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Short Communication

Quantity–Intensity Relationships of Potassium in Flue-cured Virginia Tobacco Soils of Khammam District, Andhra Pradesh

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In India, flue-cured virginia tobacco (FCV) is cultivated in about 2 lakh ha contributing Rs 8,000 crores to central excise and Rs 1,000 crores to the foreign exchange. Among the different zones of FCV tobacco production, Khammam district of Andhra Pradesh occupies the place of prominence with 5,000 ha of area under the crop, producing annually about 5.0 million kg leaf. Among the major nutrients of importance to FCV tobacco, potassium plays an important role in yield and leaf quality. Quantity (Q), Intensity (I) and buffering capacity parameters determine the K supplying power of the soils (Beckett 1964) for assessing its availability to the growing plants. In this approach, immediate availability of the potassium is related to intensity factor, reserve of non-exchangeable potassium to the quantity factor and the replenishment capacity to the potassium buffering capacity. Considering the importance of potassium to the tobacco production and quality, an attempt was made to study the quantity-intensity parameters of potassium in the FCV tobacco soils of Khammam district, Andhra Pradesh for rational potassium fertilization.

Twenty-seven surface samples (0-0.225 m) were collected from major soil groups of FCV tobacco in Khammam district where FCV tobacco is predominantly grown. Soil separates, pH, EC, and various forms of potassium viz., water soluble K, exchangeable-K, non-exchangeable-K and total K were determined following the standard methods (Table 1). Quantity and intensity parameters of soil potassium were measured (Beckett 1964) in eight selected soil samples showing the textural variation (Table 2). Five grams of each soil was equilibrated with 50 mL of 0.01 M $CaCl_2$ solution containing graded concentrations of (0, 5, 10, 20, 40, 80, 100, 150, 200, 250, 400 mg K L^{-1}) of potassium. The soil suspension was shaken on a horizontal shaker for one hour and allowed to stand overnight. The suspension was filtered, the equilibrium solution and also the original solution were analysed for potassium, calcium and magnesium following the standard methods. The loss or the gain of potassium (ΔK) in the equilibrated samples was obtained from the difference between K added and extracted, concentrations of the K gained or lost were plotted against activity ratio (AR) which was calculated from the equation: $AR^K = a_K/\sqrt{a_{(Ca+Mg)}}$ where all the concentrations are expressed as mol L^{-1} in the equilibrium solution. The AR^K values for all the solution K concentrations of each soil were plotted against $\pm\Delta K$ to obtain the Q/I curve.

The parameters obtained from the Q-I curves were:

K_O (cmol kg^{-1}): Obtained by drawing a tangent on Q/I curve from the point of AR^K where $\Delta K = 0$.

K_L (cmol kg^{-1}): Labile K, by extrapolating Q/I curve where it intercepts on the X axis.

K_X (cmol kg^{-1}): The difference between $K_L - K_O$ which is specifically adsorbed K

AR^K_O: where AR^K is neither gained nor lost. *i.e.* $\Delta K = 0$

PBC^K (cmol kg^{-1}): Potential buffering capacity was computed from the slope of the linear portion of the curve: $\Delta K / \Delta AR^K_0$

Results from the present study reveal that the soil texture in Khammam district varied from sand to clay (Table 1). Light textured soils (sand, sandy loam and loamy sand) are highly suitable for production of good quality FCV tobacco under irrigated conditions. Soils are slightly acidic to alkaline (pH 4.8 to 8.2). Electrical conductivity values (1:2 soil : water suspension) ranged from 0.07 to 0.58 dS m^{-1}, which shows that except Velerupadu all other soils are suitable (<0.40 dS m^{-1}) for tobacco production

(Krishnamurthy and Deo Singh 2002.). The water soluble-K, exchangeable-K, non-exchangeable –K and total K varied from 11.3 to 46.2, 10.2 to 358.9, 95 to 1806 and 1959 to 28520 mg kg^{-1} respectively which shows that there is wide variation in the potassium fractions in the Khammam soils. Water soluble potassium in Vasanthavada and Kunavaram was high compared to Vaddigudem and Amaravaram indicating that these soils will have higher readily available potassium. In general, the exchangeable potassium values increased as the texture tended to change to clay from sand.

Quantity-intensity relationships revealed that equilibrium activity ratio (AR^K_o), where the soil neither gains or losses K i.e. $\Delta K = 0$ which is a measure of intensity of available potassium, ranged from 1.6 to 10.0 (Table 2). The AR^K_o values were more in Vasanthavada, Kunavaram, Narsapuram, N.P.Banjar where soils are coarse textured with low clay content. Significant correlation of silt with AR^K_o values has been reported by Joshi (1992). Higher AR^K_o values in the light textured soils is due to higher ionic activity of potassium in comparison to calcium and magnesium in soil solution (Sharma and Mishra

Table 1. Forms of potassium in Khammam soils of Andhra Pradesh

Location / Village	pH	EC ($dS\ m^{-1}$)	Water soluble K (mg kg^{-1})	Exchangeable-K (mg kg^{-1})	Non-Exchangeable-K (mg kg^{-1})	Total K (mg kg^{-1})	Textural class
Vinayakapuram	6.9	0.11	46.2	42.1	284	7280	Sand
Aswaraopet	6.0	0.08	26.5	39.1	135	2095	Sand
Ananthapuram	7.1	0.09	30.9	22.8	95	3363	Sand
Guthavari Gudem	4.8	0.08	20.6	31.5	112	2095	Sand
Malkaram	5.7	0.07	30.9	10.2	95	1959	Sand
Vasanthavada	6.4	0.12	37.3	117.5	883	19680	Sand
Kunavaram	8.1	0.19	35.4	148.8	608	13607	Loamy Sand
Bhudevipeta	7.1	0.35	43.2	106.1	1806	28520	Loamy Sand
Narsapuram	8.1	0.21	23.9	130.9	575	18421	Sandy Loam
Kothavinjaram	7.9	0.21	19.0	138.6	504	10959	Sandy Loam
Venkatapuram	8.1	0.19	35.4	188.3	597	14126	Sandy Loam
N.P.Banjar	7.9	0.15	44.2	276.6	1009	15755	Sandy Loam
Pathrapuram	8.0	0.16	15.0	157.0	676	10959	Loam
R Puram	7.8	0.22	28.3	186.5	1108	9863	Loam
Velerupadu	7.7	0.58	23.9	131.7	597	13865	Loam
Alligudem	8.1	0.20	15.8	171.6	534	11186	Clay Loam
Thumpaka	8.0	0.17	14.3	163.8	642	9863	Clay Loam
N.P. Banjar	7.9	0.20	27.3	234.7	914	12851	Clay Loam
E. Bayyaram	7.8	0.19	16.6	135.4	524	11648	Clay Loam
Vaddigudem	8.2	0.25	11.3	135.3	378	8233	Clay Loam
Narsapuram	7.6	0.28	25.6	226.5	676	13100	Clay Loam
Badrachalam	7.7	0.26	15.0	185.0	676	10294	Silty clay loam
Velerupadu	8.0	0.22	19.8	330.2	914	9234	Silty clay loam
Kunavaram	8.1	0.19	26.5	311.6	791	12851	Silty clay loam
Amaravaram	7.9	0.22	18.2	259.1	676	10513	Silty clay loam
E. Bayyaram	6.7	0.19	25.6	164.9	514	7471	Clay
Kukunur	7.9	0.18	15.8	358.9	1532	11883	Clay

Table 2. Quantity-Intensity parameters of Khammam soils, Andhra Pradesh

Soil	K_L (cmol kg^{-1})	K_0 (cmol kg^{-1})	K_x (cmol kg^{-1})	AR^K_0	PBC^K (cmol kg^{-1})	Textural composition (%) Sand	Silt	Clay	Texture class
Vasanthavada	0.41	0.20	0.21	10.0	40	94.3	1.6	4.1	Sand
Kunavaram	0.59	0.37	0.22	4.0	65	83.0	8.0	9.0	Loamy sand
Narsapuram	0.50	0.25	0.25	3.0	70	75.6	10.7	13.7	Sandy loam
N.P.Banjar	0.60	0.27	0.33	7.0	70	76.9	4.8	18.3	Sandy loam
Velerupadu	0.40	0.20	0.20	2.5	90	69.3	13.7	17.0	Loam
Vaddigudem	0.20	0.10	0.10	1.6	90	54.1	21.1	24.8	Clay loam
Amaravaram	0.50	0.34	0.16	1.6	200	32.6	32.6	34.8	Sandy clay loam
Kukunur	0.60	0.43	0.17	2.2	340	41.0	10.8	48.2	Clay

1989). Lower AR^K_o values were observed in Vaddigudem, Amaravaram and Kukunur, where soils have a texture ranging from clay loam to silty clay loam. The lower AR^K_o may be due to higher clay and CEC compared to the other soils. These soils may have higher cation retentive power and have low amounts of K in soil solution. Similar results were reported by Subba Rao *et al.* (1984), Srinivas and Seshaiah (1993) and Tamuli and Baruah (2000). Higher AR^K_o and lower PBC^K were reported in the potassium-treated plots in different long-term experiments (Grewal *et al.* 2004; Rupa *et al.* 2003).

Potential buffering capacity (PBC^K) denotes the rate of change of quantity with intensity and is represented by the gradient of the curve. The PBC^K values ranged from 40 to 300. The Kukunur and Amaravaram soils where texture is silty clay loam and clay (clay >34%) show higher potential buffering capacity values compared to the light textured soils of Vasanthavada and Kunavaram (clay <9.0 %). In general soils with high clay and organic carbon contents showed higher buffering capacity (Ram and Prasad 1981). Potential buffering capacity is often used for assessing the rate of replenishment of solution potassium from the exchange phase. Similar results were also reported by Sailakshmiswari *et al.* (1986), Beckett (1964), Subbarao *et al.* (1984) and Srinivas and Seshaiah (1993). The PBC^K, ΔG and K potential were higher in the sub-surface soils compared to the surface soils (Kumar and Kumaraswamy, 2001)

The K_O values indicate the quantity of K held at the nonspecific sites and the values ranged from 0.10 to 0.43 cmol kg^{-1}. The K_O values are high in Amaravaram and Kukunur soils where the soils are clay in texture and the clay percentage is more than 34. Significant correlation of K_0 values with silt is reported by Joshi (1992). The labile form of K (K_L) is the K being exchanged by the cations from the colloidal surface. The values varied from 0.20 to 0.60 cmol kg^{-1} and no consistency was observed. K_X is the content of the exchangeable K associated with specific sites. The values ranged from 0.10 to 0.33 cmol kg^{-1} and there was no definite trend among the soils.

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