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Soil fertility status of Bt cotton cultivated fields in Dharwad district of north Karnataka

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Abstract
This study investigates the soil fertility status of Bt cotton cultivated fields in Dharwad district of north Karnataka. The cultivation of Bt cotton in Dharwad districts involves diverse soil types. This field survey conducted during the *kharif* season of 2021-22 aimed to examine the chemical attributes, nutrient levels of Bt cotton cultivated fields in these region. A total of 97 sites were chosen across Dharwad districts. Soil properties such as pH, electrical conductivity (EC), free lime and organic carbon contents ranged from 6.67 to 8.80, 0.16 to 0.67 dS m^{-1}, 5.56 to 18.49% and 1.50 to 11.56 g kg^{-1} with a mean value of 7.90, 0.38 dS m^{-1}, 11.57% and 6.30 g kg^{-1}, respectively. Among the essential nutrients, available nitrogen, phosphorus (P_2O_5), potassium (K_2O), and sulphur content in cotton fields' soils spanned from 120.56 - 562.82, 12.54 - 85.88, 110.76 - 497.28 kg ha^{-1} and 5.67 - 23.53 mg kg^{-1}, with a mean value of 290.03, 41.41, 291.46 kg ha^{-1} and 15.20 mg kg^{-1}, respectively. Likewise, exchangeable calcium ranged from 10.10 to 35.24 cmol (p+) kg^{-1} and magnesium ranged from 3.36 to 16.44 cmol (p+) kg^{-1}. The average iron and zinc (DTPA extractable) content, as well as available boron contents in soil was 5.05, 0.60 and 0.43 mg kg^{-1}, respectively. The wide range of values observed underscores the need for tailored soil management practices to optimize Bt cotton productivity in this region.

Keywords: Soil fertility, DTPA, Bt cotton, *kharif*

1. Introduction
Bt cotton, a genetically modified variety of cotton that produces its own insecticide, has gained significant attention in agricultural practices due to its potential for improved yield and reduced pest damage. This innovation has led to its cultivation across diverse soil types in various regions, including the northern transitional zone of Karnataka (zone VIII). The soil fertility status of these regions plays a pivotal role in determining the success and sustainability of Bt cotton cultivation (Sowjanya *et al.* 2022) [13].

As Bt cotton continues to be a prominent crop choice for farmers, concerns have emerged about its impact on soil health and fertility. The unique properties of the soil in this region, coupled with the intensive cultivation of Bt cotton, have spurred interest in understanding the chemical attributes, nutrient levels, and overall soil fertility status. This knowledge is essential for designing effective soil management strategies that can optimize Bt cotton productivity while maintaining the long-term health and productivity of the soil.

In response to these concerns and the growing importance of sustainable agricultural practices, a field survey was conducted during the *kharif* season of 2021-22 to comprehensively investigate the soil fertility status of Bt cotton cultivated fields in Dharwad district. This study aimed to assess the variability in soil chemical properties, nutrient content, and Bt cotton productivity across different locations within this district. The findings from this study contribute to the ongoing dialogue about sustainable agricultural practices and provide valuable insights for farmers, researchers, and policymakers striving to strike a balance between productivity and soil health in the context of Bt cotton cultivation.

2. Materials and Methods
A field survey was executed during the *kharif* season of 2021 to examine the soil characteristics linked with the growth of Bt cotton and assess the prevalence of its cultivation within the Dharwad district. A total of 97 locations were chosen, distributed across seven talukas (Dharwad, Hubballi, Alnavar, Kalaghatgi, Kundgol, Navalgund and Annigeri) in Dharwad district. The selection of these locations was based on considerations such as soil types, field area, and even distribution across different talukas.

A visual representation of these sampled locations can be found in Figure 1.

During the field survey, surface soil samples were collected from all 97 locations at a depth of 0-20 cm. This sampling was performed during the fifty percent flowering stage of the Bt cotton plants. Additionally, kapas yield, was recorded twice: once during the first picking stage and again during the second picking stage. The crop cutting technique was employed for this purpose, utilizing a one-square-meter area. The soil samples collected were subjected to analysis of pH, EC, free lime, organic carbon, nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, iron, zinc, and boron contents. These analyses were conducted in accordance with the standard procedure outlined by Jaiswal (2013) [8].

3. Results and Discussion

3.1 Soil chemical properties of the study area

3.1.1 Soil Reaction (pH): The pH levels of the soil ranged from 6.67 to 8.80, with a mean value of 7.90 (Table 1). The soils in the study area exhibit a pH range that is neutral to slightly alkaline. This finding aligns with the observations of Bidari (2000) [2], who reported that the majority of black soils in the Dharwad district exhibit a neutral to alkaline pH.

3.1.2 Total soluble salts content (EC): The investigation unveiled a spectrum of electrical conductivity (EC) measurements, reflecting the content of total soluble salts, which varied from 0.16 to 0.67 dS m^{-1}. The average value, as indicated in Table 1, stood at 0.38 dS m^{-1}. This finding resonates with previous studies Michael and Ojha (2006) [9], Ramamoorthy and Bajaj (1969) [10], and Richards (1954) [11].

3.1.3 Free lime content: The free lime content in the soils exhibited a range from 5.56 to 18.40 percent, with a mean value of 11.57 percent (Table 1). Notably, the calcareous nature of black soils in peninsular India, attributed to the region's high temperatures and limited precipitation, contributes to this phenomenon (Brundha, 2021) [4].

3.1.4 Organic carbon content: The assessment of organic carbon content showcased a span ranging from 1.50 to 11.56 g kg^{-1}, with an average of 6.30 g kg^{-1}, as depicted in Table 1. The variation in soil organic carbon content across the study area ranged from low to high levels. The increased organic carbon content can potentially be attributed to the augmented application of organic manures, by farmers, along with the incorporation of crop residues from preceding seasons. The high clay content in black soils likely facilitated the formation of colloidal complexes with humus, leading to the development of humic complexes. Conversely, in red soils with lower clay content, the formation of humus might be less pronounced. Importantly, organic carbon degradation occurs more rapidly in red soils compared to black soils (Das, 2006) [5].

3.2 Status of Major Nutrients in the Study Area

3.2.1 Available Nitrogen (Av. N): The investigation unveiled a significant spectrum of Av. N content within the study area, ranging from 120.56 to 562.82 kg ha^{-1}. The mean value stood at 290.03 kg ha^{-1}, as presented in Table 2. The soil's available nitrogen content spanned from low to medium levels. This could be attributed to factors such as limited application of nitrogenous fertilizers and organic matter. Soils exhibiting moderate nitrogen content might be linked to their fine-textured composition, which is a consequence of elevated clay content. This characteristic potentially leads to a decreased leaching of applied nitrogen in comparison to other soil varieties. Notably, the soil samples were gathered during flowering stage in September, during which there was swift nitrogen absorption by plants for their developmental phases of growth, flowering, and boll formation. This phenomenon was documented by Vasu *et al.* (2006) [14].

3.2.2 Available Phosphorus (Av. P_2O_5): The average P_2O_5 content displayed a notable range, extending from 12.54 to 85.88 kg ha^{-1}, with an average value of 41.41 kg ha^{-1}. The availability of phosphorus exhibited a spectrum ranging from low to high levels. This variance can be ascribed to the generation of weak organic acids during the breakdown of organic manures, which effectively dissolved the inherent phosphorus within the soils. Furthermore, the utilization of intricate phosphorus-based fertilizers like DAP could have contributed to the available phosphorus content.

In certain instances, the deficiency of phosphorus in black soils might be linked to the presence of excessive free calcium carbonate. This presence could potentially trigger the formation of compounds such as $Ca_3(PO_4)_2$, subsequently diminishing phosphorus accessibility. These observations are consistent with the findings of Binita *et al.* (2009) [3] and Irappa *et al.* (2016) [7].

3.2.3 Available Potassium (Av. K_2O): The Av. K_2O content varied from 110.76 to 497.28 kg $ha^{-1,}$ with an average of 291.46 kg ha^{-1}, as outlined in Table 2. The investigation noted that the soils exhibited a moderate to high availability of potassium content. This trend could be attributed to the prevalence of potassium-rich minerals along with the application of potassium-based fertilizers to the crops. A congruent pattern of findings was observed by Sadhineni *et al.* (2010) [12].

3.3 Status of Secondary Nutrients in the Study Area

3.3.1 Exchangeable Calcium and Magnesium (Exch. Ca and Mg): Regarding secondary nutrients, the soils in the cotton fields displayed a variety in exch. Ca content, ranging from 10.10 to 35.24 cmol (p+) kg^{-1}, and exch. Mg content, ranging from 3.36 to 16.44 cmol (p+) kg^{-1}. The mean values for exch. Ca and Mg were 20.64 and 8.75 cmol (p+) kg^{-1}, respectively (Table 2). The survey revealed high exchangeable calcium and magnesium contents across all sampled locations within cotton fields. This phenomenon can be attributed to the calcareous nature of deep black and medium black soils. It is a well-known fact that black soils, in general, possess higher levels of basic cations, particularly calcium and magnesium (Das, 2006) [5].

3.3.2 Available Sulphur (Av. S): The range of Av. S content extended from 5.67 to 23.53 mg kg^{-1}, with an average of 15.20 mg kg^{-1}, as indicated in Table 2. Most of the examined soils demonstrated adequate availability of sulphur. This elevated availability of sulphur within the soil can be linked to the presence of gypsum-rich components in black soils, contributing to their gypsiferrous nature. This aligns with findings from previous studies (Balasubramanian and Kothandaraman, 1985 and Jaiswal, 2013) [1, 8].

3.4 Status of Micronutrients in the Study Area (Iron, Zinc and Boron)

The DTPA extractable iron and zinc content within the soils exhibited a span from 1.86 to 8.28 mg kg^{-1} and 0.35 to 1.10 mg kg^{-1}, respectively. The average values for DTPA extractable iron and zinc were 5.05 mg kg^{-1} and 0.60 mg kg^{-1}, respectively. Additionally, the content of hot water soluble boron ranged from 0.20 to 0.72 mg kg^{-1}, with an average value of 0.43 mg kg^{-1}, as outlined in Table 2. Indeed, the prevalent observation indicated that most of the cotton fields exhibited micronutrient deficiencies. This can be attributed to several factors. The high soil pH observed in the area, combined with the calcareous nature of the soil, contributes to reduced availability of micronutrients (Fageria *et al.*, 2002) [6].

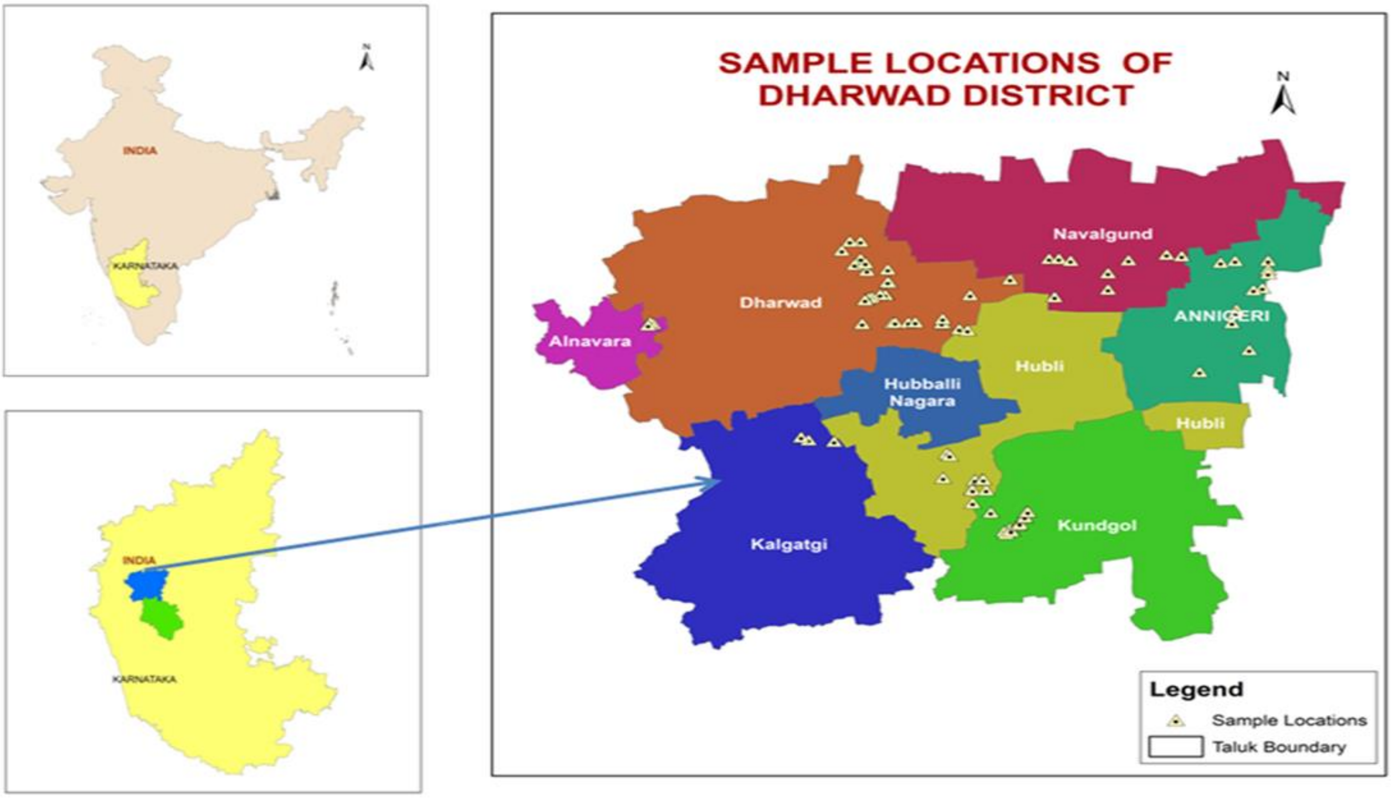

Fig 1: Geographical distribution of sampling sites in the Bt cotton cultivation area

Table 1: Soil chemical properties of the study area

Soil parameters	Range	Mean
pH (1:2.5 soil: water)	6.67 to 8.80	7.90
EC (dS m^{-1}) (1: 2.5 soil: water)	0.16 to 0.67	0.38
$CaCO_3$ (%)	5.56 to 18.49	11.57
Organic carbon (g kg^{-1})	1.50 to 11.56	6.30

Table 2: Soil nutrients status of the study area

Soil parameters	Range	Mean
Avl. Nitrogen (kg ha^{-1})	120.56 to 562.82	290.03
Avl. Phosphorus (kg ha^{-1})	12.54 to 85.88	41.41
Avl. Potassium (kg ha^{-1})	110.76 to 497.28	291.46
Exch. Calcium [cmol(p+) kg^{-1}]	10.10 to 35.24	20.64
Exch. Magnesium [cmol(p+) kg^{-1}]	3.36 to 16.44	8.75
Avl. Sulphur (mg kg^{-1})	5.67 to 23.53	15.20
DTPA extractable iron (mg kg^{-1})	1.86 to 8.28	5.05
DTPA extractable zinc (mg kg^{-1})	0.35 to 1.10	0.60
Avl. B (mg kg^{-1})	0.20 to 0.72	0.43

4. Conclusion

The investigation into the soil chemical properties and nutrients status of the study area revealed that, the soils exhibited a neutral to slightly alkaline pH, non saline, low to high in soil organic carbon, slightly to moderately calcareous, low to medium in available nitrogen, low to high in available phosphorus, medium to high in available potassium contents. Similarly majority of the soils were sufficient in exchangeable calcium and magnesium whereas deficient in micronutrients.

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