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Productivity of maize in long-term integrated nutrient management modules in a Typic Hapludalf of Himachal Pradesh

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Abstract

Current study was carried out during *kharif* 2020 and *kharif* 2021 in an ongoing long-term fertilizer experiment on soil test crop response correlation studies (STCR), initiated in *kharif* 2007, at the Experimental farm of Department of Soil Science, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur (Himachal Pradesh), to evaluate the effect of different fertilizer application approaches on maize productivity (*Zea mays* L.). In this study, eight nutrient management modules, consisting STCR based NPK fertilizer application with and without FYM, general recommended dose (GRD), soil test-based (STB) NPK application and farmers' practice, were studied. The results revealed a significant difference in maize grain yield among different fertilizer application approaches. Application of chemical fertilizers for the targeted yield of 40 q ha^{-1} recorded significantly higher maize grain and stover yield than conventional GRD and STB fertilizer application during both the years. Integration of farmyard manure with chemical fertilizers for the targeted yield of 30 and 40 q ha^{-1} increased the maize grain yield by 9.2-11.3 and 8.5-8.8 per cent over the sole application of chemical fertilizers for targeted yields, respectively. The study concluded that the target yield based application of chemical fertilizers with FYM is superior to the target yield based sole chemical fertilizers application, farmers' practice, general recommended dose and soil test-based fertilizer application.

Key words: Farmyard manure; maize; productivity; target yield based fertilizer application

Maize (*Zea mays* L.) occupies a prominent position among cereal crops in Himachal Pradesh and forms an integral part of the staple diet of the people of the state. The state produces 7.14 lakh tonnes of maize in an area of 2.62 lakh ha (Anonymous 2021), with an average productivity of 2.7 tonnes, which is far below the world's average maize production of 5.8 t ha^{-1} (Anonymous 2022). This has been attributed to the inadequate and imbalanced fertilizer use in the state as the nutrients are not applied according to the crop requirements and their status in the soil (Shabnam and Sharma 2016). The balanced application of fertilizers from both organic and inorganic sources plays a key role in enhancing the productivity of crops and soil health.

Out of numerous approaches of fertilizer application, the soil test crop response (STCR) or target yield approach has evolved as a very efficient scientific approach (Kurbah and Dixit 2019). Fertilizer application of crops based on general recommendation leads to over- or under-fertilizer application, leading to low productivity and profitability. On the other hand, prescription based fertilizer application takes available nutrient content in the soil into account to determine the nutrient requirement for obtaining desired yield levels (Ramamoorthy *et al*. 1967). Therefore, this study was carried out with an objective to evaluate the long-term effect of target yield-based fertilizers and farmyard manure (FYM) application on maize productivity compared to conventional fertilizer application approaches in a Typic Hapludalf of Himachal Pradesh.

Materials and methods

The present investigation was conducted in a long-term fertilizer experiment on soil-test crop response

on maize-wheat cropping sequence. The experiment was initiated in *kharif* 2007 in the Experimental farm of the Department of Soil Science, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur, Himachal Pradesh. The experimental area is located at an altitude of 1290 m above mean sea level at 32º7' N latitude and 76º3' E longitude. Total rainfall of 1449 and 1989 mm was received during *kharif* 2020 and 2021 (June to October), and air temperature varied from 13.2 to 30.5^{0}C and 14.9 to 31.1^{0}C, respectively. The texture of soil was silty clay loam soil and was classified as Typic Hapludalf. At the start of the experiment (*kharif* 2007), the soil was acidic (pH 5.2), organic C content was 7.2 g kg^{-1}, and available N, P and K were 236, 41 and 272 kg ha^{-1}, respectively.

The experiment comprised three replications of eight different treatments laid out in a randomized block design. These treatments were, control, farmers' practice in which 25 per cent of general recommended N dose (30 kg ha^{-1}) was applied with 5 t ha^{-1} FYM (dry weight basis), general recommended dose of N, P_2O_5 and K_2O i.e., 120, 60 and 40 kg ha^{-1} respectively, soil test-based fertilizer application, chemical fertilizers for 30 q ha^{-1} target yield, chemical fertilizers for 30 q ha^{-1} target yield with 5 t ha^{-1} FYM, chemical fertilizers for 40 q ha^{-1} target yield and chemical fertilizers for 40 q ha^{-1} target yield with 5 t ha^{-1} FYM. Fertilizer doses for target yield treatments were determined using the following equations:

i. FN = 5.88 T- 0.23 SN - 0.93 ON
ii. FP_2O_5 = 4.87 T- 1.22 SP - 0.81 OP
iii. FK_2O = 3.66 T- 0.49 SK - 0.51 OK

Where FN, FP_2O_5, and FK_2O were respective fertilizer doses of N, P_2O_5 and K_2O in kg ha^{-1}; T was the yield target (q ha^{-1}); SN, SP and SK were respective soil available N, P and K contents (kg ha^{-1}) before sowing of the crop and ON, OP and OK respectively denoted N, P and K supplied by FYM (kg ha^{-1}).

Maize was sown in the month of June and harvested on attaining physiological maturity in the month of October during both the years. One pre-sowing irrigation was given to the crop; thereafter, the crop met its water requirement through rainfall. One-third dose of N and a full dose of P and K were applied at the time of sowing through urea, single super phosphate (SSP) and muriate of phosphate (MOP), respectively. The remaining N was top dressed at knee-high and pre-tasselling stages of maize. Atrazine was applied as a pre-emergence herbicide @ 1.125 kg a. i. ha^{-1}, and thereafter, weeds were removed through manual weeding. Recommended cultural practices were followed during the crop growth period. The grain and stover yields were recorded at the time of harvesting and grain yield was expressed at 15 per cent moisture content. The data were subjected to analysis of variance and Duncan's multiple range test (DMRT) to compare the means at 5 per cent level of significance as per the standard statistical procedure (Gomez and Gomez 1984).

Results and Discussion

Maize yield

A perusal of data in Table 1 revealed a significant effect of fertilizer application on the grain and stover

Table 1. Productivity of maize (q ha^{-1}) under different nutrient management modules during *kharif* 2020 and 2021

Treatment	Grain Yield		Stover Yield		Biological Yield	
	2020	2021	2020	2021	2020	2021
Control	11.4	9.5	21.3	20.0	32.7	29.5
Farmers' practice	21.1	18.8	39.8	39.4	60.9	58.2
General Recommended Dose	25.7	22.9	50.0	49.3	75.7	72.2
Soil Test-Based Fertilizer Application	28.0	24.7	53.0	51.8	81.0	76.5
Target yield 30 q ha^{-1}	29.4	27.4	59.3	58.0	88.7	85.4
Target yield 30 q ha^{-1} with FYM @ 5t ha^{-1}	32.1	30.5	62.9	62.0	95.0	92.5
Target yield 40 q ha^{-1}	39.0	37.6	72.4	71.2	111.4	108.8
Target yield 40 q ha^{-1} with FYM @ 5t ha^{-1}	42.3	40.9	78.7	79.8	121.0	120.7

yield of maize. All the fertilizer treatments recorded significantly higher maize grain yield than the control during both the years. Combined application of chemical fertilizers and FYM @ 5 t ha^{-1} for a targeted yield of 40 qha^{-1} recorded the highest grain yield, followed by the fertilizer application in targeted yield of 40 q ha^{-1} and the lowest was recorded in control. An increase of 85 and 98 per cent in grain yield was recorded in farmers' practice compared to control in 2020 and 2021, respectively. Further improvement in grain yield was recorded with the general recommended dose and soil test-based fertilizer application over farmers' practice to the tune of 21.9 and 32.7 per cent in 2020 and 21.8 and 31.4 per cent in 2021. However, general recommended dose and soil test-based fertilizer application treatments were at par with each other during both the years.

Chemical fertilizer application as per STCR approach for yield target of 30 q ha^{-1} was statistically comparable to the soil test-based fertilizer application. On the other hand, integration of FYM @ 5 t ha^{-1} with chemical fertilizers for the targeted yield of 30 q ha^{-1} increased the grain yield significantly by 9.2 (2020) and 11.3 per cent (2021) over the sole application of chemical fertilizers for the same targeted yield. Combined application of chemical fertilizers for the targeted yield of 40 q ha^{-1} with 5 t FYM ha^{-1} recorded an increase of 8.5 and 8.8 per cent in maize grain yield over the sole application of chemical fertilizers for the same targeted yield, during the year 2020 and 2021, respectively. The per cent deviations in grain yield under treatments with fixed yield targets of 30 and 40 q ha^{-1} with and without FYM were within the permissible limits of ±10 per cent which shows suitability of fertilizer prescription equation on crop yield.

Similarly, a significant increase in the stover yield over the control was recorded in all the treatments (Table 1). The stover yield under farmers' practice and general recommended dose were 86.8 and 134.7 per cent higher than the control during 2020 and 97 and 146.5 per cent during 2021, respectively. Soil test-based application of fertilizers was significantly better than farmers' practice but was at par with general recommended dose during both the years. Application of chemical fertilizers, with and without FYM, for target yield recorded significantly higher stover yield than the rest of the treatments, but the highest was recorded in 40 q ha^{-1} target yield + FYM treatment, stover yield being 78.7 q ha^{-1} during *kharif* 2020 and 79.8 q ha^{-1} during *kharif* 2021.

Biological yield of maize during *kharif* 2020 varied from 32.8 q ha^{-1} in control to 121.0 q ha^{-1} in 40 q ha^{-1} target yield treatment with FYM during *kharif* 2020, whereas during *kharif* 2021, it ranged between 29.5 and 120.6 q ha^{-1} (Table 2). All non-STCR treatments recorded significantly higher biological yield of maize than control. Chemical fertilizer application for targeted yield of 30 q ha^{-1} significantly increased the biological yield of maize over soil test-based fertilizer application. During the year 2020 and 2021, integration of FYM @ 5 t ha^{-1} with chemical fertilizers for targeted yield of 30 q ha^{-1} increased the biological yield of maize significantly by 9.2 and 8.3 per cent over sole application of chemical fertilizers for targeted yield of 30 q ha^{-1}. In case of 40 q ha^{-1} target yield, the extent of increase in biological yield of maize with FYM application in respective year was 8.6 and 10.8 per cent.

A significantly higher maize grain and stover yield under targeted yield treatments, with and without FYM, over the general recommended dose and conventional soil test-based fertilizer application treatments might be because of the balanced application of NPK fertilizers to the crop (Choudhary and Dixit 2022). Integration of FYM with chemical fertilizers for target yield significantly improved the grain and stover yield over non-IPNS treatments. This could be ascribed to improved soil physical health in terms of higher water retention, better aggregation and reduced bulk density helping in root development, more uptake of native and applied nutrients, and enhanced microbial activities in these treatments (Parmar *et al*. 2022). Parihar *et al*. (2015) recorded 51.3 and 31.4 per cent increment in maize grain yield in fertilizer application for target yield of 35 and 30 q ha^{-1} over farmers' practice, respectively. Similarly, Meena *et al.* (2019) also reported 20.9 per cent higher maize grain yield in STCR+FYM treatment over general recommended dose. On the other hand, inadequate and imbalanced nutrients in the soil might have resulted in the low crop yield in control and farmers' practice (Kurbah and Dixit 2019).

Conclusions

Based on the results of the present study, it can be concluded that the target yield based application of chemical fertilizers is superior to the conventional fertilizer application approaches *viz*., farmers' practice, general recommended dose and soil test-based fertilizer application. Integration of FYM with chemical fertilizers significantly improved the grain, stover and biological yield of maize over non-IPNS treatments.

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