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Impact of Soil Health Card Scheme on Soil Fertility and Crop Production Among the Adopted Farmers

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ABSTRACT

The study was conducted in Bareilly district of western UP regarding adoption of recommendation of soil health card scheme and its impact on productivity and economics of different crops i.e. wheat, paddy and sugarcane. It was found that only 40 per cent farmers owned soil health card. However, due to adoption of SHT based fertilizer recommendations there was a significant increase in crop yields of wheat (30.80%), paddy (29.80%) and sugarcane (32.90%). In addition, the adoption of SHT based fertilizer recommendation had a significant reduction in production cost by Rs. 2130, 2164 and 3122/- per acre of wheat, paddy and sugarcane crops, respectively. Also, the net increase in farmer's income was realised from one acre of wheat, paddy and sugarcane was about Rs. 11197, 12058 & 29187, respectively. Thus, the application of SHT under field condition has reduced the production cost and increased the farmers' income.

INTRODUCTION

Soil health and soil fertility are the two key components that play an inevitable role to realize sustainable profits for the farming community. Certainly, the adoption of scientifically proven and recommended cropping patterns and fertilization is the first step towards sustainable farming. Adopting sustainable soil fertility management (SFM) practices is necessary to achieve sustainable agricultural production (Chowdary et al., 2018; Kapoor et al., 2021). The question here is how many farmers are using SFM practices. In fact, the majority of the farmers use either sub or supra-optimal levels of chemical fertilizers which result in declined soil health and inherent soil fertility. In accordance with the survey conducted by Kumar et al., (2021) revealed that knowledge level and adoption of SFM are relatively much less i.e., only eight percent of the farmers are aware of it. Undoubtedly, the usage of chemical fertilizers is necessary to realize crop yields, the usage should be optimal and scientific which means it should be in accordance with the 4 R's (right source, right time, right amount and right method). A study by Chowdary et al., (2018) revealed that most farmers use chemical fertilizers without knowing the actual fertility status of their fields. Ultimately, this indiscriminate use of fossil fuel-based chemical fertilizers led to reduced soil health, soil biodiversity, fertilizer use efficiency (crop: nutrient response ratio has moved down to 8.59 in 2009-10 from 14.06 in 1990-91) and environmental pollution (Singh et al., 2020).

A single solution to address all these problems is to optimize fertilizer usage by adopting sustainable soil fertility management practices based on soil testing reports (Saha et al., 2016). Therefore, keeping in view all these facts government of India launched a national flagship program namely the soil health card scheme (SHCs) on February 19th of 2015 with an aim to do a soil test of each and every individual farm and to formulate micro-level soil fertility maps (Singh et al., 2020). SHC is a complete prescription of soil quality, from its functional characteristics to nutrient and other biological properties. It provides the farmers with crop-wise fertilizer recommendations for each type of soil. In view of all these facts, the present paper has analysed the soil testing awareness and adoption by the farmers and the change in the usage of manures, fertilizers and micronutrients after the recommendation of soil health

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testing (SHT) and their impact on productivity and economics of different crops grown in Bareilly district of western UP.

METHODOLOGY

The present study was conducted in Bareilly District of Western Uttar Pradesh during 2021-22. The farmers for the study were selected by taking the list of farmers (100) from the Soil Testing Laboratory, Department of Agriculture, Bareilly who got tested their soil sample and also got Soil Health Card during the year 2015-16 to 2018-19 under the government scheme. Out of the total sample size, only 40 per cent farmers were found to own soil health card and were also following the SHC recommendations in their agriculture farm while remaining 60 per cent of the farmers were not following any recommendations. Hence, final sample size for the analysis was of 40 respondents. The collected data were analysed using percentage, mean and standard deviation, paired T-test using the SPSS package.

The impact of the adoption of soil health card (SHC) recommendations was calculated by using the following formula:

Impact of Using SHC Recommendation Δ = (Y I P=1) – (Y I P=0)

Impact of the scheme $\Delta 1$ = Production after using SHC recommendation (Y1) – Production before using SHC recommendation (Y2)

Percent change (%) after and before the use of SHC recommendation was calculated as follows:

= (Production after – Production before) * 100/ Production before

Net gain = Price of change in production/acre - Change in cost of fertilizers and manures*/acre

*Other input costs considered constant

The net gain in wheat cultivation/acre:

Wheat# x (4.5) - [NPK* x(-16.3) +DAP* x(-16.5) + Urea* x (-28) + MOP* x (-23.6) + $ZnSO_4$* x(-2.4) + $FeSO_4$* x (-3.17) + Sulphur* x (2.5) + Boron* x (-0.5) + Cu* x (1)]

The net gain in paddy cultivation/acre (Rs)

Paddy# x (5.1) - [NPK* x(-17.5) +DAP* x(-17.4) + Urea* x (-28.3) + MOP* x (-23.6) + $ZnSO_4$* x(-1.8) + $FeSO_4$* x (-3.22) + Sulphur* x (1.88) + Boron* x (0.12)]

The net gain in sugarcane cultivation/acre (Rs):

Sugarcane# x (80.2) - [NPK* x(-25.3) + DAP* x(-15.5) + Urea* x (-31.5) + MOP* x (-11) + $ZnSO_4$* x(-3) +$FeSO_4$* x (-3) + Sulphur* x (-7) + Boron* x (-2.3)]

(# Price per quantal, * price per kg of manure and different fertilizers. Details in Table 3)

Constraints were also calculated as the mean score given by each respondent to a particular constraint as Most Serious-3, Serious- 2 and Not Serious-1.

RESULTS AND DISCUSSION

Soil Testing awareness and adoption

The assessment of basic knowledge regarding the scheme and the source through which the information is obtained is essential to understand the best source to promote a new technology or newly launched scheme among the farmers. Therefore, an attempt has been done to understand the level of awareness and adoption of the recommended soil fertility management practices based on the SHC reports. Hence, it is clear from the data (Table 1) that the majority of the farmers (90%) got information regarding the importance of soil testing through the state department of agriculture. Whereas a few farmers were aware of the SHC through Krishi Vigyan Kendra's. Further data revealed that the percentage of farmers who got it done their soil samples test was increased annually i.e., from five per cent in 2015 to 82.5 per cent in 2019. It clearly indicates the impact of the implementation of SHCs scheme by the government of India. Nearly 95 per cent of the respondents were practicing the recommended practices on the basis of SHC reports. However, only 16 per cent respondents do soil testing regularly and a maximum of the farmers get it done only once.

Table 1. Soil Testing Awareness and Adoption

Attribute	Sub-attribute	Observation
Source of awareness about soil testing	State Department	36 (90%)
	KVK	4 (10%)
First time soil testing	2015	2 (5%)
	2017	3 (7.5%)
	2018	2 (5%)
	2019	33 (82.5%)
Regular doing soil testing	Yes	6 (15%)
	No	34 (85%)
Frequency of soil testing	1	31 (77.5%)
	2	6 (15%)
	More than 2	3 (7.5%)
Soil health card holder	Number	40 (100%)
Following complete recommendation of SHC	Yes	38 (95%)
	No	2 (5%)

Impact of SHC recommendations on nutrient consumption

The major objective of the study was to assess the impact of SHC recommendations on nutrient consumption patterns and crop yields. This impact was analyzed in major crops grown by the selected farmers before and after the recommendation of SHC. The responses obtained from the study were recorded and presented in Table 2.

After the soil testing, the number of farmers using FYM in wheat has increased from 14 to 23 with a percent change of 64.30 and the amount of FYM usage in wheat rose to 6000 ± 1239.2 kg/acre from 2664.2± 469.4 kg/acre indicating a change of 125.20 per cent. Also, the NPK applying farmers increased to 21 from 18 indicating a change of 16.70 per cent. Whereas the farmers using DAP reduced to 23 from 24 with a change of -4.2 per cent and the urea-applying farmers also declined by -2.8 per cent in wheat. However, the MOP and Sulphur using farmers has rose by 25 and 600 per cent, respectively. A survey conducted by Bhaskar et al., (2021) reported that the farmer who got their soil test reduced the application of inorganic chemical fertilizers viz., urea and the usage of organic manures (FYM) under Rice-Wheat cropping system.

Table 2. Changing the use of manure, fertilizer and micronutrient after the recommendation of soil health testing (SHT) and their impact on the productivity of different crops

Crop & number of farmers	Manure and fertilizer	Number of farmers using SHT			Amount of manure and fertilizer used (kg/acre)				Production (Quintal/Acre)
		Before	After	Per cent change	Before SHT	After SHT	Per cent change	P value	
Wheat (37)	Farm yard manure	14	23	64.3	2664.2±469.4	6000±1239.2	125.2	0.002	Before: 14.6±0.4
	NPK	18	21	16.7	58.3±3.5	42 ±3.2	-28.0	0.001	After: 19.1±0.4
	DAP	24	23	-4.2	56.1±4.7	39.6±3.5	-29.4	0.001	Change (%): 30.8
	Urea	36	35	-2.8	73.1±3.5	45.1±2.8	-38.3	0.001	P value: 0.001
	MOP	4	5	25.0	41.6±8.3	18±7.5	-56.7	0.18	
	Sulphur	0	6	600.0	-	2.5±0.6	-	-	
Paddy (39)	Farm yard manure	18	33	83.3	2938.8±408.1	6866.6±1022.2	133.7	0.001	Before: 17.1±0.4
	NPK	17	20	17.6	60.3± 4.3	42.8±3.9	-29.0	0.001	After: 22.2±0.6
	DAP	25	25	0.0	59.7± 5	42.3±3.2	-29.1	0.001	Change (%): 29.8
	Urea	38	38	0.0	74.3±3.3	46±2.5	-38.1	0.001	P value: 0.001
	MOP	4	5	25.0	41.6±8.3	18±7.5	-56.7	0.18	
	Sulphur	1	14	1300.0	0.5	2.35	370.0	-	
Sugarcane (35)	Farm yard manure	17	35	105.9	1662.5±378.9	6623.5±971.9	298.4	0.001	Before: 243.9±4.9
	NPK	15	18	20.0	90.6±10.5	65.3± 8.7	-27.9	0.001	After: 324.1±8.1
	DAP	23	21	-8.7	75±7.3	59.5±6	-20.7	0.001	Change (%): 32.9
	Urea	35	35	0.0	102.3±5.3	70.8±4.3	-30.8	0.001	P value: 0.001
	MOP	5	6	20.0	46±15.9	35±18.4	-23.9	0.269	
	Sulphur	1	20	1900.0	10	3	-70.0	-	

Paddy is a high input (nutrient) demand exhaustive cereal crop and generally the paddy farmers apply excess quantity of fertilizers especially Urea in order to harvest high yields. However, from the data (Table 3) it is much clear that the framers who got their soil sample tests optimized the usage of inorganic chemical fertilizers. The number of farmers applying FYM increased from 18 to 33 with a percent change of 83.30 and the amount of FYM application rose to 6866.6 ± 1022.2 kg/acre from 2938.8 ± 408.1 kg/acre indicating an increase of 133.7 percent. These findings were in line with the reports of Ghate and Kamble, 2020. The farmers using NPK complex fertilizer has been rose to 20 from 17 with a per cent change of 17.60 whereas the farmers number have no change with usage of Urea and DAP. The number of farmers using MOP has increased to 5 from 4 after soil testing and sulphur using farmers also rose to 14 from 1 indicating an increase change of 1300 percent.

The amount consumption of NPK reduced to 42.8 ± 3.9 kg/acre from 60.3± 4.3 kg/acre indicating a percent change of -29.0. Whereas the urea application reduces from 74.3 ± 3.3 kg/acre to 46 ± 2.5 kg/acre representing a percent reduction of -38.1. Makadia et al., (2017) also reported that the urea consumption by the farmers reduced significantly after adoption of SHT based recommendations. The usage of DAP reduced to 42.3 ± 3.2 kg/acre from 59.7± 5 ka/acre with a change of -29.1 per cent and the consumption of MOP also reduced significantly from 41.6 ± 8.3 kg/acre to 18 ± 7.5 indicating a percent decrease of -56.9. These findings are satisfying the findings of Gupta et al., (2019).

From the data (Table 2) it is clear that with the introduction of soil health card scheme enhanced the rate of soil testing by farmers which led to optimization of fertilizer usage in sugarcane. The number of farmers applying FYM in sugarcane increased to 35 from 17 indicating a significant increase of 105.90 percent and the amount of FYM application also rose to 6623.5 ± 971.9 kg/acre from 1662.5 ± 378.9 kg/ha representing a percent change of 298.4. These reports are in line with the findings of Makadia et al., (2017). Further data indicated that the farmer number with respect to consumption of NPK increased to 18 from 15 indicating a percent change of 20.0 and the amount usage reduced to 65.3 ± 8.7 kg/ha from 90.6 ± 10.5 kg/acre with a change of -27.9. also the consumption of DAP reduced from 75 ± 7.3 kg/acre to 59.5 ± 6 kg/acre indicating a change of -20.7. The urea applying farmers number have no cahnge, however the amount of urea usage reduced to 70.8 ± 4.3 kg/acre from 102.3 ± 5.3 indicating a signficant cahnge of about -30.8 per cent. Also the MOP using farmers increased by 20.0 after testing their soil samples and the amount appliction of MOP reduced by -23.9 per cent. The number of farmers applying sulphur in sugarcane incraesed signficantly from 1 to 20 indicating a change of 1900 per cent, however the amount consumption of sulphur in sugarcane reduced to 3.0 kg/acre from 10 kg/acre representing an percent change of -70.

These changes in nutrient consumption are mainly due to the exact knowledge of soil fertility status by soil testing (Makadia et al., 2017; Ravikishore et al., 2021; Singh et al., 2020) among the farmers. The SHC provides complete prescriptions regarding the nutrient status and their availability to the plants which in turn helps the farmers to optimize the usage of chemical fertilizers and FYM.

Impact of Soil Health Testing (SHT) recommendations on crop yields

Keeping all other production factors constant, the adoption of SHT based fertilizer recommendations resulted in a significant

increase in crop yields (Table 3). Further, data revealed that the crop yield increased significantly with the adoption of SHT-based recommendations. The wheat yields have increased from 14.6±0.4 q/acre to 19.1±0.4 q/ha indicating an increase of 30.80 per cent. Whereas in paddy the yields raised to 22.2±0.6 q/acre from 17.1±0.4 q/ha indicating a 29.80 per cent change in paddy yields. Kumar et al., (2019), also reported that after educating the importance of soil testing among the farmers, the yields of paddy and wheat crops were increased signficantly under rice-wheat cropping system. Likewise, the yields of sugarcane rose to 324.1±8.1 q/acre from 243.9±4.9 q/acre which indicated a change of 32.90 per cent. These findings are in line with the reports of Makadia et al., (2017). This increment in crop yields is mainly due to the adequate availability of organic and inorganic-based nutrients to crop plants. Moreover, the usage of FYM makes the availability of nutrients to the plants through the active vegetative stage. A study conducted by Kumar et al., (2019) reported that the adoption of fertilizer recommendations based on soil health test reports resulted in increased crop yields due to balanced crop nutrition.

Economic benefits of adoption of SHT based recommendations

The rate of adoption of a recommended technology mainly depends on the economic advantage from the adoption of proposed technology. Therefore, an analysis was done to evaluate the economic advantage of adoption of SHT based recommendations in wheat, paddy and sugarcane crops. It is clear (Table 3) that the adoption of SHT based fertilizer recommendation in wheat had a significant reduction of production cost by Rs. 2130, 2164 and 3122/- per acre of wheat, paddy and sugarcane crops, respectively. These findings are in satisfactory with the findings of Chouhan et al., (2017). Further data revealed that the net increase of income from one acre of wheat, paddy and sugarcane is about Rs. 11197, 12058 and 29187/-. Singh et al., (2020) & Jayalakshmi et al., (2021) also revealed that adoption of SFM based on soil health card report gave increased net returns as a result of optimized use of chemical fertilizers.

Constraints in getting the soil testing and adoption of SHT-based recommendations

An attempt has also been done to analyse the major constraints faced by the farmers to get soil testing. It is depicted (Table 4) that among the various constraints, the availability of soil test results at right time is the major constraint and which is followed by the accessibility of soil testing laboratories as also reported by Patel et al., (2022) & Ghaswa et al., (2019). Further, the study revealed that the lack of mobile soil testing vans (2.65 mean score, Table 5) is also one of the major reasons for the non-adoption of recommended soil fertility management practices. Further, results of soil testing are not timely available (2.1 mean score, Table 4) and due to this the farmers were not able to adopt proposed recommendations. Moreover, the farmers have no idea about the importance of micro-nutrients and the availability of improper information about micronutrient status (1.975 and 2.35 mean score, Table 4) which needs the educational programme for the farmers

Table 3. Economics of wheat, paddy and sugarcane as influenced by adoption SHT based recommendations

Crop	Reduction in production cost/acre (Rs)*	Production increase quintal/ acre	Price of increased product (Rs)*	Net increase: Rs/ acre*
Wheat	2130	4.5	9067	11197
Paddy	2164	5.1	9894	12058
Sugarcane	3122	70.2	26065	29187

*Price of crops (Rs/quintal) and fertilizers (Rs/kg): Wheat-2015; Sugarcane- 325; Paddy-1940, NPK (12:32:36)- 2940; DAP (18:46:0)- 27, Urea- 5.92, MOP- 11, $ZnSO_4$- 110, $FeSO_4$-150, Sulphur- 52.4; Boron- 220, Cu- 200. Farm yard manure price is not taken into consideration

Table 4. The perceived constraints of respondents in getting the soil testing

S.No.	Constraints	Mean score	Rank
a)	Perceived constraints of respondents in getting the soil testing		
1	The soil testing laboratory is very far	2.075	II
2	Difficulty in taking the soil sample	1.9	III
3	The price of soil testing is very high	1.625	IV
4	Results of soil testing are not timely available	2.1	I
b)	perceived constraints of respondents in implementation of recommendation of SHC scheme		
1	The time gap between the soil sample taken and issuing the card is very long	2.075	IV
2	Improper information about micronutrient status in soil	1.975	V
3	Lack of knowledge about the importance of micronutrients	2.35	III
4	Lack of knowledge about the scientific method of collection of soil sample	2.4	II
5	Lack of mobile soil testing vans	2.65	I
6	Unavailability of micronutrients in market	1.35	IX
7	Non-availability of NPK combination fertilizer	1.275	X
8	Sometimes the adequate quantity of fertilizers is not available in the market	1.1175	XI
9	Lack of interest in SHCs	1.525	VIII
10	Lack of faith in the results presented in soil health cards	1.625	VI
11	Lack of Faith in Soil Testing	1.55	VII

for their knowledge empowerment. Reddy (2019) also reported these constraints as major one perceived by the farmers.

Suggestions for improving the SHC scheme

Apart from major constraints in the implementation of the SHC scheme certain important suggestions were also provided by the farmers (Table 5). All the farmers (100%) suggested that the government must take complete responsibility to get soil testing. Apart from it, farmers (77.5%) proposed to organize more training programmes regarding the scientific way of soil sample collection and the importance of micronutrients and biofertilizers in sustaining soil fertility and health. These trainings should be supported by follow-up by the extension experts (92.5%) to know the progress of the proposed technology, practice and scheme. Further, the quick distribution of Soil Health Cards was also suggested by majority of the respondents (52.5%).

Table 5. Suggestions to improve the SHC Scheme

S.No.	Suggestions of farmers	Response (%)
1	Training on soil sampling and use of SHC	77.5
2	The entire village is to be covered by govt for soil testing	100
3	Quick distribution of Soil Health Cards	52.5
4	More number of demonstrations are to be conducted	92.5
5	Follow-up by extension agency	92.5

CONCLUSION

The study indicated that the implementation of SHCs had a significant impact on the optimization of fertilizer consumption by reducing its excess application. Moreover, farmers started using the FYM which is a vital component in keeping the soil health and to minimize the cost of cultivation. The increased crop yield has been observed as a result of balanced crop nutrition due to following recommendations. Several researches has empirically proved that balanced use of organic and inorganic nutrients resulted in improved soil physio-chemical and biological status of the soil which in turn makes the soil healthier and productive on sustainable basis.

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