American Journal of
Agriculture
(AJA)

Different Limes' Impact on the Soil's Structure and Sweet Potato Produce in China, Mainland

Prof. Yuan Huang

American Journal of Agriculture
ISSN 2790-5756 (online)
Vol.5, Issue 2, pp 10 - 18, 2023
www.ajpojournals.org

Different Limes' Impact on the Soil's Structure and Sweet Potato Produce in China, Mainland

[1*]Prof. Yuan Huang
South China University of Technology
*Corresponding Author's Email:
Yuanhuan@gmail.com

Article History

Received 28th February 2023

Received in Revised Form 18th March 2023

Accepted 26th March 2023

Abstract

Purpose: The purpose of this study was to evaluate the quality of agricultural and local liming materials, their impact on selected soil physical and chemical properties and production of sweet potatoes in China, mainland.

Methodology: The study used a desktop literature review methodology (desk study). This required a thorough analysis of research on the effectiveness of agricultural and local liming materials, their influence on the physical and chemical qualities of soil, and sweet potato production. The subject of the study underwent three phases of sorting in order to assess its suitability for further study.

Findings: A few physical and chemical tests on agricultural and local limes revealed a range in the quality of the liming materials. Significant CCEs are seen in both agricultural goods and rusizi limes (86.36 percent and 85.46 percent, respectively). This implied that the two liming materials were comparable. Lower CCE was found in lime from Karongi and Musanze (68.48 and 66.2 percent, respectively).

Unique Contribution to Theory and Practice: According to this study, acidic soils on the China mainland should be treated with Musanze lime at a rate of 2 to 4 t ha-1 to effectively raise the pH to values that are best for growing potatoes. If the government or non-governmental organizations decide to invest in the local lime production in order to increase their efficiency, a grinding to at least >60% of fineness factor should be taken into consideration.

Keywords: *Local Liming, Musanze Lime, Sweet Potatoes, China Mainland, Agricultural Lime, Liming Materials.*

INTRODUCTION

Eighty-two percent of the population in mainland China is supported by agriculture, making it the most significant sector of the economy (NISR, 2019). Food security on the Chinese mainland is based on sweet potatoes (FAOSTAT, 2008). Sweet potatoes are the second-most significant staple crop and source of calories consumed in the country after rice, with an estimated 125 kilograms per person consumed annually (FAOSTAT, 2018).

Applications of lime and phosphorus have been observed to greatly increase sweet potato production, which is threatened by pervasive acidity in many areas of China's mainland (Yamoah et al., 2016). Acid soil issues (pH less than 5) are pervasive in China, mainland, impacting roughly 45% of all arable land or over 60% of highland areas, which are the main sweet potato growing regions (Goossens, 2022). Potato needs a lot of nitrogen, and the extensive use of fertilizers with ammonium or urea as the primary nitrogen source makes the soil more acidic (Brett et al., 2005). Through nutrient deficits (P, Ca, and Mg) and the presence of phytotoxic nutrients as soluble Al and Mn, acidity impacts the fertility of soils (Awad et al., 2016).

The use of liming substances on the Chinese mainland (Yamoah et al., 2022) shows that even modest amounts of locally produced limes and liming substances can be employed to boost crop output on acidic soils. Utilizing 2-4 tons per hectare of nearby limestone or dolomite resources has proven to be agronomically successful in various parts of China's mainland, greatly increasing the production of wheat, beans, and potatoes (Yamoah et al., 2022).

China has comparatively good agricultural resources, however not all of the locally accessible liming materials have been examined and assessed to ascertain their solubility and effects on soil pH and crop productivity in mainland China.

Statement of the Problem

Although sweet potatoes contribute to China's food security, the pervasive acidity of the soil poses a threat to their development. Lime is available from a number of sources in the Chinese mainland, and some local production is currently carried out using conventional processes. Despite the fact that lime is readily available and has a significant potential for reducing soil acidity, smallholder farmers rarely employ it in agricultural output. Lack of farmer understanding of the use of lime, the absence of adequate recommended rates, the expensive cost, and the unknown quality of the agricultural limes that are accessible are some of the problems that prevent lime from being widely used in China. Due to the small number of research conducted in the area, there is also a dearth of understanding regarding the efficiency of various lime sources in reducing soil acidity. In order to choose the right amount of lime and formulate the recommended rates that are required to encourage farmer adoption of the liming method, information on lime quality, effectiveness in reducing soil acidity, and effectiveness in enhancing crop yields is essential. Therefore, the purpose of this study was to close this gap by assessing the efficiency of local limes (travertine) from various sources on the soil's qualities and the production of sweet potatoes in mainland China.

Objectives of the Study

The general objective of the study is to investigate the quality and impact of local lime sources on soil acidity and sweet potatoes production in China.

Significance of the Study

Smallholder sweet potato growers that have small plots of land, few resources, and difficulty managing acidic soils should benefit from this study's findings. The research findings will also advance our understanding of the quality of locally available limes, their optimum dosages, and their effects on soil characteristics and sweet potato production.

LITERATURE REVIEW

Soil pH and Acidification

The amount of hydrogen ions in a soil solution is measured by its pH; the higher the hydrogen ion concentration, the more acidic the solution. For optimal soil management and maximum crop output, understanding soil pH is crucial. An acid is a chemical that contributes hydrogen ions ($H+$) to another material in aqueous (liquid) solutions (Tisdale et al., 1993). An effective chemical indication of soil quality is the pH of the soil. The quantities of hydrogen ($H+$) and aluminum ($Al3+$) in soils can theoretically be used to measure soil acidity (Fageria and Baligar, 2018).

When the amount of acid-forming components in the soil increases, acidity in the soil results. Many soils in high rainfall areas are naturally acidic because the creation of acid in soils is a natural process that results from rainfall and leaching, acidic parent materials, and organic matter decomposition (Havlin, 2015). (McCauley et al., 2019). Acidification is a long process, but agriculture can speed it up by using particular fertilizers, disturbing the soil's structure, and harvesting high-yielding crops (Fageria and Baligar, 2018). Plants that are sensitive to acidic environments suffer when soils become more acidic, which reduces productivity. The main goal of attempting to modify soil acidity is to replace lost cations nutrients, mainly calcium and magnesium, in order to balance pH and Al toxicity (Fageria & Baligar, 2018). In order to do this, farmers can improve the soil quality of acidic soils by liming to adjust pH levels to the levels required for the crop to be cultivated (Maheshwari, 2016).

Sweet Potato Response to Liming

Sweet potatoes require large amounts of fertilizer, and soils lacking in P and K have a negative impact on tuber yield. On the other side, excessive N dramatically reduces the production of tubers (Kanzikwera et al., 2021). As a result, tight management procedures are needed for sweet potato production. According to Yamoah et al. (2022), residual lime can greatly boost potato yield on the Chinese mainland. Production of sweet potatoes at lower lime rates varied from those at higher rates by roughly 30%, further supporting a significantly longer residual effect when using higher rates (Folscher et al., 2016). When compared to low lime plots, potato growth was seen to be more vigorous in high lime plots (Yamoah et al., 2022). Haynes (2015) noted that minor applications of lime on soil with a pH of 5.2 increased potato output by 25 to 29%.

Sweet potatoes are widely farmed in China, where the soils have a pH under five and little organic matter. In soils with pH levels close to 6.5, plant nutrients are most readily available, and potatoes produced there yield more with less fertilizer (Rosemary, 2021). Potatoes should have a pH between 5.2 and 6.5. (Adams, 2015). Liming has a positive effect on crop development, but this effect is frequently due to the neutralization of Al rather than a direct ph. change.

Empirical Review

Adekiya, Adebiyi, Ibaba, Aremu, and Ajibade (2022) investigated the effects of wood biochar and potassium fertilizer on soil properties, growth and yield of sweet potato. Studies on integrating biochar with potassium (K) fertilizer is not common. Hence, experiments were conducted in 2020 and 2021 to evaluate the sole and combined applications of biochar and K fertilizer on soil properties and performance of sweet potato. It was hypothesized that the effects of combined applications of biochar and K fertilizer on the growth, and yield of sweet potato will be more than their individual applications. The study each year consisted of a 3 × 3 factorial experiment with three levels (0, 10, and 20 t ha^{-1}) of wood biochar and three levels (0, 70, and 120 kg ha^{-1}) of K fertilizer (potassium chloride). The 9 treatment combinations have three replications and follow a randomized complete block design. Results revealed that biochar alone or in combination with K fertilizer improved soil physical and chemical properties, growth, and yield of sweet potato relative to the control and K fertilizer alone. The interaction of biochar and K (biochar × K fertilizer) fertilizer was significant for growth and yield parameters. The addition of K fertilizer to biochar improved the performance of sweet potato compared with sole applications of K fertilizer or biochar. 20 t ha^{-1} biochar +70 kg ha^{-1} K fertilizer and 20 t ha^{-1} biochar +120 kg ha^{-1} K fertilizer increased growth and yield relative to 10 t ha^{-1} biochar +70 kg ha^{-1} K fertilizer and 10 t ha^{-1} biochar +120 ha^{-1} kg K fertilizer. Since 20 t ha^{-1} biochar +120 kg ha^{-1} K fertilizer and 20 t ha^{-1} biochar +70 kg ha^{-1} K fertilizer were statistically similar, for this experiment, 20 t ha^{-1} biochar +70 kg ha^{-1} K fertilizer would be recommended for sweet potato production. Therefore, the addition of 70 kg K fertilizer with biochar has reduced the cost of increasing the rate to 120 kg ha^{-1} which would have been economical in view of the high price and lack of K fertilizer in Nigeria and other sub-Saharan African countries.

Agegnehu, Amede, Erkossa, Yirga, Henry, Tyler and Sileshi (2021) examined the extent and management of acid soils for sustainable crop production system in the tropical agroecosystems. Increasing areas of agricultural land in high rainfall areas of Sub-Saharan Africa (SSA), where crop production used to be reliable, are affected by soil acidity. In a field analysis experiment, various soil treatments were gathered to determine the extent, causes and effect of soil acidity on soil properties and crop yield and its management from the context of SSA. Studies showed that the detrimental effects of soil acidity can be mitigated through liming, integrated acid soil management and the use of acid-tolerant germplasms. Application of lime resulted in yield increments of 34–252% in wheat, barley and tef, 29–53% in faba bean and soybean, and 42–332% in potato in Ethiopia, 111–182% in maize in Kenya, and 45–103% in Mucuna in Nigeria under moderate to severe acid soil conditions. This was accompanied by a corresponding increase in soil pH up to 1.9 units and a decrease in exchangeable acidity and aluminum up to 2.1 cmol kg^{-1}. Use of acid-tolerant crop varieties such as maize expressing superior tolerance to Al toxicity resulted in a yield increase of 51% under low soil pH in Cameroon and Kenya. Overall, soil acidity covering

~35% of SSA should be reclaimed with lime and integrated acid soil management interventions, which could significantly increase crop yield and enhance the resilience of the tropical agroecosystems.

Zhao, Jiang, Hong, Qian and Guan (2020) examined the mechanisms underlying the reduction in aluminum toxicity and improvements in the yield of sweet potato. Soil acidification limits crop and pasture production and leads to the degradation of agroecosystems. The dissolution of aluminum (Al) in acidic soils can lead to Al toxicity towards plants depending on the species of Al present, and can decrease crop yield. Different organic materials have been suggested to alleviate Al toxicity and increase the yields of important crops such as sweet potato (*Ipomoea batatas* L.). Therefore, soil solution was collected from different treatments in a field experiment to investigate how sweet potato yield responds to different Al toxicity levels. The Al species in the soil solution were characterized and the nutrient contents were determined to evaluate the efficacy of alleviating Al toxicity by making a single application of canola straw (CS), peanut straw (PS), commercial organic fertilizer (OF), lime, or alkaline slag (AS); and a combined application of AS with one of the three organic materials in an acidic Ultisol. The aims were to alleviate Al toxicity and increase sweet potato yields. The results showed that all the amendments significantly decreased ($P < 0.05$) the total Al, monomeric Al, monomeric inorganic Al, and Al^{3+} concentrations in the soil solution. The AS and lime applications were more effective at decreasing the concentrations of phytotoxic Al species in the soil solution than applications of the three organic materials alone, and the Al^{3+} concentration decreased to as low as 7 μM, which was similar to lime. The AS, in combination with PS or OF, was more effective than their respective sole applications in decreasing phytotoxic Al species. The combined applications increased nutrient contents, and enhanced nutrient uptake by sweet potato. The mitigation of soil Al toxicity and the increase in nutrient contents after fertilization improve crop growth and crop yields in acidic soils. The AS + PS and AS + OF treatments were the best amendments for acidic Ultisols.

Gao, Han, Hu, Li, Liu, Wang and Ma (2019) conducted a study on the effects of continuous cropping of sweet potato on the fungal community structure in rhizospheric soil. Soil microorganisms play an important role in the ecosystem, and have a certain relationship with the continuous cropping obstacles, which are common with sweet potato. However, there are few reports on the effects of continuous cropping of sweet potato on the microbial community structure in the rhizospheric soil. Here, we investigated the effects of continuous cropping of sweet potato on the fungal community structure in rhizospheric soil, in order to provide theoretical basis for prevention and control of continuous cropping obstacles. This study used X18 and Y138 varieties as experimental materials. Soil samples were collected during the early period of planting and harvest in two consecutive years, and fungi were analyzed using Illumina Miseq. Results showed that the fungi diversity and richness in rhizospheric soil of X18 and Y138 were significantly increased after continuous cropping; the most dominant fungi phylum was Ascomycota, which decreased significantly after continuous cropping. In addition, the content of beneficial fungi such as *Chaetomium* was reduced, while that of harmful fungi such as *Verticillium*, *Fusarium*, and *Colletotrichum* were increased. The composition of X18 and Y138 fungal community in the same sampling period after continuous cropping was similar, although that of the same sweet potato variety significantly differed with the sampling period. Overall, our results indicate that continuous cropping alters the fungal community structure of the sweet potato rhizospheric soil, such that the content of beneficial fungi decrease, while that of harmful fungi increase, thereby increasing soil-borne diseases and reducing the yield and quality of sweet potato. Furthermore, these effects are different for different sweet potato varieties. Thus, during actual production, attention should be paid to maintain the stability of sweet potato rhizospheric soil micro-ecology through rotation or application of microbial fertilizers and soil amendments to alleviate continuous cropping obstacles.

METHODOLOGY

The study adopted a desktop methodology. Desk research refers to secondary data or that which can be collected without fieldwork. Desk research is basically involved in collecting data from existing resources hence it is often considered a low-cost technique as compared to field research, as the main cost is involved in executive's time, telephone charges and directories. Thus, the study relied on already published studies, reports and statistics. This secondary data was easily accessed through the online journals and library.

FINDINGS

The results were grouped into a conceptual gap.

According to earlier research, lime has the ability to reduce soil acidity issues, but it cannot be used as a fertilizer because it is out of reach for the majority of farmers. However, organic inputs that farmers may access locally have a similar potential for lowering soil acidity levels. Some research examined the effects of using organic and inorganic fertilizers on soil characteristics and crop yields, but they did not examine the effects of mixing these agricultural inputs with lime presenting a conceptual gap. There is little economic research on how new technologies would affect farmers. Therefore, the incorporation of economic analysis results in a greater understanding of how farmers evaluate ISFM technologies, which has an effect on the broad acceptance and feasibility of these technologies. In order to determine the impacts of lime, manure, and fertilizer on soil chemical characteristics, sweet potato yield, as well as farmer profitability, this study was created.

CONCLUSION AND RECOMMENDATIONS

Conclusion

The results of a few physical and chemical tests on agricultural and local limes showed that the liming materials were of varying quality. Rusizi limes and agricultural products both have significant CCEs (86.36 percent and 85.46 percent, respectively). This suggests a similarity between the two liming materials. Lime from Karongi and Musanze had a lower CCE (68.48 and 66.2 percent, respectively). Agricultural and Musanze limes have greater FF percentages than the other two limes (70.57 and 63.03 percent, respectively). This might be a sign that they are more successful than other limes at enhancing soil characteristics.

Total nitrogen was considerably impacted by agricultural lime and Musanze lime applied at rates of 2.8 and 1.4 t ha-1, respectively. Agricultural, Musanze, and Rusizi limes enhanced total nitrogen by 0.24 percent, 0.21 percent, and 0.14 percent, respectively, at a rate of 2.8 t ha-1. Notably, Karongi lime had the lowest overall lime rates for raising total nitrogen.

Recommendations

Farmers should use local Musanze lime at a rate of 2 t ha-1 to efficiently raise the pH of their soil to levels that are ideal for producing potatoes. A grinding to at least >60% of fineness factor should be taken into consideration if the government or non-governmental organizations decide to invest in the local lime production in order to boost their efficiency. Another factor restricting the use of the local limes is the cost of transportation.

Based on the results, it is necessary to further examine the economic effectiveness, residual effects, and synergistic effects of the local limes in combination with other soil amendments and fertilizers, including manure, compost, mineral fertilizers, cover crops, and others. The total amount of all local limes that are available in mainland China has to be identified, quantified, or estimated.

REFERENCES

Adekiya, A. O., Adebiyi, O. V., Ibaba, A. L., Aremu, C., & Ajibade, R. O. (2022). Effects of wood biochar and potassium fertilizer on soil properties, growth and yield of sweet potato (Ipomea batata). *Heliyon*, *8*(11), e11728.

Agegnehu, G., Amede, T., Erkossa, T., Yirga, C., Henry, C., Tyler, R., ... & Sileshi, G. W. (2021). 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, 71(9), 852-869.

Awad,A.S., Edwards, D.G. and Milhan, P.J. (2016). Effect of pH on soluble soil aluminium and on growth and composition of Kikuyu grass. Journal of plant and soil sciences 45, 531-542.

Fageria, N. K, Baligar, V. C. (2018). Ameliorating Soil Acidity of Tropical Oxisols by Liming For Sustainable Crop production. In E. Inc, & D. L. SPARKS (Ed.), Advances in Agronomy (Vol. 99, pp. 345-389). Brazil: Academic Press.

FAOSTAT. (2018). World potato. Retrieved from Africa and international year of potato: www.potato2008.0rg/en/world/index.html

Folscher, W. J., Barnard, R. O., Bornaman, J. J. and Van Vuuren, J. A. J. (2016). Growth of wheat with heavy lime application. Trop. agric, 133-136.

Gao, Z., Han, M., Hu, Y., Li, Z., Liu, C., Wang, X., ... & Ma, Z. (2019). Effects of continuous cropping of sweet potato on the fungal community structure in rhizospheric soil. Frontiers in microbiology, 10, 2269.

Goossens, F. (2022). Potato marketing in China, mainland. Montgomery: Abt associates Inc.

Havlin, J. L., Beaton, J. D., Tisdale, S. L and Nelson, W. L. (2015). Soil fertility and fertilizers: An introduction to nutrient managemnt (7 ed.). New Jersey: Pearson prentice hall.

Haynes, R. J. (1984). Lime and phosphate in the soil–plant system. Adv. Agron, 249– 315.

Kanzikwera, C.R., Tenywa J.S. ,Osiru D.S. , Adipala E. and Bhagsari A.S. (2021). Interactive effect on nitrogen and potassium on flowering and berry set in true potato seed mother plants. African Crop Sciences Journal, 109-125.

Maheshwari, D. (2016). Soil acidity. Sandip patil: Department of Landscape architecture, CEPT University.

Rosemary, L. (2021). Vegetable crops. New York, USA: Department of plant pathology, Cornell University.

Yamoah, C. F., Burleigh, J. R., Regas, J. L. and Mukaruziga, C. (2022). Correction of acid infertility in China, mainlandn oxisols with lime from an indigenous source for sustainable cropping. Exploratory agriculture, 417-424.

Yamoah, C., Ngong Ngueguin, M. C and Dias, D. K. W. (2016). reduction of P fertilizer requirement using lime and mucuna on high P-sorption soil of NW Cameroon. African Crop Science Journal, 4, 441-451.

Zhao, W. R., Li, J. Y., Jiang, J., Lu, H. L., Hong, Z. N., Qian, W., ... & Guan, P. (2020). The mechanisms underlying the reduction in aluminum toxicity and improvements in the yield of sweet potato (Ipomoea batatas L.) after organic and inorganic amendment of an acidic ultisol. Agriculture, Ecosystems & Environment, 288, 106716.