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Possibilities to increase the technical and economic efficiencies of nitrogen fertilizers in irrigated rice in the Philippines

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6.0 Summary and conclusions

The present study compares the technical and economic efficiencies of SCU and USG obtained on experiment stations with those obtained on farmers' fields and examines if SCU and USG as well as the recommended fertilizer management are economic alternatives to farmer's own fertilizer management. It also investigates why the majority of Philippine rice farmers does not follow the recommended fertilizer management practice basal fertilizer, despite the fact that yields and benefits are thought to be higher than farmer's own fertilizer management by as much as 10%.

The data basis for estimating the technical and economic efficiencies of SCU, USG and prilled urea (PU) on research stations was provided by 81 experiments of the 3rd to the 5th international trial on nitrogen fertilizer efficiency in wetland rice conducted by the International Network on Soil Fertility and Fertilizer Efficiency in Rice (INSFFER) from 1979 to 1981 in 12 rice growing countries. At the farm level, the technical and economic efficiencies as well as the nitrogen uptake patterns and yield components of SCU, USG and PU were determined on the basis of 16 on-farm experiments which the author conducted in wet season 1980 and dry season 1980/81 in Laguna and Nueva Ecija, Philippines. To asses the potential that the new forms of nitrogen fertilizers will be adopted by Philippine rice farmers, a socioeconomic survey of 50 farmers in Laguna was carried out in wet season 1982 to quantify their fertilizer management, to compare it with the fertilizer recommendation and to determine the causes of the observed differences between actual and recommended fertilizer management.

The technical efficiency of all tested forms of nitrogen tended to be higher in the dry than in the wet season. On research stations, SCU and USG were on the average 25-30% technically more efficient as well as economically more profitable than the recommended management with prilled urea. In contrast, in half of the on-farm experiments during wet season 1980,

farmer's simulated fertilizer management was, at the recommended nitrogen rate, technically and economically more efficient than SCU, USG and recommended timing, whereas USG was the least efficient. In the dry season, the technical efficiency of SCU was highest and of simulated farmer's timing lowest.

The grain yield and total nitrogen uptake at harvest were weakly correlated and did not explain well the observed differences in grain yield between treatment groups. They were explained best by the nitrogen uptake pattern over time which differed between seasons as well as between the tested N-sources. Nitrogen uptake patterns were mainly determined by the season and the variety and less by the form and management of nitrogen. Compared to the dry season, organic matter, soil temperature and mineralisation of soil nitrogen were, during land preparation and up to 50 days after transplanting, higher in the wet season crops when planted from June to August. In the wet season, the absorption of deep-placed and incorporated fertilizer nitrogen was so high that at 45 DAT, already 90% of the total nitrogen uptake at harvest was absorbed, particularly in the plots treated with USG and to a lesser degree with SCU. This rapid early nitrogen uptake led to excessive vegetative growth, mutual shading and finally caused the relatively low yields of USG and partly of SCU. The high early nitrogen uptake also increased plant height which in case of a typhoon would increase the probability of lodging and actual yield losses. In contrast, in plots with simulated farmer's timing, nitrogen uptake was slow but constant until after heading, and particularly late absorbed nitrogen was efficiently transformed into grain. When the temperature declined from October to November and remained low up to February, the absorpotion of both soil and fertilizer nitrogen was comparatively low up to March. At heading, and regardless of the nitrogen source, dry season experiments had usually taken up just 60% of the total nitrogen at harvest. The remaining 40% of the total nitrogen up-

take were absorbed within 4 weeks between heading and harvest and most probably were provided by the mineralisation of soil nitrogen. Yet despite higher nitrogen rates applied, total nitrogen uptake was generally lower in the dry than in the wet season. The low availability of soil nitrogen, combined with low recovery rate of the first dosage of topdressed nitrogen in simulated farmer's timing, produced too few tillers in the dry season in order to transform the late absorbed nitrogen into a high grain yield in simulated farmer's timing. In both wet and dry seasons and regardless of the form of nitrogen applied, soil nitrogen contributed more to the total nitrogen uptake than fertilizer nitrogen, particularly in medium maturing varieties. To obtain a high yield, early maturing, short statured varieites were more dependent on fertilizer nitrogen compared to medium maturing and medium tall varieties. Compared to PU and USG, the slow release effect of the sulphur coating could be observed in SCU treated plots only at the first sampling at 15 DAT. In the dry season, the better yield response to SCU was perhaps more due to the applied sulphur and less due to the slow release effect of the sulphur coating. This interpretation would be in line with the observed increase of sulphur deficiency in soils which were treated for a long time with non-sulphur containing fertilizers such as urea and in which cases the application of ammoniumsulfate is now recommended.

The results of the nitrogen uptake study suggest that in the wet season, recommended basal application of PU and SCU and the deep-placement of USG are from the agronomic point of view not sound alternative fertilizer management strategies to simulated farmer's timing. In contrast, in the dry season, basal dressings of nitrogen either with PU or SCU balance the low availability of soil nitrogen and are agronomically sound.

Since the late 1960s, the Philippine fertilizer recommendation for irrigated rice are given as blanket recommendations for the country as a whole,

particularly with regard to the amount and timing recommended for nitrogen. Over time, the recommended rates changed very little and consisted of 60 kg N/ha in the wet and 90 kg N/ha in the dry season and of 30 kg P_2O_5 and 30 kg K_2O per ha in both seasons. Since the late 1970s, phosphate and potassium should be applied only on P- and K-deficient soils. The farmers were advised to apply the recommended rates in two to three splits. The first, so-called basal dressing, has to be applied prior to transplanting and to be incorporated during the last harrowing in order to promote early vigorous growth of the plants and to reduce potential fertilizer losses. The basal dressing consisted of 1/3 to 2/3 of the recommended nitrogen rate and all of phosphate and potassium. In a second and third application at maximum tillering and at around panicle initiation, the rest of the nitrogen has to be topdressed. Since the late 1970s, the basal fraction increased to 2/3 of the total nitrogen rate and instead of two topdressings, only one at panicle initiation is recommended. Before 1972, the start of the Masagana 99 rice production program, the fertilizer recommendation was additionally specified according to the N-responsiveness of the varieties.

In massive information campaigns since the late 1960s, the Philippine rice farmers were informed about the fertilizer recommendation and its advantages, particularly of the benefits of applying basal fertilizer.

More than 90% of the interviewed farmers in Laguna actually knew the recommended method and timing for nitrogen fertilizers and 40% of them had practiced the recommended basal fertilizer at least once. However, during wet season 1982, only 6% of the sample farmers applied basal fertilizer. Their mean nitrogen rate was, at 71 kg N/ha, about 20% higher than the recommended rate of 60 kg/ha. Most farmers applied only nitrogen. One-third of the respondents applied about 1/2 of the recommended rate of P and K fertilizers. Ten farmers applied fertilizers only once, 34 farmers 2 times and 3 farmers 3 times. Instead of before transplanting, the farmers usually applied the

larger portion of all fertilizers late in the season. Despite their knowledge, most farmers did not practice the recommendation because they thought that the fertility of their soils at transplanting was sufficient for 2-4 weeks and therefore, basal fertilizer is not necessary but harmful. In fact, more than 90% of the farmers expected lower yields and profits with basal fertilizer than with their own fertilizer management. They expected lower yields and profits because applying fertilizers into already fertile soils right before transplanting would result to excessive vegetative growth and to taller plants, leading to a higher risk of lodging and to a higher weed incidence and a more expensive weed control. Many farmers were afraid of additional crop losses due to more pests and diseases. The findings from the own on-farm trials as well as experimental evidence from researches of several departments at IRRI and of other countries confirm the observations and fears of the farmers. Therefore, any farmer who is not following the blanket fertilizer recommendation, particularly its timing, can not be termed a priori as technically or economically inefficient.

Under the assumption of constant labour arrangements for all potential fertilizer management strategies, the analysis of the gross margins showed that among all fertilizer management strategies, farmer's own fertilizer management had the highest gross margins and family earnings. Plowing by carabao was more economical than plowing by two-wheel tractor. Inspite of 700-1,200 kg/ha yield advantage of on-farm tested fertilizer management strategies at the recommended nitrogen levels, their gross margins were lower than for farmer's own fertilizer management because the total variable costs of the on-farm tested fertilizer management strategies were about twice as high as that of farmer's own fertilizer management. In the wet season, USG had the lowest gross margins and in the dry season, simulated farmer's timing and USG. Off-farm income contributed 50% to the family earnings in the wet season and 56% in the dry season.

For the representative leasehold farm in Laguna, one-period static linear models for the wet and dry seasons were built and the optimal fertilizer management strategy and the corresponding optimal labour arrangements were determined. The objective function of the models was to maximise the gross margins from rice farming and the application of fertilizers and the earnings from off-farm work subject to the restricted capacities of farm land and family labour.

In the dry season, the optimal fertilizer management consisted of applying 120 kg N/ha as SCU and in the wet season, of applying with simulated farmer's timing 90 kg N/ha as PU on the whole farm area. All other on-farm tested fertilizer management strategies were less profitable than farmer's own fertilizer management. In the optimal wet and dry season fertilizer management strategies, plowing was done by carabao and not by two-wheel tractor. Labourers for weeding, harvesting and threshing were hired and paid in cash on a daily basis because the commonly practiced contract system in Laguna, in which a group of labourers is paid a certain share of the gross yield, was more expensive. Family members had to do all the land and seedbed preparation and the necessary supervising activities and hire daily paid labourers for all other crop care activities. Through these changes in the labour arrangement between family and hired labour and due to higher nitrogen rates and gross incomes compared to the calculations of the actual farm organisation, the gross margins of the optimal dry and wet season fertilizer management increased by 19.6% and 5.6% and the family earnings by 16.6% and 4.4%, respectively.

Off-farm earnings contributed 49% to the family earnings in the dry and 48% in the wet season. The optimal dry and wet season solutions proved to be quite stable because changes in the prices of rice and the three forms of nitrogen and the parametrization of the farm area and supply of family labour for on- and off-farm work did not alter the optimal dry and wet sea-

son fertilizer management strategy. Payment in kind became more economical than payment in cash for weeding, harvesting and threshing when daily wages increased from ₱ 16 to ₱ 22 in the dry season and from ₱ 18 to ₱ 24 in the wet season, or when the harvesters' share declined from roughly 1/5 of the gross harvest in the basic model to 1/7. However, the optimal dry and wet season fertilizer management strategies were very sensitive to changes in the technical efficiency of the potential fertilizer management strategies which are likely to occur in the future. It was found that farmers' actual own fertilizer management would be the most profitable fertilizer management strategy if farmers can increase the technical efficiency of their own fertilizer management by 15% and the technical efficiency of the on-farm tested fertilizer management strategies remain unchanged, or if the technical efficiency of the on-farm tested fertilizer management strategies will decline by 15% in the dry season and by 10% in the wet season.

The results of both the agronomic and economic analyses of the data included in this study suggest that under real farm conditions, the on-farm tested fertilizer management strategies will be most likely not an economic alternative to farmer's own fertilizer management. This prediction rests mainly on two reasons. First, the average irrigated rice farm in the Philippines can most likely not repeat the yield responses which were only modest in the on-farm experiments in Laguna because it faces more physical and socioeconomic constraints, particularly with regard to the quality of irrigation and the availability of cash or access to credits compared to the farms included in this study. Second, the basal application of 2/3 of the recommended nitrogen rate is, in the eyes of the farmers as well as based on experimental evidence, agronomically wrong in the wet season. Therefore, it is expected that as the majority of the farmers rejected the recommended basal fertilizer, it will also reject the basal dressing of 100% of SCU and of deep-placed USG right after transplanting, should the Philip-

pine government decide to introduce these materials. Therefore, to further pursue the concepts of basal, deep-placement and slow release fertilizers without modifications will be wrong and become too costly for research institutions and governments.

The results of this study bear implications on the fertilizer recommendations-giving institutions as well as for researches to increase the nitrogen efficiency at the farm level.

The existing blanket fertilizer recommendation for irrigated rice in the Philippines is too general and even wrong in the wet season. A revision of the fertilizer recommendation in the Philippines is indispensible first, to really improve the efficiency of the applied nutrients and second, to restore the credibility of the extension service in the eyes of the farmers. Farmers' existing knowledge about the role of commercial fertilizers in increasing the grain yield should form the basis when the fertilizer recommendation is reformulated. In its revision, the findings of this study should also be included. The new fertilizer recommendations should be differentiated according to the nutritional status of the soil, the season and the variety grown. To reduce the dependency on commercial fertilizers, propagating the optimal use of alternative sources of fertilizers should be an integral part of the revised recommendation.

The findings of this study indicate that in the INSFFER, researches to increase the efficiency of nitrogen fertilizers and by these to lower the input costs for small rice farmers was too concerned with the efficiency of commercial nitrogen fertilizers. The complementarity and interactions between soil nutrients, organic fertilizers and commercial fertilizers were not addressed. However, reducing the dependency on oil-based fertilizers and exploring alternative sources of nutrients is thought to be most needed in order to cope with the global increases in fertilizer costs. Developing and examining alternative strategies to increase the nutrient content in

the rice soils without heavy reliance on commercial fertilizers promises to be less costlier than the application of new forms of fertilizer which for the rice farmers will clearly be more expensive than the conventional forms of nitrogen. To do this, the focus of INSFFER activites should be shifted to the development of an integrated soil fertility management, with the aims to improve the soil fertility status with alternative sources of nutrients and to develop technologies which use nutrients from both the soil and commercial fertilizers more efficiently.

To develop an integrated soil fertility management, a multidisciplinary team approach is absolutely necessary. Besides agronomists, the team should include soil chemists, soil microbiologists, plant pathologists and entomologists as well as economists and sociologists. From the planning stage, farmers should become more directly involved in the research program, particularly in the selection of research priorities and evaluation of the occurring research results. To sharpen researchers' understanding of the real problems at the farm level and to make their research work more relevant to the real needs of the farmers, researchers involved in the program should do most of their research directly on farms in cooperation with farmers and less on research stations. Thus, the yield gap between research stations and farmers' fields which has always to be quantified when technologies are first tested on research stations would altogether disappear, unjustified hopes would not be raised and research would instantly become cheaper and more relevant to the real problems of those for whom all the research at IRRI is (should be) carried out, the small rice farmers all over the world.