Soil acidification: myth or reality?

photo: Bert Lof

Keeping the soil fertile and in good condition.

KADAMA and KALIKASAN farmers complained about 'soil acidification'. They believe it to be one of the factors causing yield decline and why they needed to increase the use of chemical fertilisers to prevent further falls. A study on soil acidification was carried out for the ILEIA Research Programme to look more closely at the problem (Hipolito et al, 1999).

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Focus group discussion was organised amongst 82 farmer cooperators from KADAMA and KALIKASAN. Among the 82 respondents, 61% claimed that they had experienced problems with rice production. The others stated they had had no problems in the last five years. Among the difficulties experienced by farmers a lack of capital (61 respondents) and water shortage (52 respondents) ranked highest. Soil acidification (19 respondents) ranked third.

Changes in the properties of the soil leading to ploughing difficulties (1), poor water retention (2), hard soil (3), a susceptibility to pests (4) and diseases (6/7), many weeds (5) and colour changes (6/7) were identified by farmers as the main indicators of 'soil acidification'. However, some farmers admitted to having no clear concept of 'soil acidification' or any clear indicators. In most cases the term had come from 'technicians'. The farmers understood it to be the probable cause of the soil-related problems they encountered in rice production. Some of them believed that these problems were the result of intensive farming and the slow decomposition of farm residues. The slow growth of rice plants and a hardening of the soil were generally associated with 'soil acidification. However, farmers themselves were not sure whether real acidification was taking place because no soil analysis had ever been done.

Soil acidification

In the Philippines the relationship between soil acidity and plant growth has been the subject of considerable, although not extensive research. Acidification is a process in which the H+ concentration of a soil system increases resulting in a decrease in the observed pH. In the soil system, acidification is related to a complex set of processes that cannot be quantitatively described by a single parameter. One way of looking at soil acidity is through the cation exchange complex. This is the adsorption of positively charged cations on negative charges on the surface of clay minerals and soil organic matter (Reuss et al. 1986). A deficiency in adsorption capacity, CEC (Cation Exchange Capacity), may lead to the accumulation of positively charged ions like those of aluminium, hydrogen and Fe and to acidification.

Problem analysis

To establish the 'truth' about 'soil acidification', the results of the soil sample analysis carried out by the KADAMA and KALIKASAN farmers groups were examined. The analysis showed that the soils were low in organic matter content and medium to low in phosphorous, though hot sulphuric acid extractable potassium was high. Soil pH was either slightly acidic or neutral. The average pH of the soils studied ranged from 5.76 to 6.89 (Table 1), while OM ranged from 1.36% to 2.51 %. The potassium content of the soils at between 113 and 417 ppm was high. The phosphorous content, on the other hand, was between 4.81 to 16.94 ppm and could be considered deficient.

Symptoms observed by the farmers such as stunted growth, chlorosis (yellowing), necrotic spots, ageing, poor tillers, thin and erect leaves and dark green coloured leaves are indicative of nitrogen and phosphorous deficiency. No aluminium or manganese toxicities were observed. At the moment, soil acidification does not appear to be a major problem. However, if the low organic matter content of the soils persists, the buffering capacity of the soil may be lowered and toxicity, together with nutrient deficiency, may occur as a result of acidification.

Nevertheless, the indicators of 'soil acidification' mentioned by the farmers - including hard soil, low water retention, susceptibility to pests and diseases - seem to suggest problems related to 'soil degradation'. These problems are also

Table 1. Average chemical analysis of the surface soils of the KADAMA and KALIKASAN farmer cooperators in the PTD experiments (Bureau of Soils 1997)

Soil samples	pH	OM(%)	Hot K (ppm)	P (ppm)	
KADAMA					
Bunga	6.34	1.94	149	7.32	+
Rajal Centro	6.89	1.89	417	12.11	+/-
San Fernando	6.88	2.51	171	5.85	+
KALIKASAN					
Banitan	5.95	2.40	113	15.3	+/-
Mangandingay	7,6	1.96	130	4.81	++
Tayabo	5.88	1.36	166	16.94	+/-

Legend: ++ severely deficient + moderately deficient +/- slightly deficient mentioned by Pingali et al. (1997) who studied the causes of yield decline in rice production (Kabir p 14). The yield data provided by farmers covered a six-year period and although there was no evidence that yield declined, these problems will have to be taken seriously if the present level of rice production is to be sustained or even improved.

Low fertiliser efficiency

The focus group discussion also revealed that during the wet seasons in the period 1992-1997, the most commonly used fertilisers were 'complete' (14-14-14) (30-68 % of the farmers), urea (46-0-0) (55-67 %) and ammonium phosphate (16-20-0) (11-16 %). The percentage of respondents using organic fertilisers gradually increased from 3 % in 1992 to 30 % in 1997. The amount of fertiliser most commonly applied in irrigated rice production was found to be about 90-30-30 kg/ha (N-P-K) in the wet season and 100-40-30 kg/ha in the dry season. This is slightly lower than the recommended amounts of 90-40-40 kg/ha and 120-40-40 kg/ha. Many farmers, however, could hardly afford to buy this amount of fertiliser.

According to Sri Adinigsh (1988) organic matter acts as a biological buffer ensuring that a balanced supply of nutrients are available to the plant roots. Soils that are poor in organic matter lose this buffering capacity and their fertiliser efficiency will decrease. The observed deficiencies in N and P may be caused by low rate of fertiliser application and the low amount of organic matter present in the soil leading to a low efficiency of N and P fertilisers.

Benefits of increasing organic matter

Follet (1981) showed there are many benefits to be derived from organic matter. It serves as the principal storehouse for anions such as nitrates, sulphates, borates, molybdates, and chlorides that are essential for plant growth. It increases the CEC of soils by a factor five to ten times that of clay. It acts as a buffer against rapid changes caused by acidity, alkalinity, salinity, pesticides and toxic heavy metals. Organic matter also supplies food for beneficial soil organisms like earthworms, symbiotic nitrogen-fixing bacteria, and mycorrhizae (beneficial fungi).

An increased and better use of organic 'waste' and green manures (animal manure, crop residues, household refuse and leguminous plants collected within and outside the farm) as organic fertiliser would greatly enhance nutrient availability, the biological functioning of the soil and the efficiency of chemical fertilisers. The soil would be softened and water retention improved. It would also make plants more resistant to pests and disease and prevent 'soil acidification'. In a follow up study (Peñaloza et al p 25) options for organic soil fertility management have been analysed in an effort to find alternatives to current soil fertility management practices.

More studies needed

Soil degradation in rice production is a complex problem and different processes play inter-related roles (Kabir p 14). The solution does not lie in simply increasing and improving the use of organic fertilisers. Monocultures, the indiscriminate use of agro-chemicals, mechanised soil management and continuous irrigation also contribute to soil degradation. Further studies and farmer experimentation should concentrate on finding combinations of practices that best fit farmers needs and the changing conditions under which they work.

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Based on Hipolito MC, Sigua L, Hipolito RR, de Leon R, Lopez. R, 1999. **Soil acidification: problem assessment and control**. **Report to the ILEIA Research Programme.**

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Rebuilding soil fertility

The authors' task force studied options for appropriate, alternative, soil fertility management techniques. Secondary data were collected and analysed from CLSU, the Philippine Rice Research Institute (PhilRice), the Bureau of Post-Harvest Research and Extension (BPRE) in Muñoz, Nueva Ecija, the

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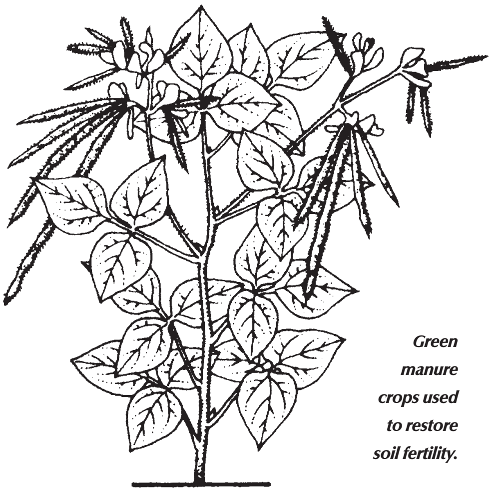
University of the Philippines at Los Baños and the International Rice Research Institute (IRRI) in Laguna. Options identified included the use of green manure, farmyard manure (FYM), crop residue, municipal waste, and night soil. Combinations of organic and inorganic fertilisers were also considered.

Studies by Ladha, et al (1989) showed that Asian farmers prefer *Sesbania aculeata* as green manure. It grows vigorously, can withstand a wide range of adverse soil conditions including salinity, alkalinity and water logging and fixes nitrogen via root nodules. The plant can produce 15 to 22.5 t/ha biomass in six weeks giving nutrient yields of 82 kg nitrogen (N)/ha, 11-16 kg phosphates (P_2O_5)/ha and 23-34 kg potash (K_2O)/ha.

Researchers have also studied the green manure properties of Ipil-ipil (*Leucaena leucocephala* Lam.) leaves. Agustin (1978), found the best application level was 3,000 kg dried ipil-ipil leaves/ha. This produced 5775 kg rice/ha. Grain yield increased by about 15% (0.9 t/ha) as applied nitrogen increased from 60 kg/ha using ipil-ipil leaves to 120 kg/ha using either ipil-ipil leaves or ammonium sulfate (Lao-lao et al, 1978)]. Other green manure crops may be more suitable for specific local conditions (Misra and Hesse, 1983)

Long-term experimental evidence reviewed by Webster and Wilson (1966) suggests green manure crops can play an important role in fertility maintenance by acting as cover crops, raising the organic matter content of the soil, holding plant



Green manure crops used to restore soil fertility.

nutrients, and fixing nitrogen. Green manure crops can supply nutrients at the same level as inorganic fertilisers. Labour is the only significant cost, otherwise there are no transport costs and livestock husbandry is unnecessary.

However, several difficulties affect their acceptability. Considerable human, animal and fossil energy is needed to plough in green manure. Providing water to further the growth and decomposition of the crop in the soil can be expensive particularly where water is a constraint. Land under green manure crops should also have a higher opportunity cost than fallow land and land requirements, particularly where population is dense and agriculture intensive as in Nueva Ecija can be a problem. Managing green manure crops requires specific knowledge and skill. KADAMA and KALIKASAN farmers have tried some green manure crops without satisfactory results.

Azolla

Azolla spp., a small aquatic fern that lives in symbiosis with the nitrogen fixing blue-green alga, *Anabaena azollae*, has proved to be a valuable green manure for wetland irrigated rice. It has a high nitrogen fixing ability, grows rapidly and can be grown before and during the rice crop (Ventura, et al., 1992). Farmers using azolla have ▶