ha^{-1} as per STCR equation with FYM @ 10 t ha^{-1} (T_3) treatment recorded significantly higher partial nutrient balance of maize was 0.538 and 0.751 kg grain kg^{-1} NPK than rest of the treatment during both the years. Significantly minimum partial nutrient balance of maize (0.295 and 0.358 kg grain kg^{-1} NPK) was observed in 100 % RDF + FYM @ 10 t ha^{-1} (T_1) treatment during both years. The nutrient application as per STCR approach produced higher recovery efficiency of applied nutrient than other nutrient management techniques. This was due to precise quantity of fertilizer application and optimum rate of application. Similar findings were also reported by Kumar *et al.* (2015) [7] and Chaudhari *et al.* (2021) [2].

Conclusion

On the basis of results of two years of field experiment on maize-chickpea cropping sequence, it can be concluded that higher level of fertilizer dose increased the nutrient use efficiency in maize. The maximum nutrient use efficiency of maize was found in target yield of 60 q ha^{-1} as per STCR equation with FYM @ 10 t ha^{-1} followed by target yield of 70 q ha^{-1} as per STCR equation with FYM @ 10 t ha^{-1} while minimum nutrient use efficiency was exhibited in control.

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