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Section A-Research paper

Characterization of Soil Acidity and its Lime Requirement in Soils of Imphal West District, Manipur

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Abstract

In the northeastern region of India, notably in the state of Manipur, where almost ninety percent of the soils are acidic, the soil conditions present a significant obstacle to agricultural productivity. The current study's title is ―Characterization of Acid Soils and its Lime Requirement in Imphal West District, Manipur was undertaken with the following objectives viz. 1. To describe the nature of acidity in Imphal West district soils. 2. To characterize the Physicochemical properties of soil. 3. To determine the lime requirement of these acid soils. Depth wise 0-15 cm, 15- 30 cm, and 30-45cm (surface and sub-surface) soil samples were collected from Imphal West district i.e. 1. Wangoi 2. Yumnam huidrom 3. Mayang Imphal 4. Samurou and 5. Mutum phibou from each block of three samples are collected with the help of stratified random sampling (proportional allocation). The total numbers of soil samples collected from Imphal West are 15. Processed soil samples were used for analysis. The soils were found to be heavy in texture and ranged from clay loam to clay while the pH ranged between 5.03 to 6.12 which were considered moderately acidic to slightly acidic. The cation exchange capacity of the studied samples varied from 8.74 to 21.21 cmol (p+) kg^{-1} soil and organic carbon contents were low and ranged between 0.76 to 2.18 percent. Total Potential Acidity ranged from 4.37 to 11.28 Cmol(p+) kg^{-1}, Exchangeable Acidity from 0.07 to 0.22 Cmol (p+) kg^{-1} and pH-Dependent Acidity ranged from 3.82 to 7.01 Cmol (p+) kg^{-1}. Lime requirement (LR) was estimated by two methods i.e., the BaCl2 –TEA method (7.54 to 16.19 t/ha), and the Dunn Equilibrium method (1.90 to 5.25 t/ha). The BaCl2 –TEA approach produced the maximum amount of LR compared to the other procedures, while the Dunn equilibrium method produced the least amount.

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In addition, it has been found that pH and clay are the primary contributors to the production of exchange acidity, whereas the organic matter and clay found in the soil are the properties responsible for pH-dependent acidity. For this reason, it is recommended that the soil be provided with the necessary amounts of lime in order to maintain both its fertility and its level of production. Hence, various acceptable remedial remedies than liming may be implemented in order to improve crop productivity.

INTRODUCTION

Manipur, one of the seven sisters of India's north-eastern region, is a remote hilly state whose latitude and longitude range from 23°50 to 25°42 N and 92°59 to 94°46 E, respectively. Its geographic area is 22,327 square kilometers or 0.7 percent of the nation's overall land area. Soil acidity is a serious agricultural problem that either directly or indirectly reduces crop productivity. Soil acidity has grown to be a significant issue in the Manipur valley districts where intensive agriculture is practiced. Soil is a big issue for crop production in India's north-eastern area, especially in the state of Manipur where 90% of the soils are acidic. In the state, there are about 16.6% highly acidic soils, 70% moderately acidic soils, and 3.7% slightly acidic soils, according to soil resource mapping (Nayak *et al*. 1996).

Lime demand for acid soil is a term that refers to the amount of liming material that must be used in order to bring the pH level up to the desired range of values. Liming materials of many different varieties are applied to soil in order to neutralize its acidity and restore its health. Some of these include lime oxides, hydroxides, carbonates, slag, and other liming materials. According to reports, 80% of all soils in North Eastern are acidic (Misra, 2004). Soil acidity has been identified as a significant agricultural issue that has a negative impact on crop productivity, either directly or indirectly. Soil acidity has become a big issue in Manipur's valley areas, where intensive agriculture is practiced. A study titled "CHARACTERIZATION OF ACID SOILS AND LIME REQUIREMENT IN IMPHAL WEST DISTRICT, MANIPUR" was therefore proposed with the following goals in consideration of the type of soil acidity that exists in Manipur.

1. To describe the nature of acidity in Imphal West district soils.

2. To characterize the Physicochemical properties of soil.

3. To determine the lime requirement of these acid soils.

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MATERIALS AND METHODS:

For the present investigation five sites in the Imphal West district, spanning a depth of 0-15 cm, 15-30 cm, and 30-45 cm (surface and sub-surface), were sampled for soil: 1. Wangoi 2. Mayang Imphal, 3. Yumnam Huidrom 4. Samurou and 5. Mutum phibou are gathered and chosen using stratified random sampling from each block of three samples (proportional allocation). The soil samples were thoroughly air-dried in the shade and crushed with a wooden roller on a wooden plank and sieved through a 2 mm sieve. The sieved samples were stored in labeled transparent polythene bags for future use for various determinations.

Air-dried soil samples were crushed and put through a 2 mm sieve, and subjected to analysis of Particle size(soil texture) analysis using the Bouyoucos hydrometer method (Bouyoucos, 1927), Soil reaction (pH) (Gupta 2006), Organic carbon (OC) by Walkley and Black rapid titration method (Jackson 1973), Cation exchange capacity (CEC) with standard alkali as described by Jackson (1973), Total Potential Acidity by BaCl2-triethanolamine buffered at pH 8.0as described by Peech et al. (1962), Exchange Acidity by I M KCl extract as described by McLean (1965), pH-Dependent Acidity was calculated as the difference between Total Potential Acidity and Exchange Acidity as described by Hesse (1971), Lime Requirement by $BaCl_2$- tea method and Dunn Equilibrium method.

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Table1. Different forms of acidity in the soils of the Imphal West district

Block	**Latitude**	**Longitude**	**Depth**	**EA (cmol(p+)/kg)**	**pHDA(cmol)p+)/kg)**	**TA (cmol(P+)/kg)**
Wangoi	24.6586	93.8988	0-15cm	0.13	4.73	6.73
			15-30cm	0.11	5.75	9.14
			30-45cm	**0.07**	6.15	11.14
Yumnam huidrom	24.6612	93.9038	0-15cm	0.18	4.68	5.22
			15-30cm	0.14	5.61	6.23
			30-45cm	0.10	6.88	9.64
Mayang Imphal	24.5994	93.8706	0-15cm	**0.22**	5.75	6.07
			15-30cm	0.18	6.17	8.98
			30-45cm	0.16	**7.01**	**10.68**
Samurou	24.6905	93.9037	0-15cm	0.20	5.14	7.38
			15-30cm	0.16	6.06	9.76
			30-45cm	0.13	6.41	11.28
Mutum Phibou	24.57964	93.89673	0-15cm	0.16	**3.82**	**4.37**
			15-30cm	0.14	4.40	8.64
			30-45cm	0.08	4.94	9.38

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Nature of soil acidity

Total Potential Acidity (TPA)

Table 1 displays the total potential acidity of the examined soil samples. The results showed that the total potential acidity ranged from 4.37 to 11.28 Cmol (p+) kg-1 soil, which is moderately high. The sub-surface soil of the Samurou block had the highest TPA value of 11.28 cmol (p+) kg-1, whereas the surface soil of Mutum phibou had the lowest TPA value of 4.37 cmol (p+) kg-1. Additionally, the findings showed that the high total potential acidity is caused by the high levels of clay and organic matter mentioned by Nayak et al. (1996).

Exchange Acidity (EA)

According to data on exchange acidity (table 1) from the examined soil samples, exchange acidity is rather low when compared to total potential acidity, which ranges from 0.07 to 0.22 Cmol (p+) kg-1 soil. The surface soil of the Mayang Imphal block included the highest EA value of 0.22 cmol (p+) kg-1, whereas the sub-surface soil of the Wangoi block contained the lowest value, 0.07 Cmol (p+) kg-1. Additionally, the data results demonstrate that exchange acidity contributes relatively little to total acidity. Sharma et al. (1990), Das et al. (1991), and Kumar et al. (1992) noted comparable results. (1995).

pH-Dependent Acidity (pH DA)

Data on pH-dependent acidity are shown in Table 1. According to Bandyopadhyay and Chattopadhyay and our analysis of the data, pH-dependent acidity considerably adds to total potential acidity. (1997). The pH-dependent acidity ranges from 3.82 to 7.01 Cmol (p+) kg-1 soil. The pH-dependent acidity value ranged from 3.82 Cmol (p+) kg-1 in the surface soil of the Mutum phibou block to 7.01 Cmol (p+) kg-1 in the sub-surface soil of the Mayang Imphal block. Furthermore, the data showed that a high level of pH-dependent acidity is caused by a high level of organic carbon. Nayak et al. (1996) and Gangopadhyay et al. (1996) reported similar findings. (2008).

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Table:2 Physicochemical properties of the soils of Imphal West district

Block	Latitude	Longitude	Depth	pH	OC (%)	N (kg/ha)	P (kg/ha)	K (kg/ha)	CEC (cmol(p^+) kg^{-1}
1.Wangoi	24.6586	93.8988	0-15cm	5.39	0.76	282.24	22.24	156.80	14.54
			15-30cm	5.66	1.36	261.33	17.60	138.88	15.78
			30-45cm	6.07	1.76	245.44	25.64	113.49	19.21
2.Yumnam huidrom	24.6612	93.9038	0-15cm	5.37	1.10	307.33	23.85	165.76	8.74
			15-30cm	5.61	1.48	283.91	20.05	151.20	12.82
			30-45cm	5.64	2.18	269.70	14.08	117.60	15.77
3.Mayang Imphal	24.5994	93.8706	0-15cm	5.55	0.94	304.99	24.36	168.00	11.24
			15-30cm	5.69	1.93	294.78	17.37	156.80	13.24
			30-45cm	6.12	1.15	272.03	23.03	143.36	15.62
4.Samurou	24.6905	93.9037	0-15cm	5.43	1.52	303.66	24.58	167.63	12.19
			15-30cm	5.62	1.76	283.91	21.93	159.04	13.70
			30-45cm	5.80	2.03	269.70	17.92	150.08	17.06
5.Mutum phibou	24.57964	93.89673	0-15cm	5.03	0.76	319.87	23.72	171.73	10.58
			15-30cm	5.23	1.98	294.78	20.91	165.01	13.89
			30-45cm	5.30	2.13	284.91	18.34	159.04	21.21

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Table:3 Particle size distribution of the studied soil samples

Block	Depth	Sand (%)	Silt (%)	Clay (%)	Soil texture
1. Wangoi	0-15cm	36.30	23.40	40.30	clay
	15-30cm	35.30	22.83	41.87	clay
	30-45cm	27.37	29.13	43.50	clay
2.Yumnam huidrom	0-15cm	27.37	36.00	36.63	Clay loam
	15-30cm	25.43	33.84	40.73	clay
	30-45cm	19.73	35.57	44.70	clay
2. Mayang Imphal	0-15cm	34.13	29.10	36.77	Clay loam
	15-30cm	33.63	24.17	42.20	clay
	30-45cm	27.00	28.10	44.90	clay
4. Samurou	0-15cm	27.07	31.83	41.10	clay
	15-30cm	22.13	32.20	45.67	clay
	30-45cm	23.97	35.70	40.33	clay
5.Mutum phibou	0-15cm	30.47	30.66	38.87	Clay loam
	15-30cm	28.20	28.40	43.40	clay
	30-45cm	25.70	27.80	46.50	clay

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Table 4: Lime requirement in the soils of Imphal West district

Block	Latitude	Longitude	Depth	BaCl2 t/ha	Dunn t/ha
1.Wangoi	24.6586	93.8988	0-15cm	11.40	2.60
			15-30cm	12.33	3.50
			30-45cm	15.76	4.81
2.Yumnam huidrom	24.6612	93.9038	0-15cm	10.20	2.30
			15-30cm	11.98	3.34
			30-45cm	16.04	5.24
3.Mayang Imphal	24.5994	93.8706	0-15cm	7.70	3.13
			15-30cm	12.33	3.77
			30-45cm	14.30	4.14
4. Samurou	24.6905	93.9037	0-15cm	9.39	4.20
			15-30cm	12.23	4.38
			30-45cm	13.01	5.01
5.Mutum phibou	24.57964	93.89673	0-15cm	7.54	1.90
			15-30cm	11.36	3.20
			30-45cm	16.19	5.25

Lime Requirement (LR)

Table no.4 contains information regarding the amount of lime required. The lime requirement (LR) of soils in the Imphal West district was evaluated using two different approaches, namely the BaCl2-Tea method and the Dunn equilibrium method. Both methods were used to calculate the LR.

$BaCl_2$- Tea method LR values of Imphal west district soils ranged from 7.54 to 16.19 t/ha. The highest $BaCl_2$- Tea -LR value of 16.19 t/ha was recorded in the subsurface soils of Mutum phibou, and the lowest $BaCl_2$ -Tea -LR value of 7.54 t/ha was recorded in the surface soil of Mutum phibou.

The Dunn Equilibrium method -LR of Imphal west district soils ranged from 1.90 to 5.25 t/ha. The highest Dunn -LR value of 5.25 t/ha was recorded in the subsurface soil of Mutum phibou, and the lowest Dunn -LR value of 1.90 t/ha was recorded in the surface soil of Mutum phibou.

In a similar fashion, it was discovered that there are considerable variances between the various types of soil. When compared to the BaCl2 – Tea method, which produced the highest levels of LR, the Dunn equilibrium approach produced the lowest levels, making it the winner in this comparison. The BaCl2–Tea technique resulted in the highest levels of LR being reported. A thorough analysis of the data showed that the subsurface layers' LR was substantially higher than the top layers. The investigation's findings suggest that this might be because of the soils' high levels of acidity, organic carbon, and clay concentration. These traits were discovered to be present. In their study from 1985, Tisdale et al. showed that the LR of soils depends on the soil's ability to act as a buffer, which is evidenced by the presence of clay and organic matter. One of their study's findings was this. According to Ananthanarayana and Ravikumar (1997), the presence of lime is required in acid soils because the various types of acidity contribute to the requirement. Research conducted by Tisdale *et al* in 1985 found that the reserve acidity and CEC of the soil both contributed to an increase in the need for lime. The surface soil of Mutum Phibou has a relatively low LR in comparison to the sub-surface soils. This can be attributed to both the low concentration of organic matter and the low percentage of clay in the surface soil. We need to add a particular amount of lime to the soil to change the pH, and that amount is directly inversely related to the clay content and organic matter already present in the soil. According to Mehra (2006), when the soil's organic matter content is high, more lime is needed to achieve the same change in pH in soil with the same other characteristics but a lower organic matter level. This is because a smaller amount of lime would be needed to generate the same pH change in soil with less organic matter.

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Correlations data for different soil properties of Imphal West district for (0-15cm) depth

Table 5.

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	pH	EC	0C	Sand	Silt	Clay	CEC	N	P	K	Ca	Mg	TA	EA	pH DA	Lime (Dunn)	Lime (Bacl2)
pH	1	-0.844	0.402	0.201	-0.116	-0.144	0.219	-0.522	0.196	-0.404	0.607	0.768	0.713	0.414	.958*	0.648	0.276
EC		1	-0.559	0.137	-0.169	0.105	-0.021	0.531	-0.106	0.498	-0.678	-0.387	-0.633	-0.355	-0.684	-0.528	-0.595
0C			1	-0.735	0.529	0.286	-0.151	0.121	0.671	0.166	.967**	0.192	0.568	.915*	0.402	0.820	0.075
Sand				1	-.892*	-0.010	0.646	-0.598	-0.659	-0.543	-0.598	0.505	0.110	-0.586	0.191	-0.241	0.144
Silt					1	-0.443	-.909*	0.693	0.702	0.639	0.466	-0.579	-0.366	0.407	-0.089	0.009	-0.283
Clay						1	0.730	-0.344	-0.245	-0.335	0.153	0.277	0.590	0.263	-0.184	0.456	0.338
CEC							1	-0.752	-0.567	-0.689	-0.127	0.671	0.666	-0.085	0.166	0.327	0.426
N								1	0.694	.984**	0.035	-0.541	-0.651	0.261	-0.323	-0.190	-0.830
P									1	0.773	0.693	0.050	0.013	0.817	0.381	0.504	-0.651
K										1	0.111	-0.381	-0.552	0.361	-0.174	-0.065	-.900*
Ca											1	0.361	0.636	.920*	0.616	0.872	0.058
Mg												1	0.802	0.385	0.821	0.705	0.071
TA													1	0.550	0.647	0.865	0.470
EA														1	0.523	.890*	-0.254
pH DA															1	0.693	-0.003
Lime (Dunn)																1	0.054
Lime (Bacl2)																	1

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

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Table 6.

Correlations data for different soil properties of Imphal West district for (15-30cm) depth

	pH	EC	0C	Sand	Silt	Clay	CEC	N	P	K	Ca	Mg	TA	EA	pH DA	Lime (Dunn)	Lime (Bacl2)
pH	1	-0.305	-0.505	0.218	-0.167	-0.212	0.046	-0.494	-0.499	-0.621	.930*	0.680	0.041	0.170	.964**	0.506	.971**
EC		1	-0.176	0.068	-0.270	0.495	0.826	-0.503	0.212	-0.192	-0.408	-0.198	0.616	-0.615	-0.302	0.103	-0.121
0C			1	-0.154	-0.008	0.474	-0.457	.895*	0.260	.905*	-0.458	-0.147	0.341	0.720	-0.298	0.127	-0.442
Sand				1	-.943*	-0.518	0.559	-0.334	-.933*	-0.530	-0.145	0.816	0.187	-0.242	0.086	-0.384	0.291
Silt					1	0.204	-0.653	0.299	0.819	0.401	0.202	-0.795	-0.501	0.154	-0.106	0.157	-0.310
Clay						1	0.035	0.214	0.642	0.529	-0.095	-0.357	0.737	0.317	0.018	0.724	-0.059
CEC							1	-0.772	-0.354	-0.631	-0.215	0.303	0.499	-0.728	-0.058	-0.080	0.208
N								1	0.342	.926*	-0.346	-0.308	-0.099	0.743	-0.332	-0.049	-0.541
P									1	0.613	-0.180	-.924*	-0.022	0.087	-0.362	0.266	-0.514
K										1	-0.429	-0.526	0.109	0.641	-0.415	0.120	-0.614
Ca											1	0.386	-0.109	0.273	.931*	0.598	0.855
Mg												1	0.280	0.158	0.626	0.117	0.735
TA													1	0.167	0.198	0.602	0.271
EA														1	0.374	0.499	0.153
pH DA															1	0.697	.960**
Lime (Dunn)																1	0.597
Lime(Bacl2)																	1

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*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

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Correlations data for different soil properties of (30-45cm) depth

	pH	EC	0C	Sand	Silt	Clay	CEC	N	P	K	Ca	Mg	TA	EA	pH DA	Lime (Dunn)	Lime(Bacl2)
pH	1	0.132	-0.776	0.421	-0.101	-0.391	-0.528	-0.785	0.697	-0.453	-0.170	0.401	0.792	0.436	0.698	-0.812	-0.422
EC		1	0.205	-0.807	0.685	-0.107	-0.708	-0.212	-0.500	-0.685	0.679	0.342	-0.138	0.074	0.703	0.170	0.138
0C			1	-0.635	0.536	-0.081	0.381	0.334	-0.703	-0.006	0.670	0.191	-0.435	-0.630	-0.467	.994**	0.319
Sand				1	-0.821	0.085	0.429	-0.308	.907*	0.243	-0.817	-0.244	0.438	0.030	-0.301	-0.599	-0.125
Silt					1	-0.639	-0.516	0.043	-0.690	-0.221	.970**	0.733	0.122	0.129	0.434	0.453	-0.357
Clay						1	0.323	0.340	-0.018	0.059	-0.592	-.950*	-0.803	-0.265	-0.353	0.017	0.791
CEC							1	0.154	0.211	0.299	-0.352	-0.366	-0.258	-0.739	-.967**	0.445	0.458
N								1	-0.667	0.789	-0.045	-0.492	-0.668	0.197	-0.397	0.349	-0.004
P									1	-0.170	-0.661	-0.036	0.595	-0.013	-0.008	-0.678	-0.071
K										1	-0.337	-0.344	-0.169	0.352	-0.478	-0.005	-0.382
Ca											1	0.734	0.076	-0.112	0.303	0.598	-0.184
Mg												1	0.731	0.090	0.430	0.099	-0.590
TA													1	0.315	0.396	-0.502	-0.714
EA														1	0.643	-0.683	-0.743
pH DA															1	-0.526	-0.407
Lime (Dunn)																1	0.406
Lime(Bacl2)																	1

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

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Table 7

Correlation of different soil properties in Imphal West district for (0-15cm) depth

The correlation of different soil properties is presented in the table no.5. It was observed that the pH in the surface soil of Imphal West had a significant positive correlation with pH-dependent acidity (.958*), and organic carbon had a significant positive correlation with exchangeable acidity (.915*). Organic carbon had a significant positive correlation with calcium (.967*). Sand had a significant negative correlation with silt (-.892*), and silt had a negative correlation with CEC (-.909*). Nitrogen had a significant positive correlation with potassium (.984**). Potassium had a significant negative correlation with $BaCl_2$ (-.900*). Calcium had a significant positive correlation with exchangeable acidity (.920*). Exchangeable acidity had a significant positive correlation with Dunn (.890*).

Correlation of different soil properties in Imphal West district for (15-30cm) depth

The correlation of different physicochemical properties of 15-30cm depth was shown in Table no.6. And it was observed that the pH in the sub-surface soil of Imphal West had a significant positive correlation with pH-dependent acidity (964**) and also with $BaCl_2$ (.971**). Organic carbon had a positive significant correlation with nitrogen (.895*) and also with potassium (.905*). Sand had a significant negative correlation with silt (-.943) and sand had a significant negative correlation with phosphorus (-.933*). Nitrogen had a significant positive correlation with potassium (.926*). Phosphorus had a significant negative correlation with magnesium (-924*). Calcium had a significant positive correlation with pH-dependent acidity (.931*). And pH-dependent acidity had a significant positive correlation with $BaCl_2$ (.960**).

Correlation of different soil properties in Imphal West district for(30-45cm) depth

It was observed that the organic carbon had a significant positive correlation with Dunn (.994**). Sand had a significant positive correlation with phosphorus (.907*). Silt had a significant positive correlation with calcium (.970**). Clay had a significant negative

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correlation with magnesium (-.950*). CEC had a significant negative correlation with pH-dependent acidity (-.967**).

CONCLUSION:

Given the information presented above, one logical conclusion is that there is an issue with moderately acidic soils. Although the organic carbon content was low range, the cation exchange capacity was also rather low. Furthermore, it has been revealed that pH and clay are the key contributors to the generation of exchange acidity, whereas organic matter and clay are the soil properties responsible for pH-dependent acidity. Total potential acidity and pH-dependent acidity had a higher correlation value, indicating that pH-dependent acidity has a greater influence than exchange acidity. This could be one of the major reasons for the decrease in agricultural production capacity, particularly in the rice field, in Imphal West district, Manipur. As a result, it is recommended that the soil get the necessary doses of lime in order to maintain its fertility and productivity. Other than liming, effective remedial countermeasures may also be used to boost crop productivity.

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