Agropedology, 2001, ***12,*** *29-37*

Mapping available potassium in the soils of Assam

S. Vadivelu, T. K. Sen, B. P. Bhaskar, Jiji Thampi, U. Baruah and J. P. Mishra*

National Bureau of Soil Survey and Land Use Planning, Jorhat 785 004, India
*NBSS&LUP, Amravati Road, Nagpur 440 010, India.

Abstract

Mapping spatial pattern of available K distribution in the soils of Assam state is important for the studies of K fertilization and to judge the adequacy of soil K. The soil map (1:500,000 scale) with family association as map units for mapping the distribution of available K the mean available K was used. Values of 19 major soil families (from 128 pedons) were analysed and they ranged from 0.07 to 0.527 cmol(p+)/kg in the surface soils (0–25 cm). The variation of soil potassium among these families was significant with a CV of 61.8%. Therefore, it is assumed that the boundaries of soil families can very well delineate the spatial distribution of soil potassium when the polygons are assigned the respective soil K values. Since some of the family polygons are too small to stand a publication (small) scale, the families were further generalized to 12 sub-groups. The variation in K content among the sub-groups, though decreased, was significant at a CV of 58.5%. Therefore, the soil K map was finalized using soil sub-group boundaries. The resultant spatial distribution of K showed that about 6% of the state has soils with a K content of less than 39 mg K kg-1 and about 59% of the area has soils with a K content (available) of 39-78 mg K kg^{-1}. These areas need attention with regard to K fertilization.

Additional Key words : Thematic map, K fertilization.

Introduction

In the Soil Testing Laboratories all over the country ammonium acetate extractable K value is taken as available K (Ghosh and Hasan 1976). Having known the available K content of the soils, what is more important is to map its spatial distribution. The results of numerous K estimations without geo reference will not be of much use. Availability of maps showing spatial distribution of K is scarce. Ghosh and Hasan (1976) classified the available K in the soil as low, medium and high and prepared a map of available potassium status of Indian soils. They used the results of nearly 180 Soil Testing Laboratories obtained between 1968 and 1974. They did not explain the procedure followed in mapping soil K particularly about the placement of boundaries of the classes. In the absence of any information on locations of the soil samples collected, subsequent monitoring of K fertility over time is not possible. Soil survey and soil maps can provide a viable medium for mapping soil K. Goulding and Loveland (1986) used soil series to map the K reserves of England and Wales. Such studies are rare in India and no procedure has been worked out to use the soil maps to map the spatial distribution of nutrients, including potassium.

This paper is to assess the usefulness of soil map of Assam to map soil K in identifying areas for conducting crop response expriments and making fertilizer recommendations.

Table 1. NH_4OAc–K (cmol(p+)/kg) in the different soil families of Assam

Sl. No.	Soil family	0–25 cm	% of mean	25–50 cm	% of mean	50–100 cm	% of mean	Mean clay (%)
1.	Coarse-silty Typic Haplaquents	0.22	107	0.240	122	0.19	110	-
2.	Fine-loamy Typic Haplaquents	0.121	59	0.114	58	0.143	83	24.95
3.	Coarse-loamy Typic Haplaquents	0.122	59	0.107	55	0.089	51	15.73
4.	Coarse-loamy Aeric Fluvaquents	0.115	56	0.095	48	0.135	78	16.9
5.	Fine-loamy Aeric Fluvaquents	0.105	51	0.115	59	0.11	64	24.41
6.	Coarse-loamy Typic Fluvaquents	0.119	58	0.098	50	0.10	58	12.8
7.	Loamy-skeletal Typic Udorthents	0.40	194	0.26	133	0.24	139	31.75
8.	Fine-loamy Aeric Haplaquepts	0.122	54	0.137	71	0.138	80	32.73
9.	Fine-loamy Typic Haplaquepts	0.136	66	0.147	75	0.09	52	26.54
10.	Fine-loamy Typic Dystrochrepts	0.166	81	0.155	79	0.153	88	25.45
11.	Coarse-loamy Typic Dystrochrepts	0.135	66	0.095	48	0.088	51	17.0
12.	Fine-loamy Umbric Dystrochrepts	0.07	34	0.04	20	0.03	17	21.8
13.	Fine-loamy Dystric Eutrochrepts	0.116	56	0.124	63	0.131	76	24.42
14.	Fine-Typic Hapludalfs	0.527	256	0.507	259	0.38	220	38.45
15.	Fine-loamy Typic Hapludalfs	0.33	160	0.38	194	0.23	133	30.92
16.	Coarse-loamy Typic Hapludalfs	0.23	112	0.20	102	0.24	139	-
17.	Fine-loamy Mollic Hapludalfs	0.32	155	0.28	143	0.28	162	31.16
18.	Fine Mollic Hapludalfs	0.405	197	0.45	230	0.365	211	41.45
19.	Clayey Typic Hapludults	0.17	83	0.17	87	0.15	87	30.55

Materials and methods

Description of area: Assam state lies between 24°08' to 28°09'N latitudes and 89°42' to 95°16' E longitudes and has a geographical area of 7.85 m ha. It is surrounded by Bhutan and Arunachal Pradesh in the North; Manipur, Nagaland and Arunachal Pradesh in the East; Mizoram, Meghalaya and Tripura in the South and Bangladesh and West Bengal in the West. The state has three distinct physiographic regions such as : (1) Brahmaputra valley (5.6274), (2) Central Assam range (Karbi Anglong, North Cachar Hills) and (3) Barak Valley. The geology of the state is dominated by the Quaternary alluvial deposits though formations of all ages are noticed. The climate is humid subtropical. The natural vegetation is dominated by (1) Evergreen and semi evergreen forests, (2) Deciduous forests, (3) Riverine forests, (4) Mixed deciduous forests and (5) Savannah. The main crops are rice and tea in upper Assam, rice and jute in middle Assam and rice in lower Assam.

Table 2. NH_4OAc- K (cmol(p+)/kg) in the different soil subgroups of Assam

Sl No.	Soil subgroup	0-25 cm	% of mean	25-50 cm	% of mean	50-100 cm	% of mean
1.	Typic Haplaquents	0.154	81	0.154	95	0.141	90
2.	Aeric Fluvaquents	0.11	58	0.105	65	0.123	79
3.	Typic Fluvaquents	0.119	63	0.098	60	0.1	64
4.	Typic Udorthents	0	212	0.26	160	0.24	154
5.	Aeric Haplaquepts	0.112	59	0.139	86	0.138	88
6.	Typic Haplaquepts	0.136	72	0.147	91	0.09	58
7.	Typic Dystrochrepts	0.151	80	0.125	77	0.121	78
8.	Umbric Dystrochrepts	0.07	37	0.04	25	0.03	19
9.	Dystric Eutrochrepts	0.116	61	0.124	77	0.131	84
10.	Typic Hapludalfs	0.362	192	0.212	131	0.283	181
11.	Mollic Hapludalfs	0.363	192	0.365	225	0.323	207
12.	Typic Hapludults	0.17	90	0.17	105	0.15	96

Soil survey techniques and procedures: Soil resource mapping of Assam was carried out using a 3-tier approach (Sehgal *et al.* 1987). The soils were classified (Soil Survey Staff-990) in 4 orders (Entisols, Inceptisols, Alfisols and Ultisols), 9 suborders, 15 great groups, 26 sub-groups and 83 soil family associations. Inceptisols are dominant with an area of 41.4 per cent of the TGA followed by Entisols (33.6 per cent), Alfisols (11.3 per cent) and Ultisols (5.6 per cent) (Sen *et al.* 1999).

Horizonwise soil samples were analysed for physical and chemical characteristics as per standard procedures (Sarma *et al.* 1987). The ammonium acetate extractable K

Table 3. NH_4OAc– K (cmol(p+)/kg) in the different soil great groups of Assam

Sl No.	Soil great group	0-25 cm	% of mean	25-50 cm	% of mean	50-100 cm	% of mean
1.	Haplaquents	0.154	79	0.154	93	0.141	89
2.	Fluvaquents	0.155	59	0.102	61	0.112	71
3.	Udorthents	0	206	0.26	157	0.24	152
4.	Haplaquepts	0.124	64	0.143	86	0.114	72
5.	Dystrochrepts	0.111	57	0.083	50	0.076	48
6.	Eutrochrepts	0.116	60	0.124	75	0.131	83
7.	Hapludalfs	0.363	187	0.289	174	0.303	192
8.	Hapludults	0.17	88	0.17	102	0.15	95

values of 128 pedons from nineteen major soil families were taken as available. Three classes of available K such as (1) <39 mg K/kg^{-1}, (2) 39–78 mg K/kg^{-1} and (3) >78 mg K/kg^{-1} were identified which roughly correspond to low, medium and high, respectively. A step-wise generalization of the soil map along with the available K data was carried out from family-subgroup-greatgroup-suborder-order to assess the variability among the member taxa with regard to available K. The soil map generated at sub-group level was used for delineating the classes of available K. Coefficient of variation among the taxa of a category with regard to available K was worked out (Gupta 1996).

Table 4. NH_4OAc- K (cmol(p+)/kg) in the different soil suborders of Assam

Sl No.	Soil suborders	0–25 cm	% of mean	25–50 cm	% of mean	50–100 cm	% of mean
1.	Aquents	0.134	61	0.128	70	0.127	73
2.	Orthents	0	183	0.26	143	0.24	139
3.	Aquepts	0.124	57	0.143	79	0.114	66
4.	Ochrepts	0.114	52	0.104	57	0.104	60
5.	Udalfs	0.363	167	0.289	159	0.302	175
6.	Udults	0.17	78	0.17	93	0.15	87

Results and discussion

Ammonium acetate extractable K (AK) status in major soil families of Assam: The AK status of nineteen major soil families (from128 pedons)are presented in table1. These families cover an area of 4.05 m ha. The Ak content varied from 0.07 cmol(p+) kg^{-1} in *Fine-loamy Umbric Dystrochrepts* to 0.527 cmol(p+)kg^{-1} in *Fine, Typic Hapludalfs* at 0–25 cm depth. The AK values at depths of 25–50 cm and 50–100 cm showed a decreasing trend. The AK values varied among the different soil families and they, when expressed as percentage of mean, varied from 34 to 256. All the families of Alfisol and two families (Coarse-silty, Typic Haplaquents and Loamy-skeletal Typic Udorthents) had higher values of AK (percentage of Mean >100). The coefficient of variation (CV) (Table 6) among the families was 61.97%. It indicated the variability of AK among the different families and the possibility of using family delineations of the soil map to delineate AK in soils. The AK in soils at 25–50 cm and 50–100 cm depths also showed a significant variability (CV 87.9% and 74.5% respectively) as in the case of surface soils (0–25 cm).

AK and soil sub-groups: The nineteen soil families were generalized (both maps and data) to the next higher category and this exercise yielded 12 sub-groups (Table 2). These subgroups cover an area of 5.68 m ha. The data sowed that the Umbric Dystrochrepts had the minimum AK content of 0.07 cmol (p+)/kg^{-1} and the Typic Udorthents have the maximum of AK content of 0.4 cmol(p+)kg^{-1}. The AK content values of these sub-groups when expressed as per cent of their mean ranged from 37 to 212. The variation among these sub-groups was confirmed by the value of CV (58.5%). Even after generalization to sub-group, the variability in AK content is maintained and this variability encouraged to use sub-group delineations to map soil potassium.

These 12 sub-groups were in turn generalised to great group and then the great groups to suborders - the suborders to orders. The AK content maintained significant variation among the member taxa when generalised at great group (Table 3), suborder

Table 5. NH_4OAc– K(cmol(p+)/kg) in the different soil orders of Assam

Sl. No.	Soil orders	0-25 cm	% of mean	25-50 cm	% of mean	50-100 cm	% of mean
1.	Entisols	0.267	116	0.194	100	0.184	99
2.	Inceptisols	0.119	52	0.124	64	0.109	59
3.	Alfisols	0.363	158	0.289	149	0.302	162
4.	Ultisols	0.17	74	0.17	88	0.15	81

(Table 4) and order (Table 5) levels. However the variability decreased gradually towards the higher categories (Table 6).

Soil taxa and soil available potassium: Based on the mean AK content, the soil taxa are ranked at the different categories as :

Order : Alfisols>Entisols>Ultisols>Inceptisols
Suborder : Orthents>Udalfs>Udults>Aquents>Aquepts>Ochrepts
Great groups : Udorthents > Hapludalfs > Hapludults > Haplaquents>Haplaquepts> Eutrochrepts>Fluvaquents>Dystrochrepts

Sub-groups : Typic Udorthents>Mollic Hapludalfs>Typic Hapludalfs>
Typic Hapludults>Typic Haplaquents>Typic Dystrochrepts>
Typic Haplaquepts>Typic Fluvaquents>Dystric Eutrochrepts>
Aeric Haplaquepts>Aeric Fluvaquents>Umbric Dystrochrepts.

Availablel potassium and some relevant soil characteristics: The AK content was positively correlated with clay (r=0.273**) and organic carbon (r=0.149**) using data from 627 horizonwise soil samples. Following regression equations were derived for approximating AK content in these soils :

i) AK (cmol (p+)/kg^{-1}) = 0.054 + 0.00368 (clay %)

ii) AK (cmol (p+)/kg^{-1}) = 0.117 + 0.04146 (organic carbon %)

Similar kind of relationships between AK *verses* clay and organic carbon were reported by Boruah and Nath (1992).

Mapping soil potassium: The soil map of Assam with soil family associations as map units was used for mapping soil available potassium. The soil map has a strong base of satellite image interpreted landform map to demarcate boundaries and adequate ground check in terms of pedon studies. Therefore, the soil unit delineations can serve the purpose of delineating soil available potassium which otherwise may prove a difficult exercise. Goulding and Loveland (1986) used soil series information in mapping soil reserve potassium in England and Wales. Broad classification of avaialable potassium status in the form of K fertility maps helps in assessing the potassium needs and making fertilizer recommendations for crops grown in the area. Attempts were made in using K information for mapping in Punjab (Vig *et al.* 1977) and Haryana state (Dixit *et al.* 1980). These maps, however, have inadequate information on pedological classification of soils and little control on choice of sample sites. Sekhon *et al.* (1992) proposed benchmark soil series as basis for making soil fertility investigations linked up with mapping of potassium. The nineteen soil families taken for the study were generalised to 12 subgroups since the family polygons were too small to stand the reduction of the soil map to the publication scale. The soil available potassium values of the twelve sub-groups at 0–25 cm depth were grouped into three

Table 6. Minimum, maximum, mean coefficient of variation of NH_4OAc–K values at different categoric levels

Category	0–25 cm				25–50 cm				50–100 cm			
	Min	Max	Mean	CV%	Min	Max	Mean	CV%	Min	Max	Mean	CV%
Family (19)	0.070	0.527	0.206	61.87	0.040	0.507	0.196	87.89	0.030	0.380	0.173	74.50
Subgroup (12)	0.070	0.400	0.189	58.50	0.040	0.365	0.162	50.16	0.030	0.323	0.156	51.66
Great group (8)	0.111	0.400	0.194	56.84	0.083	0.289	0.166	41.19	0.076	0.302	0.158	44.37
Suborder (6)	0.114	0.400	0.218	54.10	0.104	0.289	0.182	37.67	0.104	0.302	0.173	42.22
Order (4)	0.119	0.363	0.230	40.66	0.124	0.289	0.194	31.04	0.109	0.302	0.186	37.43

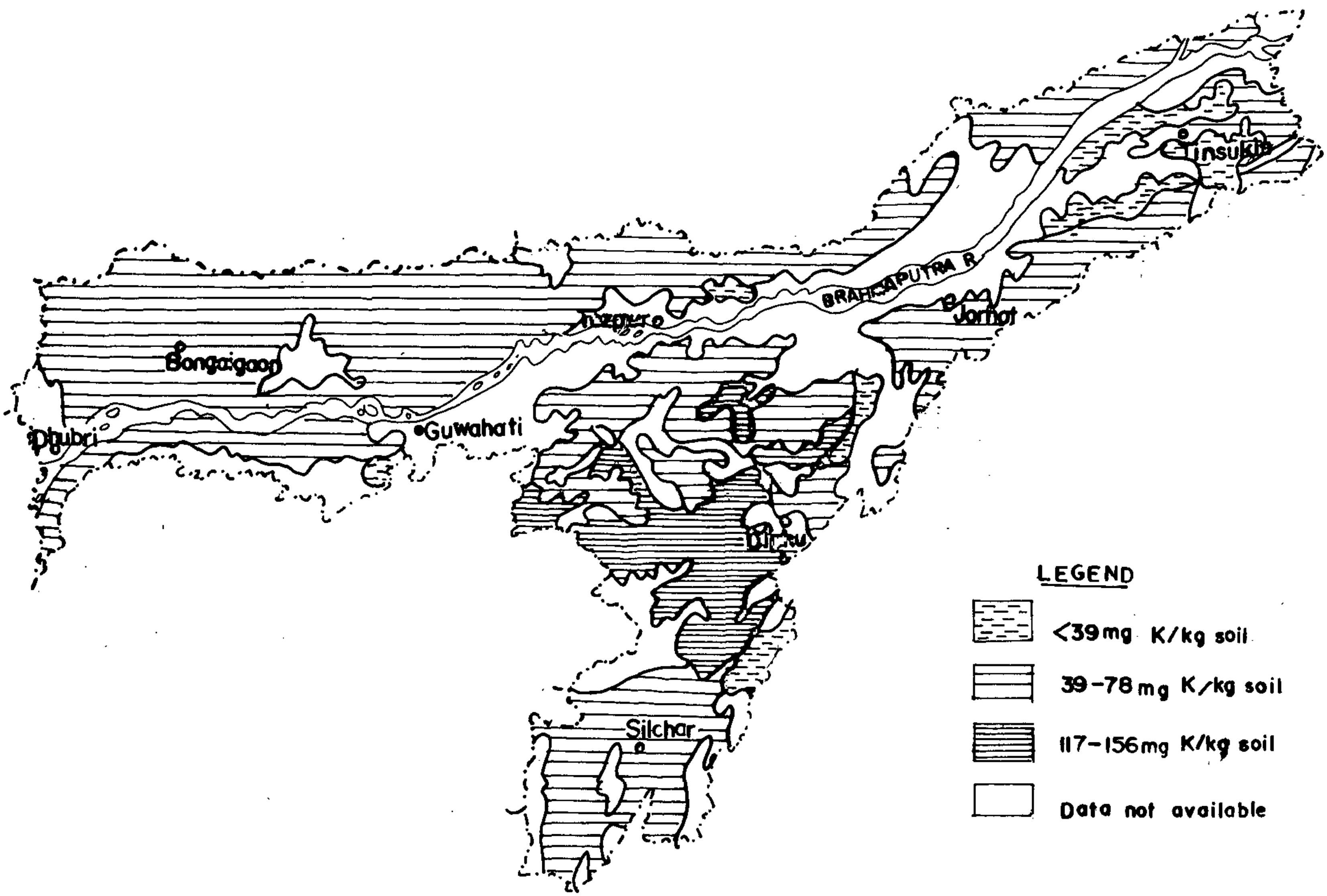

Fig. 1. Soil available potassium map of Assam state.

classes; (1) <39 mg K/kg (<0.1 cmol(+)/kg^{-1}), (2) 39–78 mg K/kg^{-1} (0.1–0.2 cmol(+)/kg^{-1}) and (3) 117–156 mg K/kg (0.3–0.4 cmol(+)/kg^{-1}) which were thought to be logical considering the data ranges. The generalised sub-group map covered 20% more of the total geographical area than the family (studied) map which covered 4.05 m ha (52% TGA) in Assam. The soil sub-group delineations were taken as the delineations of respective soil K (NH_4OAc extractable) classes. Soil potassium map (Fig. 1) show that an area of (1) 475 thousand hectare has less than 39 mg K/kg^{-1}, (2) 4646 thousand hectare has 39-78 mg K/kg^{-1} and (3) 747 thousand hectares have 117-156 mg K/kg^{-1} of soil.

Conclusions

The study showed that the soil family association map of Assam differentiated soils of varying available potassium contents. The map and data of different subgroups generalized from the soil families maintained the variability in K contents. Therefore soil subgroup delineations could be successfully used to delineate the different classes of available potassium in the soils of Assam.

Reference

Baruah, H. C., and Nath, A. K. (1992). Potassium status in three major soil orders of Assam. *Journal of Indian Society of Soil Science*, **40**, 559-561

Dixit, M. L., Sangwan, O. P., and Chaudhary, M. L. (1980). Available nutrient status of Haryana soils. *Haryana Farming*, **9** : 3-4

Ghosh, A.B., and Hasan, R. (1976). Available Potassium Status of Indian Soils. Potassium in Soils, Crops and Fertilizer. Bulletin No. 10. *Indian Society of Soil Science, pp.* 1-5.

Goulding, K. W., and Loveland, P. J. (1986). The classification and mapping of potassium reserves in Soils of England and Wales. *Journal of Soil Science*, **37**, 555-565.

Gupta, S. P. (1996). "Advanced Practical Statistics". Eighth edition. (S. Chand and Company Ltd. New Delhi).

Sarma, V.A.K., Krishnan, P and Budihal, S. L. (1987). Laboratory Methods - Soil Resource Mapping of Different States in India. Technical Bulletin. NBSS Publ. **14**.

Sehgal, J. L., Saxena, R. K. and Vadivelu, S. (1987). Field Manual - Soil Resource Mapping of Different States in India. Technical Bulletin NBSS Publ. **13.**

Sekhon, G.S., Brar, M.S., and Subba Rao, A. (1992). Potassium in benchmark soil of India. *Potash Research Institute of India. Special Publication No. 3*

Sen, T.K., Chamuah, G. S., Sehgal, J., and Velayutham, M. (1999). Soils of Assam for Optimising Land Use, *NBSS Publ.* 66.

Soil Survey Staff (1990). "Keys to Soil Taxonomy". 4th Edition. Soil Management Support Services. Tech. Monogr. 19, Blacksburg, Virginia.

Vig, A.C., Marok, A.S. and Sekhon, G. S. (1977). Evaluation of potassium status of Punjab soils. *Indian Potash Journal* **11**, 19-29

Recived : December , 2001; Accepted : July, 2002