Original Research Article

Characterization of Btcotton growing soils producing varying cotton yields in DharwadandHaveri districts of north Karnataka

Abstract

Bt cotton is being cultivated on a wide range of soils in northern transitional zone of Dharwad and Haveri districts in north Karnataka. A field survey was conducted during *kharif*2021-22 to study the physico-chemical properties and nutrients status of**soil**and Bt cotton **productivity.**A total of 153 locations were selected in Dharwad and Haveri districts. Surface soil samples were collected at fifty per cent flowering stage and kapas yield was recorded at first and second picking stages.In the study area, kapas yield ranged from 3.59 to 25.85 q ha^{-1} with a mean value of 15.95 q ha^{-1}.Bulk density, soil porosity, maximum water holding capacity and moisture content at field capacity ranged from 1.12 to 1.70 Mg m^{-3}, 35.85 to 57.74%, 34.08 to 76.27% and 13.63 to 45.76%, respectively. Soils were near neutral to slightly alkaline in reaction (6.60 to 8.80), non-saline (0.15 to 0.82 dS m^{-1}), slightly to moderately high in free lime content (4.10 to 18.40%) and low to high in soil organic carbon (1.50 to 12.60 g kg^{-1}) content.Available nitrogen, phosphorus (P_2O_5), potassium (K_2O) and sulphur contents in soils of cotton fields ranged from 113.06 to 562.82, 10.50 to 89.56, 110.16 to 497.28 kg ha^{-1} and 5.06 to 25.67 mg kg^{-1},respectively.Similarly exchangeable calcium and magnesium contents in soils ranged from 10.10 to 35.24 and 2.98 to 17.01 cmol (p+) kg^{-1}, respectively. DTPA extractable iron and zinc contents and hot water soluble boron content in soils ranged from 1.86 to 9.51, 0.20 to 1.10 and 0.10 to 0.75 mg kg^{-1}, respectively.Nutrient indices showed that soils of the study area were low in available nitrogen, medium in available phosphorus, potassium and sulphur contents. Iron, zinc and available boron contents were deficient in soils.

Key words:*Nutrients indices, Kapas yield, Bt cotton*

1. INTRODUCTION

Cotton often referred to as "White Gold", is the most important commercial crop of our country. It contributes 75 per cent of total raw material needs of the textile industry and plays a key role in the Indian economy. In India, Karnataka is one of the important cotton growing state with an area of 6.91 lakh hectares and production of 18.33 lakh bales and productivity of 451 kg ha^{-1}**(Anon., 2021).**Among the cotton growing districts in Karnataka,Haveri district ranks first and Dharwad district ranks second in the production of cotton. Now **a day's**cultivation of Bt cotton is reducing in north Karnataka owing to low productivity, poor response to nutrients, physiological disorders, erratic rainfall and lastly market rate. One of the major factors limiting cotton production in Haveri and Dharwad districts is lack of suitable nutrients management practices. The dominant soil types in these districts are vertisols, vertic intergrades, mixed red and black soils and shallow red soils. Cotton crop is being grown on these soils under rainfed conditions. Farmers apply varying quantities of different types of fertilizers and adopt management practices to get higher yields. But based on the field survey conducted during 2020-21, the cotton yields are highly varying and in some locations it is very low. Majority of the farmers in these districts apply fertilizers without studying crop requirement and soil testing. Hence there may be short or excess application of some nutrients leading to reduced yields. Nutrients are obtained from the soil and its availability isdependent on various factors including physico-chemical and biological characteristics of the soil. The information on physical and chemical properties of soils enables us to provide essential mineral elements (nutrients) in quantities and proportions for the growth of specified plants **(Brady and Weil, 1999).** Deficiency of a particular nutrient in the soil adversely affects the production of a particular crop. Supply of such nutrient in appropriate quantities may restore the crop production. Continuous cultivation of cotton crop without proper crop rotation may also lead to depletion of nutrients from the soil and may also alter the physio-chemical properties of the soil **(Marathe and Somani, 2011).** Very little information is available regarding the physico-chemical properties and fertility status of Btcotton growing soils of Dharwad and Haveridistricts. Keeping this in view, soil samples were collected from farmer's fields of Dharwad and Haveridistricts during *kharif*2021-22 to characterize the Btcotton growing soils.

2. MATERIAL AND METHODS

A field survey was conducted during *kharif* 2021 (July-August) to know the soil types associated with Bt cotton cultivation and extent of area in Dharwad and Haveri districts. Totally 153locations spread over in seven and six talukas of Dharwad and Haveri districts respectively were selected**.** . Locations were fixed based on soil types, area of the field and distribution oflocations in different talukas. Locations showing samplings sites are presented in **Fig-1.**The surface soil samples (0-20 cm) were collected from all the locations at the time of 50 percent flowering stage (during September 2021).Kapas yield was recorded at first and second picking stages from all the locations by using crop cutting technique with one square meter area.A total of fifteen fully matured bolls and kapas**were**picked from each of the three spots in a field. The kapas obtained from each of the three spots in a field was weighed and converted into quintals per hectare.

The soils samples were analysed for important physical properties,chemical and nutrients status. Standard procedures were adopted for analyzing thesamples was furnished in **Table 1.**

Categorization of soil nutrient status and computation of nutrients indices (NI) for Bt cotton fields

The soils were classified into low, medium and high categories of nutrient status using prescribed soil test ratings for each nutrient as furnished by Jaiswal (2013). For iron, zinc and boron micronutrients, the critical limits adopted were 4.5, 0.6 and 0.5 mg kg^{-1}respectively.

Nutrient index (NI) value refers to the rating of nutrient based on their soil test ratings and critical values. Based on the nutrient index values, the soil fertility is rated as low, medium and high categories. Nutrient index value for each of the nutrient was computed from the proportion of total number of soil samples falling under low, medium and high in available nutrient categories.

The following equation was used to calculate Nutrient Index Value:

$$\textbf{Nutrient Index [NI]} = \frac{1 \times N_L + 2 \times N_M + 3 \times N_H}{N_T}$$

Where, N_L = Number of samples falling in low category of available nutrient status.

N_M = Number of samples falling in medium category of nutrient status.

N_H = Number of samples falling in high category of nutrient status.

N_T = Total number of samples analysed for a nutrient in any given area.

According to Ramamoorthy and Bajaj (1969), nutrient index (NI) value if less than 1.67 indicated low fertility status, between 1.67 to 2.33 as medium and more than 2.33 was rated as high.

3. Results and Discussion

3.1 Kapas yield of cotton crop in the study area

Cotton yield in different locations (153 Nos.) of Dharwad and Haveri districts ranged from 3.59 to 25.85 q ha^{-1} with a mean value of 15.95 q ha^{-1} **(Table 2)**.Kapas yield in ninety seven locations of Dharwad district ranged from 5.63 to 25.85 q ha^{-1} with a mean value of 16.43 q ha^{-1}**(Table 3)**.Kapas yield in fifty six locations of Haveri district ranged from 3.59 to 24.02 q ha^{-1} with a mean value of 15.12 q ha^{-1}**(Table 3)**.

3.2 Soil physical properties of cotton growing fields

In the study area of Dharwad and Haveri districts, bulk density of soils ranged from 1.12 to 1.70 Mg m^{-3} with a mean value of 1.33 Mg m^{-3}. Soil porosity ranged from 35.85 to 57.74 per cent with a mean value of 49.92 per cent and maximum water holding capacity ranged from 34.08 to 76.27 per cent with a mean value of 61.83 per cent. Lastly moisture content at field capacity ranged from 13.63 to 45.76 per cent with a mean value of 34.33 per cent**(Table 5)**.Results of soil physical properties obtained in the study area closely agree with the values reported earlier by **Pulakeshi*et al.* (2012) and Bidari (2000).Pushpalatha (2020)** reported similar values for soils of Dharwad, Gadag and Haveri districts where Byadgichilli crop was grown along with cotton.Daji (1996) reported similar values for deep black and medium black soils of Maharashtra. The values obtained in the present study closely corroborate the findings of Alur (1994) for black and red soils of Koppal in Karnataka.

3.3 Soil chemical properties of cotton growing fields

The range and mean of soil chemical properties are presented in **Table 6.** The soil reaction (pH) ranged from 6.60 to 8.80 with a mean value of 7.78 and total soluble salts content (EC) ranged from 0.15 to 0.82 dS m^{-1} with a mean value of 0.37 dS m^{-1}. Similarly free lime content in soils ranged from 4.10 to 18.40 per cent with a mean value of 10.59 per cent and organic carbon content in soils ranged from 1.50 to 12.60 g kg^{-1} with a mean value of 6.12 g kg^{-1}**.**

Neutral to slightly alkaline pH in soils of the study area was due to dominance of basic cations (Ca, Mg, Na and K) in parent material (Basalt).

Further because of the fine textured nature, there was less leaching and there was accumulation of free lime due to secondary precipitation in these soils.**Bidari (2000)**reported that, majority of the black soils in the study areas where chilli crop was grown recorded neutral to alkaline pH.These soils were non-saline. Low salt content in all these soils was due to leaching of soluble salts because of assured rainfall in zone VIII of Karnataka. **Michael and Ojha (2006)**reported that, soils that were grown with long duration crops like cotton, tobacco, and sugarcane under assured rainfall conditions (transition zone) invariably contain less salt content. This was because of deep root system of t**hese** crops which absorb salts from deeper layers. Hence cotton growing soils were non-saline in nature.The soils were slightly calcareous to moderately calcareous. During the survey of cotton fields, lime nodules were noticed on the black soils. Calcareous natureof soils was due to less water available for leaching and precipitation of carbonates and bicarbonates of calcium from the surface soil. Brundha (2022) reported high free lime content in few soils of Dharwad district as attributed to higher clay content and dominance of exchangeable calcium and magnesium cations.**Daji (1996)**reported that, black soils of peninsular India are invariably calcareous because of high temperature and less precipitation.

Soils were low to high in soil organic carbon content. High organic carbon content in these soils might be due to higher application of organic manures (FYM/compost) by farmers along with previous season left over crop residues. Further high clay content in these black soils might has formed colloidal complex with humus which has led to humic complexes. But in red soils due to less clay content, there might be less humus formation. Futher organic carbon is lost more quickly in red soils than black soils **(Das, 2006).**The values of organic carbon content obtained in the present study closely agree with the values reported earlier by **Pushpalatha (2020) and Bidari (2000).**

3.4 Nutrients status of cotton growing fields

3.4.1 Major nutrients status of cotton growing fields

Data in Table (5) show that theavailable nitrogen content in the**soil study** area ranged from 113.06 to 562.82 kg ha^{-1} with a mean value of 277.25 kg ha^{-1}. Similarly available phosphorus (P_2O_5) content ranged from 10.50 to 89.56 kg ha^{-1} with a mean value of 41.17 kg ha^{-1} and available potassium (K_2O) content ranged from 110.16 to 497.28 kg ha^{-1} with a mean value of 270.82 kg ha^{-1}. Soils were low to medium in available nitrogen content. Low N content in these soils might be due to less application of nitrogenous fertilizers as well as organic. Medium nitrogen content in few soils was due to fine textured nature on account of high clay content, which resulted in less leaching of applied nitrogen compared to other soils. Since the soil samples were collected at peak flowering stage (September) there was rapid absorption of nitrogen from soil by plants for their vegetative growth, flowering and boll formation **(Vasu*et al.*, 2016)**.The available phosphorus content in cotton growing areas was low to high,This might be due to weak organic acids produced in deep black soils during decomposition of organic manures applied by farmers before planting that dissolved native phosphorus present in soils. Further the added complex Pfertilizer mostly DAP in these soils might also contributed to available phosphorous. Generally low phosphorus content in few black soils was due to the presence of excess free calcium carbonate which might has formed $Ca_3(PO_4)_2$ leading to reduction in the availability of phosphorus.Similar results were observed by **Binita*et al.* (2009) and Irappa*et al.* (2016)** in north Karnataka.Soils were medium to high in available potassium content as per the soil test ratings given by Banger and Zende (1978). Higher available potassium in surface layers (0-20 cm) of black soils was due to the dominance of potassium bearing minerals (feldspars and micas) and application of potassic fertilizers to the crop which lead to more of exchangeable potassium in surface soils **(Chahal*et al.*, 1976).**During the survey of cotton fields in the study area, it was noticed that, farmers were applying large quantities of muriate of potash fertilizer to enhance flowering to get higher yields. This might has also contributed for higher available potassium in surface soils. Similar observations on high available potassium content in black soils were **reported Sadhineni*et al.* (2010)** for Kundgol and Hubballitalukas of Dharwad district.

3.4.2 Secondary nutrients status of cotton growing fields

Among secondary nutrients, exchangeable calcium and magnesium contents in soils of cotton fields ranged from 10.10 to 35.24 and 2.98 to 17.01 with mean values of 20.31 and 8.69 cmol (p^+) kg^{-1}, respectively. Lastly available sulphur content ranged from 5.06 to 25.67 mg kg^{-1} with a mean value of 15.30 mg kg^{-1}**(Table 6)**. Exchangeable calcium and magnesium contents in all surveyed samples were high in cotton grown fields. This was due to deep black and medium black soils that were calcareous in nature and also dominance of smectite type of clay minerals present in these soils. Black soils due to high clay content offer more surface area for adsorption of Ca and Mg. Hence there was higher exchangeable Ca and Mg in soils. Das (2006) reported that, in general black soils have more of basic cations particularly Ca and Mg. Majority of the soils were sufficient in available sulphur. High available sulphur in soil might be due to thegypsiferrous nature of black soils as reported by Balasubramanian and Kothandaraman (1985). Similar results were also reported by Bidari (2000) and Srikanth*et al.* (2008).

3.4.3. Micronutrients (Iron, zinc and boron) status of cotton growing fields

Available of iron and zinccontents in soils ranged from 1.86 to 9.51 and 0.20 to 1.10 mg kg^{-1} with mean values of 5.08 and 0.59 mg kg^{-1} respectively. Lastly hot water soluble boron content ranged from 0.10 to 0.75 mg kg^{-1} with a mean value of 0.42 mg kg^{-1}**(Table 5)**. Majority of the cotton fields were having micronutrients deficiency**(Ref).**This was related to the intensive cropping and cultivation of high yielding varieties and hybrids **(Fageria*et al.*, 2002).**Further, high soil pH, calcareous nature and lack of application of micronutrient carriers to the cotton crop by the farmers also contributed for micronutrient deficiency.

Similar observations were made by **Srikanth*et al.* (2008) and Pulakeshi*et al.* (2012)** for soils of northern Karnataka.

3.5 Categorization of soils based on soil test values and nutrients indices in the study area

The number and percentage of soil samples falling in low, medium and high categories for nutrients and the computed values of nutrient indices in the study area are presented in **Table 7.** Out of 153 samples, 28 per cent of the samples (43 Nos.) were low in organic carbon, while 46 and 26 per cent of the samples were in medium (71 Nos.) and high (39 Nos.) categories, respectively. For available nitrogen, 46 per cent of the samples (70 Nos.) were under low category, while 53 and one per cent samples were in medium (82 Nos.) and high (1 Nos.) categories, respectively. In case of available phosphorus, 11 percent of the samples were in low category (17 Nos.) while 69 and 20 per cent of the samples were in medium (106 Nos.) and high (30 Nos.) categories respectively. Likewise for available potassium content, 20 and 26 per cent of the samples were in low (31 Nos.) and high (40 Nos.) categories respectively, whereas 54 per cent of the samples were in medium category (82 Nos.). For available sulphur content, 12, 74 and 14 per cent of the samples were in low (19 Nos.), medium (113 Nos.) and high (21 Nos.) categories respectively. Among micronutrients, for iron 38 and 62 per cent of samples were in deficient (58 Nos.) and sufficient (95 Nos.) categories respectively. Similarly for zinc, 53 and 47 per cent of the samples were in deficient (81 Nos.) and sufficient (72 Nos.)

categories respectively. Lastly for hot water soluble boron content, 79 and 21 per cent of the samples were in deficient (121 Nos.) and sufficient (32 Nos.) categories respectively. Based on the values of nutrient indices, it can be concluded that, soils were low in available nitrogen, medium in soil organic carbon as well as available phosphorus, potassium and sulphur contents. For DTPA extractable iron, zinc and hot water soluble boron contents in soils were low. Similar results were reported by **Pushpalatha (2020) and Bidari (2020)** for chilli crop grown in Dharwad and Haveri districts.

CONCLUSIONS

The cotton growing soils of Dharwad and Haveri districts in north Karnakata were neutral to alkaline in reaction, non-saline in nature, slightly calcareous to moderately calcareous and low to high in soil organic carbon content. Cotton crop is cultivated on a wide range of soils ranging from deep black to medium black and shallow red soils. Nutrient indices indicated that, soils of the study area were low in available nitrogen, medium in soil organic carbon as well as available phosphorus, potassium and sulphur contents. In case of micronutrients, DTPA extractable iron, zinc and available boron contents were low in cotton fields of north Karnataka.

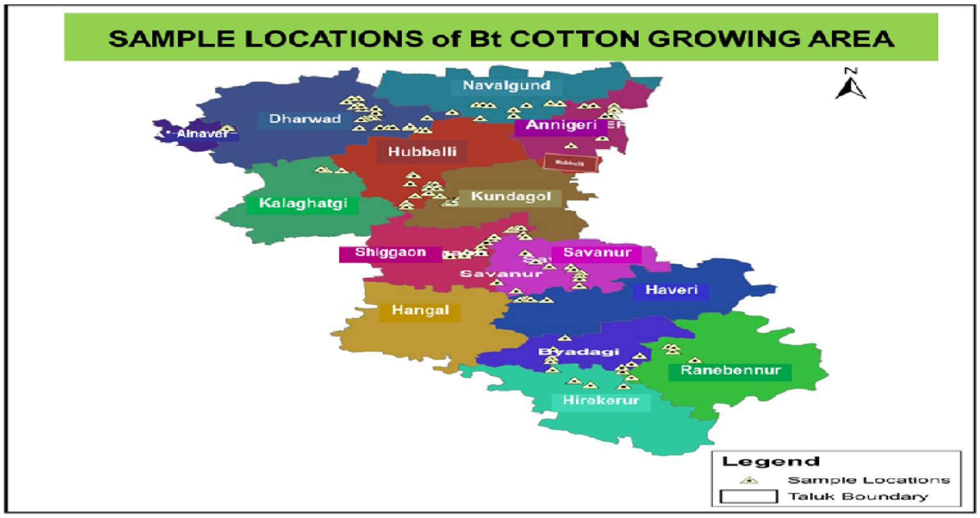

Fig. 1: Locations of sampling sites in the Bt cotton growing area

Table 1. Details of the analytical methods followed for soil analysis

Sl. No.	Properties	Method	Reference
A.	**Physical properties**		
1.	Bulk density (Mg m^{-3})	Clod method	Piper (2002)
2.	Particle density(Mg m^{-3})	Pycnometer method	Piper (2002)
3.	Pore space (%)	By calculation	Piper (2002)
4.	Maximum water holding capacity (%)	Keen Raczkowoski brass cup method	Piper (2002)
B.	**Chemical properties**		
1.	pH (1:2.5 soil water suspension)	Potentiometric method	Piper (2002)
2.	Electrical conductivity (1:2.5 soil water extract)	Conductometric method	Piper (2002)
3.	Organic carbon (g kg^{-1})	Walkley and Black's wet oxidation method	Walkley and Black (1934)
4.	Free lime (%)	Acid-Base neutralization method	Piper (2002)
C.	**Fertility status**		
5	Available nitrogen (kg ha^{-1})	Modified alkaline potassium permanganate method	Shrawat and Burford (1982)
6.	Available phosphorus (kg ha^{-1})	Olsen's method of extraction followed by spectrophotometric method	Jackson (1973)
7.	Available potassium (kg ha^{-1})	Extraction with neutral normal ammonium acetate followed by flame photometric method	Sparks (1996)
8.	Available sulphur(kg ha^{-1})	Extraction with 0.15 % $CaCl_2.2H_2O$ followed by turbidimetric method	Sparks (1996)
9.	Exchangeable Calcium and Magnesium (cmol (p^+) kg^{-1})	Extraction with neutral normal Ammonium acetate followed by complexometric titration using versenate	Piper (2002)
10.	Available Iron and Zinc (mg kg^{-1})	DTPA extraction followed by atomic absorption spectrophotometer method	Lindsay and Norvell (1978)
11	Available boron (mg kg^{-1})	Hot water extraction followed by colorimetric method using Azomethine-H method.	Jaiswal (2013)

Table 2: Range and mean of kapas yield of cotton in the study area

Locations	Yield (q ha^{-1})	
	Range	Mean
Total (n=153)	3.59 – 25.85	15.95

Table 3: Kapas yield of cotton crop in different talukas of Dharwad district

Talukas	No. of locations	Yield (q ha^{-1})	
		Range	Mean
Dharwad	41	5.63 – 25.80	16.22
Hubballi	14	7.88 – 25.85	17.09
Alnavar	4	10.81 – 23.94	18.63
Kalaghatgi	3	13.13 – 22.96	18.90
Kundgol	15	12.18 – 24.84	16.93
Navalgund	15	8.06 – 21.82	14.85
Annigeri	5	10.23 – 19.53	16.32
Total	**97**	**5.63 – 25.85**	**16.43**

Table 4: Kapas yield of cotton crop in different talukas of Haveri district

Talukas	No. of locations	Yield (q ha^{-1})	
		Range	Mean
Shiggaon	15	3.59 – 20.38	12.54
Savanur	12	7.87 – 23.88	16.56
Haveri	10	11.22 – 19.89	15.86
Byadgi	4	7.62 – 20.81	16.05
Hirekerur	5	15.38 – 24.02	18.76
Ranebennur	10	5.73 – 20.40	14.35
Total	**56**	**3.59 – 24.02**	**15.12**

Table 5: Range and mean of soil physical properties of the study area

Soil type	Bulk density (Mg m^{-3})		Porosity (%)		MWHC (%)		Field capacity (%)	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Total (n=153)	1.12 - 1.70	1.33	35.85 - 57.74	49.92	34.08 - 76.27	61.83	13.63 - 45.76	34.33

Table 6: Range and mean of soil chemical properties and nutrients status of the study area

Soil parameters	Range	Mean
pH_w (1:2.5 soil water suspension)	6.60 – 8.80	7.78
EC (dS m^{-1}) (1: 2.5 soil water extract)	0.15 – 0.82	0.37
$CaCO_3$ (%)	4.10 – 18.40	10.59
Organic carbon (g kg^{-1})	1.50 – 12.60	6.12
Available Nitrogen (kg ha^{-1})	113.06 – 562.82	277.25
Available Phosphorus (P_2O_5 kg ha^{-1})	10.50 – 89.56	41.17
Available Potassium (K_2O kg ha^{-1})	110.16 – 497.28	270.82
Exchangeable Calcium [cmol(p+) kg^{-1}]	10.10 – 35.24	20.31
Exchangeable Magnesium [cmol(p+) kg-^{1}]	2.98 – 17.01	8.69
Available Sulphur (mg kg^{-1})	5.06 – 25.67	15.30
DTPA- extractable iron (mg kg^{-1})	1.86 – 9.51	5.08
DTPA- extractable zinc (mg kg^{-1})	0.20 – 1.10	0.59
Available B (mg kg^{-1})	0.10 – 0.75	0.42

Table 7: Classification of soils into low, medium and high categories based on available nutrients ratings and nutrients indices (153 Nos.)

Nutrients	Low	Medium	High	Nutrients index (NI)
Organic carbon	43 (28)	71 (46)	39 (26)	1.97 (M)
Nitrogen	70 (46)	82 (53)	1 (1)	1.55 (L)
Phosphorus	17 (11)	106 (69)	30 (20)	2.08 (M)
Potassium	31 (20)	82 (54)	40 (26)	2.06 (M)
Sulphur	19 (12)	113 (74)	21 (14)	2.01 (M)
Micronutrients				
Nutrients	**Deficient**	**Sufficient**		**Nutrient index (NI)**
Iron	58 (38)	95 (62)		1.62 (L)
Zinc	81 (53)	72 (47)		1.47 (L)
Boron	121 (79)	32 (21)		1.21 (L)

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