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Long term effect of STCR-based targeted yield application of fertilizers on productivity, profitability and nutrient uptake by wheat (*Triticum aestivum L.*) in an acid Alfisol

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ABSTRACT

The present investigation was conducted during therabi season of 2017-18 at the research farm of CSK HPKV, Palampur (Himachal Pradesh). The effect of target yield based fertilizer application on productivity, profitability, and nutrient uptake by wheat were evaluated in a randomized block design with eight treatments. The results revealed that the continuous cropping for 10 years along with STCR based fertilizer application in target yield 35 q ha^{-1} + 5 t FYM ha^{-1} recorded the highest grain yield (34.9 q ha^{-1}) followed by target 35 q ha^{-1} (31.6 q ha^{-1}).The highest protein content (12.6 %) and protein yield (441.4 Kg ha^{-1}) of wheat grains were observed with target yield of 35 q ha^{-1} + 5 t FYM ha^{-1}. Further, the maximum net profit of Rs.61401 ha^{-1} with a B: C ratio of 3.29 was obtained under target yield 35 q ha^{-1}. A significant increase in N, P, and K uptake by wheat grain and straw was observed in STCR based target yield plots as compared to soil test based, general recommended dose, farmers' practice, and control. The available N, P, and K content in post-harvest soil were reduced in the control over their initial values. The higher values of available N (305 kg ha^{-1}), P (70 Kg ha^{-1}) and K (290 kg ha^{-1}) were recorded with target yield of 35 q ha^{-1} + 5 t FYM ha^{-1}.

Keywords: Productivity, profitability, protein content, soil test crop response, target yield, wheat

INTRODUCTION

Wheat (*Triticum aestivum L*.) is a good source of protein and calories for the burgeoning population of the country. The low productivity in the hilly state may be due to marginal landholdings, rugged terrain, fragile ecosystems, and low soil fertility. Soil is a vital natural resource that is eroding with time, and at the same time, cultivated fields are dwindling owing to urban sprawl. The loss of soil health as a result of inappropriate fertilizer application and large-scale nutrient mining in intensive cropping systems pose a threat to our farming system's long- term sustainability (Singh and Singh, 2018). The development of a scientific nutrient management strategy is required to enhance wheat crop production because the ever-increasing population poses a back-breaking danger to the food security of India. It is well documented that target yield concept based integrated nutrient management has been proven to be beneficial in increasing crop yields along with nutrient uptake and profitability (Rajput *et al.,* 2016). Fertilizers play a significant role in the ample production of crops. These are commonly applied to crops based on fertilizer recommendations formulated at the state level. However, fertilizer requirements are not constant, and they might vary from soil to soil, and even from field to field on the same soil, for the same crop. Furthermore, adopting the general recommended dose (GRD) of fertilizer application is not able to maintain yields vis-à-vis the economic returns of crops, due to the imbalanced application of fertilizers, and this necessitates refinement for balanced crop nutrition (Moharana*et al.,* 2016). STCR-based fertilizer application, on the other hand, aids in improving crop productivity and nutrient uptake. Fertilizer doses are advised using this method based on fertilizer adjustment equations devised after establishing a substantial link between soil test levels and administered fertilizer. Therefore, this research work was undertaken to achieve target yield and higher net returns with advanced nutrient application approaches.

MATERIALS AND METHODS

The present study was undertaken on wheat with crop cultivar HPW-236 during the*rabi* season of 2017-18 as a part of the long-term fertilizer experiment at the research farm of CSK HPKV, Palampur under the All India Coordinated Research Project (AICRP) on soil test crop

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response (STCR). The experimental fieldis situated at 32° 6' N latitude, 76° 3' E longitude, and an altitude of 1290 m above mean sea level. The soil was silty clay loam in texture and great group *Typic Hapludalf* with Udic moisture regime. The soil was acidic in reaction (pH 5.2); medium in organic carbon (7.2 g kg^{-1}); deficient in available nitrogen (236 kg ha^{-1}); high in available phosphorus (41 kg ha^{-1}); medium in available potassium (272 kg ha^{-1}) at the initiation of the experiment in *Kharif*, 2007. The field experiment was laid out using RBD design with three replications, comprising eight treatments. The details of treatments were: control,farmers' practice (25% GRD and5 t FYM ha^{-1}),GRD, soil test based, target yield 25 q ha^{-1}, target yield 25 q ha^{-1} with FYM, target yield 35 q ha^{-1}, target yield 35 q ha^{-1} with FYM. The following calibration equations (Verma*et al.,* 2007) were used to compute the STCR-based fertilizer doses for wheat target yields of 25 and 35 q ha^{-1}.

$FN = 5.27\ T - 0.25\ SN - 1.06\ ON$
$FP_2O_5 = 4.13\ T - 0.38\ SP - 0.98\ OP$
$FK_2O = 2.87\ T – 0.15\ SK – 0.55\ OK$

where, FN, FP_2O_5, FK_2O implies the doses of N, P_2O_5, K_2O (kg ha^{-1}); T = Yield target (q ha^{-1}); SN, SP, SK are available nitrogen, phosphorus and potassium (kg ha^{-1}), ON, OP and OK are N, P and K supplied by FYM, respectively in kg ha^{-1}. FYM used in the experiment contains 1.42, 0.42 and 0.70 % of N, P and K, respectively on dry weight basis.

The crop was sown in the 2ndfortnight of November 2017 and was harvested in the 1stfortnight of May 2018 at physiological maturity and grain and straw yields were recorded. Soil samples (0-15cm depth) were collected and analyzed for available N (Subbaiah and Asija, 1956); available P (Olsen *et al*., 1954) and available K by ammonium acetate method (Black, 1965). Plant samples were analyzed for nitrogen content by modified Kjeldahl method, P by vanado-molybdate yellow color method, and K by flame photometer (Jackson, 1973).The uptake of nutrients by grain and straw was computed by multiplying yield data with nutrient content in grain and straw. Protein content was obtained by multiplying the % nitrogen content with the factor 5.70.The economics was worked out considering the prices in the market. Net return (Rs. ha^{-1}) was calculated by deducting the cost of inputs from the gross return.The experimental data were statistically analyzed for the differential effect of treatmentsat a 5% level of significance for randomized block design as per the standard procedure (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Yield

The grain and straw yields of wheat were substantially influenced by continuous application of fertilizers ranging from 10.3 and 16 q ha^{-1} (control) to 34.9 and 58.4 q ha^{-1} (target 35 q ha^{-1} with 5 t FYM ha^{-1}). The yields produced under 4 pre-determined yield targets of 25 and 35 q ha^{-1} with and without FYM were within ± 10 % of the deviation from the target yield (Table 1). Application of FYM along with chemical fertilizers in target 35 q ha^{-1} with 5 t FYM ha^{-1} recorded the highest yield, which was found to be significantly superior as compared to all other treatments. Farmers' practice recorded a significant increase in grain and straw yield over control by 29.1 and 38.8 %, respectively. The application of FYM and 25% of the prescribed dose may have resulted in an increase in the yield of wheat under farmers' practice over control (Kurbah and Dixit, 2019). The harvest index ranged from 37.2 to 39.1 % and the highest value was noticed in control. The lowest value of 37.2 %was observed in the soil test based and there was no significant difference among the various treatments.

Quality

The protein content in wheat grain ranged from 10.6 in control to 12.6 % in target yield of 35 q ha^{-1} + 5 t FYM ha^{-1}**.** A significant increase in grain N content with the application of FYM could be attributed to more nitrogen uptake by the crop and more translocation of N to grain. Nitrogen, being the precursor of protein, increased grain protein content accordingly (Singh, 2021).The minimum value of protein content in grain was obtained in control treatment, which may be attributed to lower N status in soil. The target yield plots either with or without FYM recorded significantly the highest value of protein yields over control. The maximum value of protein yield (441.4 kg ha^{-1})

Table 1: Effect of STCR-based targeted yield application of fertilizers on yield, quality and economics of wheat

Treatment	Yield (q ha^{-1})		% deviation	Harvest index (%)	Protein content (%)	Protein yield (kg ha^{-1})	Net profit (Rs ha^{-1})	B:C ratio
	Grain	Straw						
T_1	10.3	16.0	-	39.1	10.6	109.2	11969	1.75
T_2	13.3	22.2	-	37.5	10.8	144.1	7164	1.24
T_3	18.3	30.6	-	37.5	11.3	206.9	29000	2.31
T_4	19.7	33.4	-	37.2	11.8	232.1	33768	2.57
T_5	22.8	38.2	-8.7	37.4	12.1	275.8	40746	2.77
T_6	27.1	45.2	8.3	37.5	11.5	309.9	43042	2.32
T_7	31.6	52.7	9.6	37.6	12.3	387.6	61401	3.29
T_8	34.9	58.4	-0.4	37.4	12.6	441.4	61125	2.68
CD (P=0.05)	1.6	4.2	-	NS	0.8	28.4	-	-

T_1- Control, T_2 – farmers' practice (25% GRD and 5 t FYM ha^{-1}), T_3- general recommended dose (GRD), T_4- soil test based, T_5- target 25 q ha^{-1}, T_6 – target 25 q ha^{-1} + 5 t FYM ha^{-1}, T_7- target 35 q ha^{-1}, T_8- target 35 q ha^{-1} + 5 t FYM ha^{-1}

was accrued with a target yield 35 q ha^{-1} + 5 t FYM ha^{-1}. This increase in protein yield in wheat grain may be attributed to increased grain yield and protein content in grain with an ample supply of nutrients (Walia *et al*.,2014).

Economics

The highest B: C ratio was noted in STCR based treatment with target yield 35 q ha^{-1} (3.29), followed by treatment for target yield of 25 q ha^{-1} (2.77), and was lowest in farmers' practice (1.24). The STCR-based nutrient recommendation net profit and B: C ratio ranged from Rs. 40746-61,401 ha^{-1} and 2.32-3.29, respectively, higher than the GRD (Rs 29000 ha^{-1} and 2.31, respectively). Lower B: C ratio in the treatments where FYM were applied (target yield treatments with FYM and farmers' practice) was due to huge expenditure on FYM. However, this can be inferred that FYM treated plots may have a beneficial effect on soil health and sustained yields (Rai *et al.,* 2016). Mostly farmers' do not buy FYM as there is sufficient availability. Therefore, cost of FYM may not be a constraint and maybe ignored to some extent.

Table 2: Effect of STCR-based targeted yield application of fertilizers on availableN, P, K and uptake of nutrients (Kg ha^{-1}) by wheat

Treatment	Nitrogen		Phosphorus		Potassium		Available nutrients		
	Grain	Straw	Grain	Straw	Grain	Straw	Nitrogen	Phosphorus	Potassium
T_1	19.2	8.5	2.0	0.98	2.4	11.5	148	23	196
T_2	25.3	12.3	3.8	2.40	4.8	19.2	240	35	265
T_3	36.3	18.3	4.7	3.49	6.8	24.8	266	47	264
T_4	40.7	24.2	5.5	3.85	6.7	26.4	272	42	270
T_5	48.4	23.8	7.4	4.53	7.7	30.5	282	48	278
T_6	54.4	29.5	8.8	5.83	9.5	35.1	293	63	285
T_7	68.0	33.9	10.7	7.05	11.2	45.5	296	61	280
T_8	77.4	39.5	12.8	7.90	13.4	50.0	305	70	290
CD (P=0.05)	4.99	3.07	0.77	0.98	2.15	4.14	9.4	3.7	11.1

Nutrients uptake

The uptake of nitrogen by grain and straw varied between 19.2 to 77.4 kg ha^{-1} and 8.5 to 39.5 kg ha^{-1}, respectively (Table 2). The soil test based application of fertilizers for higher yield targets along with 5 t FYM ha^{-1} recorded significantly higher nitrogen uptake by the crop. The lower uptake was noted in control. The increased uptake of N in treated plots compared to the control plot may be ascribed to optimized N supply furnished through external inputs and formation of the prolific root system with steady application of nutrients, resulting in increased productivity levels (Verma *et al.,*2012).The highest P uptake by grain and straw (12.8 and 7.9 kg ha^{-1}) were registered with the target of 35 q ha^{-1}+5 t FYM ha^{-1} to lowest value in control (2

and 0.98 kg ha^{-1}). Omission of FYM in the treatments with a target yield of 25 and 35 q ha^{-1} decreased the P uptake significantly over the same treatments with FYM. This may be attributable to the fact that FYM produces organic acids that chelate Al3+ and Fe^{3+}, which reduces the phosphorus fixing capacity, therefore leading to increased P availability (Singh, 2016). The K uptake by wheat grain ranged from 2.4 to 13.4 kg ha^{-1} and corresponding values of straw uptake were 11.5 to 50 kg ha^{-1}. As uptake is multiple of concentration and yield, if the yield is more, higher would be the uptake of a particular nutrient. Shabnam *et al.*(2017)found that in the absence of K supplements the mining of the native reserves enhances the productivity in plots where no K was applied. Moreover, the treatment target yield 35 q ha^{-1} with 5 t FYM ha^{-1}continued to maintain higher uptake values of primary macronutrients (N, P and K). Thus, prescription based application of fertilizers helps in optimum supply of nutrients to suit the situations comprising different yield targets, soil fertility, and resources of the farmer (Singh, 2017).

Soil available nutrients

The available nitrogen, phosphorus, and potassium contents were significantly higher in post harvest soil with target yield 35 q ha^{-1} + 5t FYM ha^{-1}.The available nitrogen content ranged from 148 to 305 kg ha^{-1}. It was increased by about 51.5 % in target yield 35 q ha^{-1} with 5t FYM ha^{-1} as compared to control. The increase in available nitrogen in STCR plots with FYM might be due to enhanced mineralization of FYM which further helps in the buildup of available nitrogen (Yaduvanshi *et al*., 2013). The lowest values of available nitrogen, phosphorus, and potassium content were noted for the control. The lower content in control plots is a result of crop mining and no external input. The available phosphorus ranged from 23 to 70 kg ha^{-1}. Significantly, higher amount was observed with yield target 35 q ha^{-1}along with 5 t FYM ha^{-1}which was statistically superior over other treatments. The available potassium in soil varied from 196 to 290 kg ha^{-1} and maximum increase was observed in target 35 q ha^{-1} along with 5 t FYM ha^{-1}. This might be due to the enhanced microbial activity, conversion of unavailable nutrients into available forms. Similar results were also reported by Sharma *et al*. (2016).

From the results, it may be concluded that crop yield, quality, nutrients uptake, and available nutrients in post-harvest soils were higher under target yield based treatments. The STCR-based target yield approach also reflected economic yields as it supplies nutrients as per crop requirement. Thus, STCR approach may be advised for its use by the farmers seeking higher crop productivity and profitability.

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