Effect of long term soil test crop response based nutrient management in wheat (*Triticum aestivum* L.) on physical properties in a Vertisol

ABSTRACT

A field experiment was carried out during *Rabi* season of 2020–21 and 2021–22 at the Jawaharlal Nehru Krishi Vishwa Vidyalaya research field under the ongoing AICRP on Soil Test Crop Response (STCR), managed by Department of Soil Science and Agricultural Chemistry, Jabalpur to find out the Effect of long term soil test crop response based nutrient management in wheat (*Triticum aestivum* L.) on physical properties in a Vertisol. The treatments details were T_1; Control, T_2 ; 120 N: 80 P_2O_5: 60 K_2O kg ha^{-1} , T_3; Target yield 4.5 t ha^{-1}, T_4; Target yield 6.0 t ha^{-1}, T_5; Target yield 4.5 t+FYM 5 t ha^{-1}; T_6; Target yield 6.0 t+FYM 5 t ha^{-1} and carried out in Randomized Block Design (RBD) with four replications. The results indicated that the STCR based treatment with target yield 6.0 t ha^{-1} along with application of FYM 5 t ha^{-1} recorded lowest bulk density (1.31, 1.33 and 1.35 Mg m^{-3}) and particle density (2.62, 2.62 and 2.63 Mg m^{-3}) at 0-15, 15-30 and 30-45 cm soil depth. The treatment with Target yield 6.0 t ha^{-1} along with application of FYM 5 t ha^{-1} recorded highest porosity (50.07, 49.28 and 48.52 %) as well as water holding capacity (44.42, 40.16 and 37.44 %) at 0-15, 15-30 and 30-45 cm soil depth. The long term study based on STCR clearly demonstrated that prescription based fertilizer application not only improved the physical properties of soil but also save the fertilizer without impairing soil health.

Keywords: *FYM, Bulk density, Particle density, Porosity, STCR, Water holding capacity*

1. INTRODUCTION

Wheat (*Triticum aestivum* L.) is the world's most widely cultivated food grain crop. Besides staple food for human beings, wheat straw also serves as good source of feed for animals [1]. It is grown on approximately 32 million hectares with a total production of 107.8 million tonnes and a productivity of 3370 kg ha^{-1} [2]. In Madhya Pradesh, it is grown in about 49 lakh ha with an annual production of 125.6 lakh tonnes and productivity of 2563 kg ha^{-1} [2]. The major challenge confronting India during the 21st century is to produce enough food, fodder, fiber and fuel to meet the diversified need of ever-increasing human population as well as animal's population of the country. The application of inorganic fertilizers leads to the increasing crop yield due to the immediate supply of plant nutrients [3], but its use over a long run may decrease the stability of macro and micro aggregate, moisture retention and increase bulk and particle density thus decreasing the productivity [4]. Fertilization of crops based on generalized recommendation leads to under fertilization or over fertilization, results in deteriorating physical properties (bulk density, particle density, porosity etc.), lower productivity along with environmental pollution. Therefore, it is essential to protect the soil health by adopting balanced fertilization through soil testing and organic source as an integrated manner. Among the various methods of fertilizers recommendation, soil test based nutrient recommendation cares crop demand, response of nutrients and expected crop yield. Ramamoorthy *et al.* [5] developed the methodology of soil test based nutrient recommendation for targeted yield. It is a more quantitative, precise and meaningful approach because it involves combined use of soil and plant analysis, which provide information on real balance between applied nutrient and available nutrients of soil [6]. The inorganic fertilizer along with FYM plays an important role in increasing crop yields, since inorganic fertilizers fulfilled crop nutrients need quickly and FYM provides both macro and micronutrients gradually and continuously to crop. FYM improve physical properties of soil such as aggregation, permeability and water holding capacity. It contains all the essential elements which mitigate the ill effect of imbalanced use of fertilizers [7]. Long term fertilizer experiment provides best possible means to study the changes in soil properties, dynamics of nutrient processes and future strategies for maintaining soil health [8]. Such experiments in India suggested that under continuous cropping, changes in soil fertility due to imbalanced fertilization may be recognized as an important factor limiting crop yields. Thus, it is essential to measure the changes in soil properties that occurred due to soil test based fertilizer application. Therefore, the present experiment was undertaken with the objectives to study the effect of long term STCR based nutrient management in wheat on soil bulk density, particle density, water holding capacity and porosity.

2. MATERIAL AND METHODS

2.1 Experimental Details

The experiment was started in *Rabi* 2020-21 and 2021-22 at the Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), Jabalpur's research field. The experimental site was situated in the South-Eastern part of Madhya Pradesh at 23°13´ North latitude, 79°57´ East longitudes and at an elevation of 393 meter above mean sea level. The soil samples (0-15, 15-30 and 30-45 cm depth) were collected from the experimental site. The experiment was laid out in randomized block design (RBD) with six treatments each replicated four times. The treatment details were T_1: Control, T2:120 N: 80 P_2O_5 :60 K_2O kg ha^{-1}, T3: target yield 4.5 t ha^{-1},T4: target yield 6.0 t ha^{-1}, T5: target yield 4.5 t + FYM 5 t ha^{-1} and T6: target yield 6.0 t + FYM 5 t ha^{-1}. The STCR based fertilizer doses were calculated from the fertilizer adjustment equations for target yield 4.5 and 6 t ha^{-1} of wheat. The fertilizer adjustment equations are given below:

$$FN = 4.40\,T - 0.40\,SN$$
$$FP_2O_5 = 4.00\,T - 5.73\,SP$$
$$FK_2O = 2.53\,T - 0.16\,SK$$

Whereas

FN = Fertilizer nitrogen (kg ha^{-1}); FP_2O_5= Fertilizer phosphorus (kg ha^{-1}); FK_2O = Fertilizer potassium (kg ha^{-1}); T = Desired yield target (t ha^{-1}); SN = Available soil nitrogen (kg ha^{-1}); SP = Available soil phosphorus (kg ha^{-1}); SK= Available soil potassium (kg ha^{-1}).

2.2 Soil sampling and analysis

The processed soil sample were analyzed for physical properties (bulk density, particle density, water holding capacity and porosity) from the following methods: the bulk density of soil at 0-15, 15-30 and 30-45 cm were determined using core sampler method [9], particle density of soil at 0-15, 15-30 and 30-45 cm were determined by Pycnometer [10], water holding capacity at 0-15, 15-30 and 30-45 cm were determined by Keen's Box [9] and porosity of soil at 0-15, 15-30 and 30-45 cm were determined using empirical method as described by Gupta and Dhakshinamoorthy, [11].

3. RESULTS AND DISCUSSION

3.1 Bulk density

The application of STCR based NPK level as GRD, target yield of 4.5 t ha^{-1}, target yield of 6 t ha^{-1}, target yield of 4.5 t ha^{-1} + FYM 5 t ha^{-1} and target yield of 6 t ha^{-1} + FYM 5 t ha^{-1} had significantly decreased the bulk density over control at all soil depth i.e. 0-15, 15-30 and 30-45 cm in the pooled data (Table 1 and Figure 1). However, the application of nutrient for target yield of 6 t ha^{-1} + FYM 5 t ha^{-1}, target yield of 6 t ha^{-1} and target yield of 4.5 t ha^{-1} + FYM 5 t ha^{-1} recorded significantly decreased bulk density over GRD at all soil depth except 30-45 cm in the pooled data. Target yield of 6 t ha^{-1} + FYM 5 t ha^{-1} and target yield of 4.5 t ha^{-1} + FYM 5 t ha^{-1} had significantly less bulk density over target yield of 6 t ha^{-1} at all soil depth in the pooled data. The lowest bulk density was observed at 0-15 cm depth 1.31 Mg m^{-3}, at 15-30 cm depth 1.33 Mg m^{-3}, and at 30-45 cm depth 1.35 Mg m^{-3} with nutrient application for target yield of 6 t ha^{-1} + FYM 5 t ha^{-1} in pooled data, respectively.

The significant reduction of bulk density in all soil depth with nutrient application for target yield of 4.5 t ha^{-1} + FYM 5 t ha^{-1} and target yield of 6 t ha^{-1} + FYM 5 t ha^{-1} than NPK alone (as GRD, target yield of 4.5 t ha^{-1}, target yield of 6 t ha^{-1}) might be due to the addition of FYM enhanced the OC content which increased root biomass production that might have augmented organic matter content of the soil hence reduced the BD. The addition of FYM promotes the total porosity of soils as the microbial decomposition products of organic manures such as polysaccharides and bacterial gums are known to act as soil particle binding agents. These binding agents increase the porosity and decrease the bulk density of the soil by improving the aggregation. The lowest bulk density in target yield of 6 t ha^{-1} +

FYM 5 t ha^{-1} at all soil depths was attributed application of FYM as 5 t ha^{-1} in combination with nutrient application for target yield of 6 t ha^{-1} could provide a better environment for the crop development and health of the soil. It could retain for the crop development and health of the soil than NPK alone retaining more water due to increased porosity. These results of decrease in bulk density due to addition of FYM are line with results reported by Bandyopadhyay *et al.,* [12], Thakur *et al.,* [13], Gudadhe *et al.,* [14], Moharana *et al.,* [15].

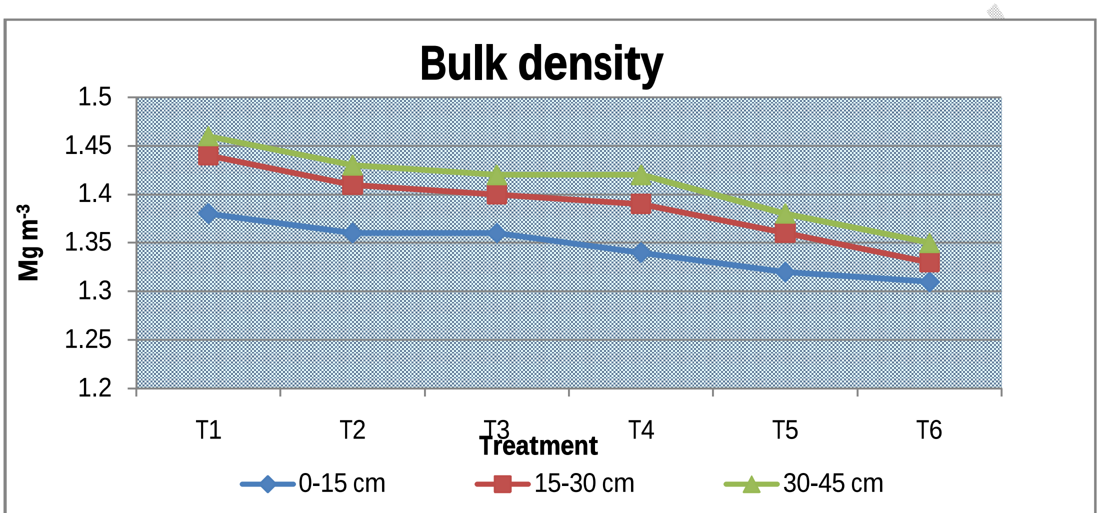

Figure 1. Effect of STCR based NPK levels on Bulk density at different depth in soil

4.3.2 Particle density

The application of STCR based NPK level as GRD, target yield of 4.5 t ha^{-1}, target yield of 6 t ha^{-1}, target yield of 4.5 t ha^{-1} + FYM 5 t ha^{-1} and target yield of 6 t ha^{-1} + FYM 5 t ha^{-1} reported slightly decreased the particle density over control at all soil depth in the pooled data but all the treatments were found non-significant to each other (Table 1). The lowest particle density was observed at 0-15 cm depth 2.62 Mg m^{-3}, at 15-30 cm depth 2.62 Mg m^{-3}, and at 30-45 cm depth 2.63 Mg m^{-3} with nutrient application for target yield of 6 t ha^{-1} + FYM 5 t ha^{-1} in pooled data respectively (Table 1). The particle density is depends on texture and exclusively on the mineralogical composition of the soil material and content of organic matter. The continuous manuring in soil might resulted in slight decrease in particle density of soil at all soil depths. The particle density of soils slightly increased with depth possibly due to lower organic matter in sub-surface soil reported by Ram *et al.,* [16]. The particle density did not show any significant change due to continuous application of fertilizer and manures. Similar findings are also reported by Nandapure *et al.,* [17].

Table 1. Effect of STCR based NPK levels on post harvest soil bulk density and particle density (pooled data)

Treatment		Bulk density (Mg m^{-3})			Particle density (Mg m^{-3})		
		0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-45 cm
T_1	Control	1.38	1.44	1.46	2.66	2.67	2.67
T_2	GRD (120 N: 80 P_2O_5: 60 K_2O kg ha^{-1})	1.36	1.41	1.43	2.64	2.64	2.65
T_3	Target Yield 4.5 t ha^{-1}	1.36	1.40	1.42	2.63	2.64	2.64
T_4	Target Yield 6 t ha^{-1}	1.34	1.39	1.42	2.63	2.64	2.63
T_5	Target Yield 4.5 t ha^{-1}+ FYM 5 t ha^{-1}	1.32	1.36	1.38	2.62	2.63	2.64
T_6	Target Yield 6 t ha^{-1} + FYM 5 t ha^{-1}	1.31	1.33	1.35	2.62	2.62	2.63
SEm ±		0.005	0.008	0.08	0.01	0.01	0.01
CD (p=0.05)		0.01	0.02	0.02	NS	NS	NS

4.3.3 Water holding capacity

The water holding capacity at 0-15 cm depth at target yield of 4.5 t ha^{-1}+ FYM 5 t ha^{-1} and target yield of 6 t ha^{-1} + FYM 5 t ha^{-1} was found significantly superior to control , GRD in pooled data. While WHC with target yield of 4.5 t ha^{-1}+ FYM 5 t ha^{-1} and target yield of 6 t ha^{-1}+ FYM 5 t ha^{-1} also significantly increased at 15-30 cm soil depth (Table 2 and Figure 2). However, the WHC at target yield of 6 t ha^{-1} + FYM 5 t ha^{-1} was found significantly superior to target yield of 4.5 t ha^{-1} and target yield of 6 t ha^{-1} but it was found at par with target yield of 4.5 t ha^{-1} + FYM 5 t ha^{-1} in pooled data. The water holding capacity at 30-45 cm with target yield of 6 t ha^{-1}, target yield of 4.5 t ha^{-1} + FYM 5 t ha^{-1} and target yield of 6 t ha^{-1} + FYM 5 t ha^{-1} and GRD was found at par during both the years. However, the water holding capacity with target yield of 4.5 t ha^{-1} + FYM 5 t ha^{-1} and target yield of 6 t ha^{-1} + FYM 5 t ha^{-1} were found significantly superior to GRD and target yield of 4.5 t ha^{-1} but the two treatments were found at par in pooled data. The maximum water holding capacity was observed at 0-15 cm depth 44.42 %, 15-30 cm depth 40.16 % and at 30-45 cm depth 37.44 % with nutrient application for target yield of 6 t ha^{-1} + FYM 5 t ha^{-1}.

The continuous application of FYM decrease bulk density, increase porosity and reduce crust formation thus increase macro and micro pores in soil which help to increase water holding capacity. The higher WHC of the surface soil was attributed to the effect of increased proportion of aggregation. As the depth increase, there will be less aggregation and more compaction in the soil as compared to surface layers which decrease the water holding capacity. The decrease in water holding capacity with increase in depth was also reported by Hati *et al.,* [18] and Pant and Ram [19].

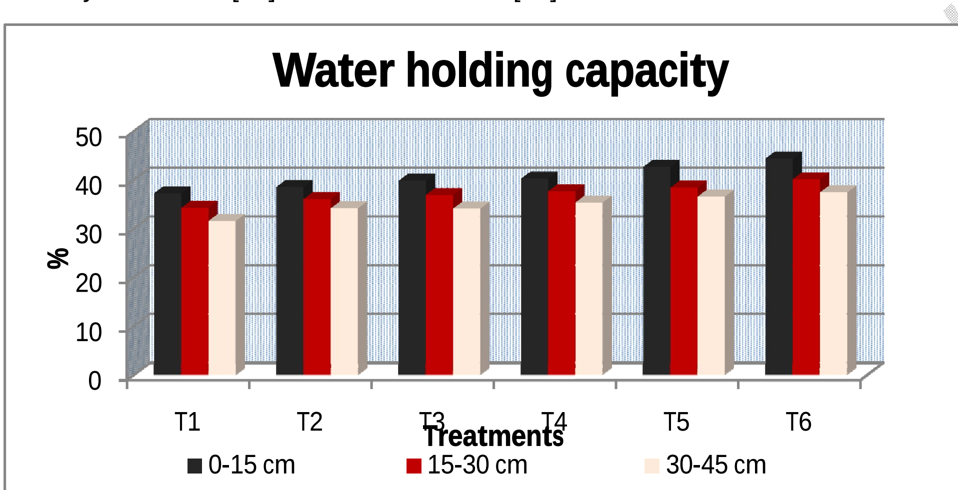

Figure 2. Effect of STCR based NPK levels on water holding capacity at different depth in soil

4.3.4 Porosity

The data presented in Table 2 indicated that the porosity with target yield of 6 t ha^{-1} + FYM 5 t ha^{-1} was found significantly superior to target yield of 6 t ha^{-1} in pooled data at 0-15 cm and 15-30 cm soil depth. The porosity at target yield of 6 t ha^{-1} + FYM 5 t ha^{-1} also found significant over target yield of 4.5 t ha^{-1} + FYM 5 t ha^{-1}. While the porosity with target yield of 4.5 t ha^{-1} + FYM 5 t ha^{-1} and target yield of 6 t ha^{-1} + FYM 5 t ha^{-1} were found significantly superior over control at 30-45 cm but the treatment were found at par at 30-45 cm soil depth in pooled data. The maximum soil porosity was observed at 0-15 cm 50.07%, 15-30 cm 49.28% and 30-45 cm 48.52% with nutrient application for target yield of 6 t ha^{-1} + FYM 5 t ha^{-1}.

Table 2. Effect of STCR based NPK levels on post harvest water holding capacity (WHC) and porosity (pooled data)

Treatment	WHC %	Porosity %

		0-15 cm	15-30 cm	30-45 cm	0-15 cm	15-30 cm	30-45 cm
T_1	**Control**	37.26	34.26	31.57	48.04	46.01	45.43
T_2	**GRD (120 N: 80 P_2O_5: 60 K_2O kg ha^{-1})**	38.55	36.06	34.17	48.53	46.65	45.88
T_3	**Target Yield 4.5 t ha^{-1}**	39.84	36.93	34.10	48.50	46.89	46.12
T_4	**Target Yield 6 t ha^{-1}**	40.26	37.68	35.36	48.91	47.38	46.12
T_5	**Target Yield 4.5 t ha^{-1}+ FYM 5 t ha^{-1}**	42.66	38.44	36.57	49.64	48.23	47.60
T 6	**Target Yield 6 t ha^{-1} + FYM 5 t ha^{-1}**	44.42	40.16	37.44	50.07	49.28	48.52
SEm ±		0.67	0.83	0.81	0.17	0.37	0.39
CD (p=0.05)		1.93	2.41	2.33	0.49	1.07	1.14

The addition of FYM promotes the total porosity of soils as the microbial decomposition products of organic manures such as polysaccharides and bacterial gums are known to act as soil particle binding agents. These binding agents increase the porosity and decrease the bulk density of the soil by improving the aggregation. The higher soil porosity of the soil of the surface layer than sub surface layer it might be due to ready exchange of O_2 and CO_2 between the soil and atmosphere thereby, promoting better root growth in soil. Similar findings were also reported by Hati *et al.,* [18], Thakur *et al.,* [13] and Moharana *et al.,* [15].

4. CONCLUSION

In the present research, Target Yield 6 t ha^{-1} + FYM 5 t ha^{-1} improve the physical properties of soil as compared to other treatments.

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