The Pharma Innovation Journal 2023; 12(6): 1250-1257

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(6): 1250-1257

www.thepharmajournal.com
Received: 11-03-2023
Accepted: 12-04-2023

Thoudam Kholen Singh,
M.Sc. Soil Science & Agriculture Chemistry Department of Soil Science & Agriculture Chemistry, Lovely Professional University, Phagwara, Jalandhar, Punjab, India

Meraj Ahmed,
Assistant Professor, Department of Soil Science & Agriculture Chemistry, Lovely Professional University, Phagwara, Jalandhar, Punjab, India

Princy Thakur
Associate Professor, Department of Soil Science & Agriculture Chemistry, Lovely Professional University, Phagwara, Jalandhar, Punjab, India

Kamini Kumari
Associate Professor, Department of Soil Science & Agriculture Chemistry, Lovely Professional University, Phagwara, Jalandhar, Punjab, India

Corresponding Author:
Meraj Ahmed,
Assistant Professor, Department of Soil Science & Agriculture Chemistry, Lovely Professional University, Phagwara, Jalandhar, Punjab, India

Acid Soils' nutrient management of Imphal west district Manipur: A review

Thoudam Kholen Singh, Meraj Ahmed, Princy Thakur and Kamini Kumari

Abstract
Acid soils are widespread in Manipur, and nutrient management is crucial for sustaining crop production in these areas. Soil testing, lime application, organic matter management, and integrated nutrient management are some of the essential strategies for optimizing nutrient availability and crop growth in acid soils. Nutrient management in the acid soils of Manipur requires a comprehensive approach that addresses soil acidity, nutrient deficiencies, and environmental sustainability. Using a combination of soil testing, lime application, organic matter management, and integrated nutrient management practices can help farmers maximize crop yields while minimizing the negative impacts of agricultural practices on the environment. Hence, nutrient management in the acid soils of Manipur is essential for ensuring food security and sustaining rural livelihoods. By using a combination of soil testing, lime application, organic matter management, and integrated nutrient management practices, farmers can optimize crop yields, reduce input costs, and promote environmental sustainability in acid soils.

Keywords: Lime application, integrated nutrient management, organic matter, *etc.*

Introduction
Manipur is a state in north-eastern India with a unique geography and geology that results in the presence of acid soils in some areas. Managing nutrients is essential for crop growth in Manipur's acid soils. Low amounts of nitrogen, phosphorus, and potassium, as well as high concentrations of aluminium and other hazardous components, characterize acid soils. Soil fertility, crop development and productivity, and long-term agricultural sustainability all depend on prudent nutrient management. When working with acid soils, farmers in Manipur encounter a number of difficulties.

Some of them include a lack of information on how to properly manage soil fertility and a scarcity of resources, such as fertilizers and other inputs. In addition, the heavy precipitation that characterizes this area often results in the leaching of nutrients from the soil, making it hard to sustain sufficient nutrient levels over time. Manipuri farmers may use a variety of methods for dealing with the issues posed by acid soils. To restore soil nutrients, conservation tillage practices such as crop rotation and the use of animal manure or compost can be implemented, as can the use of organic fertilizers like manure. In addition, farmers can consult with agricultural extension agents and other specialists to create nutrient management programs that are unique to their farm's soil and crop conditions. NER India's soils are acidic, especially in Manipur (Sharma *et al*. 2006), 11.2 Mha of acidic, chemically disturbed soils are in India's NER. Soil acidity is Manipur's biggest issue. To increase crop productivity, acid soils have been treated with lime and other organic ingredients for years. Promoting long-term agricultural output on Manipur's acid soils necessitates careful nitrogen management. Farmers can protect the long-term health and productivity of their soil by implementing best practices for maintaining soil fertility, which in turn benefits their crops. All of India's soils are acidic due to significant precipitation that removes exchangeable base- forming cations (Ca, Mg). Rainfall acidifies Manipur soil. Rainfall, leaching, organic matter decomposition, and high-yield crop harvests create acidic soils. Crop management, organic matter removal, and acid-forming fertilizer induce soil acidity (Behera and Shukla, 2015; Fageria and Nascente, 2014). Manipur's acidic soils lower agriculture output. Acid soils need lime. Lime requirement techniques abound. Soil acidity is caused by rainfall, temperature, topography, and morphology (Abebe, 2007; Brady and Weil, 2016). Acidic parent materials, high rainfall, and plant cover naturally generate acid soils (Ritcher 1986).

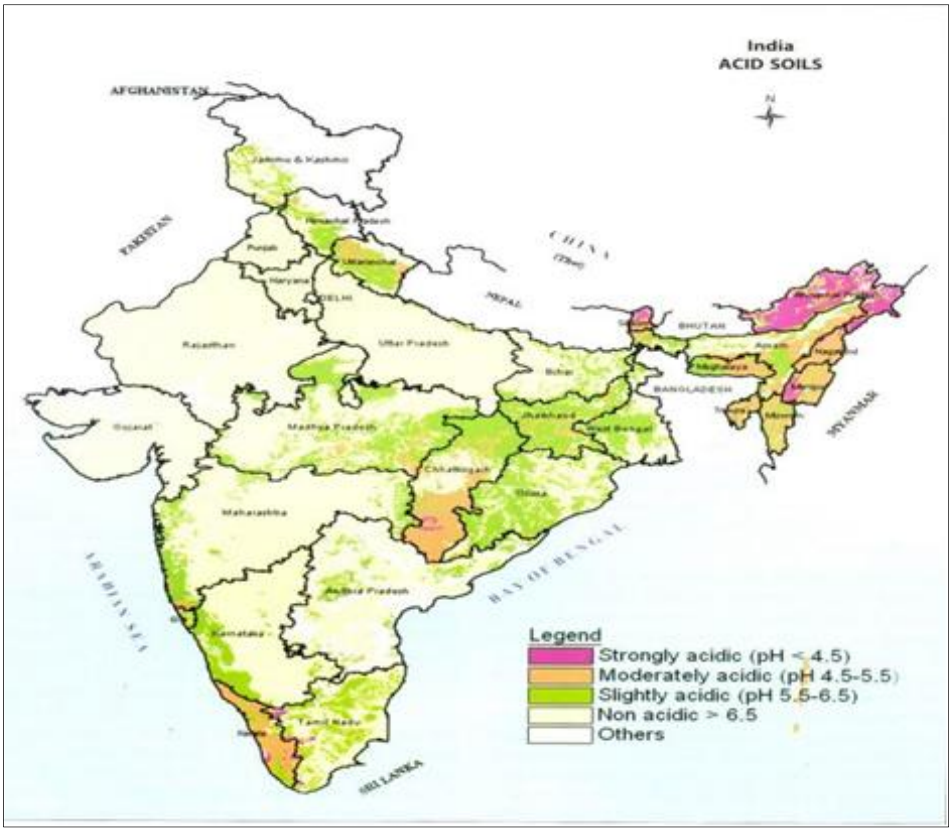

Fig 1: India map

Acidification releases aluminum (Al) According to these maps, Manipur soils are moderate to extremely acidic.

NER India has more than 21 MHA of acid soils, compared to 16 MHA in the North-Eastern Hill (NEH) region, which excludes Assam. North-Eastern soils are low-fertile. Arunachal Pradesh, Assam, Meghalaya, and Manipur have the most acidity. One-third of Assam's soils are mildly acidic. Most of Arunachal Pradesh (4.8 Mha) has strongly acidic soils (pH less than 4.50). East and west Khasi Hills in Meghalaya, Tuensang and Kohima in Nagaland, Aizawal in Mizoram, west Siang and Dibang Valley in Arunachal Pradesh, Churachandpur in Manipur, Karbi Angl-ong in Assam, west and south Tripura in Tripura, and north Sikkim in Sikkim have disproportionately more acid soils. Nagaland and Tripura have 10Y" of acid soils, Meghalaya percent, Manipur 98.07 %, and Mizoram 97.25 %.

Effect of acidity on N Availability

Acidic soils in Manipur can have a significant impact on the availability of nitrogen, which is an essential nutrient for plant growth and development. In acid soils, the low pH level can lead to the accumulation of hydrogen ions (H+) and aluminum ions (Al3+) in the soil solution. These ions can displace other positively charged nutrients, such as calcium (Ca2+), magnesium (Mg2+), and potassium (K+), from soil particles, making them more soluble and available for uptake by plant roots. However, the high concentration of H+ and Al3+ ions can also reduce the availability of nitrogen in the soil. This is because nitrogen exists in various forms in soil, such as ammonium (NH4+) and nitrate (NO3-), and its availability is affected by soil pH. In acidic soils, the conversion of ammonium to nitrate is inhibited, resulting in a lower supply of nitrate for plant uptake. Additionally, the increased activity of soil microbes in acidic soils can lead to greater rates of nitrogen mineralization, which can further reduce the amount of nitrogen available for plants. To overcome these limitations, farmers in Manipur may adopt a range of strategies to increase nitrogen availability in acidic soils. For example, they may apply lime or other soil amendments to raise the pH level, which can promote the conversion of ammonium to nitrate and increase the availability of nitrogen for plant uptake. Additionally, farmers may use nitrogen-fixing crops or leguminous plants, which can fix atmospheric nitrogen and release it into the soil as a form of organic nitrogen that is available for other plants to use. Overall, the impact of acidity on nitrogen availability in Manipur highlights the importance of effective soil management practices. By understanding the interactions between soil pH, nutrient availability, and crop growth, farmers can develop strategies for managing soil acidity and promoting sustainable agricultural production.

Effect of acidity on P Availability

Acidic soils in Manipur can also have a significant impact on the availability of phosphorus, another essential nutrient for plant growth and development. In acid soils, the low pH level can lead to the formation of insoluble complexes between phosphorus and aluminum or iron, which can reduce the amount of phosphorus available for plant uptake. This can result in phosphorus deficiency in plants, which can negatively impact crop yield and quality.

Additionally, in acidic soils, the activity of soil microbes that break down organic matter is increased, leading to greater competition for available phosphorus between microbes and plants. This can further reduce the amount of phosphorus available for plant uptake. However, overuse of phosphorus fertilizers can cause water pollution and is unsustainable. Thus, farmers may use cover crops or green manure crops to recycle phosphorus and reduce fertilizer use or add organic matter to the soil to boost phosphorus-solubilizing bacteria.

Manipur's acidity's effect on phosphorus availability shows the significance of good soil management for sustainable agriculture. Farmers may manage soil acidity and increase phosphorus availability by understanding the relationships between soil pH, nutrient availability, and crop growth.

Phosphorus is another essential nutrient for plant growth, but acidic soils can make it more difficult for plants to access it. This is because phosphorus has the propensity to form strong bonds with the particles of the soil in acidic soils, which makes it less available to plants.

The availability of phosphorus decreased with an increase in the pH of aquaponics nutrient solutions. High pH values influenced the formation of insoluble calcium phosphate species that precipitated from the solution. It has been discovered that the acidity of the soil has a substantial influence on the availability of phosphorus, particularly through the production of cation ions such as Al and Fe-P. This was discovered as a result of the research conducted by scientists. According to Brady and Weil (1997), when the pH of the soil is below 5.0, both the solubility and availability of phosphorus for plant absorption are negatively affected.

Therefore, the availability of iron was the primary factor that determined the amount of phosphorus present in the soil.

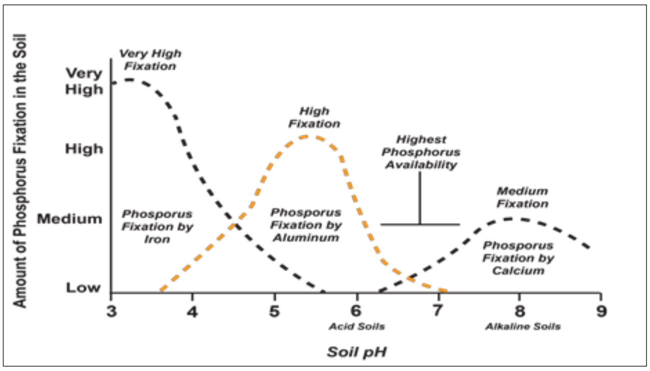

Fig 2: Phosphorus availability was relative to pH ranges (adapted from https://www.nachurs-alpine.com)

Effect of acidity on Potassium Availability

When the soil becomes too acidic, potassium ions in the soil tend to bind with other elements, such as aluminum and iron, forming compounds that are unavailable to plants. The amount of potassium (K) trapped and fixed at some locations between clay layers seems to be lower in acidic conditions (Haile W. and Boke S. 2011). In addition, acidic soil can also reduce the activity of soil microorganisms that are involved in breaking down organic matter and releasing potassium. Soil testing in Manipur is needed to ascertain the soil's pH and nutrient levels so that the impact of acidity on potassium availability can be evaluated. Based on the results, appropriate management practices can be implemented, such as lime to raise the pH and improve nutrient availability. Adding organic matter to the soil can also help to improve potassium availability and soil fertility.

Effect of acidity on secondary Nutrients:

Acidity can have significant effects on the availability and uptake of secondary nutrients in Manipur's soils. The most important secondary nutrients are calcium, magnesium, and sulfur (Singh, *et al*. (2018).

When the soil pH is too low, these nutrients become less available to plants. In acidic soils, calcium and magnesium can become bound to soil particles and unavailable for plant uptake, leading to nutrient deficiencies. Sulfur is another essential secondary nutrient that is affected by soil acidity. In acidic soils, sulfur can be converted to sulfates, which are highly soluble and can be leached from the soil. This can lead to sulfur deficiencies in plants, which can cause reduced growth, delayed maturity, and decreased yield (Singh, L. T. *et al*. (2015).

Therefore, it is important to maintain an appropriate soil pH for optimal nutrient availability and plant growth. In highly acidic soils, lime can be applied to raise the pH and improve the availability of secondary nutrients. If plants are given the right amount of water and fertilizer, they will have a better chance of flourishing.

Effect of acidity on Micronutrient

The effect of acidity on micronutrients in Manipur would depend on various factors, such as the type of soil, the level of acidity, and the specific micronutrients being considered (Zhang, *et al*., (2016). In general, high acidity in the soil can lead to reduced availability of micronutrients for plant uptake. For example, high soil acidity can result in decreased availability of iron and manganese, which can lead to deficiencies in plants. This can have a negative impact on crop yields and quality. Overall, the effect of soil acidity on micronutrients in Manipur would depend on the specific conditions and factors involved. It's important to regularly monitor soil pH and nutrient levels to ensure that plants are receiving adequate nutrition.

Components inducing soil acidity: Decomposition of organic matter

The decomposition of organic matter produces H+ ions, which increase soil acidity. Organic matter breakdown increases soil acidity, but it has a little short-term effect. The majority of carbonic acid produced by microbes, higher plants, and other physicochemical and biological processes is lost to the environment as carbon dioxide, reducing its dissociation (Kochian *et al*., 2004; Paul, 2014). The soil's acidity comes from bacteria and higher plants' chemical activities and high carbonic acid levels (Paul, 2014).

Removal of elements (macro and micro) through harvesting of high-yielding crops Harvesting high-yielding crops removes elements, especially from soils with poor bases. Crops grow unevenly and soils acidify with mechanical cultivation. Base cations are taken with crops when soils are disturbed or worked, enhancing leaching (Brady and Weil, 2016; Fageria, 2009). High-yield crops increase soil acidity the most. During germination, plants absorb calcium, magnesium, and potassium. Thus, cereal harvesting affects soil acidity less than Bermuda grass and lucerne harvesting (Fageria and Baligar, 2008; Rengel, 2011).

Most soil's physical, chemical, and biological qualities are affected by land use and management (Gebrekidan and Negassa, 2006). Conant *et al*. (2003) observed that these approaches increase bulk density, decrease soil organic matter

(SOM), and lower CEC, decreasing soil fertility. Farming, overgrazing, deforestation, and mineral fertilizer can impair yield and soil qualities (Kang and Juo, 1986; Lemenih *et al*., 2005).

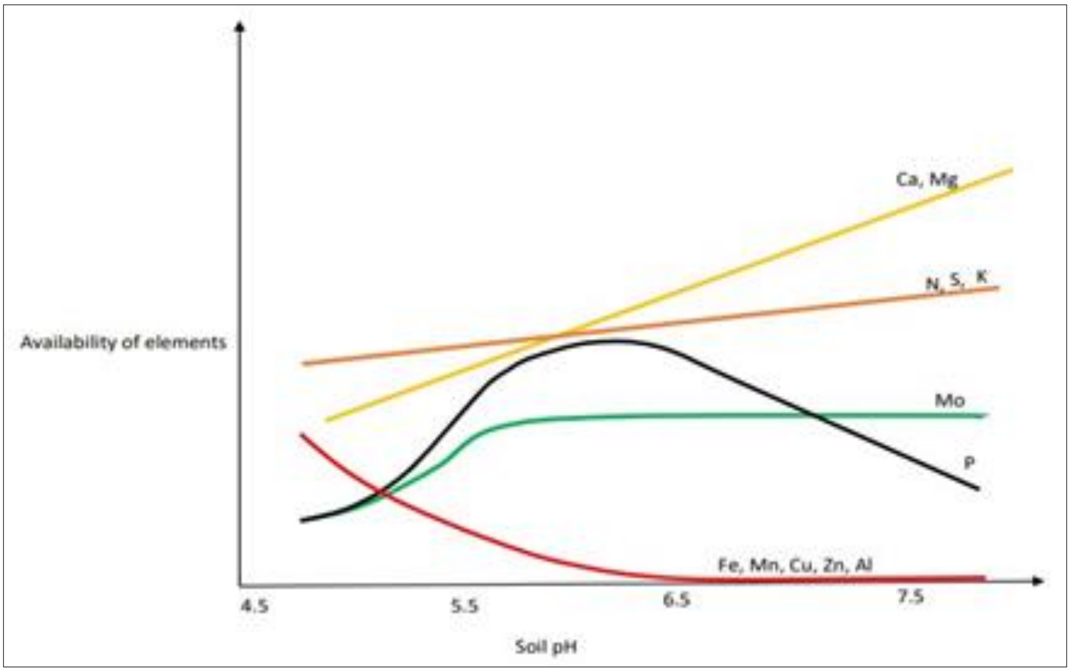

Fig 3: Relation between soil pH and nutrient availability, in acidic soils.

Table 1: optimum pH range for some crops.

Crop	Optimum pH for best growth	Crop	Optimum pH for best growth
Alfalfa	7.0-8.0	Sugar beet	5.8-7.0
Cotton	7.0-8.0	Millets	5.5-7.5
Oats	7.0-8.0	Sorghum	5.5-7.5
Cabbage	6.0-6.5	Sweet potato	4.5-6.5
Wheat	6.0-7.0	Potato	4.5-6.5
Barley	6.0-7.0	Tomato	5.5-7.5
Maize	6.0-7.2	Deciduous fruits	6.5-7.5
Clover	6.0-7.0	Mango	5.0-6.0
Faba bean	6.0-8.0	Papaya	6.0-6.5
Field pea	6.0-7.0	Avocado	5.0-8.0
Chickpea	7.0-8.0	Pineapple	4.5-6.5
Lentil	6.5-8.0	Flax	5.0-7.0
Soybean	6.2-7.0	Tea	4.0-6.0
Beans	5.5-8.0	Carrot	5.5-7.0
Onions	5.8-6.5	Rye	5.0-7.5
Sugarcane	5.0-8.5	Lupin	4.5-6.0

Management practices

Acidic soil management should aim to recover production potential by adding amendments to acidity treatment and controlling agricultural practices to maximize crop yields. The soil pH determines the soil's acidity/alkalinity, which is important for nutrient availability and toxicity. At low pH, Al can become toxic and be taken up by roots, Ca levels can drop, and P may become unavailable, while at high pH, except for Mo and Fe, other micronutrients are safeguarded by insoluble carbonates and hydroxides (Slattery and Hollier, 2002).

Liming

For highly acidic soil and acid-sensitive crops, liming with hydrated lime, marl, chalk, or limestone adds magnesium (Mg) and calcium (Ca). Lime, primarily CaCO3, neutralizes the acid. Lime boosts Ca, Mg, and base saturation. Inactivating reactive components reduces P and Mo fixation. Liming corrects excess soluble Al, Fe, and Mn toxicity, increases root growth and nutrient uptake, and boosts N fixation and mineralization microbial activity, benefiting legumes. Over-liming reduces micronutrient bioavailability, which decreases with pH. Plant Fe deficiency may result. Acidity limits root growth, water and nutrient intake, and agricultural output (Fageria and Baligar, 2008; Pilbeam and Morley, 2007; Marschner, 2011). Acidic soils lack basic cations (Ca, K, Mg) and micronutrients needed for crop growth and development (Wang *et al*., 2006). Soil acidity can kill crops depending on several factors. Liming inactivates or precipitates exchangeable and soluble Fe and Al hydroxides, exchangeable cations, and percent base saturation, raising pH, accessible P, and root hair density and length for P uptake (Marschner, 2011).

Fig 4: Applying lime in maize crops source (Sarkar, D., *et al*. 2018).

Liming or adding basic minerals neutralizes soil acidity quickly. Agricultural limestone— calcitic or dolomitic—is the cheapest and easiest. To mix with soil and react with acidity, agricultural limestone must be finely powdered. Dolomitic limestone is CaCOMgCO3, while calcitic limestone is CaCO3. Wood ashes, hydrated lime (Ca(OH)), burned lime (CaO), and other materials are also used in liming (Pilbeam and Morley, 2007; Rengel, 2011).

Agegnehu *et al*. (2006) reported a linear response with mean fababean seed production advantages of 45%, 77%, and 81% over the control when lime was administered at one, three, or five tonnes per hectare. According to Desalegn *et al*. (2017), adding 0.55, 1.1, 1.65, and 2.2 t of lime per hectare reduced Al by 0.88, 1.11, 1.20, and 1.19 mill equivalents per 100 g of soil and raised soil pH by 0.48, 0.71, 0.85, and 1.1 units. Exchangeable acidity decreased yield and soil pH enhanced it. Fababean yield increased as pH improved and exchangeable acidity decreased. Lime increased pea yields by 30% in soils under 5.4, while legume seed yields were best between 5.7 and 7.2. Although phosphorus availability in acidic soils can be increased by the application of fertilizers and amendments, there are other methods that can be employed.

To raise the pH and enhance nutrient availability, one strategy is to add organic matter to the soil, such as compost or manure.

Name	Chemical formula	Equivalent (%CaCO3)
Calcitic limestone	CaCO3	90-100
Dolomitic limestone	CaCO3+MgCO3	95-110
Oxide/burned lime	CaO	150-175
Hydrated lime	Ca(OH)2	120-135
Ground shells	CaCO3	80-95
Basic slag	CaSiO3	50-80
Wood ashes	Oxides and hydroxides	30-70

Fig 5: some common liming materials and their properties Michael (2000).

Adoption of Acid tolerant crop varieties

Tolerant plants can lower soil pH. Liming is needed to prevent soil acidification. Soil acidification can be slowed in numerous ways. Nitrogen(N) fertilizer management lowers nitrate leaching in high-rainfall locations. Hay fed back into cut paddocks decreases export. Crop rotations should exclude legume hay (Bolland *et al*., 2004). Many commercially important plant species began in acid soil and adapted to soil restrictions. Some species can tolerate acid soil. Quantitative plant tolerance studies include tolerance to high Al or Mn levels and deficits in Ca, Mg, P, etc. Species and genotypes vary in Al and Mn tolerance. Choose plants that thrive at high Al saturation and use little lime.

Acid-resistant crop types are another way to manage acid soil. through favoring genotypes and/or cultivars that are more acid-tolerant. Many Indian crop cultivars are acid-tolerant.

Table 2: (Sabyasachi Majumdar,*et al*. 2022)

Slightly tolerant to acid soil (pH 6.8-8.0)	**Moderately tolerant (pH 6.8-5.5)**	**Highly tolerant to acid soil (pH 6.8- 5.0)**
Mango (*Mangifera indica*)	Pineapple (*Ananas comosus*)	Strawberry (Fragaria x ananassa)
Citrus (*Citrus spp*.)	Orange (*Citrus Sinensis*)	Gooseberry
Banana (*Musa spp*.)	Litchi (*Litchi chinensis*)	Elephant apple (Dilleni an indical)
Guava (*Psidium guajava*)	Passion fruit (*Passiflora dulls*)	Plum (Prunus domestic)
Papaya (*Carica papaya*)	Jackfruit (Aftocar Fiis h hetero phallus).	
Apple (*Malus domestica*)		

Addition of organic fertilizer in acidic soils

In addition to being a source of organic plant nutrients, farmyard manure (also known as FYM) and crop residues have the potential to improve the soil's physical and chemical characteristics. Returning crop leftovers to the soil as amendments is vital for recycling plant nutrients; 20 to 60 kg of N, P, K, and Ca per Mg of crop residues and totaling 118 million Mg of N, P, K in residues produced annually in the world (equating to 83.5 percent of the world's fertilizer usage). In acid soils, where P fixation is an issue, the application of farmyard manure produces a spectrum of raw acids. These acids can form stable complexes with Al and Fe, thereby inhibiting the P retention sites. As a result, the availability and use deficit of P are improved (Agegnehuand Amede, 2017).

Table 3: contents of selected nutrients in manure (M.N. Khan, S.A. Alamri).

Type	DM[a]	OC	N_{total}	NH_4-N	P	K	Mg	Ca	S	Cu	Mn	Zn	B	Mo
		%	g kg^{-1}							mg kg^{-1}				
Cattle														
F[b]	32.3	32.3	9.7	1.7	2.1	9.3	0.23	0.63	0.58	4	45	50	5	0.2
S[c]	6.3	25.8	24.3	12.7	3.3	21.9	0.60	1.4	1.5	5	20	15	3	0.1
L[d]	2.0	7.5	2.35	2.0	0.07	5.2	0.06		0.09					
Poultry														
Dry[e]	50	37.5	20	7.5	8.4	10.8	3.0	30.0	0.80	27	45	185	14	0.7
S	14	47.5	8.1	4.8	2.8	3.6	1.1	10.7	0.32	8.4	49	35	4.2	0.42
Pigs														
F	23	37.5	5.9	1.5	1.6	2.1	1.2	2.9	0.24	20	105	440	6	0.4
S	4.5	12.5	3.9	2.6	1.2	2.4	0.54	1.6	0.16	5	12.5	15	1.5	0.05
Biogas														
Digestate	6.0	41.1	18.3	2.6	8.0	21.0	3.1	16.1	0.87	0.05	0.3	0.3		0.05

a DM = dry mass.
b F = farmyard manure.
c S = slurry.
d L = liquid manure.
e Dry = dry chicken feces.

The use of organic fertilizers has proven to be an efficient method for reducing phytotoxic levels of aluminum in acidic soils, which has led to an increase in crop yields. It is believed that the primary mechanisms responsible for these enhancements are either the development of organo-Al complexes, which render the Al less poisonous, or the direct neutralization of Al as a result of the increase in pH generated by the organic matter. According to Martinez *et al*. (2013), alternatives to lime include the use of organic sources such as manures, compost, agricultural residues, and biochar. This is a potential option.

Integrated soil fertility management (ISFM)

Innovative integrated soil fertility management (ISFM) improves soil health and fertility (Agegnehu and Amede, 2017; Fageria and Baligar, 1997). ISFM involves acid soil management. Organic plant nutrition sources including crop wastes and farmyard manure (FYM) may improve soil's physical and chemical qualities. In acidic soils where FYM is difficult to apply, this procedure generates a medium range of organic acids that form stable complexes with Al and Fe and obstruct P retention sites, increasing P availability (Agegnehu and Amede, 2017; Prasad and Power, 1997; Sharma *et al*., 1990). Manures increase crop yields by cation exchange between root surfaces and soil colloids (Sharma *et al*., 1990; Walker *et al*., 2004).

Organic fertilizers minimize phytotoxic Al levels in acidic soils, increasing production. The development of organo-Al complexes that make the metal less hazardous or the direct neutralizing of the metal by the organic materials' rising pH is assumed to be the main mechanism behind these benefits. Thus, lime could be replaced with organic elements such as agricultural waste, manures, compost, and biochar (Agegnehu and Amede, 2017).

Integrated Nutrient Management (INM)

It considers the impact of soil acidity on the availability and absorption of nutrients by plants. Soil acidity can impact the availability of macronutrients like nitrogen, phosphorus, and potassium, as well as micronutrients like iron, zinc, and manganese. When the soil pH is too low (acidic), nutrients can become immobilized and inaccessible to plants. This can result in nutrient deficiencies, decreased crop yields, and poor plant development.

Conversely, when the soil pH is too high (alkaline), certain nutrients may become insoluble and therefore unavailable to plants.

INM strategies seek to control soil acidity and pH levels via a combination of liming, organic matter management, and nutrient management practices. Liming is the application of calcium or magnesium-containing materials to the soil in order to increase its pH and decrease its acidity. Organic matter management entails incorporating organic materials such as compost, manure, and crop residues to enhance soil fertility and nutrient availability.

In addition, even in acidic soils, nutrient management

practices such as balanced fertilization, the use of slow-release fertilizers, and the use of micronutrient fertilizers can enhance nutrient availability and uptake by plants.
Hence, INM emphasizes the significance of managing soil acidity and pH levels to maximize nutrient availability and plant uptake, resulting in increased crop yields and improved soil health.

Seed Priming

In order to improve plant nutrient uptake and utilization, seed priming is commonly utilized as a part of integrated nutrient management (INM) methods. The goal of integrated nutrient management (INM) is to increase soil fertility and plant growth through the use of a wide range of organic and inorganic nutrient sources, such as fertilizers, composts, and biofertilizers. Seed priming, in which water and nutrient solutions like phosphorus (P) and zinc (Zn) are applied to germinating seeds, is an effective method for decreasing the need for fertilizer, bolstering crop establishment, and raising crop yields. According to research (Sekiya and Yano, 2010). Overall, seed priming is a useful tool in integrated nutrient management practices, as it can enhance the efficiency of nutrient uptake and utilization by plants, reduce fertilizer use, and promote sustainable agriculture.

Pulp and Paper mill effluents as an acid soil management practice

Pulp and paper mill effluents can be used as an acid soil management strategy, as they typically have a high pH and contain alkaline materials such as calcium carbonate and calcium hydroxide. These materials can help to neutralize soil acidity, improve soil structure, and increase nutrient availability for plant growth. In acid soils, massive pulp and paper, tannery, and textile effluents can be used for irrigation. Reddy *et al*. (1981) found that six years of effluent irrigation increased acid soil pH and cane output. Therefore, while pulp and paper mill effluents can be a useful resource for acid soil management, their use should be carefully evaluated to ensure that they do not have negative impacts on soil quality or human health.

Effect of organic amendments on acid soil fertility

Organic amendments can have a positive effect on acid soil fertility by increasing soil pH and providing essential nutrients to plants (Krishnappa, R. (2016). When added to acid soils, organic amendments such as compost, manure, and green manure release basic cations such as calcium, magnesium, and potassium, which can neutralize soil acidity and increase the availability of nutrients like nitrogen, phosphorus, and sulfur. In addition to their direct effects on soil fertility, organic amendments can also help to promote the growth of beneficial soil microorganisms, such as bacteria and fungi, which can help to break down organic matter and make nutrients more available to plants. Therefore, the effectiveness of organic amendments in improving soil fertility can vary depending on factors such as the type and quality of the amendment, the application rate and timing, and the soil properties.

Conclusion

Acid soils are prevalent in Manipur, and nutrient management is essential to ensure sustainable crop production in these areas.
In conclusion, nutrient management is crucial for optimizing crop growth and yield in acid soils in Manipur. By using a combination of soil testing, lime application, organic matter management, and integrated nutrient management practices, farmers can maintain soil fertility, reduce nutrient losses, and promote sustainable agriculture.

References

1. Agegnehu G, Amede T, Erkossa T, Yirga C, Henry C, Tyler R, Sileshi GW. Extent and management of acid soils for sustainable crop production system in the tropical agroecosystems: a review. Acta Agriculturae Scandinavica, Section B— Soil & Plant Science. 2021;71(9):852-869.
2. Bandyopadhyay S, Ray P, Padua S, Ramachandran S, Jena RK, Roy PD, Ray SK. Forms of acidity in soils developed on different landforms along an altitudinal sequence in Nagaland, India. Journal of the Indian Society of Soil Science,2018:66(2):125-135.
3. Bedassa M. Soil acid Management using Biochar: a review. Int J Agric Sci Food Technol. 2020;6:211-217.
4. Bhattacharjee SARAJ, Singh AK, Kumar MANOJ, Sharma SK. Phosphorus, sulfur, and cobalt fertilization effect on yield and quality of soybean (Glycine max L. Merrill) in acidic soil of northeast India. Indian J Hill Farm. 2013:26(2):63-66.
5. Coleman NT. Management and future research strategies for enhancing the productivity of crops on the acid soils. Journal of the Indian Society of Soil Science. 2007;55(4):411-420.
6. Craswell ET, Pushparajah E. Management of acid soils in the humid tropics of Asia. Australian Centre for International Agricultural Research/International Board for Soil Research and Management, 1989.
7. Crozier C, Hardy D. Soil acidity and liming for agricultural soils. Soil Facts, 2003.
8. Datta M, Singh NP. Nutrient management in rice-based cropping systems is influenced by applying cattle manure alone or in combination with fertilizers in upland acid soils of Tripura. Journal of the Indian Society of Soil Science. 2010;58(1):94-98.
9. Doruk K, Sarangthem I, Devi NS, Luikham E, Singh NG. Status and Distribution of Sulphur in Acid Soils of Imphal East District, Manipur. International Journal of Plant & Soil Science. 2022;34(20):492-503.
10. Gogoi B, Borah N, Baishya A, Nath DJ, Dutta S, Das R, Petrosillo I. Enhancing soil ecosystem services through sustainable integrated nutrient management in the double rice-cropping system of North-East India. Ecological Indicators, 2021, 13.
11. Goulding KWT. Soil acidification and the importance of liming agricultural soils with particular reference to the United Kingdom. Soil use and management, 2016;32(3):390-399.
12. Hazarika S, Sarma AK. Advances in Integrated Nutrient Management (INM) in the Production of High-Value Crops. Training Manual on Entrepreneurship and Skill Development on Market Driven Production and Processing of High-Value Crops of NEH Region, 2017, 84.
13. Jena D. Acid soil management in India-challenges and opportunities. Strategy for Arresting Land Degradation in South Asian Countries, 2011, 172-190.

14. Kumar M, Jha AK, Hazarika S, Verma BC, Choudhury BU, Ramesh T, *et al*. Micronutrients (B, Zn, Mo) for improving crop production on acidic soils of northeast India. National Academy Science Letters. 2016;39:85-89.
15. Kumar R, Meena VS. Towards the sustainable management of problematic soils in Northeast India. Conservation agriculture: an approach to combat climate change in Indian Himalaya, 2016, 339-365.
16. Majji AK, Reddy GPO, Sarkar D. Acid Soils of India: Their Extent and Spatial Variability, 2012.
17. Majumdar S, Wanniang SK, Behera U. Acid soil management in the northeastern hill region of India, 2022.
18. Mandal DK, Mandal C, Prasad J, Bhattacharyya T. Acid soils in agro- ecological sub-regions of India: a revisit. Indian Journal of Fertilisers,2019:15(10):1156- 1166.
19. Manoj-Kumar JA, Hazarika S, Verma BC, Choudhury BU, Ramesh T, Moirangthem P, *et al*. Micronutrients (B, Zn, Mo) for Improving Crop Production on Acidic Soils of Northeast India, 2016.
20. Marius C. Managing soil resources to meet the challenges to mankind. ISSS, 1982.
21. Mohammed W, Aman K, Zewide I. Review the role of lime on soil acidity and soil chemical properties. Journal of Catalyst & Catalysis. 2021;8(1):33-41.
22. Myers RJK, De Pauw E. Strategies for the management of soil acidity, 1995.
23. In Plant-Soil Interactions at Low pH: Principles and Management: Proceedings of the Third International Symposium on Plant-Soil Interactions at Low pH, Brisbane, Queensland, Australia, 12–16 September 1993. Springer Netherlands, 1993, 729-741.
24. Patra A, Sharma VK, Nath DJ, Purakayastha TJ, Barman M, Kumar S, *et al*. Impact of long-term integrated nutrient management (INM) practice on aluminum dynamics and nutritional quality of rice under acidic Inceptisol. Archives of Agronomy and Soil Science. 2022;68(1):31-43.
25. Patra B, Jena S, Phonglosa A. Date of Planting, Spacing and Integrated Nutrient Management Practices Improves Soil Microbial Populations and Soil Fertility Status Under Rice-Arhar Cropping System in Acidic Soils of Eastern India. Communications in Soil Science and Plant Analysis, 2022, 1-18.
26. Preston C. Soil pH Effects Potassium and Phosphorus Fertilizer Availability and Management.
27. Saha R, Chaudhary RS, Somasundaram J. Soil health management under hill agroecosystem of North East India. Applied and Environmental Soil Science, 2012.
28. Sahoo S, Vasu D, Paul R, Sen TK, Ray SK, Chandran P. Acid soils of Manipur of the north-eastern region of India: their mineralogy, pedology, taxonomy, and edaphology. Clay Research. 2020:39(1):31-43.
29. Singh BR. Integrated Nutrient Management. In Managing Soils and Terrestrial Systems. CRC Press, 2020, 419-433.
30. Singh RP. Nutrient management in drylands with special reference to cropping systems and semi-arid red soils (No. 8). All India Coordinated Research Project for Dryland Agriculture, 1984.
31. Srivastava AK, Ngullie E. Integrated nutrient management: Theory and practice. Dynamic Soil, Dynamic Plant. 2009;3(1):1-30.
32. Thakuria D, Hazarika S, Krishnappa R. Soil acidity and management options. Indian Journal of Fertilisers. 2016;12(12):40-56.
33. Von Uexküll HR, Mutert E. Global extent, development and economic impact of acid soils. Plant and soil. 1995;171:1-15.
34. Watham L, Sarangthem I, Singh AH, Singh LN, Singh NO, Sharma LD. Distribution of different forms of soil acidity in Imphal East district of Manipur. Journal of Pharmacognosy and Phytochemistry. 2019;8(4):1262-1264.
35. Yirga C, Erkossa T, Agegnehu G. Soil acidity management, 2019.
36. Zhang C, Sun Y, Wang X, Wu J, Feng Y. Effects of soil pH on the availability of soil micronutrients and their uptake by crops: A review. Acta Agriculture Scandinavica, Section B-Soil & Plant Science. 2016;66(5):385-397.