International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(5): 1090-1094

Received: 13-07-2019
Accepted: 15-08-2019

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Soil nutrient status and its effect on reddening of cotton in Nanded district of Maharashtra

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Abstract
The study was conducted to know the available nutrient status in soil, nutrient content in leaves and chlorophyll and anthocyanin pigment at square formation stage of cotton in the month of October. Twenty four fields was finalized and forty eight soil samples (0-30 & 30- 60 cm depth) was collected for laboratory analysis at square formation stage of cotton in Nanded district of Maharashtra. Soil fertility status was found low to high and which was found significantly affected by $CaCO_3$ and moisture content in soil at square formation stage. It was found that soil is very low to low in available nitrogen, low to moderately high in available phosphorus, low to very high available potassium, medium to high sulphur, high in magnesium and high in micronutrient except zinc low to medium status in soil. The trace of nutrients dominated by S followed by N, K, Mg, P and Cu at square formation stage creates the trace of nutrients in cotton leaves at square formation stage. This causes reduction in chlorophyll formation and increased the accumulation of anthocyanin pigment, which induce the reddening in cotton as well as reduction in growth and yield of cotton.

Keywords: Available macro- micronutrient, chlorophyll and anthocyanin

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; popularly known as 'White Gold'. Nanded is one of the district of Maharashtra states which, belongs to semi-arid and tropical (hot and dry) region with an average annual rainfall 1150 mm. The soils of Nanded district are basaltic parent material developed from weathering of basaltic parent material of Deccan trap rock which are rich in Ca, Mg and carbonates but poor in N, P, and K. Soil is a medium for plant growth and development that leads to crop productivity. Crop productivity depends on many factors and soil fertility is major amongst all. Soil fertility has a direct relation with the crop yields, provided other factors are in optimum level. Soil fertility must be periodically estimated as there is continuous removal of macro and micro nutrients by the crop intensively grown in every crop season. Due to continuous cropping system for periods without adequate supply of additional amount of nutrients, there is every possibility of deficiencies of essential nutrients in due course of time. The productivity of soil depends equally on its physical, chemical properties and the nutrients status.

Material Method
Geographically Nanded district of Maharashtra state is located in between 18^0 15'to 19^0 57' N Latitude and 77^0 07'to 78^0 15' E Longitude with the total geographic area about 10528 sq. km, meter. The climate of the Nanded district is hot, dry semi-arid and characterized by mild winter and hot summer season which extends up to first week of June. The mean annual rainfall is 875 mm. Out of which 95 percent (829.37 mm) is received during June to September. The length of growing period 149 days and humid period 106 days soils has *Ustic* moisture regime and *Hyper thermic* temperature regime. district was surveyed and representative cotton fields were be selected around adjoining area of already examine seven soil profile (Ghode, 2016) [6]. Twenty four fields were finalized and forty eight soil samples (0-30 & 30- 60 cm depth) were collected at square formation stage in the month of October-November. Collected soil sample was air dried, ground and sieved using to 2 mm sieve. Available nitrogen was determined by method suggested by Subbiah and Asija (1956) [22], whereas phosphorus and potassium was determined by Standard procedure described by

Jackson (1967) [8]. Available sulphur and boron was determined by Spectrophotometer (William and Steinberg, 1969 and Berger and Traug, 1939 respectively) [25, 1]. DTPA extractable micronutrient was determined by AAS (Lindsay and Norvell, 1978) [11]. Anthocyanin and Chlorophyll pigment were estimated by using the standard method (Swain and Hillis, 1959) Statistical analysis physical and chemical properties of soil with yield was done as per the procedure described by Panse and Sukhatme (1985) [15].

Result Discussion

The present investigation was carried out to know the dynamics of soil nutrients at square formation stage of Bt cotton crop varied with different soil orders in relation to leaf tissue concentration, and yield of Bt cotton in the fields of Nanded district, of Maharashtra.

Macronutrient status in soil

Available Nitrogen

The data pertaining to available nitrogen content in soil at square formation stage of cotton in the month of October under cotton growing soils of Nanded district at different soil type was varied from 128.69 to 185.6 kg ha^{-1} at 0-30 cm soil depth, whereas 88.5 to 165.2 kg ha^{-1} at 30-60 cm depth, it was corresponding to very low to low. The availability of nitrogen was found decreased with depth. This might be due to surface application of fertilizers. The maximum available nitrogen (163.2 to 174.1 kg ha^{-1}) was noticed in Typic Haplusterts and minimum (108.5 to 122.7 kg ha^{-1}) was noticed in Typic Ustorthents.

Available Phosphorus

Available phosphorus content under cotton growing soils of Nanded district at square formation stage of cotton was varied from 8.3 to 21.7 kg ha^{-1} at0 – 30 cm soil depth, whereas4.1 to 17.3 kg ha^{-1} at 30 – 60 cm soil depth. This indicate that phosphorus content in studied soil were low to moderately high and it was decreased with depth. The higher available phosphorus (10.7 to 18.5 kg ha^{-1}) was noticed in Calcic Haplusterts and minimum (6.7 to 10.2 kg ha^{-1}) was noticed in Typic Ustorthents.

Available Potassium

Available potassium content under cotton growing soils of Nanded district at square formation stage of cotton was varied from 251.3 to 537.8 kg ha^{-1} at0 – 30 cm soil depth, whereas102.4 to 384.2 kg ha^{-1} at 30 – 60 cm soil depth. This indicate that potassium content in studied soils were low to very high and decreased with soil depth. The higher available potassium (375.4 to 430.5 kg ha^{-1}) was noticed in Calcic Haplusterts (P_{19} to P_{24}) and minimum (180.7 to 203.7 kg ha^{-1}) was noticed in Typic Ustorthents.

Available Magnesium

Available magnesium content under cotton growing soils of Nanded district at square formation stage of cotton was varied from 1116 to 2148 mg kg^{-1} at 0 – 30 cm soil depth, whereas1163 to 2184 mg kg^{-1} at 30 – 60 cm soil depth. This indicate that magnesium content in studied soil was increase with soil depth. This is due to high levels of exchangeable Mg, which are hardly leach in low rainfall region (Brady and Weil, 1999) [2]. The maximum available magnesium (1668 to 2166 mg kg^{-1}) was noticed in Calcic Haplusterts and minimum (1158to 1350 mg kg^{-1}) was noticed in Typic Ustorthents.

Available Sulphur

Available sulphur content under cotton growing soils of Nanded district at square formation stage of cotton was varied from 11.7 to 33.7 mg kg^{-1} at0 – 30 cm soil depth, whereas 11.1 to 24.1 mg kg^{-1} at 30 – 60 cm soil depth. This indicate that sulphur content in studied soil was high in 0-30 cm depth than 30-60 cm depth, this may be due to fertilizer application at surface and it was found medium to high status in soil. The higher available sulphur (22.8 to 26.3 mg kg^{-1}) was noticed in Typic Haplustepts and minimum (15.0 to 16.6 mg kg^{-1}) at Typic Ustorthents (P_{13} to P_{18}).

Available Micro nutrient status in soil:

Available micronutrients (Fe, Mn, Zn, Cu and B) content under cotton growing soils of Nanded district at square formation stage of cotton was varied from 10.0 to 22.8, 7.83 to 19.4, 0.31 to 0.96, 1.46 to 5.81 and 0.26 to 1.33 mg kg^{-1} respectively in0 – 30 cm soil depth, whereas 9.5 to 21.5, 5.47 to 18.8, 0.23 to 0.81, 1.42 to 5.48 and 0.16 to 1.27 mg kg^{-1} respectively in 30 – 60 cm soil depth. This indicate that available micronutrient content in studied soil found to be decrease with soil depth and found high except zinc low to medium status in soil.

Similar result regarding available macro-micronutrient statusin Marathwada region was also reported by Manwar *et al.*(2014), Mane *et al.* (2015) [12], Syamber (2015) [19], Ghode *et al.* (2016) [6].

Relationship between soil nutrient status with reddening of cotton

The positive significant correlation of available N, P, K, Mg and S with chlorophyll pigment at square formation stage was found r = 0.58, -0.42, 0.52, 0.51, and 0.60 respectively, whereas significant negative correlation with anthocyanin pigment r = -0.54, -0.55, -0.57, -0.72, and -0.53 respectively. This indicated that availability of nutrient decreased in soil leading increased the accumulation of anthocyanin pigment in cotton and decreased the chlorophyll content which induce the reddening in cotton leaves.

It was also observed that the Cu content in soil at square formation stage of cotton was significant positively correlated with chlorophyll content in red leaves (r = 0.43) and negatively correlated with anthocyanin pigment (r = -0.64).

Similar result regarding reddening also reported by Edreva *et al.* that red colouring of leaves was due to an anthocyanine accompanied by decrease in chlorophyll content and accumulation of proline in leaves causes reddening. Dhopte *et al.* reported that, leaf reddening was caused by the deficiency of N, P, K and trace elements. Khot *et al.* reported that, the red leaf disease might be due to the deficiency of the nitrogen and magnesium or some other physiological condition.

Conclusion

From the above result it was observed that cotton crop at square formation stage facing the stress of nutrient dominated by sulphur followed by nitrogen, potassium, magnesium, phosphrous and copper, this creates the trace of N, K, Mg, P and Cu in cotton leaves. This causes reduction in chlorophyll formation and increased the accumulation of anthocyanin pigment, which induce the reddening in cotton as well as reduction in growth and yield of cotton.

Table 1: Relationship between soil nutrient status with chlorophyll - anthocyanin pigment in cotton leaves at square formation stage.

Soil nutrient status	Chlorophyll					
	Red leaf			Green leaf		
Depth	**0-30**	**30-60**	**W.M.**	**0-30**	**30-60**	**W.M.**
N	0.50*	0.61*	0.58*	0.42*	0.26	0.34
P	0.44*	0.34	0.42*	0.62*	0.60*	0.66*
K	0.40	0.58*	0.52*	0.44*	0.39	0.44*
Mg	0.48*	0.48*	0.51*	0.49*	0.34	0.35
S	0.66*	0.45*	0.60*	0.12	0.27	0.20
Fe	0.21	0.13	0.17	0.13	0.13	0.13
Mn	-0.42*	-0.43*	-0.43*	-0.24	-0.26	-0.25
Zn	0.34	0.21	0.37	0.08	0.12	0.15
Cu	0.46*	0.38	0.43*	0.23	0.31	0.26
B	0.14	0.31	0.24	-0.15	0.10	-0.03
Soil nutrient status	**Anthocyanin**					
	Red leaf			**Green leaf**		
Depth	**0-30**	**30-60**	**W.M.**	**0-30**	**30-60**	**W.M.**
N	-0.54*****	-0.58*	-0.54*	0.30	0.30	0.31
P	-0.59*	-0.44*	-0.55*	-0.41*	-0.08	-0.26
K	-0.54*	-0.54*	-0.57*	0.31	0.28	0.31
Mg	-0.72*	-0.74*	-0.72*	0.24	0.32	0.32
S	-0.62*	-0.48*	-0.53*	0.00	-0.31	-0.21
Fe	-0.09	-0.08	-0.09	0.36	0.40*	0.39
Mn	0.48*	0.49*	0.49*	-0.51*	-0.47*	-0.49*
Zn	-0.16	-0.15	-0.20	0.00	-0.07	-0.12
Cu	-0.66*	-0.61*	-0.64*	-0.03	-0.02	-0.02
B	-0.13	-0.40	-0.28	0.41*	0.53*	0.50*

**Significant at 5% = 41, * Significant at 1% = 51.

Table 2: Available nutrient status under cotton growing soils of Nanded District Maharashtra

Pedon	Depth (cm)	Available Nutrients (kg ha^{-1})			Mg	S	DTPA extractable (mgkg^{-1})				Available boron
		N	P	K	(mgkg^{-1})		Fe	Mn	Zn	Cu	(mgkg^{-1})
	Adjoining area of Typic Haplustepts: Chenapur										
P1	0-30	164.7	21.7	423.4	1116	27.1	13.7	14.8	0.71	3.81	0.49
	30-60	132.1	14.1	307.1	1488	19.7	11.2	12.4	0.44	3.12	0.38
	W.M.	148.4	17.9	365.2	1302	23.4	12.4	13.6	0.57	3.4	0.43
P2	0-30	161.8	21.7	417.9	1248	29.2	13.3	11.2	0.75	3.78	0.47
	30-60	135.2	14.1	318.7	1356	23.4	10.4	7.4	0.53	3.02	0.38
	W.M.	148.5	17.9	368.3	1302	26.3	11.8	9.3	0.64	3.4	0.42
P3	0-30	159.2	20.7	391.2	1092	33.7	11.9	19.5	0.31	4.13	0.53
	30-60	142.3	13.1	287.4	1176	18.3	11.1	15.5	0.36	3.45	0.40
	W.M.	150.75	16.9	339.3	1134	26	11.5	17.5	0.33	3.79	0.46
Adjoining area of Typic Haplustepts: Pingali											
P4	0-30	133.4	16.3	323.6	1440	30.2	14.7	10.5	0.33	4.48	0.82
	30-60	123.3	4.1	253.3	1776	18.6	12.3	7.3	0.25	3.13	0.64
	W.M.	128.9	10.2	288.4	1608	24.4	13.5	8.9	0.29	3.80	0.73
P5	0-30	132.4	15.1	319.3	1344	29.7	14.2	8.1	0.41	4.23	0.79
	30-60	122.1	5.2	254.1	1644	17.1	11.8	7.1	0.35	3.19	0.63
	W.M.	128.5	10.15	286.7	1494	23.4	13	7.6	0.38	3.71	0.71
P6	0-30	134.3	18.4	338.8	1320	21.6	13.8	9.0	0.38	4.22	0.72
	30-60	123	11.7	230.2	1776	24.1	12.4	7.8	0.30	3.51	0.51
	W.M.	129.6	15.05	284.5	1548	22.8	13.1	8.4	0.34	3.86	0.61
G.M. of. H.epts		138.7	14.7	322.1	1398.0	24.4	12.6	10.9	0.4	3.7	0.6
Adjoining area of Typic Haplustert: Hadsani											
P7	0-30	185.6	13.6	372.8	1776	27.1	14.0	19.4	0.88	5.81	1.17
	30-60	161.3	5.9	319.5	1836	21.9	13.7	16.2	0.51	5.42	0.78
	W.M.	173.4	9.75	346.1	1806	24.5	13.8	17.8	0.69	5.61	0.97
P8	0-30	181.3	13.7	367.2	1776	27.4	14.5	19.2	0.96	5.78	1.21
	30-60	157.0	5.9	307.4	1800	18.6	13.2	17.4	0.44	5.48	1.20
	W.M.	169.1	9.78	337.3	1788	23	13.8	18.3	0.7	5.63	1.20
P9	0-30	176.1	10.3	323.7	1776	30.7	13.8	18.5	0.81	4.38	1.30
	30-60	152.3	6.1	302.2	1836	15.1	11.3	17.1	0.52	3.96	1.16
	W.M.	164.2	8.2	312.9	1806	22.9	12.5	17.8	0.66	4.17	1.23
P10	0-30	172.1	12.5	361.9	1776	28.8	14.4	17.9	0.94	3.38	1.19
	30-60	154.3	8.8	329.2	1800	14.3	10.0	14.9	0.68	3.12	0.86
	W.M.	163.2	10.6	345.5	1788	21.5	12.2	16.4	0.81	3.25	1.02
P11	0-30	184.8	13.5	397.3	1776	31.6	14.0	19.3	0.71	3.71	1.33

	30-60	163.5	7.4	311.6	1836	17.1	12.9	17.9	0.38	3.03	1.27
	W.M.	174.1	10.4	354.4	1806	24.3	13.4	18.6	0.54	3.37	1.30
P12	0-30	181.3	12.8	398.7	1776	31.9	13.8	15.4	0.65	3.78	1.26
	30-60	158.0	7.6	339.8	1800	16.9	12.4	18.8	0.36	3.13	1.22
	W.M.	169.6	10.2	369.2	1788	24.4	13.1	17.1	0.50	3.45	1.24
G.M. of T.H.erts		169.0	9.8	344.3	1797.0	23.5	13.2	17.7	0.7	4.2	1.2
Adjoining area of Typic Ustorthents : Umri											
P13	0-30	138.2	14.0	274.1	1176	18.1	11.3	9.5	0.74	2.18	0.39
	30-60	98.7	6.1	133.4	1188	15.2	10.0	7.8	0.38	2.14	0.31
	W.M.	118.4	10.0	203.7	1182	16.6	10.6	8.7	0.56	2.16	0.35
P14	0-30	136.4	13.3	269.7	1163	18.5	11.5	8.64	0.70	2.31	0.37
	30-60	100.1	7.2	131.9	1163	14.7	11.1	5.96	0.37	2.19	0.30
	W.M.	118.2	10.2	200.8	1166	16.6	11.3	7.3	0.53	2.25	0.33
P15	0-30	136.3	13.6	274.7	1175	17.2	11.2	8.18	0.71	2.24	0.35
	30-60	97.2	6.7	132.2	1178	15.3	10.4	7.02	0.38	2.03	0.23
	W.M.	116.7	10.1	203.4	1176	16.2	10.8	7.6	0.54	2.13	0.29
P16	0-30	128.6	10.6	251.3	1200	18.5	10.0	9.22	0.66	1.87	1.19
	30-60	88.5	4.7	110.6	1236	12.1	9.5	7.58	0.24	1.72	0.27
	W.M.	108.5	7.65	180.9	1218	15.3	9.75	8.4	0.45	1.79	0.73
P17	0-30	134.2	8.3	259.8	1152	17.1	11.3	8.35	0.58	1.61	1.17
	30-60	111.3	5.1	102.4	1164	14.2	10.0	6.85	0.23	1.42	0.23
	W.M.	122.7	6.7	181.1	1158	15.6	10.6	7.6	0.40	1.51	0.70
P18	0-30	133.8	8.8	257.3	1308	16.7	10.2	9.64	0.84	1.68	0.26
	30-60	107.0	4.9	104.1	1392	13.4	10.7	8.96	0.81	1.44	0.16
	W.M.	120.4	6.8	180.7	1350	15.0	10.4	9.3	0.82	1.56	0.21
G.M. of T. U. ents		117.5	8.6	191.8	1207.9	15.9	10.6	8.1	0.6	1.9	0.4
Adjoining area of Calcic Haplusterts : Takali											
P19	0-30	168.8	11.3	476.8	1716	19.6	22.8	9.31	0.71	1.81	0.78
	30-60	153.3	11.2	384.2	1728	13.5	19.6	7.39	0.48	1.72	0.75
	W.M.	161.0	11.2	430.5	1722	16.55	21.2	8.35	0.59	1.76	0.76
P20	0-30	166.4	14.8	469.7	1680	19.4	22.6	7.95	0.72	1.77	0.79
	30-60	156.1	9.1	382.9	1728	14.2	21.5	6.65	0.43	1.68	0.72
	W.M.	161.2	11.9	426.3	1704	16.8	22.0	7.3	0.57	1.72	0.75
P21	0-30	178.5	16.3	473.3	1632	18.1	21.2	9.23	0.65	1.46	0.92
	30-60	165.2	14.0	372.1	1704	12.4	21.0	7.97	0.31	1.44	0.87
	W.M.	171.8	15.15	422.7	1668	15.25	21.1	8.6	0.48	1.45	0.89
Adjoining area of Calcic Haplusterts : Koli											
P22	0-30	168.4	19.7	532.6	2076	14.8	13.6	7.83	0.73	4.41	0.71
	30-60	121.5	17.3	294.3	2100	12.8	13.2	6.27	0.54	4.32	0.63
	W.M.	144.9	18.5	413.4	2088	18.45	13.4	7.05	0.63	4.36	0.67
P23	0-30	165.1	17.1	537.8	2148	16.3	13.4	8.07	0.73	4.62	0.68
	30-60	119.8	16.1	304.4	2184	13.5	14.8	6.13	0.48	4.40	0.66
	W.M.	142.4	16.6	421.1	2166	16.8	14.1	7.1	0.60	4.51	0.67
P24	0-30	153.2	13.6	486.3	1764	11.7	13.9	7.83	0.91	4.94	0.59
	30-60	128.6	13.1	264.5	1896	11.1	15.3	5.47	0.52	3.73	0.57
	W.M.	140.9	13.35	375.4	2166	23.3	14.6	6.65	0.71	4.51	0.58
G.M. of C.erts		153.7	14.5	414.9	1863.0	14.8	17.7	7.5	0.6	4.75	0.7

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