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Distribution of Various Forms of Phosphorus in Flue-cured Tobacco Grown Soils of Khammam District in Andhra Pradesh

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Phosphorus fractionation studies in Flue-cured Virginia (FCV) tobacco growing areas of Khammam district revealed that a wide variation exists in concentration of different P- fractions in the three major soil groups. Saloid bound–P was less in Aswaraopet, Malkaram and E. Bayyaram soils, while Al-P is high in E. Bayyaram and Narsapuram soils where Al-P varied from 45-499 mg kg^{-1}. The Fe-P ranged from 6.2-47.9 mg $kg^{-1}$and was high in E. Bayyaram soils. Among all the fractions studied, Fe-P was the lowest in all the tobacco soils of the district. The calcium–P varied from 6.9-438.2 mg kg^{-1} which was very low in Aswaraopet, Malkaram and E. Bayyaram red soils. The reductant soluble P or R-P varied from 31-644 mg $kg^{-1}$and it was low in Aswaraopet and Malkaram soils, whereas it was highest in Kunavaram soils. The total P concentration in Khammam soils varied between 91 to 1487 mg kg^{-1}. It was observed that the total P content was low in Aswaraopet and Malkaram. In contrast, the total P content was high in Narasapuram, Kunavaram and Velerupadu. Available P status ranged from 2.81 mg kg^{-1} in Ananthapuram soils to 42.2 mg kg^{-1} in Narsapuram soils. Significant positive correlation was observed between pH and S-P, Ca-P and R-P. Silt content of soil showed significant positive relation with total-P. Significant positive relation was observed between S-P, Ca-P and total-P. As there was no significant response to phosphorus application in high P soils, requirement of phosphorus being low (4-6 kg ha^{-1}) for a yield level of 1600-1800 kg ha^{-1}, phosphorus application can be minimized for FCV tobacco wherever soils are high in phosphorus content in Khammam district.

*(**Key words** : P- fractions, Flue-cured tobacco soils, Saloid–P, Ca-P, Al-P, Fe-P, Total P)*

In India, Flue-cured Virginia (FCV) tobacco is cultivated in 1,50,000 ha area generating revenue to the tune of Rs. 9,000 crores as central exercise and Rs. 1100 crores as foreign exchange to the national exchequer. Among different districts growing FCV tobacco in Andhra Pradesh, Khammam district occupies a place of prominence with 2900 ha area under this crop with an annual production of 4.0 million kg leaf, most of which is used for the manufacture of cigarettes. In this district, FCV tobacco is cultivated in a wide variety of soils ranging in texture from sands, sandy loams, sandy clay loams, silt loams and heavy black clays.

Among the major nutrients phosphorus plays an important role in the improvement of yield and quality of FCV tobacco. It is reported that phosphorus hastens root growth, establishment of roots, crop maturity besides promoting the FCV tobacco yield (TSO, 1970). However, P requirement of flue-cured tobacco is low and only 10% of applied P is recovered by the crop (Russel, 1953). Phosphorus content in the leaf ranges from 0.2-0.4% and the uptake varies from 8-10 kg P ha^{-1} under Indian conditions (Krishnamurthy *et al.*, 2001, 2004). But, it is a well established fact that soils differ in their ability to supply phosphorus to the plant. In soils, phosphorus exists in different forms and these forms differ from one soil to another. Further, plants have affinity for specific P fraction for absorption from the soil (Tarafdar *et al.*, 2006). Since scanty information is available on different fractions of phosphorus and their interrelationship in FCV tobacco soils of Khammam district in Andhra Pradesh, the present investigation has been undertaken.

MATERIALS AND METHODS

Twenty-seven surface soil samples from 0-22.5 cm depth were collected from different locations in Khammam district where FCV tobacco is grown. These soil samples were processed and analysed for sand, silt and clay contents (Piper, 1966), soil reaction, electrical conductivity (Jackson, 1967), 0.03N NH_4F + 0.025N HCl-P (Bray and Kurtz, 1945), 0.5M $NaHCO_3$-P (Olsen *et al.*, 1954). Total P was determined by the fusion method and fractionations of inorganic P, *viz.* Saloid-P (IN NH_4Cl), Al-P (0.5N NH_4F), Fe-P (0.1N NaOH), Ca-P (0.5N H_2SO_4), R-P (0.3M Sodium citrate and Sodium dithionate) were done by the method of Chang and Jackson (1957),

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Table 1. *Physicochemical properties of FCV tobacco soils of Khammam district, Andhra Pradesh (0-22.5 cm)*

Location / Village	pH	EC (dSm^{-1})	Coarse Sand (%)	Fine Sand (%)	Silt (%)	Clay (%)	Textural class	Available P (ppm)	Total P (ppm)
Vinayakapuram	6.9	0.11	73.95	20.39	1.58	4.08	Sand	5.63	211
Aswaraopet	6.0	0.08	74.68	21.58	1.20	2.54	Sand	8.51	291
Ananthapuram	7.1	0.09	87.08	10.81	1.97	0.14	Sand	2.81	91
Guthavari Gudem	4.8	0.08	84.92	12.69	2.75	0.14	Sand	37.2	415
Malkaram	5.7	0.07	73.07	21.70	2.19	3.05	Sand	23.7	216
Vasanthavada	6.4	0.12	60.06	30.31	2.77	6.86	Sand	40.2	712
Kunavaram	8.1	0.19	3.23	79.91	7.96	8.90	Loamy Sand	9.20	1114
Bhudevipeta	7.1	0.35	35.24	43.79	5.61	15.36	Loamy Sand	3.20	716
Narsapuram	8.1	0.21	18.82	56.8	10.73	13.65	Sandy Loam	13.6	984
Kothavinjaram	7.9	0.21	46.74	29.51	8.40	15.35	Sandy Loam	9.7	736
Venkatapuram	8.1	0.19	24.21	54.24	11.31	10.24	Sandy Loam	18.3	942
N.P.Banjar	7.9	0.15	24.12	52.75	4.84	18.29	Sandy Loam	15.9	1135
Pathrapuram	8.0	0.16	0.91	56.76	19.25	23.08	Loam	22.2	1404
V R Puram	7.8	0.22	15.17	45.79	18.31	20.73	Loam	17.0	1162
Velerupadu	7.7	0.58	0.46	68.84	13.67	17.03	Loam	10.5	1220
Alligudem	8.1	0.20	0.584	50.13	20.89	28.44	Clay Loam	9.2	1309
Thumpaka	8.0	0.17	7.18	40.28	22.69	29.85	Clay Loam	11.9	1161
N.P. Banjar	7.9	0.20	8.97	49.22	16.18	25.63	Clay Loam	17.6	1157
E. Bayyaram	7.8	0.19	4.16	42.92	20.30	32.62	Clay Loam	17.7	1202
Vaddigudem	8.2	0.25	16.07	38.03	21.06	24.84	Clay Loam	5.4	955
Narsapuram	7.6	0.28	8.48	47.54	15.57	28.41	Clay Loam	42.2	1433
Badrachalam	7.7	0.26	6.77	40.08	25.89	27.26	Silty clay loam	10.6	1249
Velerupadu	8.0	0.22	1.04	22.89	39.65	36.42	Silty clay loam	6.7	1487
Kunavaram	8.1	0.19	1.61	33.69	32.89	31.81	Silty clay loam	18.9	1448
Amaravaram	7.9	0.22	30.33	30.33	32.57	34.81	Silty clay loam	10.7	1406
E. Bayyaram	6.7	0.19	3.91	26.02	17.90	52.17	Clay	12.3	1113
Kukunur	7.9	0.18	13.67	27.36	10.80	48.17	Clay	18.3	1333

Table 2. *Phosphorus fractions in FCV tobacco soils of Khammam district (0-22.5 cm)*

Location	Fractions of phosphorus in surface soil ($mgkg^{-1}$)				
	S-P	Al-P	Fe-P	Ca-P	R-P
Aswaraopet	28.3	54.7	12.0	6.9	31.0
Malkaram	31.2	74.0	11.6	25.0	31.0
Kunavaram	61.3	112.0	11.8	366.4	358
Kothavinjaram	69.6	45.0	9.0	45.6	345
N.P. Banjar	52.8	168.0	11.5	438.2	375
Velerupadu	64.7	83.6	7.7	386.3	365
Alligudem	64.7	62.7	7.5	336.0	568
E. Bayyaram	77.4	499.0	11.4	181.5	331
Narsapuram	61.2	247.0	41.6	420.0	387
Badrachalam	62.2	64.1	6.4	257.0	526
Kunavaram	78.4	66.1	6.2	325.0	644
E. Bayyaram	13.5	68.7	47.9	39.4	585

Table 3. Correlation matrix for soil P-fractions and soil properties

	pH	EC	S-P	Al-P	Fe-P	Ca-P	R-P	Sand	Silt	Clay	Available P	Total P
pH	1.0	0.436	0.831**	0.221	-0.249	0.723**	0.697*	-0.432	0.528	0.109	-0.085	0.819**
EC		1.0	0.403	0.003	-0.057	0.502	0.304	-0.208	0.272	0.113	-0.021	0.499
S-P			1.0	0.355	-0.521	0.572*	0.383	-0.240	0.500	0.105	0.068	0.585*
Al-P				1.0	0.13	0.181	-0.06	-0.204	0.121	-0.152	0.406	0.283
Fe-P					1.0	-0.108	0.159	-0.347	-0.005	-0.192	0.501	0.157
Ca-P						1.0	0.463	-0.205	0.311	0.042	0.253	0.763**
R-P							1.0	-0.871**	0.831**	0.250	-0.065	0.862**
Sand								1.0	-0.899**	-0.252	-0.108	-0.763**
Silt									1.0	0.384	0.064	0.760**
Clay										1.0	-0.164	0.173
Available P											1.0	0.189
Total P												1.0

*, ** Significant at p = 0.05 and 0.01 levels, respectively

which was later modified by Peterson and Corey (1966). An attempt was also made to correlate soil P fractions with the soil properties.

RESULTS AND DISCUSSION

Soil analysis data revealed that the soils were acidic to alkaline in soil reaction (pH 4.8-8.2) and the EC values ranged from 0.07 to 0.58 dSm^{-1} indicating the suitability of these soils for FCV tobacco cultivation (Krishnamurthy *et al.*, 1999). Textural composition varied from sand to clay (Table 1). Total P content ranged from 91-1487 mg $kg^{-1}$and the lowest P content was found in sandy soils of Ananthapuram village where soils were sandy while the highest P content was found in the black soil of Velerupadu (Table 1) where soils were silty clay loam in nature. However, the available P content of the soils varied from 2.81 to 48.2 mg kg^{-1}. Phosphorus application can be minimized wherever soils have high amount of available and total P content because of the low requirement of phosphorus (4-6 kg ha^{-1}) for tobacco (Rao and Rao, 1993), due to not non-significant response of tobacco to phosphorus application in light textured red soils (Alfisols), and also in case of heavy textured black soils (vertisols) where soil available phosphorus was high (Rao *et al.*, 2001, Reddy *et al.*, 2000).

Among the 27 soil samples, 12 soil samples were which are different in texture were selected and were estimated for P fractionation studies. Data on soil P fractions showed these soils varied widely in their content of different P fractions (Table 2). Saloid bound P ranged from 13.5 to 78.4 mg kg^{-1}, was less in Aswaraopeta, Malkaram and E. Bayyaram red soils. Aluminum bound P ranged from 45 to 499 mg kg^{-1}, was high in E. Bayyaram and Narsapuram red soils. Among all the P fractions studied, the content of iron bound P was the lowest which varied from 6.2-48.0 mg kg^{-1}, the highest content found in E. Bayyaram soils (Table 2). Calcium bound P ranged from 6.9 to 438.2 mg kg^{-1}, was low in Aswaraopeta and Malkaram light soil villages where the soils were sandy and acidic. In contrast, the reductant soluble P (R-P) varied from 31.0 to 644 mg kg^{-1} which was low in Aswaraopeta and Malkaram red soils, while it was high in E. Bayyaram soils.

Correlation matrix was prepared to study the interrelationship of phosphorus fractions with soil properties (Table 3). Significant positive correlation was observed between pH and S-P, Ca-P, R-P and Total-P. Silt content of soil showed significant positive relation with Total-P. Significant positive

relation was observed between S-P, Ca-P and Total-P. Total-P showed significant positive correlation with Ca-P and R-P which occupied the major share in Total-P. Similar results of significant positive relation among the soil P fractions and also with soil properties were reported by Patgiri and Dutta, 1993, Sood *et al.*, 1991, Pritam *et al.*, 1992.

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