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Suitability of fertilizer recommendation equation derived for wheat crop in a Vertisol of farmer's field

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Abstract
The present experiment entitled "Suitability of fertilizer recommendation equation derived for wheat crop in a Vertisol of farmer's field" was conducted at village- Selud, block Patan, district – Durg of Chhattisgarh state during Rabi season, 2020. The objectives of the study were to test the validity of fertilizer recommendation equations derived for wheat crop in Vertisol and to estimate the nutrient requirement and efficiencies of soil, fertilizer and FYM. The experiment was consisted with 8 treatments replicated four times in a randomized block design. Treatments were T_1- Control ($N_0P_0K_0$), T_2- FYM @ 5 t/ha, T_3- ($N_{120}P_{60}K_{40}$), T_4- ($N_0P_{60}K_{40}$), T_5- ($N_{120}P_0K_{40}$), T_6- ($N_{120}P_{60}K_0$), T_7- (Fertilizer dose for yield target of 25 q/ha (81:32:21 kg/ha NPK), T_8- Fertilizer dose for yield target of 35 q/ha (139:57:50 kg/ha NPK). GW-366 variety of wheat was taken as test crop.

Keywords: NPK fertilizer, FYM, soil physico chemical properties

Introduction
Introduction of high yielding fertilizer responsive varieties of any crop with expansion of assured irrigation can only contribute to higher food grain production. Simultaneously, impact of imbalanced and indiscriminate use of chemical fertilizer has negative effect on soil fertility and productivity. Decline in soil fertility is more alarming in intensively cultivated region where in nutrient uptakes by crops are high and replenishment is not only inadequate but also imbalanced in favour of Nitrogen. Status of soil fertility reduce fast and long period, it may influence sustainability and productivity. Therefore, it is essential to protect the soil health by using judicious and balanced fertilization through soil testing.

"Balanced fertilization of crops ensures improved quality of produce, maintenance of soil fertility and conservation of our precious soil and water resources. Balance nutrition does not mean the application of nitrogen, phosphorus and potassium alone in certain proportion through fertilizer, but it should ensure that the nutrient in available forms is in adequate quantity and in required proportion in the soil to meet the requirement of the crops for obtaining the desired levels of yield. Nutrient available in the soil are rarely present in adequate amounts and in balanced proportion to meet the requirement of the crops. This requires intervention by application of external sources of nutrients i.e., fertilizers and manures. Soil test provides the requisite information about amounts of the nutrients available in soil and their imbalances, while fertilizer recommendations aim to correcting the imbalances in nutrient to crop requirement.

Soil test crop response (STCR) studies help to generate fertilizer adjustment equations and calibration charts for recommending fertilizers on the basis of soil tests and achieving targeted yield of crops (Singh and Biswas, 2000) [20]. In India, Ramamoorthy *et al.* (1967) [21] established the theoretical basis and experimental proof for the fact that Liebig's law of minimum operates equally well for N, P and K.s

Under All India Coordinated Research Project on Soil Test-Crop Response at Raipur center have generated many useful information on soil test-based fertilizer application for different crops under various soil condition. This information is needed to test their suitability for similar soil situation on farmer's fields with different varieties of the same crop.

Materials and Methods
The present investigation entitled "Suitability of fertilizer recommendation equation derived for wheat in a Vertisols of C.G. Plans" was carried out under farmer's field conditions at

Village/Post – Selud, Block – Patan, District – Durg (C.G.) during *Rabi* season, 2020-21. Soil pH was determined in 1:2.5 water-soil suspension (by Jackson, 1967) [16] than samples were allow to settled down for recording electrical conductivity (Black, 1965) [7]. The organic carbon was determined by Walkley and Black rapid titration method (1934) [19]. Available nitrogen was estimate by alkaline potassium permanganate method (Subbiah and Asija. 1956) [18], available phosphorus by 0.5 M Sodium bicarbonate extractant method (Olsen *et al.*, 1954) [17] and available potassium was determined by neutral normal ammonium acetate extractant. The soil of the experimental field locally known as Kanhar and it comes under the order of Vertisol. It is clayey in texture, pH is neutral (7.15), medium in organic carbon (0.37%), available N (191 kg ha^{-1}) is low, medium in available P (12.32 kg ha^{-1}), high in available K (569 kg ha^{-1}) and medium in available micronutrient S (24.55 kg ha^{-1}), micronutrient Zn is near about CL (critical level).

Results and Discussion

Agronomical data of grain and straw

Grain and straw yield of wheat

Results presented in the Table 1 reveal that average grain and straw yields of wheat in relation to different fertilizer treatments application. The objective of the experiment was to test the suitability of soil test based fertilizer equations derived for wheat crop during previous season. It is clear from the results that application of soil test based fertilizer N P K yielded less than the targeted crop yield however, the yields achieved were within the limitation of ±10% variation. Application of soil test based fertilizer dose to achieve a yield target of 35 q/ha produced significantly highest yield followed by blanket recommendation of NPK @ 120:60:40 kg/ha and was at par with that of same dose of N and P application without K. This indicated no crop response to K application due to well supply of K by the soil under study i.e. Vertisol. Grain yield was significantly higher by the application of FYM over control and was at par with T_4 treatment that received only P and K. This shows the importance of N nutrition with which yield could be tremendously increased by two and half folds if N is included with P and K application (T_3) in a balanced manner.

Based on the results, it can be concluded that fertilizer doses applied on the basis of soil test level of experimental field soil, the fertilizer prescription equation derived for wheat crop during previous season is valid on the farmer's field. Many workers also have tested the STCR equation derived for various crops and found varid with ±10% variation.

Table 1: Average grain and straw yields of wheat in relation to different Fertilizer treatments

S. No.	Treatments	Grain yield q/ha	Straw yield q/ha
1.	Control ($N_0P_0K_0$)	8.30f	13.40e
2.	FYM @ 5 t/ha	12.33 e	17.45 e
3.	$N_{120}P_{60}K_{40}$	28.60 b	43.42 b
4.	$N_0P_{60}K_{40}$	11.08 e	15.98 e
5.	$N_{120}P_0K_{40}$	19.99 d	25.30 d
6.	$N_{120}P_{60}K_0$	29.37 b	45.08 b
7.	Fertilizer dose for yield target of 25 q/ha (81:32:21 kg/ha NPK)	23.92 c	36.50 c
8.	Fertilizer dose for yield target of 35 q/ha (139:57:50 kg/ha NPK)	32.94 a	51.50 a
Mean		20.82	31.08
S.Em±		0.89	1.44
CD		2.71	4.37
CV		7.44	8.03

Nutrients uptake and efficiencies

Nitrogen Uptake in grain, straw and total

Table 2 show the N uptake by wheat grain, straw and their total. Nitrogen uptake by grain, straw and their total significantly affected by different fertilizer treatments. Highest N uptake was observed in the treatment that received fertilizer application for yield target of 35 q/ha which was statistically at par with the treatments T_3 and T_6 that received RDF with or without K application. Similarly, N uptake in wheat straw also differed significantly with different fertilizer treatments with FYM application.

Table 2: Mean Nitrogen uptake (kg/ha) in grain, straw and total in relation to different fertilizer treatments

S. No.	Treatments	Grain	Straw	Total
1.	Control ($N_0P_0K_0$)	10.13d	5.50c	15.63f
2.	FYM @ 5 t/ha	15.60d	7.88c	23.48e
3.	$N_{120}P_{60}K_{40}$	36.32a	19.83a	56.15b
4.	$N_0P_{60}K_{40}$	13.92	6.94c	20.87e
5.	$N_{120}P_0K_{40}$	25.59bc	11.16bc	36.75d
6.	$N_{120}P_{60}K_0$	37.10ab	20.30a	57.39b
7.	Fertilizer dose for yield target of 25 q/ha (81:32:21 kg/ha NPK)	30.45b	16.90ab	47.35c
8.	Fertilizer dose for yield target of 35 q/ha (139:57:50 kg/ha NPK)	41.62a	23.15a	64.77a
Mean		26.34	13.96	40.30
S.Em±		1.10	0.62	1.54
CD		3.25	1.88	4.68
CV		7.04	7.69	6.63

Phosphorus Uptake in grain, straw and total

Results on phosphorus uptake by wheat in grain, straw and their total are given in the Table 3 and depicted in that P uptake significantly affected with different fertilizer treatments. Highest P uptake was observed by the crop in grain, straw and their total P uptake. Grain and straw P uptake were statistically at par with the treatment T_3 that received recommended dose of fertilizer and T_6 without potassium application. However, the total P uptake by the crop was significantly higher with the treatment T_8 followed by T_3 and T_6. Minimum P uptake was recorded in control treatment. P uptake in T_2 and T_4 that received application of 5 t/ha FYM and $N_0P_{60}K_{40}$showed at par results.

Table 3: Mean Phosphorus uptake (kg/ha) in grain, straw and total in relation to different fertilizer treatments

S. No.	Treatments	Grain	Straw	Total
1.	Control ($N_0P_0K_0$)	3.35f	0.74c	4.09f
2.	FYM @ 5 t/ha	5.24e	0.97c	6.21e
3.	$N_{120}P_{60}K_{40}$	11.23b	1.87b	13.10b
4.	$N_0P_{60}K_{40}$	4.71e	0.85c	5.57e
5.	$N_{120}P_0K_{40}$	8.59d	1.20c	9.79d
6.	$N_{120}P_{60}K_0$	12.44a	2.27a	14.70a
7.	Fertilizer dose for yield target of 25 q/ha (81:32:21 kg/ha NPK)	9.97c	1.85b	11.82c
8.	Fertilizer dose for yield target of 35 q/ha (139:57:50 kg/ha NPK)	12.82a	2.08a	14.91a
Mean		14.43	2.52	10.02
S.Em±		0.25	0.17	0.31
CD		0.77	0.52	0.92
CV		3.05	11.73	5.26

Potassium Uptake in grain, straw and total

Results presented in Table 4 and revealed that K uptake in grain, straw and their total significantly differed by different fertilizer application. Treatment that received fertilizer application based on soil test to achieve a yield target of 35 q/ha recorded highest K uptake which was statistically at par with T_3 and T_6 that received recommended dose of fertilizer with K or without K in case of K uptake in straw as well as in total K uptake. K uptake was found to be higher in straw part as compared to grain part. K uptake followed with grain and straw yield of wheat as it is a multiple of content and yield. Control treatment had lowest K uptake significantly to other fertilizer treatments.

Table 4: Mean Potassium uptake (kg/ha) in grain, straw and total in relation to different fertilizer treatments

S. No.	Treatments	Grain	Straw	Total
1.	Control ($N_0P_0K_0$)	3.51f	15.40e	18.91e
2.	FYM @ 5 t/ha	5.16e	20.00d	25.16d
3.	$N_{120}P_{60}K_{40}$	11.52b	49.90a	61.42a
4.	$N_0P_{60}K_{40}$	4.21	18.91de	23.12d
5.	$N_{120}P_0K_{40}$	7.78d	29.52c	37.29c
6.	$N_{120}P_{60}K_0$	11.44b	49.18a	60.62a
7.	Fertilizer dose for yield target of 25 q/ha (81:32:21 kg/ha NPK)	9.43c	40.33b	49.76b
8.	Fertilizer dose for yield target of 35 q/ha (139:57:50 kg/ha NPK)	12.86a	53.78a	66.64a
Mean		8.24	34.63	42.87
S.Em±		0.42	1.66	1.91
CD		1.26	5.04	5.81
CV		8.75	8.31	7.74

Nutrient requirement, efficiencies of fertilizer, soil test and FYM

Nutrient requirement as kg per quintal of grain production, efficiencies of fertilizer nutrients, soil nutrients and organic nutrients are the basic parameters that can be estimated from nutrients omission treatments as under.

Table 5: Nutrient requirements, fertilizer, soil and FYM nutrients efficiencies estimated under study for wheat (GW-366)

Nutrients	Nutrient Requirement (kg q^{-1})	Fertilizer use efficiency (%)	Soil test use efficiency (%)	FYM nutrients use efficiency (%)
N	1.92	31.10	8.20	31.4
P	0.47	15.40	28.5	14.13
K	2.04	140.2	3.30	15.61
Nutrient content in FYM		0.5% N, 0.30% P and 0.8% K		

The amount of nutrients absorbed by the crop decides a definite amount of biomass production. The amount of nutrient required to produce one quintal of wheat grain yield was found to be 1.92 kg N, 0.47 kg P and 2.04 kg K.

Conclusion

- Application of soil test-based fertilizer N, P and K yielded less than the targeted crop yield however, the yields achieved were within the limitation of ±10% variation. Application of soil test-based fertilizer dose to achieve a yield target of 35 q/ha produced significantly highest yield followed by blanket recommendation of NPK @ 120:60:40 kg/ha and was at par with that of same dose of N and P application without K. This indicated, no crop response to K application due to well supply of K by the soil under study *i.e.* Vertisol.

- The amount of nutrient required to produce one quintal of wheat grain yield was found to be 1.92 kg N, 0.47 kg P and 2.04 kg K. The fertilizer efficiencies of N, P and K for wheat crop were estimated as 31.10, 15.40 and 140.2 per cent, respectively. Similarly, the efficiencies of soil nutrients for wheat were recorded as 8.20 % N, 28.5% P and 3.30% K. The efficiencies of nutrients from organic source (FYM) were observed as 31.4% N, 14.13% P and 15.61% K for wheat crop in Vertisol under testing.
- It indicates that soil test-based fertilizer application provides a balanced fertilization based on the crop nutrients requirement, and efficiencies of different nutrients sources.

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