Journal of Pharmacognosy and Phytochemistry
Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(6): 134-137
Received: 24-09-2018
Accepted: 25-10-2018

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Secondary nutrients and chloride content of tobacco growing soils of Prakasam district, Andhra Pradesh

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Abstract
The present study was carried out by collecting 100 representative soil samples from tobacco growing soils of Prakasam district. The soils were found to be neutral to moderately alkaline in reaction. All the soil samples were non-saline. The exchangeable calcium was found to be the most dominant cation followed by magnesium on soil complex which ranged from 3.10 to 35.80, 0.20 to 8.50 cmol (p^+) kg^{-1}, respectively and medium content of sulphur. The average chloride content was 43.85 which varied from 14.20 to 86.00 ppm, which comes under highly suitable and suitable classes for tobacco cultivation. About 89 percent soil samples were highly suitable and remaining 11 percent soil samples were suitable for tobacco cultivation.

Keywords: Tobacco growing soils, Ca, Mg, Sulphur, chloride, suitable

Introduction
Tobacco also called "Golden leaf" is one of the important commercial crops of India being so it is vital to the economy. It provides employment directly and indirectly to 36 millions of people and contributed as much as Rs. 17,854.81 crore as excise duty and Rs. 6,092.86 crore in terms of foreign exchange to the national exchequer, during 2013-2014. Tobacco, a quality conscious commercial crop is grown in the soils of Prakasam district. The tobacco growing area in Prakasam district was 71,593 ha.

Evaluation of fertility status of the soil before tobacco planting is a pre-requisite for optimum fertilizer recommendation to get quality leaf. These properties influence the type, grade and quality of tobacco produced. Among several other factors influencing tobacco productivity, soil fertility and fertilizer use contribute nearly 50 percent of yield and quality improvement (Krishnamurthy and Deosingh, 2002) [9]. The knowledge about the limitations related to soil fertility would help us making accurate fertilizer recommendation to the tobacco farmers. This would also help in increasing the yield of the major crops of the area like tobacco.

Chloride is an important micronutrient for tobacco. It plays an important role in influencing the leaf quality and leaf burn. When present in small quantities (< 1.0%), it improves the yield and certain quality factors like colour, moisture content and keeping quality. Larger amount of chloride (>1.5%) produces cured leaves of muddy and uneven colour with excessive hygroscopicity and poor burning quality (Ravisankar *et al*., 2013) [19].

Keeping all these points in view, the study was conducted in tobacco growing areas covering eight mandals of Prakasam district, Andhra Pradesh. The present investigation is formulated with the following objectives.

Materials and Methods
Survey was conducted in the tobacco growing areas of Prakasam district covering eight mandals during the month of June, 2014 and collected one hundred representative surface soil samples (0-15 cm) from farmer's fields. Soil reaction was determined in 1:2.5 soil water suspension using glass electrode pH meter and the conductivity was estimated using Wheatstone conductivity bridge (Jackson, 1973) [7].

Exchangeable cations were extracted by centrifuge extraction procedure using neutral normal ammonium acetate as described by Bower *et al*. (1952). where as calcium (Ca^{+2}) and magnesium (Mg^{+2}) ions were determined by versanate titration method (Jackson, 1973) [7]. Available sulphur in soil was extracted with 0.15% $CaCl_2$ extractant and turbidity was developed with barium chloride followed by measuring turbidity with spectrophotometer at 420 nm as outlined by Hesse (1971) [6].

Chloride content of the soil was estimated in 1:5 soil: water extract. It depends upon the formation of a sparingly soluble brick-red silver chromate ($AgCrO_4$) precipitate at the end point when the sample is titrated against standard silver nitrate ($AgNO_3$) solution in the presence of potassium chromate as indicator. Initially the chloride ions are precipitated as AgCl and dark brick-red precipitate of Ag_2CrO_4 starts just after the precipitation of AgCl is over (Piper, 1950) [15].

Results and Discussion

The analytical data of soil samples revealed that the pH of studied mandals in Prakasam district ranged from 7.2 to 8.4 with mean of 7.7. These soils were neutral to moderately alkaline in reaction. About 4 percent soil samples were under neutral (6.6-7.3), 70 percent samples were mildly alkaline (7.4-7.8) and remaining 26 percent were under moderately alkaline (7.9-8.4) in reaction according to Brady (2000) [2]. EC of soil samples varied from 0.10 to 0.80 with a mean value of 0.27 dS m^{-1}. All soils were non-saline due to continuous preparatory cultivations and agricultural practices in tobacco growing areas. Similar results were reported by Krishnamurthy *et al*. (2007) [10].

Exchangeable calcium

The average exchangeable calcium content of the soils of Naguluppalapadu mandal ranged from 13.20 to 33.50 with a mean value of 23.19 cmol (p^+) kg^{-1}. In soils of Ongole mandal the exchangeable calcium content ranged from 13.00 to 35.80 with a mean of 26.94 cmol (p^+) kg^{-1}. The mean of exchangeable calcium content was 24.41 which varied from 18.40 to 31.20 cmol (p^+) kg^{-1} in the soils of Santhanuthalapadu mandal. In soils of Tanguturu mandal the discernible ranges of exchangeable calcium content were in between 3.10 and 30.00 with a mean of 14.56 cmol (p^+) kg^{-1}. The observed range of exchangeable calcium content in the soils of Kandukuru mandal was 12.00 to 29.00 with a mean of 19.43 cmol (p^+) kg^{-1}. The exchangeable calcium content varied from 14.10 to 26.00 with a mean of 20.78 cmol (p^+) kg^{-1} in Jarugumalli mandal. In soils of Maddipadu mandal, the exchangeable calcium content ranged from 13.10 to 28.50 with a mean of 18.75 cmol (p^+) kg^{-1}. The soils of Korisapadu mandal showed range and mean of exchangeable calcium content values were 12.80 to 25.20 and 17.99 cmol (p^+) kg^{-1}, respectively.

Exchangeable calcium was found to be the most dominant cation on the exchangeable complex and ranged from 3.10 to 35.80 with mean value of 21.01 cmol (p^+) kg^{-1} in soils of surveyed mandals in Prakasam district. Highest (35.80 cmol (p^+) kg^{-1}) calcium concentration was found in Throvagunta whereas, the lowest (3.10 cmol (p^+) kg^{-1}) of the same was found in case of Turupunaidupalem. The higher calcium content might be due to the fact that Ca^{2+} showed the strongest relationship with all the species, comparing these ions (Ca^{2+}, Mg^{2+}, K^+ and Na^+). It was clear that Mg^{2+} was present in low amount than Ca^{2+} because of its mobility and accumulation of $CaCO_3$ content. These results were evidenced by positive correlation between exchangeable Ca and CEC (r=0.958**) which might be due to strong adsorption of Ca on the soil colloids (Demiss and Beyene, 2010) [3].

Exchangeable magnesium

In soils of Naguluppalapadu mandal, the exchangeable magnesium content ranged from 2.00 to 7.80 with mean value of 3.89 cmol (p^+) kg^{-1}, whereas in soils of Ongole mandal exchangeable magnesium ranged from 1.00 to 6.70 with mean of 3.76 cmol (p^+) kg^{-1}. The exchangeable magnesium content varied from 3.90 to 8.50 with average of 6.11 cmol (p^+) kg^{-1} in soils of Santhanuthalapadu mandal. The average exchangeable magnesium content noticed in soils of Tanguturu mandal was 3.17 which varied from 0.20 to 8.40 cmol (p^+) kg^{-1}.

The mean exchangeable magnesium was 2.77 which ranged from 0.80 to 5.60 cmol (p^+) kg^{-1} in soils of Kandukuru mandal. The soils of Jarugumalli mandal contained exchangeable magnesium that ranged from 1.40 to 5.90 with mean of 4.44 cmol (p^+) kg^{-1}. In soils of Maddipadu mandal, the exchangeable magnesium content varied from 2.50 to 6.20 with mean of 4.18 cmol (p^+) kg^{-1}.The mean of exchangeable magnesium was found in Korisapadu mandal was 3.97 which varied from 2.50 to 5.00 cmol (p^+) kg^{-1}.

Exchangeable magnesium was the second most dominant cation next to exchangeable calcium but higher than exchangeable sodium and exchangeable potassium. In tobacco growing soils of Prakasam district, the values ranged from 0.20 to 8.50 with mean value of 4.05 cmol (p^+) kg^{-1}. Highest (8.50 cmol (p^+) kg^{-1}) exchangeable magnesium was observed in Santhanuthalapadu whereas, lowest (0.20 cmol (p^+) kg^{-1}) was observed in Surareddypalem and Turupunaidupalem. Exchangeable Mg was positively correlated with CEC (r=0.718**), clay (r=0.670**), clay+silt (r=0.592**) which might be due to adsoption on soil colloids. However, adsorption of Mg on soil colloids was less than Ca.

Available Sulphur

The data related to available sulphur content of tobacco growing soils of Prakasam district are presented in table 1.

The sulphur content in soils of Nagulupppalapadu mandal varied from 4.80 to 80.30 with mean of 38.20 mg kg^{-1}. The sulphur content varied from 3.25 to 72.05 with mean of 29.98 mg kg^{-1} in soils of Ongole mandal. The average sulphur content in the soils of Santhanuthalapadu mandal was 17.51 which varied from 2.15 to 32.73 mg kg^{-1}. In soils of Tanguturu mandal the sulphur content ranged from 11.53 to 90.33 with mean of 50.93 mg kg^{-1}.

The sulphur content ranged from 3.35 to 71.03 with average of 34.31 mg kg^{-1} in soils of Kandukuru mandal. In soils of Jarugumalli mandal the discernible ranges of sulphur content were in between 2.13 and 89.30 with a mean of 34.87 mg kg^{-1}. The average sulphur content was 49.05 which ranged from 13.15 to 91.33 mg kg^{-1} in soils of Maddipadu mandal. The sulphur content of soils of Korisapadu mandal ranged from 2.13 to 87.28 with mean of 38.09 mg kg^{-1}.

The range of sulphur content noticed in tobacco growing soils of Prakasam district was 2.13 to 91.33 with mean of 36.48 mg kg^{-1}. Similar results were reported by Jamuna *et al*. (1984) [8] and Ramesh *et al*. (1998) [18]. As per the ratings given by Hariram and Dwivedi (1994) [5], 14 percent soil samples were low, 20 percent soil samples were medium and the remaining 66 percent were high in sulphur.

The nutrient index value of sulphur was 2.52 indicated that the soils under investigation were high in available sulphur content (Ramamoorthy and Bajaj, 1969) [17]. It might be due to application of sulphur containing fertilizers like ammonium sulphate, potassium sulphate, single super phosphate and gypsum. These results were confirmed by Ramesh *et al*. (1998) [18]. Available sulphur content was found to be significantly and positively correlated with organic carbon (r=0.268**) but negatively correlated with pH (r=-0.381**) content. These results were supported by Rai *et al*. (2000) [16].

Table 1: Secondary nutrient status of tobacco growing soils of Prakasam district

S. No	Name of the mandal	Ca^{2+} (cmol (p^+) kg^{-1})		Mg^{2+} (cmol (p^+) kg^{-1})		S (mg kg^{-1})	
		Range	Mean	Range	Mean	Range	Mean
1	Naguluppalapadu	13.20-33.50	23.19	2.00-7.80	3.89	4.80-80.30	38.20
2	Ongole	13.00-35.80	26.94	1.00-6.70	3.76	3.25-72.05	29.98
3	Santhanuthalapadu	18.40-31.20	24.41	3.90-8.50	6.11	2.15-32.73	17.51
4	Tanguturu	3.10-30.00	14.56	0.20-8.40	3.17	11.53-90.33	50.93
5	Kandukuru	12.00-29.00	19.43	0.80-5.60	2.77	3.35-71.03	34.31
6	Jarugumalli	14.10-26.00	20.78	1.40-5.90	4.44	2.13-89.30	34.87
7	Maddipadu	13.10-28.50	18.75	2.50-6.20	4.18	13.15-91.33	49.05
8	Korisapadu	12.80-25.20	7.99	2.50-5.00	3.97	2.13-87.28	38.09
	Overall	3.10-35.80	21.01	0.20-8.50	4.05	2.13-91.33	36.48

Chloride Content

The data related to available chloride content in tobacco growing soils of Prakasam district are presented in Table 2 & 3.

Chloride is one of the essential element for plant growth. It influences the tobacco leaf quality and leaf burn. When present in small quantities, it improves the yield and certain quality factors like colour, moisture content and keeping quality. Larger amount of chloride produces cured leaves of muddy and uneven colour with excessive hygroscopic and poor burning quality (Ravisankar *et al*., 2013) [19].

The average available chloride content of the soils of Naguluppalapadu mandal ranged from 28.40 to 56.80 with a mean value of 38.54 mg kg^{-1}. In soils of Ongole mandal, the chloride content ranged from 14.20 to 86.00 with a mean of 48.60 mg kg^{-1}. The mean of chloride content was 44.97 which varied from 42.60 to 56.80 mg kg^{-1} in the soils of Santhanuthalapadu mandal. In soils of Tanguturu mandal the discernible ranges of chloride content were in between 28.40 and 81.00 with a mean of 60.59 mg kg^{-1}. The observed range of chloride in the soils of Kandukuru mandal was 28.40 to 81.00 with a mean of 44.15 mg kg^{-1}. The chloride content varied from 14.20 to 84.00 with a mean of 50.75 mg kg^{-1} in soils of Jarugumalli mandal. In soils of Maddipadu mandal the chloride content ranged from 14.20 to 42.60 with a mean of 35.50 mg kg^{-1}. The soils of Korisapadu mandal showed range and mean chloride values were 28.40 to 42.60 and 31.95, respectively.

The data with regard to the percentage of chloride content of the soils samples in each mandal and distribution in soils are presented in Table 2.

The average chloride content was 43.85 which varied from 14.20 to 86.00 mg kg^{-1} in study area of Prakasam district. According to Krishnamurthy and Nagarajan (2001) [11], the limits of chloride content were <80 mg kg^{-1} highly suitable, 80 to 100 mg kg^{-1} suitable and >100 mg kg^{-1} unsuitable. Similar ratings were reported by Krishnamurthy *et al*. (1992) [13]. In a similar way, Krishnamurthy *et al*. (1987) [12] estimated chloride content in 1:5 soil water extract by volumetric silver nitrate titration using potassium chromate as an indicator and gave the critical limits as 0.01 percent.

Table 2: chloride content of tobacco growing soils of Prakasam district

S. No	Name of the mandal	Cl^- (ppm)	
		Range	Mean
1	Naguluppalapadu	28.40-56.80	38.54
2	Ongole	14.20-86.00	48.60
3	Santhanuthalapadu	42.60-56.80	44.97
4	Tanguturu	42.60-81.00	60.59
5	Kandukuru	28.40-81.00	44.15
6	Jarugumalli	14.20-84.00	50.75
7	Maddipadu	14.20-42.60	35.5
8	Korisapadu	28.40-42.60	31.95
	Overall	14.20-86.00	43.85

As per the ratings given by Krishnamurthy and Nagarajan (2001) [11], 89 percent soils of the study area samples were highly suitable and remaining 11 percent samples were suitable for tobacco cultivation. As per the above data the water soluble chloride content in the tobacco growing soils of Prakasam district was not much. It was attributed to application of potassium fertilizers in the form of sulfate of potash instead of muriate of potash (KCl). The other reason was due to continuous preparatory cultivation, the mobile chloride ions were moved from surface to deeper layers of soils. The other reason could be due to addition of manures resulted in solubilization of chloride composition and mobilized and enhance the movement of chloride ions from surface to deeper layers. So the chloride content was less in the soils. The caution for tobacco growers was to apply good quality organic manures (without chloride content) (Nichols *et al*. 1962) [14]. The results of the study area indicated the suitability of these soils for tobacco cultivation. EC values showed that the gradient tend to increase as the chloride concentration increased, which might be evidenced by the significant positive correlation (r=0.692**) between electrical conductivity and chloride content of soil. Similar results were reported by Guevara *et al*. (2012) [4].

Table 3: Soil test summary for chloride content of tobacco growing soils of Prakasam district

S. No	Name of the mandal	No. of samples	Highly suitable (<80 ppm)		Suitable (80-100 ppm)		Unsuitable (>100 ppm)	
			Number	Percent	Number	Percent	Number	Percent
1	Naguluppalapadu	14	14	100.00	-	-	-	-
2	Ongole	14	12	85.71	2	14.29	-	-
3	Santhanuthalapadu	12	12	100.00	-	-	-	-
4	Tanguturu	10	6	60.00	4	40.00	-	-
5	Kandukuru	12	10	83.33	2	16.67	-	-
6	Jarugumalli	12	9	75.00	3	25.00	-	-
7	Maddipadu	14	14	100.00	-	-	-	-
8	Korisapadu	12	12	100.00	-	-	-	-
	Total	100	-		-	-	-	-
	Overall		89.00		11.00		-	-

Conclusions

The exchangeable calcium was found to be the most dominant cation followed by magnesium on soil complex with mean values of 21.01 and 4.05 cmol (p^+) kg^{-1}, respectively. The range of available sulphur content in soils was 2.13 to 91.33 with mean of 36.48 ppm and medium in content.

The chloride content fluctuated between 14.20 and 86.00 with an average value of 43.85 ppm, indicating the suitability of soils for tobacco cultivation. Chloride is one of the essential element for plant growth. It influences the tobacco leaf quality and leaf burn. When present in small quantities, it improves the yield and certain quality factors like colour, moisture content and keeping quality. Larger amount of chloride produces cured leaves of muddy and uneven colour with excessive hygroscopic and poor burning quality.

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