Rice: declining productivity in Bangladesh?

Growing rice has long been an important human activity and historically it has supported large populations. Rice first became popular about 2000 BC and by the fourth century BC it was grown on a large scale following the introduction of irrigated agriculture in China. Today, rice is the staple crop throughout south and south-east Asia and increases in yield and production have kept pace with the growing population. Bangladesh is a prime example. It is one of the most densely populated countries in the world and is self sufficient in rice.

The foliage contained high levels of nitrogen but there was less than expected in the rice grains themselves

BANGLADESH'S SUCCESS

Through the 1970s and 80s, the national strategy of Bangladesh was to increase rice production by introducing high yielding modern varieties developed as part of the green revolution in Asia. Traditionally rice was grown in the summer monsoon season in the deltas and floodplains, which have long been recognised as highly productive and fertile ecosystems. It was grown from broadcast seed in low-lying areas, which were then inundated when the rains started, and from transplanted seedlings in slightly higher lying fields where farmers could have better control over water.

Yields were generally low (up to 3 t/ha) but reliable as these varieties where not so sensitive to random flooding of varying depths and prolonged dry spells. The modern varieties can produce much higher yields (up to 6 t/ha) but they require much more careful control over water depths and fertilizer applications. The introduction of controlled irrigation using groundwater and flood storage enabled farmers to take advantage of them. Irrigation also meant that rice could be grown in the dry season to take advantage of the higher radiation and yield potential. As a consequence rice cultivation has largely shifted away from the summer monsoon season towards what is locally termed *boro* cultivation. This is the dry season prior to the monsoon.

The strategy was successful and led to Bangladesh's self sufficiency in rice. It accounts for approximately 80% of the total cropped area in Bangladesh. But the strategy focused on wealthier medium and large landholders at the expense of smallholders farming less than 0.2 ha, who make up more than 50% of the rural population. They tend to rely as much on fishing as on farming for their livelihoods but this too has suffered due to the loss of seasonal wetlands associated with the intensification of rice production.

A FERTILITY PROBLEM?

Although rice is a success story in Bangladesh, farmers there have become increasingly concerned about the declining productivity of their rice crop. This is not so much a decline in yield as a decline in the net financial returns they get from the inputs they make. They are worried about having to put more and more in just to get the same output. So a research project was undertaken to investigate the problem. The research, carried out in farmers' fields, demonstrated that although farmers apply adequate fertilizer, the returns to its use, in respect of grain yield, were poor. At first it was thought that the problem was the classic one of poor fertilizer management or the lack of availability of nitrogen (N) to the plant. However, plant analysis indicated that this was not the case. Rather, the foliage contained large amounts of nitrogen whilst grain formation was less than expected for the amount of nitrogen available in the plant. Such findings caused the researchers to think along quite a different pathway to find out what other factors, other than nitrogen, were limiting grain yield. This directed attention to other aspects of crop growth such as possible imbalances in the supply of other nutrients, inadequate irrigation, poor pest, disease and weed control, low solar radiation, and poor seed quality or inappropriate seedling transplanting. So far there is no clear indication as to what factor or combination of factors might be the cause of the problem. But in addition to the nitrogen uptake problem, as much as 80% of the added nitrogen fertiliser was not recovered by the crop and presumably this was lost through either nitrate leaching, ammonia volatilisation or denitrification. Such losses are not just a major financial burden but they can also have serious environmental consequences.

Looking beyond Bangladesh for clues to solve the problem, the evidence is somewhat conflicting. Two recent reviews of rice experiments undertaken throughout Asia have produced different trends. One analysed experiments of yield trends in 47 long-term experiments of continuous rice cultivation and of rice followed by wheat grown in the residual moisture following the monsoon. It argued that

yield declines were not very common; particularly yield levels achieved by farmers. But another review of yields in long term rice – wheat experiments showed that rice yields were declining in eight out of eleven experiments while wheat yields were more stable with time, declining at only three sites. The controversy continues but the fact that some data indicate a decline, adds weight to the concerns of farmers at the sharp end of production in Bangladesh.

ECOLOGICAL FARMING

Chemical fertilizers are expensive and at present the returns are poor so some farmers have turned to using organic matter as an alternative fertility strategy. PROSHIKA, a major Bangladeshi NGO with widely based staff throughout the country working at village level, has been strongly promoting this as part of its programme of 'ecological' farming as a better alternative to the current dependency on chemical fertilisers.

The principle of using organic manure is to achieve controlled and rapid cycling of nutrients. This means obtaining organic waste from within the farm or from the local area. It

may be from household activities such as raising chickens and livestock to the more extensive use of green manure crops grown either in rotation in the field or on bunds. Given suitable preparation, a compost with high concentrations of nutrients, particularly nitrogen, and low in bulk can be produced quickly. But there are drawbacks. Not all organic waste is easily and quickly broken down into useful compounds and the limited amount of waste available on small farms means that this source is some way from meeting the nitrogen demands of the rice crop. So supplementing with chemical fertilizer is inevitable, particularly when as much as 80% of available nitrogen is being wasted anyway.

Interestingly, tests showed that there was no observable impact of ecological farming on total soil organic matter status. This could be explained by the fact that a large proportion of the total carbon is in chemical forms that are processed over many years in the soil. Measurement of the more active fractions, which turnover in months, did however show differences in some cases. Computer models, developed as part of this research, can predict the changes in the size of these fractions and relate them to nitrogen supply enabling them to be used to evaluate how changes in management may affect soil organic matter and also provide a basis for making recommendations for soil management practices.

But ecological farming has not resulted in a more efficient use of nitrogen. Farms using ecological techniques were found to have similar problems to those using chemical fertilizers, which suggests that there is still considerable scope for improvements in nutrient management in both systems.

IDENTIFYING THE PROBLEM

Although current research has not clarified why there is low physiological efficiency of nitrogen, it has clearly identified the problems. Research is now underway to find a solution. But soil chemistry and rice agronomy are not the only issues that need to be investigated. The ways in which farmers prefer to use their land can also play a crucial role. For instance, farmers commonly remove the surface soil from some of their fields to construct embankments and to make bricks for homesteads. Why do farmers do this when they are well aware that it may affect their farm income? They may have many reasons. Perhaps they perceive that removing poor topsoil will give them access to more fertile layers below. Perhaps soil used for construction has a greater value to them than for growing crops. Whatever the perceptions and the realities, any technical solutions that do not take such farmer preferences into account are unlikely to bring a lasting benefit.

R6750 Modelling soil organic matter transformations and nitrogen availability

R6751 Soil fertility and organic matter dynamics in floodplain rice ecosystems

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