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Nature of Acidity and Lime Requirement in Acid Soils of Manipur

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***Abstract*— In North-Eastern region of India, soil poses a great problem for crop production, particularly in Manipur state where about 90 % of soils are acidic. The present research entitled "Characterization of Soil Acidity in Soils of Manipur" was undertaken with the following objectives viz. i) To characterize the nature of acidity in soils ii) To study the relationship between the different forms of acidity and the soil properties iii) To study the lime requirement assessments. Depth wise 0-15 cm and 15-30 cm (surface and sub-surface) soil samples were collected from Thoubal district covering all blocks i.e. 1. Thoubal 2. Lilong and 3. Kakching, from each block 10 villages and 3 respondent farmers per village was selected with the help of stratified random sampling (proportional allocation). The total numbers of soil samples collected from Thoubal district are 180. Processed soil samples were used for analysis. The soils were found to be of heavy in texture and ranged from clay loam to clay while the pH ranged between 4.86 to 6.19 which were considered as strongly acidic to slightly acidic. The cation exchange capacity of the studied samples varied from 7.61 to 20.61 cmol (p+) kg^{-1} soil and organic carbon contents were high and ranged between 3.40 to 20.30 g kg^{-1}. Extractable Al and Exchangeable Al ranged from 0.60 to 3.30 Cmol (p+) kg^{-1} and 0.10 to 2.16 Cmol (p+) kg^{-1}, respectively. Total Potential Acidity ranged from 4.11-12.00 Cmol (p+) kg^{-1}, Exchangeable Acidity from 0.24-2.97 Cmol (p+) kg^{-1} and pH Dependent Acidity from 2.81 to 9.23 Cmol (p+) kg-1. Lime requirement (LR) was estimated by three methods i.e. $BaCl_2$ –TEA method (7.00 to 18.70 t/ha), Dunn Equilibrium method (1.40 to 5.28 t/ha) and 1N KCl method (0.17 to 3.50 t/ha). Among the methods, highest quantity of LR was recorded by $BaCl_2$ –TEA method and lowest by 1N KCl method. Further, it is observed that the major contributing factors for producing exchange acidity are pH, exchangeable Al, extractable Al & clay whereas soil properties responsible for pH- dependent acidity are organic matter, extractable Al & clay. Therefore, it is advisable to supply the required doses of lime requirement to the soil to sustain its fertility as well as productivity. Also suitable remedial counter measures other than liming may be adopted to enhance crop production.**

***Keywords**: Total Potential acidity, Exchangeable acidity, pH dependent acidity and LR.*

I INTRODUCTION

In India, acid soils contribute nearly one-third of the area under cultivation. Acid soils are widely distributed in Himalayan regions, Eastern, North-Eastern and in Southern states under varying climatic and environmental conditions (Panda, 1987). In North-Eastern region of India, soil poses a great problem for crop production, particularly in Manipur state where about 90 % of soils are acidic. Soil resource mapping of the state, revealed that about 16.6 % soils are strongly acidic, 70 % are moderately acidic and 3.7 % are slightly acidic (Nayak *et al.* 1996). Hence the present investigation was carried out with the following objectives 1. To characterize the nature of acidity in soils of Thoubal and 2. To study the relationship between different forms of acidity and the soil properties and lime requirement.

II MATERIALS AND METHODS

Depth wise 0-15 cm and 15-30 cm (surface and sub-surface) soil samples were collected from Thoubal district covering all blocks i.e. 1. Thoubal 2. Lilong and 3. Kakching, from each block 10 villages and 3 respondent farmers per village was selected with the help of stratified random sampling (proportional allocation). The total numbers of soil samples collected from Thoubal district are 180. Processed soil samples were used for analysis.

The pH of the soil sample was determined by using glass electrode Beckman pH meter with soil ratio of 1:2.5 as described by Gupta, (2006). Mechanical analysis was carried out by Bouyoucos hydrometer method, organic carbon by chromic acid digestion method, Available K and Na was determined flame photometrically, Available Ca and Mg by EDTA (versenate) method, CEC by neutral NH_4OAc and exchangeable Al and exchange acidity by unbuffered 1M KCl (Mc Lean 1965).Total potential acidity was determined by $BaCl_2$ -tri ethanol amine buffered at pH 8.0 (Peech *et al.*, 1962). pH dependent acidity is the difference between total potential acidity and exchange acidity (Hesse, 1971). Extractable Al was determined by leaching the soil with 1M NH_4OAc buffered at pH 4.8 and Al in the extract was determined using aluminon method (Hesse, 1971).

III RESULTS AND DISCUSSION

Soil Characteristics

Some characteristics of the soils are presented in table 1. All the investigated soil samples were moderately to slightly acidic varying from 4.86 to 6.19. The soils were rich in organic carbon varying from 3.40 to 20.30 g kg^{-1}. The CEC of the soils is low to medium 7.61 to 20.61 cmol (p+)kg^{-1} due to dominance of kaolinite clay minerals in soils and low in exchangeable bases (Ca^{++}, Mg^{++}, K^{+} & Na^{+}) and heavy in texture.

Nature of Soil Acidity

Total Potential Acidity (TPA)

Total potential acidity of the studied soil samples are presented in table 2. Result revealed that total potential acidity is moderately high ranging from to 4.11-12.00 Cmol (p+) kg^{-1} soil. The highest TPA value of 12.00 cmol (p+) kg^{-1} was recorded in sub-surface soil of Khangabok village, Thoubal block, and the lowest TPA value of 4.11 cmol (p+) kg^{-1} was recorded in surface soil of Loushipat village, Kakching block.. Data also revealed that high total potential acidity is due to high content of organic matter and clay reported by Nayak *et al*. (1996).

Exchange Acidity (EA)

Data on exchange acidity (table 2) of the studied soil samples indicated that exchange acidity value is low compare to total potential acidity ranging from 0.24-2.97 Cmol (p+) kg^{-1} soil. The highest EA value of 2.97 cmol (p+) kg^{-1} was recorded in sub-surface soil of Hiyanglam village, Kakching block and lowest with a value of 0.24 Cmol (p+) kg^{-1} in surface soil of Khongjom village, Thoubal block. Data result shows that exchange acidity have relatively low contribution towards total acidity. Similar findings were observed by Sharma *et al.* (1990), Das *et al.* (1991) and Kumar *et al*. (1995).

pH Dependent Acidity (pHDA)

Data on pH dependent acidity presented in table 2 revealed that pH dependent acidity contributes significantly towards total potential acidity which was similarly reported by Bandyopadhyay and Chattopadhyay (1997). The value of pH dependent acidity ranges from 2.81to 9.23 Cmol (p+) kg^{-1} soil. Highest value of pH dependent acidity was found in in sub-surface soil of Khangabok village, Thoubal block which was 9.23 Cmol (p+) kg^{-1} and lowest value of 2.81 Cmol (p+) kg^{-1} in in sub-surface soil of Wabagai village, Kakching block. Data also revealed that high pH dependent acidity is due to high content of organic cabon. Similar finding were observed by Nayak et *al*. (1996) and Gangopadhyay et *al*. (2008).

IV CORRELATION BETWEEN SOIL PROPERTIES AND FORMS OF ACIDITIES OF THOUBAL DISTRICT

Correlation between soil properties and forms of acidities of the soil samples are presented in table 3. It was observed that the pH in surface soils of Thoubal had significant negative correlation with all types of acidity viz. exchange Acidity (-0.779^{**}), pH-dependent acidity (-0.498^{**}) and total acidity (-0.703^{**}). Organic carbon had significant positive correlation with pH-dependent acidity (0.443^{*}) and total acidity (0.448^{*}). Exchange acidity had significant negative correlation with Calcium (-0.472^{**}) and Magnesium (-0.470^{**}). Exch. Al had had significant positive correlation with exchange acidity (0.804^{**}) and total acidity (0.635^{**}). Extractable Al had significant positive correlation with all types of acidity viz. exchange Acidity (0.920^{**}), pH-dependent acidity (0.533^{**}) and total acidity (0.797^{**}). CEC had significant positive correlation with pH-dependent acidity (0.401^{*}) and total acidity (0.423^{*}).Clay had significant positive correlation with exchange acidity (0.369^{*}), pH-dependent acidity (0.391^{*}) and total acidity (0.424^{*}) (Table 3). Likewise, the pH in sub-surface soils of Thoubal had significant negative correlation with all types of acidity viz. exchange Acidity (-0.735^{**}), pH-dependent acidity (-0.483^{**}) and total acidity (-0.652^{**}). Organic carbon had significant positive correlation with pH-dependent acidity (0.555^{**}) and total acidity (0.505^{**}). Exchange acidity had significant negative correlation with Calcium (-0.625^{**}) and Magnesium (-0.824^{**}). Exch. Al had had significant positive correlation with exchange acidity (0.607^{**}) and total acidity (0.495^{**}). Extractable Al had significant positive correlation with all types of acidity viz. exchange Acidity (0.529^{**}), pH-dependent acidity (0.636^{**}) and total acidity (0.730^{**}). CEC had significant positive correlation with pH-dependent acidity (0.437^{*}) and total acidity (0.422^{*}).Clay had significant positive correlation with exchange acidity (0.462^{*}) and total acidity (0.363^{*}) (Table 4). Similar observation was also given by Nayak *et al.* (1996) and Kumar *et al.* (1995).

Lime Requirement (LR)

Data on lime requirement are presented in table 5. Lime requirement (LR) of soils of Thoubal District was estimated by three methods i.e. $BaCl_2$ –TEA method, Dunn Equilibrium method and 1N KCl method.

$BaCl_2$ –TEA method -LR values of Thoubal District soils ranged from 7.00 to 18.70 t/ha. The highest $BaCl_2$ –TEA-LR value of 18.70 t/ha was recorded in sub-surface soil of Khangabok village, Thoubal block and the lowest $BaCl_2$ – TEA-LR value of 7.00 t/ha was recorded in surface soil of Loushipat village, Kakching block.

The Dunn Equilibrium method -LR of Thoubal District soils ranged from 1.40 to 5.28 t/ha. The highest Dunn -LR value of 5.28 t/ha was recorded in sub-surface soil of Khangabok village, Thoubal block and the lowest Dunn -LR value of 1.40 t/ha was recorded in surface soil of Khongjom village, Thoubal block.

1N KCl-LR of both surface and sub-surface soils of Thoubal District values ranged from 0.17 to 3.50 t/ha. The highest 1N KCl -LR value of 3.56 t/ha was recorded in surface soil of Chairel Kakching village, Kakching block and the

lowest 1N KCl -LR value of 0.17 t/ha was recorded in sub-surface soil of Loushipat village, Kakching block.

Similarly, wide variation was noticed between soils also. Among the methods, highest quantity of LR was recorded by $BaCl_2$ –TEA method and lowest by 1N KCl method. Detailed study of the data revealed that the LR in the sub-surface layers was more than those in the surface layers in all the methods except 1N KCl and this may be due to high values of acidity, organic carbon and clay content of the soil. Tisdale *et al.,* (1985) showed that the LR of the soil depends on the buffering capacity as reflected by clay and organic matter. Different forms of acidity contribute to the lime requirement of the acid soils (Ananthanarayana and Ravikumar, 1997). Lime requirement increases with increase in reserve acidity and CEC of the soil (Tisdale *et al.*1985). The relatively low LR in surface soils of Thoubal District compared to sub-surface soils is due to the low organic matter content and low clay percentage.. If soils are high in organic matter, more lime is required to bring the same change in pH than in a similar soil that is low in humus (Mehra, 2006).

V CONCLUSION

From the data, it can be concluded that there exists problem of moderate soil acidity. Organic carbon content was high but cation exchange capacity was low. Extractable aluminium content was higher than that of exchangeable aluminium. Further, it is observed that the major contributing factors for producing exchange acidity are pH, exchangeable Al, extractable Al & clay whereas soil properties responsible for pH- dependent acidity are organic matter, extractable Al & clay. Therefore, it is advisable to supply the required doses of lime requirement to the soil to sustain its fertility as well as productivity. Also suitable remedial counter measures other than liming may be adopted to enhance crop production.

Table 1 Physico-Chemical properties of the soils of Thoubal District

Block	Village	Latitude	Longitude	Depth	pH	OC g /kg	CEC (cmol (p+)kg^{-1})	Ca (cmol (p+)kg^{-1})	Mg (cmol (p+)kg^{-1})
1.Thoubal	1.Charangpat	24.644531	94.009995	0-15 cm	5.28	9.12	16.23	0.55	0.41
				15-30 cm	5.62	18.00	19.35	1.27	0.76
	2.Heirok 1	24.584648	94.077457	0-15 cm	5.37	6.54	14.75	0.50	0.45
				15-30 cm	5.63	12.00	15.97	1.40	0.84
	3.Khangabok	24.616199	94.007696	0-15 cm	5.23	10.80	15.14	0.78	0.40
				15-30 cm	5.23	20.30	20.61	1.12	0.21
	4.Langathel	24.524912	94.055494	0-15 cm	5.37	6.43	13.64	0.71	0.41
				15-30 cm	5.69	12.60	16.18	1.30	0.98
	5.Tentha	24.573063	93.972538	0-15 cm	5.43	5.50	12.94	1.30	0.55
				15-30 cm	5.70	12.50	15.66	1.50	1.00
	6.Chandrakhong	24.689816	94.122593	0-15 cm	5.35	7.10	10.82	1.36	0.59
				15-30 cm	5.63	15.00	19.20	1.43	0.52
	7.Khongjom	24.538628	94.041446	0-15 cm	5.39	6.24	14.63	1.37	1.00
				15-30 cm	5.70	11.00	15.28	1.52	0.82
	8.Tekcham	24.52179	94.005704	0-15 cm	5.33	11.10	16.27	0.33	0.30
				15-30 cm	5.37	18.10	20.18	1.13	0.37
	9.Thoubal Khunou	24.663797	93.997542	0-15 cm	5.29	8.60	16.42	0.34	0.31
				15-30 cm	5.60	18.30	19.58	1.56	0.96
	10.Wangjing	24.590961	94.044833	0-15 cm	5.35	3.75	14.19	1.41	0.40
				15-30 cm	5.63	13.00	16.99	1.58	0.56
2.Lilong	1.Haoreibi	24.680572	93.941941	0-15 cm	5.28	13.10	12.07	0.95	0.43
				15-30 cm	5.78	15.30	15.17	1.37	0.74
	2.Irong Cheksaba	24.633811	93.905283	0-15 cm	5.33	3.50	10.28	0.80	0.45
				15-30 cm	6.05	5.20	11.33	1.46	0.70
	3.Moijing	24.648827	93.954264	0-15 cm	5.26	11.40	16.35	0.94	0.40
				15-30 cm	5.76	15.00	17.20	1.20	0.83
	4.Leisangthem	24.606538	93.939393	0-15 cm	5.37	4.50	10.12	0.85	0.41
				15-30 cm	6.04	8.30	12.46	1.58	0.88
	5.Lilong	24.719716	93.933139	0-15 cm	5.44	9.01	11.62	1.12	0.51
				15-30 cm	6.19	10.00	10.90	1.42	0.72

	6.Nungei	24.636981	93.943194	0-15 cm	5.29	6.50	14.25	0.84	0.23
				15-30 cm	5.80	12.00	15.55	1.45	0.87
	7.Laiphrakpam	24.664014	93.922222	0-15 cm	5.89	9.20	12.32	1.16	0.54
				15-30 cm	6.10	10.00	10.82	1.30	0.99
	8.Atoukhong	24.653075	93.933465	0-15 cm	5.30	5.50	10.07	0.71	0.61
				15-30 cm	5.83	9.00	15.15	1.50	0.98
	9.Chaobok	24.65579	93.98274	0-15 cm	5.29	7.80	15.26	0.52	0.23
				15-30 cm	5.89	12.00	15.34	1.68	0.94
	10.Khekman	24.637588	93.950451	0-15 cm	5.37	8.72	13.43	1.20	0.33
				15-30 cm	6.04	8.50	13.58	1.39	0.50
3.Kakching	1.Langmeidong	24.470156	93.939393	0-15 cm	5.14	7.60	12.31	0.74	0.55
				15-30 cm	4.94	10.10	13.17	1.14	0.47
	2.Irengband	24.514714	93.994591	0-15 cm	5.25	3.40	10.49	0.78	0.48
				15-30 cm	5.34	6.00	12.28	1.45	0.50
	3.Chairel Kakching	24.496869	93.983053	0-15 cm	5.03	7.20	12.13	0.75	0.41
				15-30 cm	4.86	10.00	13.45	1.10	0.33
	4.Serou	24.267433	93.87554	0-15 cm	5.40	9.10	10.00	1.38	0.43
				15-30 cm	5.15	9.30	10.51	1.21	0.35
	5.Wabagai	24.531038	93.94224	0-15 cm	5.55	7.00	8.60	1.11	0.40
				15-30 cm	5.45	7.20	16.14	1.30	0.40
	6.Hiyanglam	24.51887	93.925255	0-15 cm	5.20	7.90	11.06	0.72	0.70
				15-30 cm	5.10	10.00	12.87	1.20	0.30
	7.Loushipat	24.503866	94.010809	0-15 cm	5.57	4.00	7.61	1.21	0.77
				15-30 cm	5.47	4.20	7.68	1.45	1.00
	8.Thongam	24.542635	93.888442	0-15 cm	5.25	5.50	10.06	0.75	0.76
				15-30 cm	5.06	8.20	13.19	1.42	0.83
	9.Thounaojam	24.44162	93.953413	0-15 cm	5.18	11.80	10.09	0.35	0.70
				15-30 cm	5.08	12.10	13.63	1.20	0.63
	10.Kakching	24.496869	93.983053	0-15 cm	5.44	8.64	8.19	0.43	0.91
				15-30 cm	5.15	9.30	9.00	1.52	0.84

Table 2. Different forms of acidity in the soils of Thoubal District

Block	**Village**	**Latitude**	**Longitude**	**Depth**	**TA** (cmol (p+)/kg)	**EA** (cmol (p+)/kg)	**pH DA** (cmol (p+)/kg)
1.Thoubal	1.Charangpat	24.644531	94.009995	0-15 cm	6.73	2.15	4.59
				15-30 cm	9.11	1.05	8.06
	2.Heirok 1	24.584648	94.077457	0-15 cm	5.28	1.35	3.93
				15-30 cm	9.71	1.35	8.37
	3.Khangabok	24.616199	94.007696	0-15 cm	8.58	2.78	5.80
				15-30 cm	12.00	2.78	9.23
	4.Langathel	24.524912	94.055494	0-15 cm	5.34	1.47	3.87
				15-30 cm	9.65	1.47	8.18
	5.Tentha	24.573063	93.972538	0-15 cm	4.38	1.25	3.12
				15-30 cm	8.99	1.25	7.73
	6.Chandrakhong	24.689816	94.122593	0-15 cm	6.05	1.97	4.08
				15-30 cm	10.66	1.97	8.69
	7.Khongjom	24.538628	94.041446	0-15 cm	4.29	0.24	4.05
				15-30 cm	8.98	1.24	7.74
	8.Tekcham	24.52179	94.005704	0-15 cm	6.25	2.05	4.20

				15-30 cm	10.39	2.15	8.24
	9.Thoubal Khunou	24.663797	93.997542	0-15 cm	6.28	2.15	4.12
				15-30 cm	10.16	1.15	9.00
	10.Wangjing	24.590961	94.044833	0-15 cm	5.63	1.75	3.88
				15-30 cm	9.35	1.75	7.60
2.Lilong	1.Haoreibi	24.680572	93.941941	0-15 cm	6.81	2.05	4.76
				15-30 cm	7.50	1.15	6.35
	2.Irong Cheksaba	24.633811	93.905283	0-15 cm	5.33	1.36	3.97
				15-30 cm	6.89	1.36	5.53
	3.Moijing	24.648827	93.954264	0-15 cm	8.90	2.81	6.09
				15-30 cm	9.00	1.51	7.49
	4.Leisangthem	24.606538	93.939393	0-15 cm	5.77	1.97	3.79
				15-30 cm	6.27	1.28	4.99
	5.Lilong	24.719716	93.933139	0-15 cm	4.39	1.25	3.13
				15-30 cm	4.99	1.25	3.73
	6.Nungei	24.636981	93.943194	0-15 cm	6.17	2.15	4.02
				15-30 cm	8.77	1.05	7.73
	7.Laiphrakpam	24.664014	93.922222	0-15 cm	4.35	0.26	4.09
				15-30 cm	4.56	0.90	3.66
	8.Atoukhong	24.653075	93.933465	0-15 cm	5.87	1.78	4.09
				15-30 cm	7.65	1.97	5.67
	9.Chaobok	24.65579	93.98274	0-15 cm	6.04	2.02	4.02
				15-30 cm	8.74	1.02	7.71
	10.Khekman	24.637588	93.950451	0-15 cm	5.63	1.49	4.15
				15-30 cm	7.27	1.49	5.79
3.Kakching	1.Langmeidong	24.470156	93.939393	0-15 cm	7.07	2.07	5.00
				15-30 cm	11.20	2.17	9.03
	2.Irengband	24.514714	93.994591	0-15 cm	5.50	1.71	3.78
				15-30 cm	6.09	1.88	4.21
	3.Chairel Kakching	24.496869	93.983053	0-15 cm	8.61	2.66	5.96
				15-30 cm	11.30	2.66	8.64
	4.Serou	24.267433	93.87554	0-15 cm	5.39	1.40	3.99
				15-30 cm	8.91	2.40	6.51
	5.Wabagai	24.531038	93.94224	0-15 cm	4.35	1.24	3.11
				15-30 cm	5.06	2.24	2.81
	6.Hiyanglam	24.51887	93.925255	0-15 cm	5.93	1.97	3.95
				15-30 cm	10.60	2.97	7.63
	7.Loushipat	24.503866	94.010809	0-15 cm	4.11	0.25	3.86
				15-30 cm	8.86	1.25	7.61
	8.Thongam	24.542635	93.888442	0-15 cm	5.73	1.97	3.75
				15-30 cm	9.75	1.97	7.78
	9.Thounaojam	24.44162	93.953413	0-15 cm	6.04	1.98	4.06
				15-30 cm	9.91	1.98	7.93
	10.Kakching	24.496869	93.983053	0-15 cm	5.42	1.54	3.88
				15-30 cm	9.19	1.54	7.65

Table 3. Coefficients of correlation between forms of acidities and soil properties of Thoubal District (0-15 cm)

Types of Soil Acidity	Soil Properties							
	pH	OC	Ca	Mg	Exch. Al	Extr. Al	CEC	Clay
Exchangeable acidity	-0.779**	0.357	-0.472**	-0.470**	0.804**	0.920**	0.355	0.369*
pH-dependent acidity	-0.498**	0.443*	-0.191	-0.192	0.360	0.533**	0.401*	0.391*
Total acidity	-0.703**	0.448*	-0.361	-0.360	0.635**	0.797**	0.423*	0.424*

*** = Significant at 5% level, ** = Significant at 1% level**

Table 4. Coefficients of correlation between forms of acidities and soil properties of Thoubal District (15-30 cm)

Types of Soil Acidity	Soil Properties							
	pH	OC	Ca	Mg	Exch. Al	Extr. Al	CEC	Clay
Exchangeable acidity	-0.735**	0.012	-0.625**	-0.824**	0.607**	0.529**	0.093	0.462*
pH-dependent **acidity**	-0.483**	0.555**	-0.191	-0.056	0.351	0.636**	0.437*	0.252
Total acidity	-0.652**	0.505**	-0.356	-0.292	0.495**	0.730**	0.422*	0.363*

*** = Significant at 5% level, ** = Significant at 1% level**

Table 5. Lime Requirement in the soils of Thoubal District

Block	Village	Latitude	Longitude	Depth	$BaCl_2$ t/ha	Dunn t/ha	1N KCl t/ha
1.Thoubal	1.Charangpat	24.644531	94.009995	0-15 cm	13.10	4.10	2.50
				15-30 cm	15.69	4.81	2.29
	2.Heirok 1	24.584648	94.077457	0-15 cm	10.20	2.30	0.75
				15-30 cm	11.07	3.40	0.58
	3.Khangabok	24.616199	94.007696	0-15 cm	13.60	3.80	2.48
				15-30 cm	18.70	5.28	2.31
	4.Langathel	24.524912	94.055494	0-15 cm	11.70	2.60	2.08
				15-30 cm	12.20	3.47	0.96
	5.Tentha	24.573063	93.972538	0-15 cm	7.90	1.90	0.93
				15-30 cm	10.23	3.12	0.17
	6.Chandrakhong	24.689816	94.122593	0-15 cm	10.80	3.10	2.73
				15-30 cm	12.92	3.97	2.34
	7.Khongjom	24.538628	94.041446	0-15 cm	7.00	1.40	0.25
				15-30 cm	8.99	3.44	0.17
	8.Tekcham	24.52179	94.005704	0-15 cm	12.50	3.50	3.53
				15-30 cm	13.75	4.06	3.50
	9.Thoubal Khunou	24.663797	93.997542	0-15 cm	12.30	3.50	2.78
				15-30 cm	14.06	4.21	1.16

	10.Wangjing	24.590961	94.044833	0-15 cm	11.70	2.90	2.06
				15-30 cm	12.60	3.77	1.82
2.Lilong	1.Haoreibi	24.680572	93.941941	0-15 cm	14.30	4.00	2.22
				15-30 cm	18.48	4.31	1.76
	2.Irong Cheksaba	24.633811	93.905283	0-15 cm	9.39	2.50	1.02
				15-30 cm	8.67	3.10	0.98
	3.Moijing	24.648827	93.954264	0-15 cm	17.90	4.20	2.48
				15-30 cm	18.03	4.38	2.34
	4.Leisangthem	24.606538	93.939393	0-15 cm	11.80	2.50	2.21
				15-30 cm	12.61	3.58	1.23
	5.Lilong	24.719716	93.933139	0-15 cm	10.20	1.70	1.85
				15-30 cm	8.78	3.22	0.38
	6.Nungei	24.636981	93.943194	0-15 cm	12.70	3.50	2.79
				15-30 cm	17.86	4.23	1.77
	7.Laiphrakpam	24.664014	93.922222	0-15 cm	10.50	1.60	0.80
				15-30 cm	9.39	3.13	0.94
	8.Atoukhong	24.653075	93.933465	0-15 cm	10.70	3.20	2.40
				15-30 cm	13.02	3.74	1.97
	9.Chaobok	24.65579	93.98274	0-15 cm	12.80	3.60	2.77
				15-30 cm	13.03	4.14	1.65
	10.Khekman	24.637588	93.950451	0-15 cm	11.50	2.60	2.86
				15-30 cm	11.44	3.35	1.43
3.Kakching	1.Langmeidong	24.470156	93.939393	0-15 cm	14.60	4.00	2.46
				15-30 cm	14.78	4.91	1.82
	2.Irengband	24.514714	93.994591	0-15 cm	10.10	2.40	2.18
				15-30 cm	13.45	4.16	1.49
	3.Chairel Kakching	24.496869	93.983053	0-15 cm	14.20	4.20	3.56
				15-30 cm	14.76	5.00	3.47
	4.Serou	24.267433	93.87554	0-15 cm	9.60	2.50	2.57
				15-30 cm	12.95	4.13	2.50
	5.Wabagai	24.531038	93.94224	0-15 cm	7.70	1.90	2.26
				15-30 cm	11.96	3.70	0.66
	6.Hiyanglam	24.51887	93.925255	0-15 cm	11.80	3.20	2.89
				15-30 cm	13.75	4.35	2.76
	7.Loushipat	24.503866	94.010809	0-15 cm	7.00	1.70	0.24
				15-30 cm	11.21	3.20	0.17
	8.Thongam	24.542635	93.888442	0-15 cm	10.40	3.30	2.38
				15-30 cm	13.63	4.30	1.47
	9.Thounaojam	24.44162	93.953413	0-15 cm	12.30	3.80	2.66
				15-30 cm	14.37	4.85	1.91
	10.Kakching	24.496869	93.983053	0-15 cm	11.10	2.30	1.98
				15-30 cm	12.95	4.06	0.94

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