PRECISION NUTRIENT MANAGEMENT IN COTTON AT DIFFERENT YIELD TARGETS IN NORTHERN TRANSITIONAL ZONE OF KARNATAKA

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ABSTRACT

Nutrient management in cotton is complex due to the simultaneous production of vegetative and reproductive structures during the active growth phase. Lot of spatial variation in soil available nutrients is observed under similar management situation. In view of this an experiment was conducted to study the precision nutrient management by assessing status of soil nutrients in cotton growing area for precision application of nutrients. Bisanahalli cotton belt is selected for this study. The study area is a centre place of cotton growing belt in Haveri district of northern Karnataka consisting of both red soils (Alfisols), deep black soils (Vertisols) and mixed red and black soil. Totally, 178 soil samples were collected from 55.84 hectare cotton growing area at 60 m grid. The location of the sample was recorded using GPS. The samples were processed and analyzed for available nutrients status. Results show that, spatial variability observed with respect to all chemical properties between soil types and within each class of soil. The soil pH varied from 5.66 to 7.32, and 6.12 to 8.6, EC varied from of 0.07 - 0.84 and 0.08 to 0.24 dS/m, organic carbon from 0.74 and 0.68 % in red and black soil, respectively. Major nutrient status shows that, 60 per cent of the soil samples were low and 40 per cent samples were medium in available N status. With respect to P, 4 per cent samples were low and 96 per cent samples were medium in available status. Available K status was medium (86%) to high (14%). Available Fe and Zn status were deficient to the extent of 38 and 4 percent as against higher levels in 60 and 36 percent in alfisols and vertisols, respectively. Available Cu ranged from 0.66 to 3.6 ppm with higher levels in all grids. Available Mn was in the range of 0.26 to 20.6 ppm. Based on this soil fertility status, a field experiment on precision farming in cotton was carried out on an area of 55.84 ha by planning target yields of 20 and 25 q/ha for alfisols and 25 and 30 q/ha for vertisols. The soil fertility maps for different nutrients are generated using Arc GIS. Total area was delineated in to 4 management zone (MMM, LMM, MMH and LMH (low, Medium and High for N, P& K, resp.,) in red soil and MMM, LMM, MHM and LMH in black soil) based on available nutrient status and near neighbor wood classification. The required soil nutrient maps were generated based on site specific nutrient management (SSNM) concept by considering soil available status, crop uptake/ ton of seed cotton yield, and the target yield. As such, variable rate applicators (VRA) are not available at Indian conditions. Hence, variable rate of nutrients were applied manually according to the management zone. The results revealed that, the seed cotton yield target of 20 and 25 q/ha was achieved in alfisols and vertisols, respectively at all the nutrients status. However, we could able to achieve only 88 percent of the higher targets fixed (25 and 30 q/ha seed cotton yield, in alfisols and vertisols, respectively) due to prolonged dry spell during peak boll development stage and soil moisture constraints.

Key words: Cotton, Management zone, Precision application of nutrients, SSNM, Soil variability, Target yield.

INTRODUCTION

The high input demanding crop like cotton require precision resource management for sustained yield, enhance cost effectiveness and keeping the environment, pollution free. The Precision Agriculture (PA) activities will provide a firm base for the development of research knowledge base for up scaling its adoption. The present study was carried out for cotton with precision agriculture (PA) techniques. Under the circumstances, PA has used on farm level for enhancing production with improved nutrient use efficiency, monitoring crop condition, and assessment to manage soil and water resources, pest and diseases appropriately.

Intensively cultivated soils are being depleted with available nutrients especially secondary and micronutrients. Therefore assessment of fertility status of soils that are being intensively cultivated with high yielding crops needs to be carried out. Soil testing is usually followed by collecting composite soil samples in the fields without geographic reference. The results of such soil testing are not useful for site specific recommendations and subsequent monitoring. Soil available nutrients status of an area using Global Positioning System (GPS) will help in formulating site specific balanced fertilizer recommendation and to understand the status of soil fertility spatially and temporally.

Cotton is an important commercial crop and forms principal raw material for a flourishing textile industry. As much as 70 per cent of raw material need of textile industry is met only from cotton. In India 60 million people are involved in raw cotton production, processing, yarn and garment production. Export of Indian cotton has touched 55 lakh bales. India takes pride in having largest area (101.5 lakh ha) of cotton and being second largest cotton producing (295 lakh bales) country in the world. However the productivity (494 kg/ ha) is lower than world average (600 kg/ha) (Anonymous, 2010). With the popularization of Bt. cottons, productivity of cotton in Karnataka is constantly increasing. In Karnataka, cotton occupies an area of 5.40 lakh ha with a production of 14.0 lakh bales and with productivity of 434 kg lint per ha (CAB, 2011).

Cotton being deep rooted crop removes large quantities of nutrients from the soil profile. Nutrient management in cotton is complex due to the simultaneous production of vegetative and reproductive structures during the active growth phase. The Bt cotton retains relatively more number of bolls and synchronous boll development and hence it needs higher quantity of nutrients compared to Non Bt hybrids. It has been found that Bt cotton need 25% extra nutrients (100:50:50 Kg N, P_2O_5 and K_2O Kg/ha respectively in rain fed and 150:75:75 Kg N, P_2O_5 and K_2O Kg/ha respectively under irrigated condition) than non Bt cotton. Soil spatial variation is observed under similar management situation in cotton growing soils of Northern Karnataka. In view of this an experiment was carried out to study the nutrient status of cotton growing area for precision application of nutrients and to assess spatial variability in soil with respect to soil reaction (pH), Electrical conductivity (Ec), Organic carbon (OC%), all major (N, P, K), secondary (Ca, Mg and S) and micronutrients (Fe, Zn, Cu and Mn) by assessing soil nutrients in alfisols, vertisols and mixed soils of the Bisanahalli cotton belt of Haveri district of northern Karnataka for precision nutrient management.

MATERIAL AND METHODS

The selected Bisanahalli village is located in Haveri district of northern Karnataka with an average elevation of 750 m above MSL. The climate is tropical with maximum temperature of 31.7^{o}C and minimum temperature of 20.1^{o}C. The area receives a mean annual rainfall of 528 mm. Soil samples (0-30 cm) at 60 m grid interval covering cotton growing belt of the village were collected and the sample location was recorded using GPS. The soil fertility maps for different nutrients are generated using Arc GIS (Fig. 1and 2) Processed soil samples were analyzed for nutrient availability by following standard analytical techniques (Jackson, 1973). Fertility status of N, P, K and S are interpreted as low, medium and high and that of zinc, iron, copper and manganese interpreted as deficient and sufficient by following the criteria given by (Arora, 2002). Based on the soil test results, large scale research cum demonstration trials were conducted on cotton with the target yield of 20 and 25 q/ha for alfisols and 25 and 30 q/ha for vertisols. The nutrients required to achieve the yield target was worked out based on site specific nutrient management (SSNM) concept by considering native soil fertility status, crop uptake/ ton of seed cotton the nutrient requirement of cotton as per target yield. Management zones are delineated based on the soil fertility status as low, medium and high by following UAS, Dharwad classification (Table1).

Nutrient prescription maps are prepared based on the target yield assigned to particular grid as per SSNM concept. The required major nutrients like N, P and K are applied in the form of Urea, Di-ammonium Phosphate (DAP) and Muriatic of Potash (MOP). Sulphur is applied in the form of Gypsum ($CaSo_4$). Micro nutrients like Iron and Zinc were applied to deficient grids in the form of Iron sulphate and zinc sulphate, respectively. Crops are grown at 90 X 60 cm spacing.
Table1. Soil fertility ratings for available nutrients

Nutrients	Fertility rating		
	Major nutrients		
	Low	Medium	High
Organic carbon (%)	<0.5	0.5-0.75	>0.75
Nitrogen (kg/ha)	<280	280 – 560	>560
Phosphorus(P_2O_5) (kg/ha)	<22	22– 55	>55
Potassium (K_2O) (kg/ha)	<110	110 – 280	>280
Sulphur (kg/ha)	<20	20 - 40	>40
Micronutrients	Deficient	Sufficient	Excess
Zinc (mg/kg)	<0.6	0.6 – 1.5	>1.5
Iron (mg/kg)	<2.5	2.5 – 4.5	>4.5
Copper (mg/kg)	<0.2	0.2 – 5.0	>5.0
Manganese (mg/kg)	<2.0	2.0 – 4.0	>4.0

Standard recommended agronomic practices are followed to establish the crop. Need based plant protection measures are taken as and when pest and diseases are occurred. Foliar application of magnesium sulphate ($MgSo_4$) @ 1 per cent was taken up at 90 days after planting to prevent leaf reddening. However the crop suffered from moisture stress at peak boll development stage due to long dry spell up to 30 days. Crop was harvested grid wise manually at 130 and 150 days after sowing, weighed and converted to kg/ ha. Yield maps are prepared to know the spatial variability of crop performance.

RESULTS AND DISCUSSION

Table 2. Soil chemical properties of the precision farming site in alfisols and vertisols at Bisanahalli

Range	**pH**	**EC**	**OC**	**N**	**P_2O_5**	**K_2O**	**Cu**	**Fe**	**Mn**	**Zn**
		dS/m	**%**	**Kg/ha**			**mg/kg**			
Alfisols										
Minimum	5.66	0.07	0.40	197.0	23.6	150.0	1.88	11.8	1.17	1.00
Maximum	7.32	0.84	1.48	527.0	70.9	387.5	3.26	37.8	19.6	11.17
Mean	6.24	0.16	0.77	309.4	46.0	250.0	2.45	25.1	14.6	2.55
Vertisols										
Minimum	6.12	0.08	0.36	184.8	24.4	137.5	0.66	2.95	0.37	0.28
Maximum	8.44	0.24	1.08	404.8	71.7	350.0	3.45	71.8	10.8	4.34
Mean	7.23	0.13	0.75	304.9	49.7	244.8	1.87	25.4	4.53	1.27

The fertility status of study area in Bisanahalli village revealed that soil reaction tends towards slightly acidic (23.1 ha) and alkaline (27.07 ha) with pH range from 5.66 to 7.32 and 6.12 to 8.44 in alfisols and vertisols, respectively (Fig.1A). The

Table 3. Over all fertility status of alfisols in precision farming site on cotton at Bisanahalli village Taluka Shiggaon

Alfisols	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Class	Number of grids			Percentage		
Low	37	6	1	47.4	7.69	1.28
Medium	41	68	48	52.5	87.18	61.5
High	0	4	29	0.00	5.13	37.1
Total	78	78	78	100.0	100.0	100.0

Table 4. Over all fertility status of vertisols in precision farming site on cotton at Bisanahalli village taluka Shiggaon

Vertisols	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Class	Number of grids			Percentage		
Low	33	32	6	50.0	48.4	9.09
Medium	33	33	37	50.0	50.0	56.0
High	0	1	23	0.00	02.0	34.8
Total	66	66	66	100.0	100.0	100.0

electrical conductivity of both the soils are normal (Table 2 and Fig 1B). Organic carbon content ranged from 0.40 to 1.48 in alfisols and 0.36 to 1.08 per cent in vertisols. However, the organic carbon status of the alfisols is higher than vertisols with an average of 0.74 and 0.68 percent in alfisols and vertisols respectively (Fig 1C). The OC content of majority of the area was under medium (43.64 ha) to higher status (11.48). The organic carbon in the soil depends on application of FYM and crop residues. The organic matter degradation and removal taken place at faster rate coupled with low vegetation cover thereby leaving less changes of accumulation of organic matter in the soil. The available N status in 60 per cent of the grids were low (33.46 ha) and 40 per cent grids were medium (22.38 ha). The available nitrogen content was low in major portion of the study area which might be due to low to medium organic matter content and removal by exhaustive crops like cotton and corn in these soils (Fig 1D). Low vegetation in the area facilitates faster degradation and removal of organic matter leading to nitrogen deficiency. The available N in majority of alfisols was in medium range as compared to low status in Vertisols. The variation in N content may be related to soil management, application of FYM and fertilizer to previous crop. Ashok Kumar (2000) and Nagaraj (2001) observed a similar trend of nutrient status in black soils of North Karnataka. Manna et al. (2005) noticed that balanced application of plant nutrients has been proved to enhance crop yield and organic matter content of the soil.

In contrast the available soil P status was low in only 4 per cent grids when compared to medium in 96 per cent grids (Fig 1E). The alfisols were low in available phosphorus, which may be due to low CEC, low clay content and acidic soil reaction of less than 6.5 (Anon., 2003). Available K status was high in 14 per cent samples, medium in 86 per cent (Fig 1F). Vertisols were higher in available potassium status than alfisols which may be due to predominance of K rich

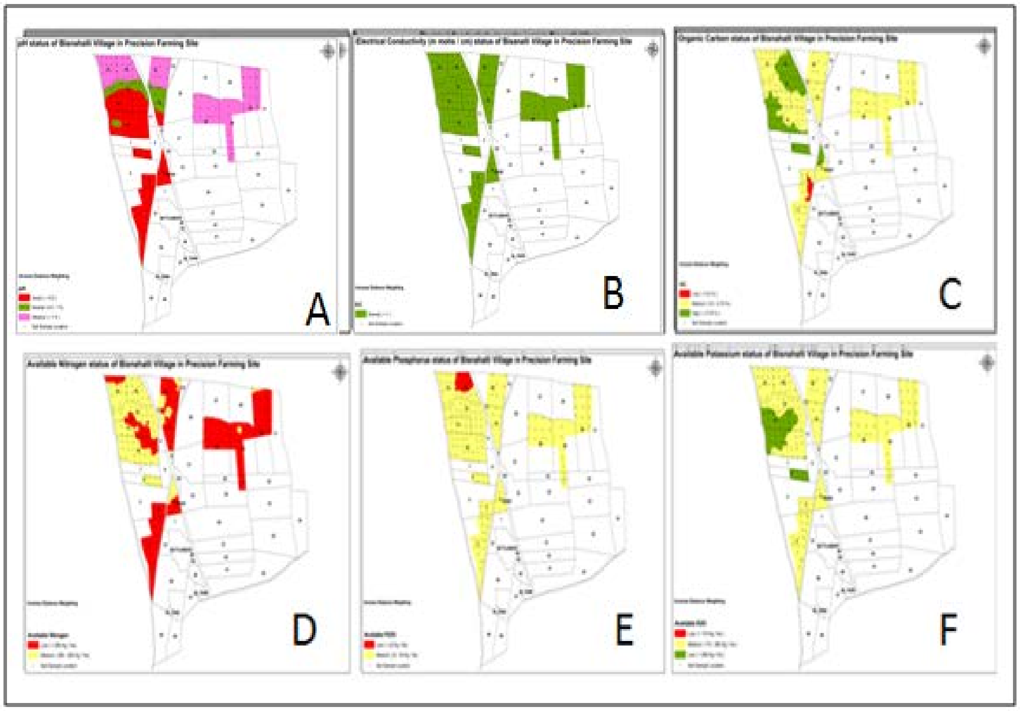

Fig 1. Soil fertility maps of cotton fields at Bisanahalli village generated through GIS for (A) pH status, (B) Electrical conductivity (Ec), (C) Organic carbon (OC%), (D) available nitrogen (N) , (E) Available phosphorus (P), (F) available potassium (K).

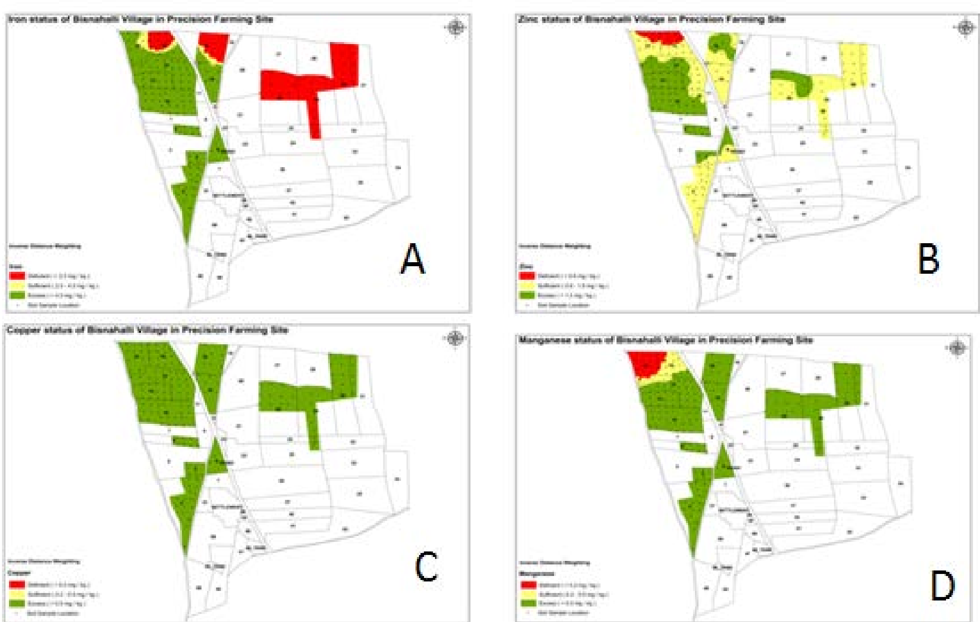

Fig 2. GIS maps of Bisanahalli village for available (A) Iron (B) Zinc (C) Copper (D) Manganese

micaceous and feldspars minerals in parent material. Similar results were observed by Ravikumar et al. (2007a). Major portion of area was under medium and low category of available potassium status in alfisols, because these soils are coarser in texture. Ananthanarayana et al. (1986) reported higher exchangeable K contents in vertisols than alfisols. Available Fe status was high, ranging from 2.9 to 71.83 ppm (Table 3). However, the available Fe in alfisols were sufficient to excess in available Fe (1.92 and 32.97 ha) as compare to deficient in vertisols (20.97 ha) (Fig 2A). Low Fe content in vertisols may be due to precipitation of Fe^{2+} by $CaCO_3$ (Table 3). Similar results were also observed by Ravikumar et al. (2007b). Available Zn ranged from 0.28 to 11.17 ppm (Fig 2B.). The available Zn status in majority of the soil was sufficient and excess (33.35 ha and 20.31 ha respectively as compared to deficient status (2.18 ha). Available Cu ranged from 0.66 to 3.6 mg /kg soil which is normal in both the soils (Fig 2C). Raghupathi (1989) reported that available copper content in North Karnataka soils ranged from 0.4 to 1.2 ppm. Similar results were also observed by Ravikumar et al. (2007b). Available Mn was in the range of 0.26 to 21.25 mg / kg soil (Fig 2D). In vertisols and alfisols soils, the available manganese was found to be sufficient to excess in majority of the study area (3.45 and 48.5 ha, resp.) and deficient in remaining fields (3.80 ha), which may be due to neutral to low pH and nature of the parent material as reported by Prasad and Sahi (1989). Sufficient content of manganese due to high organic matter content was observed in upper Krishna command area (Vijayshekar et al., 2000).

The yield variability varied from 15 to 22.5 q/ha, and 20 to 25 q/ha in alfisols with 20 and 25 quintal targeted grids, respectively (Table 5). Similarly, the yield varied from 18.75 to 27.5 and 20 to 26.25 q/ha in 25 and 30 q/ha targeted yield in vertisols, respectively. The target yield of 20 quintals /ha was achieved in alfisols. However, at higher targeted grids 21.9 q/ha seed cotton yield was achieved against the target of 25 q/ha. This accounts for 87.5 percent of the target fixed. The lesser cotton yield obtained ranged from -6.25 to -25 percent. This could be ascertained to low moisture holding capacity of the alfisols as compared to other fields. Similarly, in Vertisols, the target yield of 25 quintals /ha was achieved in majority of grids with nutrient management based on SSNM concept. However, in other grids, the target yield obtained were -10 to -30 per cent less due to lower water holding capacity of the soil. The target yield of 30 q/ha was not achieved in spite of application of higher nutrients to achieve the target yield of 30 q/ha, The yield reduction from the target yield was -12.5 to 33.3 percent. The higher deviation with higher target yield was mainly due to moisture stress prevailed at the time of boll development and reproductive stage (Table 5).

CONCLUSION

Soil variability exists with respect to soil reaction, Electrical conductivity and organic carbon. This study also clearly shows that the soil spatial variability exists with respect to major, secondary and micro nutrients. The Yield target was achieved with 20 and 25 q /ha under Alfisols and Vertisols, respectively at all the nutrients status for assigned target yield, whereas, it was not achieved for higher targets (25 and 30 q/ha) due to soil moisture constraints. The higher deviation with higher target yield was mainly due to moisture stress prevailed at the time of boll development and reproductive stage. The cotton yield depends on factors other than the nutrients for showing its potentiality like rainfall, pest and disease occurrence etc which needs more attention apart from nutrients.

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Table 5: Cotton Yield obtained in different yield target at Bisnahalli village, Haveri district during *Kharif* 2011

Sl.No	Survey No.	Total yield achieved (q/ha)	Target Yield Fixed (q/ha)	Per cent Deviation
1	2	20	20	0
2	2	15	20	-25
3	2	18.7	20	-6.25
4	4	20	20	0
5	6	20	20	0
6	2	25	25	0
7	3	20	25	-20
8	10	20	25	-20
9	10	20	25	-20
10	12	20	25	-20
11	12	25	25	0
12	13	20	25	-20
13	13	25	25	0
14	14	20	25	-20
15	14	25	25	0
16	15	25	25	0
17	15	25	25	0
18	16	27.5	25	10
19	16	25	25	0
20	18	27.5	25	10
21	18	25	25	0
22	32	18.75	25	-25
23	36	20	25	-20
24	49	20	25	-20
25	50	17.5	25	-30
26	62	22.5	25	-10
27	23	20	30	-33.3
28	24	25	30	-16.6
29	25	20	30	-33.3
30	26	25	30	-16.6
31	28	25	30	-16.6
32	28	20	30	-33.3
33	28	22.5	30	-25
34	29	25	30	-16.6
35	29	25	30	-16.6
36	36	26.25	30	-12.5