Korean J. Soil Sci. Fert. **40**(1), 95-97(2007)

Short communication

Should Acidic and Alkaline Soils be Amended to Neutrality Always?

Chong-Woon Hong*

Soil Management Division, National Institute of Agricultural Science and Technology, Suwon, 441-707, Korea

Our understanding on the plant's capability to acquire the nutrients from the soil under harsh circumstance, like unfavorably high pH, and the plant's capability to protect itself under very low soil pH, has been remarkably increased in the recent years. Having those knowledges, it seems not to be wise to abide to the traditional approach to deal the problems of acidic or alkaline soils via chemical methods like liming or using acidic materials. Instead, we may try to select the crops and varieties that can better withstand soil acidity or alkalinity. This stance will be more welcomed when the conservation of environments is high priority issue.

Introduction

It has been accepted for a long time, that majority of plant nutrients in the soils are better available to crops when the pH of soil (suspended in water) is in the vicinity of 7, or soil's reaction is near neutrality. Invariably, the soil science text books, old and new alike, support this view point (Brady and Weil 2004; Cho 1972; Cook 1962; Forth 1984; Morita 1966; Troeh and Thompson 2005). Upon the basis of this notion, it has been recommended that acidic soils and alkaline soils had better be neutralized by liming, or by applying adequate acidic materials, respectively. When only the influence of soil solution pH on the solubilities of various compounds in the soil bearing plant nutrients is considered, those speculations are valid. However, when plants' capabilities to withstand the unfavorable soil conditions is taken into account, the way of thinking that acidic and alkaline soils should be neutralized cannot be valid universally.

Observations on crop performance on different soils

Sorghum(Sorghum bicolor (L.) Moench on an alkaline soil The author has had an opportunity to work at the International Crops Research Institute for Semi-Arid Tropics(ICRISAT) at Patancheru, Andra Pradesh, India. Two kinds of soils prevail in the ICRISAT experimental farm; red soil (Alfisol) and black soil (Vertisol). Temperature being high (day time temperature about 40℃ year round, while annual precipitation is relatively small (350-750 mm); potential evapotranspiration exceeds the rainfall, soils are alkaline with pH of around 8.5. This soil pH should be considered too high for the soil to be favorable for crops, according to soil science text books. Strangely enough no scientists there showed any concern on this aspect. I realized later that there should be no need to be concerned with such high soil pH. All the crops performed well indeed, if they were adequately supplied with water and nutrients. In a field with black soil, I planted sorghum with relatively large amounts of fertilizer (180, 60, 60 kg ha^{-1} of N, P_2O_5, K_2O, respectably) to see the performance of the crop under the absence of constraints in nutrients and water. Since the rainfall was sufficient in that season, there was no need to irrigate the field. The performance of sorghum was very good, with the yield of 6.5 Megagram ha^{-1}.

The sorghum variety used in this plot is known to perform well in soil pH range of 5-8.5. At the ICRISAT Center experimental farm, various crops such as millet, pigeonpea, chickpea, groundnut and sorghum were grown then. In no occasion, I did not see any sign of

Fig. 1. Performance of sorghum crop on an alkaline soil(pH 8.5) at ICRIST Center.

Received : 24 January 2007 Accepted : 15 February 2007
*Corresponding author: Phone : +82312900289,
E-mail : hongcw@rda.go.kr

nutritional disorder symptoms on any of those crops due to high soil pH (Fig. 1). Elsewhere, I have seen sever iron deficiency symptoms when soil pH was as high as 8.5.

Normal vegetations observed on acidic soils in Colombia I have had an opportunity to make observation on the vegetations in Colombia, when I visited the country to identify some problems associated with uses of hillside lands under the support of Korea International Cooperation Agency (KOICA) in 1993. Columbia is a country in the humid tropics, with annual rainfall of 3500-5000 mm; rainfall exceeds the potential evaporation. As a result, strongly acidic soils (pH about 4.5) occur widely. Despite of this, vegetations there did not demonstrate any problem associated with strong acidity of soils, as shown in Fig. 2. It appears that plants or varieties of a plant possess the capabilities to withstand unfavorable soil acidities.

Fig. 2. Vegetation on Colombian soil; soil pH was about 4.5.

Theories behind the plants' capabilities to survive under unfavorable soil acidities If the conventional notion that soils strongly acidic or alkaline are problematic to crops is valid universally, crops should suffer form some nutrient deficiency in dry regions, where soil pH is undesirably high, and from some mineral toxicity in highly humid zones, where soil pH is undesirably low, unless plants possess the ability to acquire the nutrients under alkaline soil and the ability to protect themselves in strongly acidic soil. Indeed, recent studies on the behaviors of plants under different circumstances have proven that plants can acquire certain kinds of nutrients in alkaline soil and can protect themselves in the strongly acidic soil.

Plants' nutrient acquisition in alkaline soil In fact, scientists suspected that plant roots may dissolve some compounds containing plant nutrients, in the soil, from long time back. That was why they attempted to use some weak acids to extract plant available nutrients in soil analysis for plant available nutrients, from early days. Citric acid, and hydrochloric acid and sulfuric acid at low concentration, have been used. In the tenth edition of "Soil Conditions and Plant Growth" Russel (1973) stated; "There are three possible sources from which roots can extract their nutrient: the soil solution, the exchangeable ions, and the readily decomposable minerals..." By mentioning the possibility of plant roots to obtain nutrients from readily decomposable minerals, he implied that plant roots might have some function to decompose some soil minerals to extract its nutrients. It appears that from early days, scientists imagined that plants would have some ability to acquire their nutrients in an aggressive way, other than passive absorption of nutrients via water transpiration through plant body.

Okajima (2001) reported that studies on plants' nutrient acquisition have been revived in the recent years and even mathematical models on it, have been developed in the 1970s.

Two lines of interest are there in plants' aggressive behaviors; acquisition of nutrients from less soluble compounds in soil and the protection of themselves in strongly acidic soils. One of typical examples of former is plant's acquiring of phosphate by dissolving sparingly soluble phosphate compounds by excreting some organic acids like citric acid, malonic acid, oxlic acid, etc. (Otani and Ae, 2001). In some plants, iron could be acquired by the role of certain compound like mugineic acid which was found in the roots of some variety of barley (Mori, 2001). It has been found that the roots of plants or varieties tolerating the strong acidity of soil, do have distinct mechanisms to protect themselves from the intrusion of too much aluminum ion into the roots (Delhaize 2001; Wagatsuma et al., 2001).

The expanse of acidic soils and alkaline soils are huge in the world. It is estimated that 30-40% of world's arable land soils are acidic and about 70% of potentially arable land soils are acidic. As for the occurrence of alkaline soil in the world, the estimates are not readily available. However, it would not be surprising to imagine the area of alkaline soils would be also huge, because all of the

soils affected by marine water and soils under arid climates would be alkaline.

It would be impractical to attempt to correct the soil pH by using lime or sulfur and sulfuric acid in all of the farms with acidic or alkaline soils. In many places such resources would not be readily available. Even where resources are readily available, it would not be environmentally acceptable. For liming, for instance, lime stone should be mined, crushed, bagged, transported, stored and applied. Every step would require energy and would result in the disturbance of environment in one way or another. Same would be true for the use of sulfur or sulfuric acid for the amendment of alkaline soils.

Current trend is to adopt biological approaches; notably through breeding of varieties tolerant to acidic soils. The International Maize and Wheat Improvement Center(CIMMYT) is leading the research in the breeding of soil acidity tolerant varieties of maize and wheat. Commonwealth Scientific And Industrial Research Organization in Australia is being actively engaged in this area too. References regarding this area are numerous on Internet.

Situation in Korea In Korea, since early 1960s, Ministry of Agriculture and Forestry, and relevant research institutions began to show strong interest in the improvement of acid soils in the country. Both research and extension wings of Rural Development Administration (RDA) have allocated much resources on this area. People believed faithfully what they had learned from the soil science text books. They believed acid soils are problematic, thus should be improved by chemical means; by liming.

From now on, if we pay adequate attention on the newly emerging concept that the plants can possess the ability to withstand the harsh conditions by way of adoption, we may be able to look at the acidity of Korean soils from different view point, and we may try to find out the means to deal with the possible problems involved in our soils in more amicable way for both farmers and the environments. In short, to deal with the acidity (which is only mild) of Korean soils, instead of chemical means, biological means should be more viable option. If calcium is to be applied to soil to supplement the removal by the crops, much smaller amount than currently used to neutralize the soil acidity would be sufficient. This consideration should be much relevant in the time when environment conservation bears much meaning, as now and future.

References

Brady, N.C., and Weil, R.R. 2004. The Nature and Properties of Soils. p. 286. Apprentice Hall.

Cho, B.H., S.J. Cho, and C.S. Park 1972. New Soil Science. p. 198. Hyangmunsa. Seoul.

Cook, RL 1962. Soil Management for Conservation and Production. p. 223-224. John Wiley and Sons Inc.

Delhaize, E. 2001. The role of root exudates in aluminum tolerance. in Ae. N. et al. (ed.). Plant nutrient acquisition--New Concept. p. 140-155. Springer. Tokyo. pages 519.) pp: 140-155.

Foth, H.D. 1984. Fundamental of Soil Science. p. 205. John Wiley and Sons. New York pp: 205.

Morita, S. 1966. General Soil Science. p. 256-264. Yokendo. Tokyo.

Okajima, H. 2001, Historical signifcance of nutrient acquisition in plant nutrition research. in Ae. N. et al (ed.) Plant nutrient acquisition--New Concept. p.3-31. Springer. Tokyo.

Otsani, T., N. Ae. 2001. Interspecific differences in the role of root exudates in phosphorus acquisition. Ibd. p. 101-119.

Russel, E.W. 1973. Soil Conditions and Plant Growth(10th ed.) p. 542-544. Longman.

Troeh, F.R. R.R. Thompson. 2005. Soil and Soil Fertility. p. 165. Blackwell Publishing.

Wagtsuma, T., S. Ishikawa, P. Ofi-Manu. 2001. The role of the outerspace of the plasma membrane in aluminum tolerance. in Ae. N. et al (ed.) Plant nutrient acquisition--New Concept. p.159-184. Springer. Tokyo.