AMELIORATING SOIL ACIDITY IN GHANA: A CONCISE REVIEW OF APPROACHES

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ABSTRACT

The paper concisely reviews the causes and effects of soil acidity and the approaches used to ameliorate acid soils for sustained crop production in Ghana. Acid soils which are characterized as toxic and impoverished, posing serious constraints to crop production were only visible in the western part and lowland areas of the country, but have now become a nationwide threat. Both natural and anthropogenic factors cause soil acidity. However, anthropogenic activities exacerbate the rate of acidification. Application of lime, organic materials, the use of acid tolerant crops and agroforestry are some of the management options adopted in curbing the menace associated with soil acidity. A combination of lime and organic materials, however, are considered the most effective management option considering their availability and long term effectiveness. There is also the need to limit or curtail practices such as injudicious application of fertilizers that produce acidulating effects, and practices that can greatly deteriorate the soil’s inherent fertility.

Keywords: soil acidity, crop production, amelioration, Ghana, tropical soils

INTRODUCTION

Agriculture is the main sector which absorbs the majority of the people in the country as more than 60 per cent of country's population depends on agricultural activities in support of their livelihoods. Agriculture therefore plays a central role in promoting growth and poverty alleviation in the Ghanaian economy. (Egyir and Beinpuo, 2009). It is the goal of every farmer in the country to have high crop yields and to ensure their sustenance or betterment since they depend on such for their livelihoods. Conversely, a decline in crop yields in most regions of the country has been observed over the years. Significantly lower yields of 1.2 t/ha, 16 t/ha and 11 t/ha compared with their potential yields of 5 t/ha, 28 t/ha and 37 t/ha for staple crops such maize, cassava and yams, respectively, have been reported (MOFA, 2003; SRI, 2003). The gravity of this threat is so enormous that it has culminated in food pressures and food insecurity, which has also necessitated the imports of huge amounts of food into the country. In recent years, many discussions have centered on identifying the reasons for the decline in crop yields of which soil acidification has been pinpointed as one of the main factors. Soil acidification which used to be a problem only in the western parts and lowland areas of the country is now a menace that threatens crop production nationwide. Investigations by several researchers have indicated that soils in Ghana have increased in acidity over the years, the rate of which is very alarming. A substantial proportion of agricultural soils nationwide are currently ranging from very slightly to extremely acidic (Buri et al., 2005). Several efforts have been made by both researchers and farmers to alleviate or control this problem. The intent of this paper is to review some of the approaches adopted for acid soil amelioration in Ghana.
Soils that are acid have pH values less than 7 on the pH scale (SSSA, 1997). Theoretically, soil acidity is largely associated with the presence of hydrogen and aluminium ions in exchangeable forms (Brady, 2001; Fageria and Baligar, 2003). Thus, the higher the concentrations of these ions in soil solution, the higher the acidity. Most acid soils have been found to be low in fertility, have poor physical, chemical, and biological properties. Crop production on such soils is seriously constrained, particularly in areas where proper management measures have not been put in place (He et al., 2003). Generally, soils have natural buffering capacity by which they are able to resist changes in soil pH upon marginal increases in their acidity or alkalinity (Black, 1968). This natural buffering ability of soils, however, varies from region to region as the parent materials and the unconsolidated soil strata differ greatly in their physico-chemical properties. The buffering capacity of soils, regardless of the location is, however, attenuated when soils are continuously exposed to processes that lead to soil acidification. Soil acidity develops from a combination of natural and anthropogenic processes. Naturally, soil acidity develops gradually over time as part of the soil development process and other natural phenomena. In Ghana acidity caused via anthropogenic activities, however, by far exceeds the natural causes of soil acidity. In some areas, anthropogenic activities have exacerbated the rate of acidification caused through natural phenomena.

WEATHERING AND LEACHING

Usually, the parent rocks or materials from which soils are formed are the main provenance for both essential and non-essential plant nutrient elements. If the parent material is acidic, there will be acidifying effect and alkaline effect on the hand will manifest if the parent material is basic. During weathering both acidic and basic cations are released into the soil. The influx of these nutrient elements to the soil is, however, annulled through leaching, where most of the basic cations (Ca\textsuperscript{2+}, Mg\textsuperscript{2+}, Na\textsuperscript{+} and K\textsuperscript{+}) that would counteract the acidity effects of the acidic cations (mainly H\textsuperscript{+} and Al\textsuperscript{3+}) are removed from the soil, resulting in the preponderance of these acidic cations which give rise to soil acidity. This process is very effective in areas where there is high temperature and where precipitation exceeds evaporation and plant transpiration to induce weathering and leaching. By reason of Ghana's location on the globe, most of the soils, particularly those in the south-western parts are naturally highly weathered and leached rendering them acidic and less fertile, hence the predominance of Oxisols and Ultisols.

ORGANIC MATTER DECOMPOSITION

In the course of their lives, plants and animals take up nutrients in various forms. When these plants and animals expire, the process of decomposition supervenes, whereby these organic tissues are broken down into humus with a concomitant release of many sundry chemicals. As a corollary of this eternal natural cycle, acids are either formed or consumed. Generally, organic matter contains reactive substances such as carboxylic and phenolic groups which behave as weak acids. The dissociation of these groups results in the release of H\textsuperscript{+} ions which are responsible for acidity (Seatz and Peterson, 1964). Decaying organic matter also produces CO\textsubscript{2} which reacts with H\textsubscript{2}O to form weak carbonic acids. The conversion of organic N to mineral N through nitrification can also increase soil acidity. Brady (2001), however, indicated that the contribution to acid soil development by decaying organic matter is generally very small and it is only the accumulated effects that might ever be measured.
Acid rain

Rainfall is characteristically acid and it is made so by oxides of sulphur and nitrogen fed into the atmosphere from the internal combustion engines, the burning of coal and agricultural activities. The acidity of the rain which can have a pH value between 4 and 4.5 (Brady, 2001) is imparted to the soil through precipitation (Coy et al., 1990). The quantity of H₂SO₄ and HNO₃ that is brought to the earth in acid precipitation globally is enormous but the amount falling on a given hectare in a year which can induce any significant changes in pH is somewhat low, particularly in the less industrialized countries like Ghana. With time, however, the cumulative effects of acid precipitation can influence both soils and plants that grow in them (Brady, 2001).

Crop production and removal

Obviously the main aim of any agricultural production system is to produce saleable products. However, this often saddled with some problems such as soil acidification. The respiration of plants and micro-organism in the soil is necessary for their survival. However, this results in large quantities of carbonic acids with acidulating effects being produced. According to Black (1968), however, this effect is relatively small because most of the carbonic acid decomposes and is lost to the atmosphere as CO₂. Also, the uptake of nutrients by plants results in partitioning of acidity into the soil and alkalinity into the plant (Tang and Rengel, 2003). Crops absorb basic cations such as Ca²⁺, Mg²⁺ and K⁺ and also NH₄⁺ from the soil solution for their nutrition. Consequently, there is a release of H⁺ from the plants in order for electrical balance to be established, particularly when plants absorb nutrient in the form of NH₄⁺. The release of these H⁺ ions has an acidulating effect in the soil (Tisdale and Nelson, 1975). When these crops are subsequently harvested from the field, or burnt and washed away via surface run-off, these basic cations which are responsible for counteracting the acidity developed by other processes are lost and the net effect is increased acidity (Chen and Barber, 1990). The amount of these nutrients removed by cropping, however, depends on the type of crop grown, the part of crop harvested, and stage of growth at harvest. The leaves and stem portions of the plant contain larger amounts of these basic nutrients than the grains. Therefore, high-yielding forages such as Bermuda grass, hay and alfalfa have a larger effect on soil acidity than grains when harvested.

APPLICATION OF ACID FORMING FERTILIZERS

Generally, as a result of high temperatures and other natural phenomena such as, precipitation and incessant leaching of nutrients, there is deterioration of the soils’ inherent capacity to support crop production. The continuous use of agricultural lands without appropriate management measures to ensure their rejuvenation has also given rise to many infertility problems. The levels of organic matter and most of the essential plant nutrients, particularly nitrogen and available phosphorus are low in most Ghanaian soils. By reason of this intrinsic poverty of most of the soils, most farmers depend on external sources of fertilization to replenish the soil of its fertility. The reliance on chemical fertilizers far surpasses that of organic amendments for soil fertility replenishment in Ghana. Chemical fertilizers mostly used in Ghana include ammonium sulphate (AS), muriate of potash (MOP), urea, single and trisuperphosphate (SSP and TSP), etc. (FAO, 2004). There is no denying the fact that significant successes in terms of crop yields have been recorded in so many places via the use of such chemical fertilizers. Albeit these fertilizers are vital for high yields, their use is saddled with many ramifications such as soil acidification.
EFFECTS OF SOIL ACIDITY ON CROP PRODUCTION

Soil acidity has been shown to have detrimental effects on plant growth by affecting plant nutrient availability and plant development. Two fundamental factors are associated with acid soil infertility; nutrient deficiencies such as P, Ca, and Mg, and the presence of phytotoxic substances such as soluble Al and Mn. In the soil, plants absorb nutrients mainly in soluble forms. Under acidic conditions some of the vital nutrients such as P, Ca, and Mg are made unavailable in the soil solution for plant uptake due to the abundance of elements such as Al and Mn. As mentioned in the preceding chapters, soil acidity is usually associated with H+ and Al3+. Surprisingly, however, not so much deleterious effects on plant growth as a result of increased activity of H+ ions under acidic conditions have been documented compared to that of Al (Black, 1968; Rao et al, 1993). Soluble aluminium in the soil causes most of the problems associated with acidic soils. The principal effects on plant growth from soluble aluminium in the soil solution is increased acidity via Al hydrolysis and reduced root proliferation and function, which is generally observed in the roots on field as stunted, club shaped. This reduces the ability of plants to extract water and other nutrients in the soil. Several studies have also shown that when Al is in abundance, P is fixed as aluminium phosphate which is insoluble, hence making it unavailable for plant uptake (Fageria and Baligar, 2003). This is one of the main problems farmers in Ghana are faced with concerning acid soils. With the exception of molybdenum, the availability of micro-nutrients generally increases as soil acidity increases. Since micro-nutrients are needed by the plants in only minute quantities, plant toxicity and other detrimental effects occur with excess amounts.

MANAGEMENT OF SOIL ACIDITY

The preceding sections have shown that soil acidity is an ongoing natural process which can be augmented via anthropogenic activities. However, with appropriate management practices, soil acidity and its deleterious effects can be mitigated or prevented. Studies have shown that a wide array of possibilities exist for mitigating the effects of soil acidity. Some of the methods commonly used in Ghana include liming, the use of acid tolerant crops (Sanchez, 1977), organic material addition and agroforestry (Ofori, 1971; Lathwell, 1979; Dennis and Issaka, 1986; Anane-Sekye, 1997).

Liming

Several liming materials such as crushed limestone (CaCO3), dolomitic lime (CaMgCO3), slaked lime (Ca(OH)2), quick lime (CaO) etc., can be used to reduce soil acidity. They can be used either singly or in combined form. Studies have shown that apart from reducing the acidity of the soil by counteracting the effects of excess H+ and Al3+ ions (Fageria and Baligar, 2005), liming also has several other benefits including, its ability to reduce the toxicity effects of some micro elements by lowering their concentrations while increasing the availability of plant nutrients such as Ca, P, Mo, and Mg in the soil (Naidu et al., 1990) and reducing the solubility and leaching of heavy metals (Lindsay, 1979; Sauvé et al., 2000). Crops absorb most of these nutrient elements particularly Ca, P, and Mg in substantial amounts and therefore by increasing their amounts in soil crop yields can be significantly improved. Application of lime is, however, affected by factors such as quality of the liming material, soil texture, soil fertility, crop rotation, conservation tillage, crop species and the use of organic manure (Fageria and Baligar, 2008). Several studies have been conducted to buttress the beneficial effects of liming in Ghana. Lathwell (1979) conducted an experiment on improving the
fertility of some acid and impoverished soils in Ghana by liming. The study revealed a concomitant increase in pH and Ca+Mg contents and a decrease in Al concentration of the soil. This altogether resulted in a mammoth increase in crop yield. In a similar experiment conducted elsewhere in the country where 1.0 t/ha and 2 t/ha lime were applied, the authors recorded 72% and 48% increases in yield, respectively, over no lime treatments (Buri et al., 2005). Other experiments conducted by the same authors when they combined lime-phosphorus on an Oxisol and Ultisol with pH ranging from 4.1-4.5 and 4.7-5.4, respectively, also showed a considerable increase in maize grain yield by both lime and phosphorus. The apparent reason was the increase in pH and the availability of other essential nutrient elements. Dennis and Issaka (1986) in their investigations indicated that by applying lime at 0.5 t/ha to some forest Ultisols with pH range of 4.7 to 5.5, highly significant yields over other treatments and a 73% increase in yield over the control was observed.

Application of organic materials

For simplicity, the use of organic materials herein represents all forms of organic materials from both plants and animal origins. It has long been established that apart from improving the fertility, structure and some biological properties of the soil, organic materials have the capacity to reduce soil acidity and Al saturation. Though still enigmatic, a number of possible mechanisms have been suggested by several workers in their quest to elucidate how this occurs. Plant materials generally contain excess cations, and the balance between cations and anions is maintained by synthesis of organic acid anions such as oxalate, citrate and malate (DeWit et al., 1963). During microbial decomposition of plant materials, theses organic acid anions are decarboxylated (Yan et al., 1996; Tang et al., 1999). Noble et al. (1996) therefore posited that the decarboxylation of organic acid anions in the process of plant residue decomposition requires a proton for this reaction to be complete. By consuming a proton, the hydroxyl ions increase and this results in an increase in alkalinity. Thus the greater the content of cations in plant material, the greater will be this effect. Plant materials such as legume residues (soybean, red clover, and acacia) were observed to have a substantially higher Ca, Mg, and total basic cation contents than the nonlegumes (maize and sorghum), and consequently, ash alkalinity values were also higher (Bessho and Bell, 1992; Pocknee and Sumner, 1997; Wong et al., 1998). Another mechanism was adduced by Wong et al. (1998) who indicated that functional groups associated with organic materials can also consume protons and in the process, increase the alkalinity of the soil. To this extent, all the mechanisms presented are related to organic acids.

A study was conducted by Safo et al (1997) to assess the effects of Palm bunch ash (PBA) on growth of cowpea and the characteristics of a Ghanaian soil. According to the authors, the palm bunch ash is very hygroscopic, extremely basic (pH 10-12) and contains 25-34% K, 3.6-5.5% Ca, 1.6-3.6% Mg, 0.5-1.7% P, and approximately 0.1% N. Their study revealed an incredible increase in pH of about 2.5 units (4.7 to 7.2) and concluded that PBA applied at 4.0 mg/kg of soil may be as effective as limestone in ameliorating acidity in poorly buffered soils. A more recent study conducted by Arthur (2009) whose milestone was to investigate the changes in soil physico–chemical properties following the application of crop residues on some acidic soils in Ghana found that when maize stover was applied at 10t/ha for 3 years, the pH of the soil was significantly raised from 5.06 to 6.27. It was indicated that the residue on the soil surface, apart from releasing alkali elements into the soil, also protected it from raindrop impact that could lead to erosion and leaching of basic cations (Schomberg and Steiner, 1999).
Use of acid tolerant crops

Although this approach is not able to reverse acidic soil conditions, the constraints of acid soil to crop production can be alleviated by growing acid tolerant crops in such areas with limited inputs such as lime (Clark, 1997). Quite a variety of crops have been found to thrive well in acid soils because of their varying degrees of tolerance to acidity. Chillies, sweet and Irish potatoes are among the crops that have shown tolerance to acidity and can somewhat do well in soils with pH values well below 5.5. Most of the horticultural crops (onions, spinach, carrots, cabbages and cauliflower), however, do not tolerate acidity and can only grow well in soils with pH values above 6.0. Cassava and rice are, however, some of the successful crops so far used in this regard (Rao et al., 1993). Currently, most of the lowland areas occupying about one million hectares in Ghana have been cultivated to rice with outstanding results (Buri et al., 2005).

Agroforestry

Though not clearly defined, the considerable potential for agroforestry as a land management alternative for conserving soils as well as maintaining soil fertility and productivity in the tropics is becoming obvious. It involves the deliberate integration of trees with crops on the same land. Several positive effects have been documented from this interaction. Nutrients such as nitrate, Ca, Mg, etc. leached from the root zones of crops to sub-horizons can be taken up by these deep rooted species and return them to the surface via litter fall. Ridley et al. (1990) observed a reduction in nitrate loss through leaching when deep rooted species such as perennial grass, multi-purpose trees or shrubs instead of annuals were strategically located within crops in the field. Agroforestry systems such multi-story systems can also reduce erosivity of rain drops and leachability of nutrients. The ability of this system to reduce soil acidity, however, depends on the tree species and the structure of the agroforestry system. Baggie et al. (2000) investigated the potential of organic residues from nitrogen fixing trees such as Albizia zygia and Gliricidia sepium for ameliorating acid infertile rice soil in Ghana. Their study revealed that after 4 weeks of incubation, Albizia zygia and Gliricidia sepium had increased the pH of the soil from 4.4 to 5.1 and 5.3, respectively due to the high content of basic cations in these tree species.

DISCUSSION

Both natural and anthropogenic activities cause soil acidity. Rapid population growth, however, has increased anthropogenic activities thereby accelerating the rate of acidification and aggravating its effects on crop production in Ghana. It is obvious that liming is the most commonly used method in mitigating soil acidity and improving crop production on acid soils worldwide. Even though several evidences regarding the beneficial effects of liming can be found in the literature, inimical effects due to over application and some other limitations have also been documented. Over application of lime has been shown to result in phosphorus adsorption and deficiencies of micronutrients like Fe, Mn, Zn, Cu, and B. Another limitation of lime is its inability to reach the subsoil when placed on the surface. Lime percolates extremely slowly to the subsoil and therefore it has been recommended that it should be placed deeper in the soil in order to warrant any profitable returns. However, this practice can be very expensive and may not be affordable by resource poor farmers. According to Ismail et al, (1993), the low solubility of lime can be resolved by the using gypsum (CaSO₄). The effect of gypsum on subsoil pH is insignificant. However, it has high solubility which makes it able to supply large amount of Ca ions deep into the soil. It is further mentioned that the dissociated sulfates (SO₄²⁻) from the gypsum can combine with Al³⁺ ions to form
aluminum sulfate (AlSO$_4^{1+}$). The authors tentatively assumed that this compound can alleviate the detrimental effects of Al$_3^+$ and can be less phytotoxic than Al$_3^+$ alone. This hypothesis was corroborated by a study conducted to examine the effects of dolomitic limestone and gypsum on corn growth on an Oxisol and Ultisol in Malaysia (Ismail et al., 1993). Lungu and co (1993) also have reported that liming can be ineffective on some tropical soils because of the large amount of leaching. Most tropical soils such as the Oxisols and the Ultisols have low cation exchange capacity but high anion adsorption capacity due to the dominance of Al and Fe oxides and low organic matter (Fontes and Weed, 1996) thereby leaving the positively charged macro nutrient elements at the mercy of inclement weather. The effect of liming on the soil pH of tropical soils therefore tends to be smaller and more temporary than in temperate soils. This may require the application of large amounts of lime which can be worrying to the resource poor farmer (Shainberg et al., 1989).

In the early 80s, the then government of Ghana removed all subventions on agriculture. The use of chemical inputs including lime in agriculture declined because the resource poor farmers were unable to afford them, and most of them were also not readily available as all chemical substances used the time were imported. The need for alternatives that were relatively cheap and locally available became of paramount importance. Addition of organic materials was and is still one of the cheapest alternatives, and investigations done by authors such as Hoyt and Turner, (1975), Ahmad and Tan (1986), Bessho and Bell (1992), Wong and Swift (1995), Wong et al. (1995), and Wong et al., (1998) have all pointed to the fact that organic materials can be a suitable substitute for lime in acid soil amelioration. Practically, the return of crop residues to the field is an important agronomic practice not only for nutrient recycling but also for minimising soil acidification through alkalinity recycling (Yan et al., 1996). Some studies have even shown that some organic materials are more effective than lime. Lungu et al (1993) conducted a study that compared the effects of lime and farmyard manure (FYM) on the acidity and crop yields in tropical soils in Zambia. It was concluded that, regardless of the rate of the lime applied, its effects on both soil acidity and crop yields could not be substantiated. On the contrary significant effects of FYM was observed on both soil pH and crop yield, while also reducing the levels of exchangeable Al in the top 20 cm of the soil. It is therefore possible to infer that significant savings can be made by using these organic materials. Nonetheless, the rapid rate of decomposition of organic matter due to high temperatures and incessant rainfall can result in rapid wearing out of its effects. The relatively large amounts required to neutralize acidity can also make its usage somewhat cumbersome and deterring. For example, addition of 2 t ha$^{-1}$ of lime led to an increase in pH of 0.2 - 0.6 (Buri et al., 2005) whereas an application of 40-50 t ha$^{-1}$ of organic matter resulted in increases of pH of 0.8 -1.9 (Haynes, 2001). Antagonistic effects of some nutrients on others via application of organic materials have also been reported by some authors. For instance the use of PBA in the study by Safo et al (1997) resulted in high residual soil K and low residual soil Mg, leading to wide soil K/Mg ratios. The authors therefore suggested that lower rates of PBA should be applied to ensure proper K and Mg nutrition of cowpea and other plants on acid soils that are low in these plant nutrients. However, by lowering its amount, its effectiveness may also be attenuated. It is also worth mentioning that, not all organic materials can be used in this regard with positive results as they differ greatly in their composition and ability to amend soils. Another reason that further affects its use is that some crop residues are used as firewood and feed for animals.

There is, however, evidence intimating that when lime and organic materials are applied very phenomenal results can be obtained. The reason stems from the fact that organic matter reduces Al toxicity and its acidulating effects either by chelating or encapsulating the Al$^{3+}$. In addition, it
enhances plant growth through the improvement of physical properties and the fertility of the soil and can also reduce leaching of basic cations. On the other hand, nutrients can be readily made available for plant uptake by liming. A study done by Lungu et al., (1993) on an Ultisol to compare the effectiveness of lime, wheat straw (organic matter), and their combination on the growth of soybeans supported this assertion. The result of the work showed a significant effect for the combined treatment by producing the tallest plants, the largest dry weights, and the greatest reduction of Al toxicity and therefore. The case of Ghana shows that when a combination of lime and organic materials is used significant results can also be obtained.

The use of acid tolerant crops is one of the alternatives for alleviating the effects of acid soil on crop production. However, this has not been well embraced due to several reasons such as the economic importance of these species, and ability to thrive in environmental conditions other than acid soils. In addition, most of these acid-tolerant plant species do not encompass many of the staple crops in Ghana. Continuous use of such lands will also result in soils gradually becoming more acidic and then the choice of crops will be very limited. Stringent efforts to further develop more strains within the non-acid-tolerant plant species which can also grow in acidic soils and also with the possibility of exuding some organic acids such as citrate, gluconate, malate or oxalate that can chelate Al and reduce its toxicity effects in the rhizosphere (Bennet and Breen 1991; Conyers et al. 2005) is necessary.

The massive campaign in the recent past about the use of agroforestry as a way of rehabilitating degraded lands is in the right course. Notwithstanding the many advantages it has, some disadvantages such as competition for water and nutrients during tree establishment phase and long-term organic matter decline as suggested by some workers on long-term experiments in Africa (Qureshi, 1991) are inevitable. Also, soils that are poorly buffered will increase in acidity in sub-layers and may therefore not be beneficial for plant roots within such horizons. Further analysis of this approach shows that it is not economical for farmers with farms that are small in size as land will be too small to allow for the integration of tree species.

There are other measures that could be adopted to reduce soil acidity. For instance, in areas where there is a risk of leaching by rainfall, there can be synchronization of nutrient supply and plant uptake of nutrients. This may reduce leaching of nutrients and the effects of over application of some acidulating chemical fertilizer. Selection of fertilisers to prevent or minimise acidic inputs can also be useful. For example, it is possible to replace nitrogen fertilisers that are acidic (ammonium related fertilizers) with nitrate fertilizers as N source because nitrate gives alkaline effect since it is exchanged by plant roots with bicarbonate and hydroxyl ions. Sources of nitrates may, however, be scarce and can be expensive, particularly for resource poor farmers, but whenever available, it can be a good substitute.

CONCLUSION

As a natural process, soil acidification may only be reduced and not completely eliminated on already-made-acid-soils. Preventive measures can, however, be adopted for the remaining which have not yet been plagued by this menace by ensuring a balance in removal and input of soil nutrients. In this review, however, it is inferred that a combination of organic materials and lime are effective considering their merits and demerits and the case of Ghana. By this, problems such as high cost of liming and the low supply and rapid putrefaction of organic materials can be reduced to the barest
minimum. However, in areas where it is extremely expensive to apply lime and access to effective organic ameliorants is a problem, the use of acid tolerant crops may be the best option. Its use is, however, still in the infancy and therefore its potentials are yet to be fully tapped. Agroforestry has unambiguous benefits but may not be able to eliminate soil acidity. Farmers are also encouraged to limit or desist from using fertilizers that can have acidulating effects for correcting soils naturally low in essential plant nutrients. In addition, there is the need to curtail or modify practices such as slash and burn and continuous mining of soil nutrients without rejuvenating its fertility. Such practices enhance rapid depletion of soil organic matter and hasten soil acidification. More sustainable and soil rehabilitation practices such as recycling crop waste and crop rotations should be adopted. More studies also need to be done in areas where there is potential for development, such as the development of acid tolerant strains.

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