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Tailoring Soil Test Based Fertilizer Doses to Obtain Higher Wheat Yield

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The wheat growing fields of north Karnataka were non-saline (ECe < 4 dSm$_{-1}$) and pH of these soils was buffered at 8.4. Most of the fields were low in organic carbon content. Among major nutrients, Nitrogen was the most deficient with the average available nitrogen status of 148 kg ha$_{-1}$. The available phosphorus was rated as medium to high and available potassium was very high. Among the micronutrients, Fe, Zn and Cu were deficient in the wheat soils whereas, Mn available status was rated high. The grain yield remained significantly higher under STCR fertilizer dose that had 190:89:91 kg ha^{-1} N, P_2O_5 and K_2O, respectively compared to recommended fertilizer dose (100:75:50 kg ha^{-1} N, P_2O_5 and K_2O, respectively) under LMH category of soil test values. Under the LML category of the soil fertility status, STCR dose (178:100:135 kg ha$_{-1}$ N, P_2O_5 and K_2O, respectively) registered the highest grain (29.2 q ha^{-1}) and straw yield (49.2 q ha^{-1}) of the crop. This treatment was significantly higher compared to all other treatments except the dose that was modified by $\pm$ 25 per cent for nitrogen and potassium which were low in soil (125:75:62 kg ha^{-1} N, P_2O_5 and K_2O, respectively). Similarly, STCR (200:89:103 kg ha^{-1} N, P_2O_5 and K_2O, respectively) and $\pm$ 50 per cent modified fertilizer dose (150:56:25 kg ha^{-1} N, P_2O_5 and K_2O, respectively) recorded higher grain and straw yields compared to the RDF under LHH category of soil nutrient status category. Fertilizer use efficiency remained the least and significantly lower in STCR dose compared to all other soil test based doses.

Key words: Saline soil, wheat, soil test, yield.

Present day recommended fertilizer doses for different crops were developed in 1960's (five decades ago). The crop, water and land management and their properties have had sea change during this period. The changed scenario demands significant modification not only in the recommended dose of fertilizers but even the soil test based fertilizer recommendation. The farmers have developed tendency to apply either excessive or imbalanced nutrient doses in an effort to obtain higher economical yields (Shivakumar *et al.,* 2010). The escalating cost of fertilizers also demand efficient, judicious and profitable use. To feed burgeoning population of the country, need of the hour is to harvest higher crop yields and to sustain it without deteriorating natural resources like land, water and bio-diversity. To obtain sustainable and economically viable yields, it is essential that practically suitable soil test based fertilizer recommendation approaches need to be tailored for major field crops. Categorization of the soils into low, medium and high based on soil available nutrient status also needs validation under changed soil conditions. Keeping these ideas in background, field experiments were conducted in farmers' fields to evaluate various approaches of fertilizer recommendations based on soil test and to assess soil fertility status in wheat growing areas of North Karnataka.

Materials and Methods

Thirty representative composite soil samples were collected from traditionally wheat growing farmers' fields in Dharwad, Gadag and Belgaum districts of North Karnataka. The samples were subjected to analysis for pH (1:2.5 soil water suspension), electrical conductivity (1:2.5 soil water suspension), organic carbon (wet oxidation), available nitrogen (alkaline permanganate), available phosphorus (0.5 N $NaHCO_3$ extraction), available potassium (neutral normal NH_4OAc extraction) and available micronutrients (DTPA+$CaCl_2$+TEA extraction). Based on the available N, P and K, the soils were categorized into low, medium and high fertility status.

Based on frequency of the occurrence of soils under particular fertility category (LMH status), eight field experiments were conducted in the farmers' fields spread over Dharwad, Belgaum and Gadag districts. Under LMH nutrient status of available N, P and K, respectively, experiments were conducted in Amargoal (Dist: Dharwad), Dandapur (Dist: Gadag), Madanbhavi (Dist: Belgaum) and Yettinagudda (Dist: Dharwad) villages. Three

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experiments were conducted in Karadiguddi village (Dist: Belgaum) where the soils were categorized under LHH category of available N, P and K, respectively. One more experiment was conducted in Kalkeri Village (Dist: Gadag) under LML category. All the eight experiments were conducted during *rabi* 2010-11 using DWR-162 variety. The field experiments were conducted with the following treatments (fertilizer doses) and were replicated four times.

Table 1. Details of the treatments and nutrient doses.

Sl No.	Details of the treatments	Nutrient doses (N, P_2O_5 and K_2O kg ha^{-1})		
		LMH	LML	LHH
T_1	UAS, Dharwad Recommended fertilizer dose	100:75:50	100:75:50	100:75:50
T_2	STCR dose	190:89:91*	178:100:135@	200:89:103#
T_3	Karnataka State Soil Testing laboratory recommendation dose	113:75:38	113:75:63	113:63:38
T_4	UAS, Dharwad Recommended fertilizer dose modified by ± 25 per cent	125:75:38	125:75:62	125:56:38
T_5	UASD Recommended fertilizer dose modified by ± 50 per cent	150:75:25	150:75:75	150:56:25
T_6	Karnataka State Soil Testing laboratory recommendation N & K dose+ modified P by 75% of RDF for medium soil P and 50 % of RDF for high soil P+PSB	113:56:38	113:56:63	113:38:38

* Average of four locations @ Average of three locations # one location

The fertilizer use efficiency was calculated for grain and straw yield separately by dividing the respective yield (expressed in kg) by total nutrient applied through fertilizer.

Results and Discussion

Soil fertility status: Wheat growing soils of the Northern Karnataka are predominantly black calcareous. These soils are classified under US taxonomical classification as Typic Pellusterts.

The soils had neutral to slightly alkaline reaction. The pH values (1: 2.5 soil water suspension) ranged between 7.54 and 9.20 with an average value of 8.46 (Table 2) . The soils being predominately calcareous, it is logical that soil pH was buffered at around 8.46. Yogeshappa (2007) also reported based on the survey conducted in Bijapur district that black soils in the North Karnataka were having 8.19-8.50 pH values. Electrical conductivity (1: 2.5 soil water suspension) ranged between 1.1 and 1.75 dSm^{-1}. The average value was 1.34 dS m^{-1}. The wheat growing soils were non-saline to slightly saline. Soil organic carbon was low to medium in most of the soils. The average value was 6.79 g kg^{-1}.

The available nitrogen was low in all the sampled wheat fields except one. The average available

Table 2. Chemical properties and nutrient status in wheat growing soils in zone no. III and VIII

Sl No.	Location of the soil sample	pH (1:2.5)	EC(1:2.5) (dSm^{-1})	OC gkg^{-1}	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	Fe (mg kg^{-1})	Cu (mg kg^{-1})	Zn (mg kg^{-1})	Mn (mg kg^{-1})	Fertility rating
		Available nutrients										
01	Amrgolcross(Tq:Navalgund)	9.03	1.43	12.0	202	43.0	546	0.31	0.14	0.28	17.7	LMH
02	Kelkeri (Tq:Navalgund)	9.17	1.60	9.0	126	46.0	534	0.37	0.23	0.37	13.8	LMH
03	Banahatti (Tq:Navalgund)	8.66	1.25	10.5	328	44.8	486	1.01	0.30	0.32	18.3	LMH
04	Hooli (Tq:Saundatti)	9.20	1.10	7.2	101	59.8	498	0.44	0.26	0.39	15.2	LHH
05	Hooli (Tq:Saundatti)	9.04	1.13	5.4	151	50.1	582	1.12	0.31	0.21	16.0	LMH
06	Hooli (Tq:Saundatti)	8.96	1.15	2.5	101	40.4	612	0.37	0.39	0.01	9.8	LMH
07	Tadakod (Tq:Dharwad)	8.09	1.20	5.4	202	43.7	372	1.03	0.46	0.32	16.1	LMH
08	Budarkatti (Tq:Bailhongal)	8.10	1.33	6.3	126	40.4	144	1.21	1.02	0.24	17.3	LMM
09	Karadiguddi (Tq:Belgaum)	8.40	1.22	2.1	101	39.6	156	1.15	1.01	0.70	14.9	LMM
10	Karadiguddi (Tq:Belgaum)	7.54	1.30	7.5	126	39.6	300	0.75	1.16	0.24	12.8	LMM
11	Karadiguddi (Tq:Belgaum)	8.19	1.15	2.7	151	34.8	126	0.41	0.29	0.27	14.9	LML
12	Karadiguddi (Tq:Belgaum)	8.36	1.15	7.8	126	53.8	216	0.51	0.39	0.16	17.6	LMM
13	Karadiguddi (Tq:Belgaum)	8.40	1.24	14.1	126	45.6	120	3.51	0.14	0.36	13.2	LML
14	Devalapur (Tq:Bailhongal)	7.82	1.25	11.4	126	37.7	234	1.10	0.23	0.18	17.3	LMM
15	Devalapur (Tq:Bailhongal)	8.20	1.32	8.4	126	39.2	150	1.13	0.03	0.01	15.9	LMM
16	Chikodhadi(Tq:Bailhongal)	8.14	1.19	5.4	126	39.6	162	1.02	0.33	0.02	13.5	LMM
17	Hosur (Tq:Saudatti)	8.51	1.26	8.1	101	44.8	222	0.89	0.38	0.03	18.0	LMM
18	Yettinagudda(Tq:Dharwad)	8.09	1.21	5.4	126	39.6	168	0.45	0.32	0.03	13.5	LMM
19	Amargol (Tq:Navalgund)	8.92	1.43	2.7	151	55.0	948	0.50	0.21	0.31	17.1	LMH
20	Kelkeri (Tq:Naragund)	8.38	1.52	10.8	152	50.0	138	0.18	0.21	0.28	14.1	LML
21	Banahatti (Tq:Naragund)	8.58	1.75	10.2	202	68.0	984	0.24	0.28	0.24	17.7	LHH
22	Mugnur (Tq:Naragund)	8.40	1.42	8.4	152	54.0	900	0.31	0.32	0.19	14.1	LMH
23	Dandapur (Tq:Naragund)	9.12	1.41	5.7	152	51.0	582	0.30	0.4	0.12	18.3	LMH
24	Tadakod (Tq:Dharwad)	8.18	1.48	4.5	101	57.0	594	0.37	0.36	0.18	14.7	LHH
25	Karadiguddi (Tq:Belgaum)	8.71	1.51	8.4	177	44.0	936	0.32	0.4	0.14	17.1	LMH
26	Karadiguddi (Tq:Belgaum)	8.31	1.43	3.9	126	58.0	606	0.39	0.32	0.21	14.7	LHH
27	Karadiguddi (Tq:Belgaum)	8.15	1.39	2.4	126	58.0	876	0.42	0.41	0.33	18.3	LHH
28	Karadiguddi (Tq:Belgaum)	8.35	1.70	2.1	177	59.0	516	0.39	0.5	0.26	11.3	LHH
29	Madanbavi(Tq:Bailhongal)	8.18	1.48	10.8	202	53.0	576	0.30	0.52	0.23	18.4	LMH
30	Nagnoor (Tq:Bailhongal)	8.48	1.24	2.7	152	57.0	324	0.31	0.47	0.14	16.8	LHM
Minimum		7.54	1.10	2.1	101	34.8	120	0.18	0.03	0.01	9.8	-
Maximum		9.20	1.75	14.1	328	68.0	984	3.51	1.16	0.70	18.4	
Average		8.46	1.34	6.8	148	48.2	454	0.69	0.39	0.23	15.6	
SD	0.41	0.17	3.4	46.26	8.36	278	0.63	0.25	0.14	2.2		

nitrogen status was 148 kg ha-1. Similar observations had also been made by Yogeshappa (2007). Since the soils were poor in the organic carbon content, they were found to be low in available nitrogen. It is essential to apply more than recommended dose of the fertilizer to meet crop requirement of nitrogen. However, phosphorus availability remained medium to high indicating that phosphorus status of these black soils was relatively higher compared to nitrogen. Available phosphorus ranged from 34.8 to 68.0 kg ha-1 with an average value of 48.2 kg ha-1. The wheat growing farmers have the tendency to apply higher doses of easily available di-ammonium phosphate compared to other fertilizer and most of the applied phosphorus gets retained in the soil leading to increased available status of P. Pradeep (2004) also reported that groundnut growing black soils in North Karnataka had medium to higher level of available P. Available potassium content was higher in all most all the soils. These soils being dominated by the primary minerals (feldspar, biotite mica etc.,) that are rich in potassium, they probably contain higher available potassium. The average potassium status was 454 kg ha-1. Among the major nutrient elements nitrogen followed by phosphorus were the most deficient. Majority of the soils were categorized as low (less than 250 kg ha-1), medium (between 22.2 and 55 kg ha-1) and high (more than 360 kg ha-1) for available N, P_2O_5 and K_2O, respectively.

Available micronutrients content in the sampled wheat fields were low (Table 2). The nutrients such as Fe (0.69 mg kg-1), Zn (0.23 mg kg-1) and Cu (0.39 mg kg-1) were deficient whereas Mn was sufficient (15.6 mg kg-1). Calcareous nature of the soil, prevalence of alkaline pH values and intensive cultivation of high yielding exhaustive crops might have caused the deficiency of the micronutrients.

Grain and straw yield: The grain yield remained significantly higher under STCR (Soil Test Crop Response) fertilizer dose that had 190:89:91 kg ha^{-1} N, P_2O_5 and K_2O, respectively compared to recommended fertilizer dose (100:75:50 kg ha-1 N, P_2O_5 and K_2O, respectively) under LMH category of soil test values (Table 3). However, the yield under

Table 3. Influence of soil test based fertilizer doses on grain and straw yield of wheat under LMH, LML and LHH category (pooled over locations)

Treatment	N, P_2O_5, K_2O Applied (kg ha-1)	LMH category Grain yield (q ha-1)	LMH category Straw yield (q ha-1)	N, P_2O_5, K_2O Applied (kg ha-1)	LML category Grain yield (q ha-1)	LML category Straw yield (q ha-1)	N, P_2O_5, K_2O Applied (kg ha-1)	LHH category Grain yield (q ha-1)	LHH category Straw yield (q ha-1)
T_1	100:75:50	26.7	37.1	100:75:50	23.2	45.1	100:75:50	26.5	45.9
T_2	190:89:91*	31.8	41.8	178:100:135@	29.2	19.2	200:89:103#	31.4	51.0
T_3	113:75:38	27.4	37.8	113:75:63	24.4	46.3	113:63:38	27.0	46.6
T_4	125:75:38	28.5	38.8	125:75:79	28.3	48.1	125:56:38	28.0	47.5
T_5	150:75:25	31.1	41.1	150:75:75	26.0	47.6	150:75:75	29.5	49.8
T_6	113:56:38	27.0	37.4	113:56:63	25.1	45.8	113:38:38	25.9	47.4
	SE±	0.74	0.99		0.66	0.84		0.86	1.12
	CD (0.05)	2.23	3.00		2.00	2.56		2.61	3.37

* Average of four locations @ Average of three locations # one location

STCR dose was on par with fertilizer dose that was modified by ± 50 per cent (150:75:25 kg ha^{-1} N, P_2O_5 and K_2O, respectively). This indicated that increased doses of nitrogen were required to harvest higher yield of wheat under deficient conditions of the soil. The nitrogen dose has to be increased by at least 50 per cent (from 100 to 150 kg ha-1) to increase the crop yields. Long-term studies conducted by Sarwad and Singh (2004) revealed that nitrogen availability got decreased and wheat yield reduced when its application was withheld leading to it's sever deficiency. State agricultural department approach to modify fertilizer dose (113:75:38 kg ha^{-1} N, P_2O_5 and K_2O, respectively) under LMH category did not increase yield compared to recommended fertilizer dose. Similar observations were made by Suresh and Sarangamath, 2000). Therefore, it is inferred that State Agricultural Department approach seems to be not suitable to recommend fertilizer dose under deficient status of available nitrogen. This is mainly due to the lower dose of recommendation by State Agricultural Department approach for the most deficient nutrient, nitrogen (113 compared to 150 kg ha-1 N).

Higher phosphorus dose by 14 kg ha-1 in STCR dose compared to RDF increased the yield significantly. Though available phosphorus was medium (under LMH category) in the soil, the increase in P dose was required to obtain higher crop yields. The potassium dose was also higher in the STCR dose compared to the RDF by 41 kg ha-1. Since, soil was rated as high for potassium, higher dose of potassium might not be the cause for increased yield of wheat. This is justified by registering on par yield in the treatment that was modified by altering RDF dose by ± 50 per cent (150:75:25 kg ha^{-1} N, P_2O_5 and K_2O, respectively). This treatment had lower potassium dose and almost on par phosphorus but very high nitrogen. Therefore, it could be inferred that most deficient nutrient, nitrogen was the critical input that increased the yield under the LMH category compared to P or K. Under LMH category, straw yield also indicated similar trend of variations under different treatments of fertilizer doses.

Under the LML category of the soil fertility status, STCR dose (178:100:135 kg ha^{-1} N, P_2O_5 and K_2O,

Table 4. Influence of soil test based fertilizer doses on fertilizer use efficiency of wheat under LMH, LML and LHH category (pooled over locations)

Treatment	N, P_2O_5, K_2O Applied (kg ha^{-1})	LMH category Grain (kg kg^{-1})	Straw (kg kg^{-1})	N, P_2O_5, K_2O Applied (kg ha^{-1})	LML category Grain (kg kg^{-1})	Straw (kg kg^{-1})	N, P_2O_5, K_2O Applied (kg ha^{-1})	LHH category Grain (kg kg^{-1})	Straw (kg kg^{-1})
T_1	100:75:50	11.9	20.6	100:75:50	10.3	20.0	100:75:50	11.8	20.4
T_2	190:89:91*	8.5	13.8	178:100:135@	7.1	11.9	200:89:103#	8.0	13.0
T_3	113:75:38	12.1	21.1	113:75:63	9.7	18.4	113:63:38	12.6	21.8
T_4	125:75:38	11.1	19.1	125:75:79	9.5	16.1	125:56:38	12.8	21.7
T_5	150:75:25	12.4	20.4	150:75:75	8.7	15.9	150:75:75	9.2	15.6
T_6	113:56:38	13.0	22.7	113:56:63	10.8	19.7	113:38:38	13.7	25.1
	SE±	1.1	2.5		1.2	2.4		1.5	3.1
	CD (0.05)	3.3	7.7		3.5	7.2		3.6	9.0

*Average of four locations @Average of three locations # one location

respectively) registered highest grain (29.2 q ha^{-1}) and straw yield (49.2 q ha^{-1}) of the crop. This treatment was significantly higher compared to all other treatments except the dose that was modified by -+ 25 per cent (125:75:62 kg ha^{-1} N, P_2O_5 and K_2O, respectively). The higher yield recorded in this treatment might be attributed to the higher doses of N, P and K compared to RDF. Among these nutrient elements, N and K were the most deficient and the crop responded to application of higher doses of these nutrients by registering higher yield. Therefore, it could be inferred that fertilizer dose need to be modified by at least ± 25 per cent under LML category to obtain higher yield levels. Singh *et al* , (2011) reported that soil test based and nitrogen inhibitor blended N, P and K fertilizer application through organic and inorganic sources recorded higher wheat grain yield.

Under LHH category with low nitrogen and high phosphorus and potassium, STCR dose (200: 89: 103 kg ha^{-1} N, P_2O_5 and K_2O, respectively) along with ± 50 per cent modified fertilizer dose (150:56:25 kg ha^{-1} N, P_2O_5 and K_2O, respectively) recorded higher grain and straw yield of the crop compared to RDF (100:75:50 kg ha^{-1} N, P_2O_5 and K_2O, respectively). Tulsa and Mir (2006) had also recorded higher wheat grain yield and yield attributes with enhanced dose of nitrogen dose (compared to control) in the deficient soils of Jammu and Kashmir. Therefore, it is inferred that a minimum of 150:89:25 kg ha^{-1} N, P_2O_5 and K_2O, respectively) was required for the wheat crop to harvest higher yields. The State Agricultural Department approach to fine tune the nutrient dose based on soil testing did not increase the yield of the crop under LMH, LML and LHH category.

Fertilizer use efficiency: Grain and straw yield per kg of applied nutrient was the highest for fertilizer dose that was modified by STL recommendation approach + phosphorus solubilizing fungi applied plots (13 and 22.7 kg/kg for grain and straw, respectively) under LMH category. However, these values remained on par with rest of the treatments except STCR dose. The STCR fertilizer dose registered lowest efficiency of 8.5 and 13.8 kg/kg of fertilizer use for grain and straw, respectively. Similarly, the STCR dose remained lowest in fertilizer use efficiency in LML and LHH category of the available N, P and K, respectively. The STCR dose differed significantly from all the other treatments. Though STCR dose registered higher grain and straw yields, fertilizer dose was also higher compared to all the other treatments. Therefore, the fertilizer prescription equations for wheat may be refined and verified in the different locations of black soils of North Karnataka.

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References

Pradeep, R. 2004. Nutrient status of some groundnut growing soils of shorapur and shahapur taluks. M. Sc (Ag) Thesis, University of Agricultural Sciences, Dharwad.

Sarwad, I.M. and Singh Dhyan. 2004. Effect of long-term fertilizer use on yield and nutrient uptake by maize-wheat-cowpea sequence. *Karnataka J. Agric. Sci*. **17**: 705-711.

Shivakumar, K. M., Nagraja, M. S., Champa, B. V. and Kuligod, V.B. 2010. Comparative analysis of different levels of management in dry chilli production – A case study. *Indian J. Fert.,* **6**: 12-16

Singh, C.M., Sharma, P.K., Prem Kishor, Mishra, P. K., Singh, A.P. Verma, Rajhans and Raha, P. 2011. Effect of integrated nutrient management on growth, yield and nutrient uptake by wheat (*Triticum aestivum* L.). *Asian J. Agric. Sci*., **5**: 76-82.

Suresh V. V. and Sarangamath P. A. 2000. Effect of nitrogen and potassium on yield and quality of parameters of byadagi chilli. M.Sc (Ag) Thesis, University of Agricultural Sciences, Dharwad

Tulsa Ram and Mir, M.S. 2006, Effect of integrated nutrient management on yield and yield attributing characters of wheat (*Triticum aestivum*). *Indian J. Agron*. **51**: 189 -192.

Yogeshappa, H. 2007. Yield and quality of grapes (CV. Thompson seedless) in relation to soil fertility status of vine yards in Bijapur taluk of Karnataka M.Sc. (Ag) Thesis, University of Agricultural Sciences, Dharwad.

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