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Correlation Studies of Bt Cotton Growing Soils of Kurnool District in Andhra Pradesh

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ABSTRACT

The present investigation was carried out to study the delineation of nutrient status of Bt cotton grown soils under predominant soil orders of different villages in various mandals in Kurnool district of Andhra Pradesh. Based on the status report of scarce rainfall zone, 2001 (Andhra Pradesh), the soils were identified into three predominant orders viz; Alfisols, Inceptisols and Vertisols. The soils were slightly acidic to moderately alkaline in reaction, non saline and medium to high in organic carbon. Regarding the correlation studies, in alfisols, available N was positively and significantly correlated with silt content; available Mg was negatively and significantly correlated with bulk density and EC; available Ca was positively and significantly correlated with $CaCO_3$. However, available B was positively and significantly correlated with clay and bulk density and negatively and significantly correlated with sand content. In inceptisols, available K was negatively and significantly correlated with sand content; available Ca was positively and significantly correlated with clay content; available B was negatively and significantly correlated with EC and $CaCO_3$ and available copper was positively and significantly correlated with pH. Whereas, in vertisols, available N was positively and significantly correlated with bulk density; available Ca was positively and significantly correlated with clay content and pH; and negatively and significantly correlated with sand content. However, vertisols did not show any correlation between micronutrients and physical and physico-chemical properties.

Key words: *Bt cotton, Soil survey, Nutrients, Correlation, Alfisols, Inceptisols, Vertisols, Kurnool district.*

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is one of the most important commercial crops playing a key role in economical, political and social status of the world. Cotton (*Gossypium hirsutum* L.) crop accumulates an average of 36 kg Mg ha^{-1}, 890 g Fe ha^{-1}, 340 g B ha^{-1}, 130 g Zn ha^{-1} and 51 g Cu ha^{-1}. On average, seed within the harvested seed cotton removes 12 kg Mg ha^{-1}, 136 g Fe ha^{-1}, 41 g B ha^{-1}, 96 g Zn ha^{-1} and 20 g Cu ha^{-1}.

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For crops yielding about 1800 kg ha^{-1}, 70 per cent of the Zn and P taken up was removed in the seed, also 38 per cent of Cu, 34 per cent of Mg, 17 per cent of Fe and 12 per cent of B[12]. The black cotton soils are mostly deficient in nitrogen, inorganic phosphorus and organic matter but rich in potash, calcium, magnesium and iron. Cotton on these soils is mostly grown under rainfed conditions. The red soils are light, porous and friable. They are deficient in nitrogen, humus, inorganic phosphorus and lime but rich in iron. The nutrient supply is the second most important limiting factor in cotton production only after water. Most often soils in the rainfed areas are not only thirsty but also hungry. It is a well established fact that adequate quantities of nutrients are needed for achieving high yields. Cotton plant being a heavy feeder, needs proper supply of plant nutrients for its successful cultivation. It showed better response in general to N and P while in particular to K in deficient soil. Hence, adequate supply of fertilizers and manures is essential to sustain high seed cotton yields. Keeping the above aspects and said constraints in view, there is need to scientifically analyse and statistically correlate between soil physical, physico-chemical characteristics and chemical properties of the soils.

MATERIAL AND METHODS

The present investigation "Delineation of nutrient status of Bt cotton grown soils under predominant soil orders of different villages in various mandals in Kurnool district of Andhra Pradesh" was carried out to understand the dynamics of soil nutrients and correlation studies between soil physical, physico-chemical properties with soil nutrients. The survey area in Kurnool district of Andhra Pradesh is located at the East longitude of 76°.58' and 79°.34 ,' North latitude of 14°.54' and 16°.18' on eastern side of peninsular India. The study area is confined to semi-arid monsonic climate with distinct summer, winter and rainy seasons**.** During crop season *i.e.* June, 2010 to March, 2011, the highest mean maximum temperature of 37.60°C was recorded in the month of June, 2010. The lowest absolute mean minimum temperature of 16.00°C was recorded in the month of January.

Based on the status report 2001, scarce rainfall zone, the soils were identified in to three predominant orders *viz,* Alfisols, Inceptisols and Vertisols. From each of the three orders, 30 holdings were selected from which the soil samples were collected at flowering stage (60 DAS). Soil samples were collected at two different depths *viz.,* 0-15 cm and 15-30cm, by covering six locations in the field, and mixed thoroughly, pooled out as one sample (0-30 cm). The samples were air dried and pounded with a wooden hammer and passed through 2 mm sieve and used for particle size distribution All the 90 soil samples were analysed for pH, EC, organic carbon and available K as per the standard procedures[6]. Available N was determined by alkaline permanganate method. The available P was extracted with 0.5M $NaHCO_3$ extractant and was determined by using ascorbic acid as reducing agent and the available K in the soils was extracted by employing neutral normal ammonium acetate and determined by aspirating the extract into the flame photometer[6]. Available Ca and Mg were determined by versenate method[1] whereas available S was determined turbidimetrically using 0.15% $CaCl_2$ extractant[2]. DTPA exctractable Fe, Mn, Zn, Cu and B were determined as per Lindsay and Norvell[7].

The data were subjected to statistical analysis by adopting the simple correlations to find out the extent of relationship between soil physical, physico-chemical characteristics and available soil nutrients, as per the procedure described by Gomez and Gomez[4].

RESULTS AND DISCUSSION

The present investigation was carried out to know the dynamics of soil nutrients at flowering stage of Bt cotton crop varied with different soil orders in relation to soil physical, physico-chemical properties of Bt cotton in the fields of Kurnool district, Andhra Pradesh. The soil analysis was done for important physical, physico-chemical and chemical parameters and correlate the available nutrients with soil physical, physico-chemical characteristics.

Relationship of Available Soil Nutrient elements with Physical Characteristics of soils (Alfisols, Inceptisols and Vertisols)

Simple correlations were worked out in between soil physical characteristics and available soil nutrients in alfisols, inceptisols and vertisols and the correlation coefficients are presented in Tables 1, 2 and 3 respectively. In alfisols, available boron was negatively and significantly (1% level) correlated with sand content(r=-0.452*) (Table 1). However, sand was positively correlated with N, P, K, Ca, S, Fe, Cu and negatively correlated with Mg, Mn and Zn without significant difference between them. Among the soil nutrients studied, available nitrogen was positively and significantly (1% level) correlated with silt content (r=0.393*) (Table 1) whereas available P, Ca, Mg, S, Fe and Cu positively and K, Mn, Zn and B were negatively correlated with silt content but did not show any significance. With respect to clay, available boron was positively and significantly (1% level) correlated with clay content (r=0.373*) (Table 1). Available N, P, K, Ca, S, Fe and Cu had negatively correlated and Mg, Mn and Zn had positively correlated with clay content, without significant differences between them. Available magnesium and copper were negatively and available Mn was positively and significantly correlated (r= -0.407*), (r= -0.378*) and (r= 0.472**) (Table 1) respectively with bulk density of the soil at 1% level, 1% level and5% level respectively. However, bulk density was positively correlated with P, S, Fe, Zn, B and negatively correlated with N, K, and Ca did not show any significant differences with bulk density.

Simple correlations were worked out in inceptisols, between soil physical characteristics and available soil nutrients and presented in Table 2. Among the available nutrients studied, potassium was negatively and significantly correlated with sand content (r=-0.531**) at 5 per cent level of significance (Table 2). Available N, Ca, Mg, Fe, Mn, Zn, Cu and B were negatively correlated and available P, and S positively correlated with sand, but without significant differences among them. There was no significant correlation between the soil available nutrients with silt content. However, soil available N, K, Mg, Fe, Mn, Zn, Cu and B was positively and available P, Ca and S was negatively associated with silt without any significant differences. With respect to clay, available calcium had positive correlation with clay content (r=0.477**) at 5 per cent level of significance (Table 2). However, available P, Fe, Mn, Zn and B showed negative and available N, K, Mg, S and Cu showed positive correlation with clay content without significant differences among them. Bulk density of soil did not show any significant correlation with all the soil available nutrients tested. However, available K, Ca, Mg, Fe, Mn, Zn, and Cu were negatively and N, P, S, and B were positively associated with bulk density of the soil.

With respect to vertisols, among the soil available nutrients, calcium was negatively and significantly correlated with sand content (r=-0.467**) at 5 per cent level of significance (Table 3) and other available soil nutrients did not showed any significant correlation with sand. However, available P, S, Fe, Mn, Zn and B positively and N, K, Mg and B were negatively correlation with sand content. Among the soil available nutrients tested, there was no significant correlation between the available soil nutrients and silt content. Available calcium was positively and significantly correlated with clay content (r=0.440*) at 1 per cent level of significance (Table 3). But available P, S, Fe, Mn, Zn and Cu was negatively and available N, K, Mg and B was positively associated with clay content without any statistical differences among the soil nutrients. Available nitrogen was positively and significantly correlated with bulk density (r= 0.362*) at 1 per cent level of significance (Table 3). However, the available Ca, Mg, S, Mn, Zn and B positively and available P, K, Fe and Cu were negatively correlated with bulk density of the soil without significant difference.

Correlation coefficients between soil physical characteristics and available soil nutrients in alfisols, inceptisols and vertisols brought out the following trends. Available potassium, Calcium and Boron were negatively and significantly correlated with sand content. Mohan Murali[9] and Prasad *et al.*[10] also reported similar relationship between available calcium, magnesium and sand content. The available Nitrogen content in soil was positively and significantly correlated with silt content. Ramesh Kumar[11] reported similar relationship between available Nitrogen and silt content. However, available Calcium and Boron contents in soil were positively and significantly correlated with respect to clay content. Sagare *et al.*[14] also reported similar relationship between available calcium and clay content. This might be attributed to the fact that the Boron content and their forms were higher in fine textured soils than in coarse textured ones[15]. The low available boron content in coarse textured soils might be due to heavy leaching by excessive rain or irrigation as boron is not retained in such soils[16]. The available Nitrogen and Manganese contents in soil were positively and significantly correlated with respect to bulk density[3].

Relationship of Available Soil Nutrient elements with Physico-chemical Characteristics of soils (Alfisols, Inceptisols and Vertisols)

Simple correlations were worked out in between soil physico-chemical characteristics and available soil nutrients in alfisols, inceptisols and vertisols and the correlation coefficients are presented in Table 4, 5 and 6 respectively. In alfisols, the soil pH did not show any significant correlation with all the nutrients but positively correlated with available calcium, sulphur, manganese, zinc, copper and boron and negatively correlated with available nitrogen, phosphorus, potassium, magnesium, and iron (Table 4). There was strong negative correlation between available Mg and electrical conductivity with significant differences between them (r= -0.423*) at 1 per cent level of significance (Table 4). However, the available nitrogen, phosphorus, calcium, sulphur, and copper negatively and potassium, iron, manganese, zinc and boron positively correlated with electrical conductivity without any significance difference. Among the soil available nutrients estimated, available N, P, K, Fe, Mn, Zn and B showed positive and available Ca, Mg, S and Cu negative correlation with organic carbon, but the differences among the available soil nutrients with organic carbon were not traceble statistically (Table 4). Soil calcium was positively and significantly correlated with calcium carbonate content (r= 0.416*) at 1 per cent level of significance (Table 4). However, the rest of the available soil nutrients like P,, Mg, S, Fe, Zn, Cu and B positive and N, K and Mn negative correlation with calcium carbonate content but did not show any significance.

In inceptisols, soil available copper was positively and significantly correlated with soil pH (r= 0.433*) at 1 per cent level of significance (Table 5). There was no significant correlation observed with all the other soil nutrients and soil pH. But positively correlated with available N, P, K, Ca, Mg, Zn and B and negative correlation with S, Fe and Mn. Soil boron was negatively and significantly correlated with electrical conductivity (r= -0.433*) at 1 per cent level of significance (Table 5). Among the available soil nutrients tested. There was no significant correlation observed with all the other soil nutrients and electrical conductivity. However, positive correlation with K, Ca, Mg, Fe, Mn and Zn and negative correlation with N, P, S and Cu. The correlation between organic carbon and available soil nutrients were not statistically traceble, but available N, P, K, Mg, Fe, Cu and B had positive and available Ca, S, Mn and Zn had negative correlation with organic carbon. Among the soil available nutrients tested, soil boron was negatively and significantly correlated with calcium carbonate content (r= -0.462*) at 1 per cent level of significance (Table 5), and rest of the available soil nutrients did not show any correlation with $CaCO_3$.

With respect to vertisols, available soil calcium was positively and significantly correlated with soil pH (r= 0.446*) at 1 per cent level of significance (Table 6), and rest of the available soil nutrients showed no statistically difference with soil pH but positive correlation with available P, Mn and Zn and negative correlation with available N, K, Mg, S, Fe, Cu and B. All the soil available nutrients did not show any significant correlation with electrical conductivity but negatively correlated with Ca, Mg, Zn and B and positively correlated with available N, P, K, S, Fe, Mn and Cu. With respect to organic carbon, all the soil available nutrients did not show any significant correlation with organic carbon (Table 6). However, positive correlation with available major nutrients (N, P and K) and negative correlation with Mg, S, Mn and Zn. There was no significant correlation between available soil nutrients and $CaCO_3$ (Table 6). But positively correlated with available N, S, Mn and B, rest of nutrients negative correlation with $CaCO_3$.

Correlation coefficient between soil physico-chemical characteristics and available soil nutrients in Alfisols, Inceptisols and Vertisols brought out the following trends.The available copper and calcium contents in soil were positively and significantly correlated with soil pH. Similar result was reported by Gopichand *et al.*[5] and Rupa and Shukla[13]. The available boron and Magnesium contents in soil were positively and significantly correlated with EC and all soil nutrients did not showed any significant correlation with EC[8]. Available Zn was did not show any correlation with organic carbon[17]. All the soil nutrients showed no significant correlation with calcium carbonate[8]. The available calcium content in soil was positively and significantly correlated with calcium carbonate and available boron contents in soil wasnegatively and significantly correlated with calcium carbonate. Similar finding was recorded by Sharma *et al.*[15].

Table 1: Correlation coefficients between soil physical characteristics and available soil nutrients in Alfisols

Physical characteristics	Soil Available Nutrients										
	N	P	K	Ca	Mg	S	Fe	Mn	Zn	Cu	B
Sand	0.0318	0.0346	0.0855	0.1600	-0.1386	0.0129	0.0774	-0.1468	-0.1966	0.0741	-0.4524*
Silt	0.3932*	0.1881	-0.0664	0.0276	0.2437	0.3448	0.2965	-0.0481	-0.0953	0.1131	-0.3070
Clay	-0.1407	-0.1511	-0.1486	-0.2676	0.0633	-0.1204	-0.1692	0.1590	0.2092	-0.0844	0.3733*
B.D	-0.1301	0.0722	-0.2092	-0.1999	-0.4076*	0.0592	0.1932	0.4725**	0.2150	-0.3789*	0.2183

* * At 1% level of significance
* At 5% level of significance

Table 2: Correlation coefficients between soil physical characteristics and available soil nutrients in Inceptisols

Physical characteristics	Soil Available Nutrients										
	N	P	K	Ca	Mg	S	Fe	Mn	Zn	Cu	B
Sand	-0.2120	0.2587	-0.5318**	-0.2962	-0.0831	0.1979	-0.0176	-0.1437	-0.0388	-0.2258	-0.1159
Silt	0.1211	-0.0864	0.2253	-0.0896	0.0015	-0.3225	0.2472	0.2000	0.0436	0.0782	0.3135
Clay	0.1081	-0.0551	0.2298	0.4772**	0.0926	0.1050	-0.3402	-0.2391	-0.1854	0.1960	-0.0468
B.D	0.0969	0.0568	-0.2639	-0.0913	-0.3597	0.0799	-0.1240	-0.1625	-0.1484	-0.1118	0.2922

* * At 1% level of significance
* At 5% level of significance

Table 3: Correlation coefficients between soil physical characteristics and available soil nutrients in Vertisols

Physical characteristics	**Soil Available Nutrients**										
	N	**P**	**K**	**Ca**	**Mg**	**S**	**Fe**	**Mn**	**Zn**	**Cu**	**B**
Sand	-0.1924	0.1292	-0.0786	-0.4671**	-0.1079	0.2507	0.2937	0.0031	0.0076	0.3475	-0.2613
Silt	0.2031	-0.0373	-0.2813	-0.3320	-0.1102	0.0555	0.0848	0.0169	0.0297	0.0133	-0.0785
Clay	0.0470	-0.1092	0.2612	0.4406*	0.1136	-0.2005	-0.2561	-0.0297	-0.0160	-0.2368	0.1800
B.D	0.3623*	-0.0543	-0.0030	0.0942	0.1333	0.1992	-0.0769	0.3534	0.0267	-0.1385	0.1168

* * At 1% level of significance
* At 5% level of significance

Table 4: Correlation coefficients between soil physico-chemical characteristics and available soil nutrients in Alfisols

Physico-chemical characteristics	**Soil Available Nutrients**										
	N	**P**	**K**	**Ca**	**Mg**	**S**	**Fe**	**Mn**	**Zn**	**Cu**	**B**
pH	-0.1909	-0.0133	-0.1319	0.1372	-0.1261	0.0964	-0.2351	0.2447	0.0825	0.3043	0.2159
EC	-0.2456	-0.1723	0.1507	-0.1547	-0.4231*	-0.0305	0.3241	0.0973	0.1272	-0.1104	0.1098
OC	0.0469	0.3261	0.1789	-0.0277	-0.0864	-0.1866	0.2816	0.2356	0.0189	-0.0879	0.1067
$CaCO_3$	-0.0945	0.3000	-0.1144	0.4162*	0.2045	0.1878	0.1393	-0.1231	0.1045	0.2884	0.3346

* * At 1% level of significance
* At 5% level of significance

Table 5: Correlation coefficients between soil physico-chemical characteristics and available soil nutrients in Inceptisols

Physico-chemical characteristics	**Soil Available Nutrients**										
	N	P	K	Ca	Mg	S	Fe	Mn	Zn	Cu	B
pH	0.1594	0.2220	0.2942	0.1662	0.2652	-0.1539	-0.0333	-0.1235	0.2475	0.4332*	0.1104
EC	-0.0645	-0.1011	0.1572	0.0003	0.2073	-0.1210	0.2570	0.0235	0.0620	-0.1219	-0.4332*
OC	0.0813	0.1106	0.2092	-0.0245	0.1477	-0.2037	0.1400	-0.0440	-0.1388	0.1463	0.0197
$CaCO_3$	-0.0700	0.0509	0.0006	-0.0265	0.0009	0.1807	0.1407	0.0860	0.0349	-0.2770	-0.4621*

* * At 1% level of significance
* At 5% level of significance

Table 6: Correlation coefficients between soil physico-chemical characteristics and available soil nutrients in Vertisols

Physico-chemical characteristics	**Soil Available Nutrients**										
	N	P	K	Ca	Mg	S	Fe	Mn	Zn	Cu	B
pH	-0.2755	0.0446	-0.1842	0.4466*	-0.0598	-0.2135	-0.1236	0.0839	0.0397	-0.0427	-0.2787
EC	0.1897	0.1699	0.3266	-0.2729	-0.0473	0.0464	0.0765	0.1345	-0.0681	0.0595	-0.0379
OC	0.0320	0.2582	0.1328	0.2856	-0.1318	-0.1475	0.0341	-0.1955	-0.0416	0.1930	0.2343
$CaCO_3$	0.2389	-0.2218	-0.1641	-0.0363	-0.0134	0.1357	-0.0827	0.1743	-0.0828	-0.0095	0.1292

* * At 1% level of significance
* At 5% level of significance

CONCLUSION

Based on correlation studies, the following trends brought out. In alfisols, available N was positively and significantly correlated with silt content. In inceptisols, available K was negatively and significantly correlated with sand content, whereas in vertisols, available N was positively and significantly correlated with bulk density. In alfisols, available Mg was negatively and significantly correlated with bulk density and EC and available Ca was positively and significantly correlated with $CaCO_3$. In inceptisols, available Ca was positively and significantly correlated with clay content and in vertisols, available Ca was positively and significantly correlated with clay content and pH; and negatively and significantly correlated with sand content. In alfisols, available B was positively and significantly correlated with clay and bulk density; and negatively and significantly correlated with sand content. In inceptisols, available B was negatively and significantly correlated with EC and $CaCO_3$; and available copper was positively and significantly correlated with pH. vertisols, did not show any correlation with micronutrients, physical and physico-chemical properties.

Thus, it can be concluded, in case of fibre crop like cotton, more detailed and systematic work needs to be done to fix the critical limits of available nutrient status especially with reference to micronutrients in soil, which is very much essential for preparing balanced fertilizer schedule for different agro-climatic regions. Hence, it can be envisaged that application of organic manures, nitrogenous fertilizers and fertilizers containing boron not only improve the soil fertility but also increase the seed cotton yield of cotton on sustainable basis.

REFERENCES

1. Chopra, S. L. and Kanwar, J. S., Analytical Agricultural Chemistry. Kalyani Publishers. New Delhi.pp. 279 (1991).
2. Cottenie, A., Virloo, M., Velghe, G. and Kiekins, L., Analytical Method for Plants and Soils. State University, Ghent, Belgium (1979).
3. Giridhar, S. A. S. S., Bhanu Prasad, V., SeshagiriRao, M., Pillai, R. N. and HariprasadaRao, K., Trends of nutrient status with depth in red, black and their associated soil profiles of Komarolemandal, (AP). *The Andhra Agricultural Journal*. **45 (3&4):** 206-207 (1998).
4. Gomez, K. A. and Gomez, A. A., Statistical Procedures for Agricultural Research. (2nd Edition). Wiley-Inter SciencePublications, New York (1984).
5. Gopichand, S., Satyanarayana, P. H., Subbarao, A. and Subbaiah, G. V., Available micro nutrient status of representative soils of Andhra Pradesh. *The Andhra Agricultural Journal*. **32:** 210-216 (1985).
6. Jackson, M. L., Soil Chemical Analysis. Oxford and IBH Publishing House. Bombay. pp 38 (1973).
7. Lindsay, W. L. and Norvell, W. A., Development of DTPA soil test for zinc, iron, manganese and copper. *Soil Science Society of America Journal*. **42(3):** 421-428 **(**1978).
8. Moafpouryan, G. R. and Sukla, L. M., Forms of boron in inceptisols of Delhi and their relationships with soil characteristics and sunflower plant parameters. *Journal of the Indian Society of Soil Science*. **52(1):** 109-111 (2004).
9. Mohan Murali, V., Studies on nutrient status of banana growing soils under predominant textural classes of Kadapa and Kurnool districts in Andhra Pradesh. M.Sc (Ag.) thesis. Acharya N.G. Ranga Agricultural University, Hyderabad, India (2004).
10. Prasad, J., Srivastava, N. C. and Mathur, B. S., Available nutrient status of continuously fertilized and cropped acid soil. *Journal of the Indian Society of Soil Science*. **44:** 171-173 (1996).
11. Ramesh Kumar, D., Study of nutrient status of cotton growing areas of Prakasam district. M.Sc. (Ag.) thesis Acharya, N. G., Ranga Agricultural University, Hyderabad, India (1992).
12. Rochester, I., Nutrient uptake and export from an Australian cotton field. *Nutrient Cycling in Agroecosystem*. **77(3):** 213-223 (2007).
13. Rupa, T. R. and Shukla, L. M., Copper fraction in soils of Rayalaseema region of Andhra Pradesh. *Journal of the Indian*

Society of Soil Science. **46:** 301-304 (1998).

14. Sagare, B. N., Rewatkar, S. S. and Babhulkar, V. P., Effect of land configuration and gypsum levels on dynamics of soil properties and productivity of cotton grown in sodicvertisols. *Journal of the Indian Society of Soil Science*. **49(2):** 377-379 (2001).
15. Sharma, R. P., Megh Singh, and Sharma, J. P., Correlation studies on micronutrients vis-à-vis soil properties in some soils of Nagpur district in semi-arid region of Rajasthan. *Journal of the Indian Society of Soil Science*. **51(4):** 522-527 (2003).
16. Singh, K. P. and Sinha, H., Availability of boron in relation to certain soil properties. *Journal of the Indian Society of Soil Science*. **24:** 403-408 (1976).
17. Srinivas, G., Pillai, R. N. and Subbaiah, G. V., Study of nutrient status of cotton growing areas of Guntur district. *The Andhra Agricultural Journal*. **45(1&2):** 100-101 (1998).