Event: 7th IPI-FAI Round Table in collaboration with IPNI
Date and venue: 20/3/2012; NAAS Committee Room No.1, NASC Complex, New Delhi
Theme: Refinement of K recommendations in Vertisols

Potassium requirement of crops grown in Vertisols: Experience from STCR

Pradip Dey and S. Srivastava
Indian Institute of Soil Science
Nabibagh, Berasia Road, Bhopal

Occurrence

Vertisols occur extensively in the agro-ecoregions of 5, 6, 7, and 10.

Agroecoregion 5: Central (Malwa) Highlands, Gujarat Plains & Kathiawar Peninsula, hot semi-arid ecoregion, with medium & deep Black soils & GP 90-150 days

Agroecoregion 6: Deccan Plateau, hot semi-arid ecoregion with shallow and medium (with inclusion of deep) Black soils & GP 90-150 days

Agroecoregion 7: Deccan (Telangana) Plateau and Eastern Ghats, hot semi-arid ecoregion, with Red & Black soils & GP 90-150 days

Agroecoregion 10: Central Highlands (Malwa, Bundelkhand & Satputra), hot subhumid ecoregion, with Black and Red Soils & GP 150-180 (to 210) days

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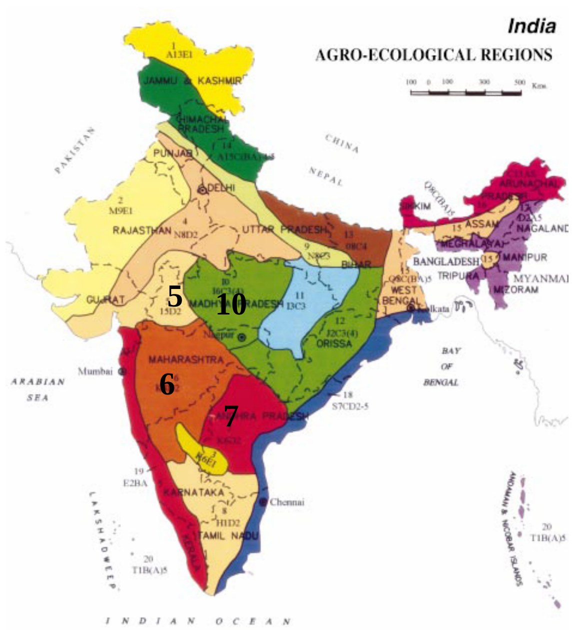

Common Vertisols Series

Sarol	**Typic Chromusterts**	**Basalt**	**Indore (M.P.)**
Kamliakheri	**Vertic Ustochrepts**	**Basalt**	**Indore (M.P.)**
Shendvada	**Typic Chromusterts**	**Alluvium**	**Dhule (M.S.)**
Kasireddipalli	**Vertisol**	**Basalt**	**Medak (A.P.)**
Pemberty	**Vertic Ustochrepts**	**Granitic alluvium**	**Warangal (A.P.)**
Periyanaickenpalayam	**Vertic Ustropepts**	**Calcic gneiss**	**Coimbatore (T.N.)**

Hence, vertisols have developed on different parent materials mainly basalt, granite and gneiss.

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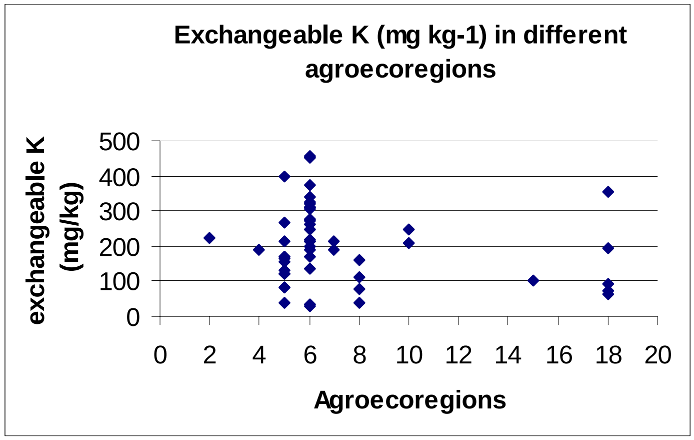
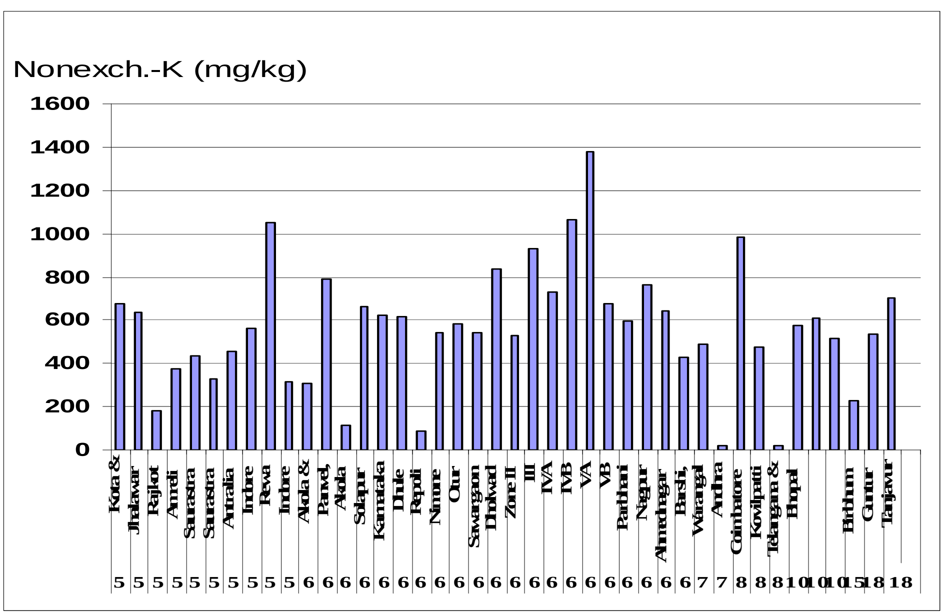


A wide variation is observed even within an agroecoregion.



A similar wide variation is also observed in non-exchangeable K

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Proportion of exchangeable and non-exchangeable K

Agroecoregion 5: High in available K, but medium/ medium to high in nonexchangeable K. These soils have high CEC and relatively high available K, but the per cent K saturation is quit low.
Agroecoregion 6: High in available K but low to high in nonexchangeable K.
Agroecoregion 7: Often associated with red soils and are medium in nonexchangeable K.
Agroecoregion 10: Vertisols and Vertic Ustochrepts are dominant in this region and are high in both exchangeable and non exchangeable K.

Contribution of exchangeable K to yield sustainability

Location	Crops	Control	N	NP	100 % NPK	150 % NPK	100 % NPK+FYM	Ym (t ha^{-1})
Coimbatore	Fingermillet	0.05	0.12	0.48	0.47	0.51	0.55	4.85
	Maize	0.05	0.07	0.40	0.43	0.45	0.50	5.60
Jabalpur	Soybean	0.18	0.20	0.38	0.44	0.38	0.47	3.72
	Wheat	0.13	0.13	0.49	0.53	0.54	0.57	6.20

Higher SYI indicates better sustainability of the system. The sustainability of yield was affected more in soybean-wheat system at Jabalpur than fingermillet-maize system at Coimbatore. SYI was lower in NP when compared to NPK, depicting that the sustainability of the higher yield is threatened in the absence of K application in these soils

Wanjari et al., 1994

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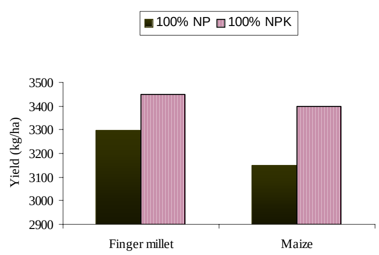
Effect of various fertilizer treatments on yield levels of different crops (pooled data for 10 years)

S.No.	Treatment	Groundnut (pod yield) (kg ha^{-1})	Wheat (kg ha^{-1})	Fodder sorghum (t ha^{-1})
1	Control	669	840	8.3
2	Full does of N and P recommended for irrigated conditions but no K	668	2133	18.1
3	As per treatment 2 but with K	1226	3178	24.1
4	Application of N and P according to soil test but no K	693	2248	18.9
5	N and P according to soil test but with K.	1240	3132	24.4
SEm+		21.1	47.3	0.44
cv%		12.5	13.3	-

Responses to applied K were observed on groundnut, wheat and fodder sorgum in a long-term field experiment on a calcareous medium black soil in region 5. Further, the extent of response was more when K was applied with recommended or soil test based dose of NP (Malavia et al. 1993).

Effect of potassium fertilization on the grain yield of finger millet and maize in medium black calcareous soil of Coimbatore (Mean of five crops 1993-1998)



In a long-term field experiment in medium black calcareous soils, the yields of finger millet and maize crops increased with 100 kg K2O/ha. The response, however, was more prominent for maize (Santhi *et al.*, 2003).

Sub Soil Potassium

Although a major portion of plant nutrients is absorbed by crop plants from the surface soil, contribution of sub soil layers is often substantial. Sub soil nutrient contribution may be more important to crops in dryland regions where root growth and function depend on sub soil water. The drying of surface soil under dry land cultivation reduces diffusion of nutrients and plant uptake from that layer. In that condition, nutrient availability in sub soil is crucial during critical times of plant development such as flowering and grain filling.

In an study conducted under pulse growing regions, the two lower layers contributed from 47 per cent in Sehore (Black soils) profile to 75 per cent in Kanpur (alluvial soils) profile. Hence, the contribution of sub soil was low in black soils. Similar such studies need to be conducted for the contribution of subsols towards crop uptake.

Vertisol behaviour in K fertility Management

In smectitic soils, having high exchangeable K, but low to medium non exchangeable K, ammonium acetate K may not be able to sustain itself and response may occur within two to three years. But no change in K forms and lack of response for a longer period needs explanation. Smectitic soils differ in depth and in their tendency to crack. Where mixing of surface and subsurface layers occur continually, depletion of available and reserve K will take longer time since considerable K is available in deeper layers. Accordingly smectitic soils should be viewed in the context of soil depth and their tendency to crack (Sekhon 2001). Direct evidence, however, of this phenomenon is required and its impact on K fertility and response should be studied.

Diffusion and availability of K in vertisol

Release of K from non exchangeable sources increases the K fixation capacity of a soil requiring high K application eventually. Diffusion proceeds slower in a heavy (black) soil than in a light soil. Also, the diffusion rates are high where the soil is moist and vice-versa. Consequently, black soils often present in dry region need more K to maintain a high diffusion rate. The K concentration in the saturation extract is linearly and positively correlated with diffusive flux. But even if K content does not change, K availability may vary appreciably during a season depending upon water content in the soil.

Importance of biotite mica in K supply to crops

Review on the role of minerals in potassium management of Indian soils indicates that weathering of muscovite in presence of biotite is improbable.

Therefore, the quantity of muscovite can not be used as an index of K reserve in soils wherever biotite and muscovite occur together in soil environments.

Crop response to K fertilizers will depend on the biotite reserves in various soil size fractions.

Pal and Srinivasa Rao, 2001

Response to applied K in Vertisols

Responses to applied K were observed on groundnut, wheat and fodder sorgum in a long-term field experiment on a calcareous medium black soil in region 5. Further, the extent of response was more when K was applied with recommended or soil test based dose of NP (Malavia et al. 1993). In a field experiment, both grain yield and protein content of chickpea were improved with potassium application in black calcareous soils at Junagarh (Tomar et. al, 2001). Also at Junagarh, in similar soils, the total K uptake increased significantly in five different varieties of groundnut (Patil et al., 2003). This shows that the fresh K fertilization has a significant impact on K supply or availability in these soils. Puri and Jaipurkar (1989) studied the response of linseed (*Linum usitatissimum*-L) and safflower (*Carthamus tinctorious* L.) to applied potassium on typic Chromusterts and found that the maximum production of safflower was 1720 kg ha^{-1} with application of 38 kg K_2O + 60 kg N+ 60 kg P_2O_5 ha^{-1}. Thus, there are instances where swell-shrink soils having high exchangeable K respond to K application.

Lessons from STCR

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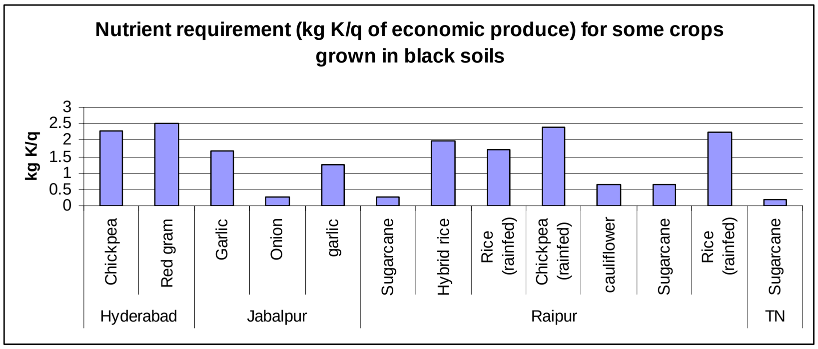
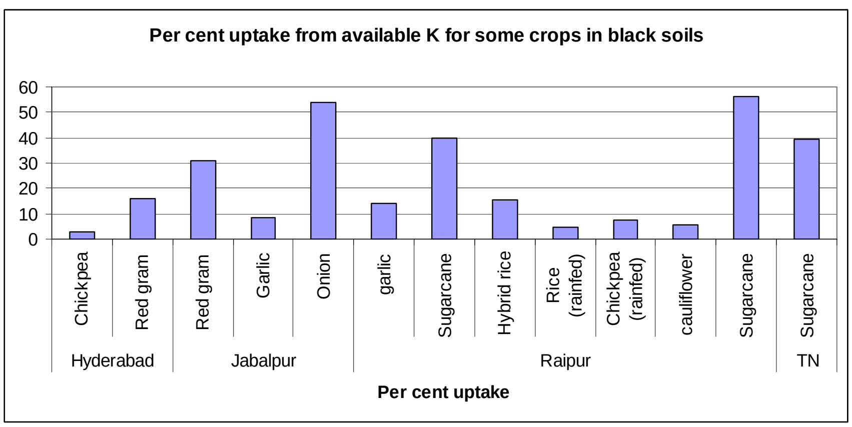


Potassium requirement (kg/q of economic produce) for some crops in vertisols



Soil potassium recovery efficiency for some crops grown in black soils

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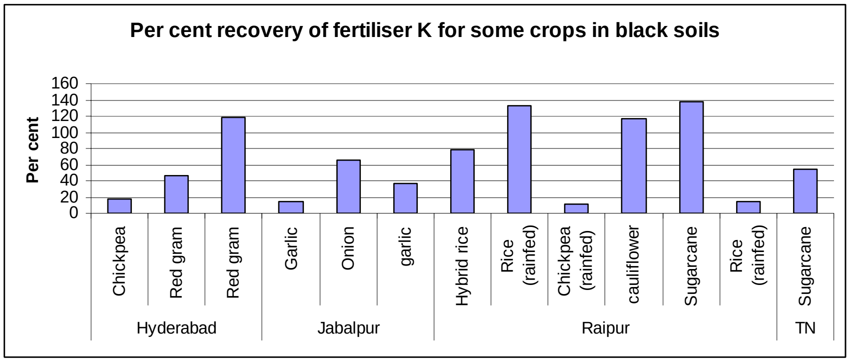
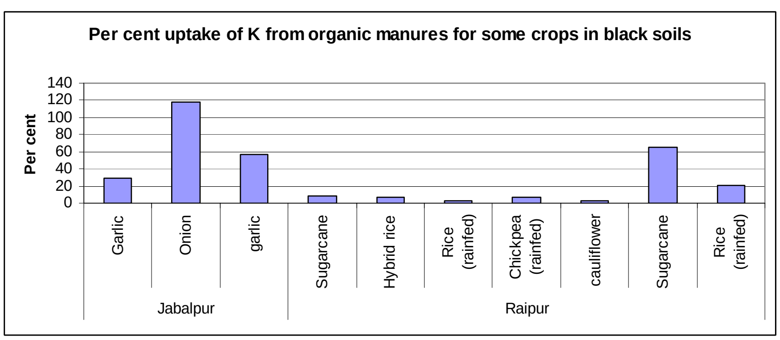


Potassium recovery efficiency of fertilizer for some crops grown in Vertisols



Per cent recovery of K from farmyard manure for some crops in black soils

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Potassium fertilizer recommendations obtained from Soil Test Crop Response Correlation studies

District	Crop	Target (q/ha)	Fertiliser K2O (kg/ha)*
Hyderabad	Red gram	20	7
Jabalpur	Onion	500	0
Raipur	Hybrid rice	50	42
	Rice (rainfed)	40	35
	Chickpea (rainfed)	13	2
	Cauliflower	20	0
	Sugarcane	800	65
Jabalpur	Gram	20	4
	wheat	50	59
	Urad	20	30
	Mustard	20	38
	Pea	20	25
Bengaluru	Safflower	15	0

•At a soil test value of 425 kg/ha available K

Critical limits of potassium in some Vertisols of India

District	Crop	Target (q/ha)	STV K (kg/ha)
Hyderabad	Red gram	20	449
Jabalpur	Garlic	20	397
	Onion	500	233
	garlic	20	179
Raipur	Hybrid rice	50	633
	Chickpea (rainfed)	13	427
	cauliflower	20	228
	Sugarcane	800	923
	Rice (rainfed)	40	644
Jabalpur	Gram	20	447
	wheat	50	791
	Urad	20	492
	Mustard	20	717
	Pea	20	528
Bengaluru	Safflower	15	117
	Mean		**480**
	Range		**179-791**

Conclusions

The data emanated from Soil Test Crop Response Correlation studies clearly show that K fertilizer recommendations have to be not only soil and crop specific but they would also change based on expected yield targets.

Rice, and wheat, the two important cereal crops need K fertilizer if higher yields are targeted.

There have been wide variation in response to K but for most of the crops in swell shrink soils the upper critical level of K is 480 kg/ha above which the response is seldom expected. This holds true under irrigated conditions with good management.

K response studies and K recommendations should take into account the swell-shrink behaviour and contribution of sub-soil K in Vertisols.

With the inclusion of more area under irrigation in future, there is a clear need of refinement of existing K fertilizer recommendations.

So far we have incorporated only available K in the fertilizer prescription equations; the critical limits and the prescription models could be refined if we include non-exchangeable K into fertilizer prescription equations.

Thanks