

## **REVIEW OF EXTENSION ACTIVITIES ON PLANT NUTRIENT MANAGEMENT IN RICE**

S.T. DISSANAYAKE and S. WIRASINGHE

*Extension and Training Centre*

*Department of Agriculture, Peradeniya*

### **INTRODUCTION**

During the 1990s fertilizer recommendations on rice saw a more realistic approach by shifting back to recommend straight fertilizers instead of the mixtures, which dominated over a period of two decades. The complete withdrawal of the fertilizer subsidy in the late 1980s and subsequent fall of fertilizer use on rice production necessitated to look at realistic amounts of plant nutrients required to get economic yields of rice.

The ability to substitute potassium by rice straw was inscribed in the recommendations and farmer managerial capacity was also considered by recommending a higher rate of urea for the higher productive farmers. Also weight was given to the plant nutrients derived through the addition of organic manures. The introduction of a soil test based fertilizer recommendation in 1993 was the result of the observations made on the build up of P and K in continuously fertilized soils using mixtures, specially the rice-vegetable, rice-potato and rice-Subsidiary Food Crops (SFC) cropping systems.

Importance of other plant nutrients in rice production in addition to NPK were also highlighted during this period. A deficient level of zinc and copper was reported in the Minipe area of the Kandy district ( Seneviratne *et al.*, 1992), while Deb (1993) reported the deficiency of Zn and Cu in most rice growing soils of the country through a limited study.

The importance of maintaining soil organic matter was highlighted by the FAO (1984). Dissanayake *et al.*, (1992) have shown that fertilizer use efficiency (FUE) of added NPK increases when the soil organic matter percentage is over 2%.

With these propositions it was apparent that the extension division should carry the proposed changes suggested in the recommendations and the information generated in other studies through a series of demonstrations. Some demonstrations were carried out as demonstration trials in spite of the paucity of conclusive information available on the treatments used. The series of demonstrations carried out can be grouped as follows:

### **Demonstrations, centered around the 1990 fertilizer recommendations**

- i. Testing of 1990 revision of the fertilizer recommendations.
- ii. The application time of the basal fertilizers.
- iii. The usefulness of the different rates and treating rice straw at the time of application.
- iv. The substitution of K by using rice straw.
- v. The benefits of applying high rates of N under good management.

### **Demonstration trials continued with Integrated Plant Nutrient Systems (IPNS)**

The demonstrations carried out by the FAO fertilizer programme in collaboration with the extension division continued. This programme had a wide coverage and included the management of two plots in addition to the zero plot by having one treatment at the recommended rate and another split into four; the 'H' plot. Here application of different rates of NPK or addition of soil ameliorants like liming or the addition of manure and gypsum were carried out. These additions were considered to be steps of Integrated Plant Nutrient Systems (IPNS). The FAO (1984) has made emphasis on this nutrient management system to enhance yields and sustain productivity.

The use of organic manure was expanded to utilize animal waste, such as poultry litter, cow dung and goat dung hitherto not used in the cultivation of rice. It was not practical to apply goat dung at the surface due to floating and segregation during flooding before ploughing, as it could not be ploughed into the soil.

The results obtained with combined use of organic and inorganic fertilizer were encouraging which led into organized large scale demonstrations. These demonstrations initiated in 1996 were continued for four seasons in the same location with the provision of, fertilizers and cattle manure. The initiation was to meet the policy requirement to increase per unit production of raw rice to 6 t ha<sup>-1</sup>.

### **FARMER FIELD EXPERIMENTS ON FERTILIZER APPLICATION**

Described below are experiments related to fertilizer application.

#### **Testing of the 1980s vs 1990s fertilizer recommendations**

Fertilizer demonstrations were carried in selected farmer fields. The selection was done by the extension staff at the district level. Wherever possible soil samples were collected and analyzed for pH, EC<sub>(w)</sub>, available P

and exchangeable K. A three plot design to include a 10 m<sup>2</sup> check plot and two 100 m<sup>2</sup> plots to test the 1980 and the 1990 recommendations were laid out at each location. The series of demonstrations continued for four seasons in different locations within the districts. A 10% of the number were repeated at the same location for four seasons. The 1980 recommendation had a rate of 85 - 100 kg N, 25 kg P and 37 kg K and the 1990 recommendation had 60-100 kg N, 11 kg P and 12.5 kg K depending on the location. The N rates changing with the age of the variety described in the 1980 recommendation was omitted in the latest recommendation. Seed materials used were certified seed paddy and registered seed paddy purchased by farmers. Straight fertilizers were used and were mixed at the rates identified. The Department of Agriculture (DOA) recommendations were used for spacing, weed and pest control etc. A 10 m<sup>2</sup> plot was harvested and air dried rice weight was taken to estimate yield.

### **Time of application of basal fertilizer**

The time to apply NPK basal fertilizers was recommended to be at the time of leveling, after harrowing. Since farmers were accustomed to applying the basal at the surface, few treatments were included in a multi location trial demonstration carried out in the Kurunegala, Kegalle, Matale and System C Mahaweli. This was carried out during the two seasons of *maha* and *yala* of 1990 and 1991. A 50 m<sup>2</sup> plot was used for each treatment. All practices recommended by DOA were followed. A crop cutting was done to evaluate yield.

### **Benefit of applying different rates of rice straw and treating of rice straw with urea at the time of application**

According to the 1990 fertilizer recommendation if more than 3 t ha<sup>-1</sup> of rice straw is applied the K requirement of the crop will be entirely met by the K in the straw. In practice farmers have shunned the use of rice straw due to fear of hindering proper land preparation. It was earlier suggested that an initial treatment of the addition of 30-50 g urea per heap, dispersed over a *liyadda* was useful to promote decomposition (Tennakoone *et al.*, 1987). The usefulness of the practice was evaluated for two rates of rice straw applied after treating and not treating with urea. A 50 m<sup>2</sup> plot size was used for each treatment.

### **Substitution of K by recycling rice straw**

These documentations were done in many districts for four seasons on an extent of 0.1 ha. A soil analysis was done in each plot at the beginning of each demonstration. Only N and P fertilizers were used. The results obtained at each season were compared to the one obtained at the beginning. Crop cuttings were used to evaluate yield.

### **The benefit of applying high rates of N under high management.**

Plots of 0.4 ha were selected in farms obtaining high yields from areas of the dry zone with assured water supply. Nitrogen at the rate of 140 kg N ha<sup>-1</sup> was applied, with the recommended rates of P and K.

### **The IPNS demonstrations**

#### **Direct application of rice straw and gypsum with NPK fertilizers**

A series of demonstration trials were carried out in the 1989/1990 *maha* and 1990 *yala* seasons on the direct application of rice straw and gypsum at two levels of NPK. The direct application was to be popularized among farmers. A 50 m<sup>2</sup> plot size was used and these demonstration trials were carried out in the districts of Ampara, Polonnaruwa, Mahaweli System H and Kalawewa.

#### **Combined use of organic and inorganic sources of plant nutrients**

The type of demonstrations centered on the combined use of inorganic fertilizers and organic manure and crop residue. Rice straw, animal litter and green manure were the materials used. The first of a series were carried out in the early nineties in locations around Peradeniya. The plot size used was 50 m<sup>2</sup> for each treatment and demonstration trials were continued for four seasons continuously.

#### **The 0.4 ha production demonstration trials**

These demonstrations began as a follow up to the organic–inorganic combinations carried over in the H plot of the FAO fertilizer demonstrations program and the combined organic inorganic demonstration trials. Here a larger extent of 0.4 ha (one acre) were used. Initially two sites were selected to carry out the demonstrations; one at Pallewatta in the Kandy (IP) area and another at Tabbowa in the Puttalama district.

Initial treatments carried out had NPK at the recommended rates with addition of two tons of cattle manure and 1.5 t of rice straw of the previous harvest. Rice straw was incorporated after land preparation and cattle manure was distributed after the second ploughing. In the second season the N rate was increased to 140 kg N, P to 25 and K to 60 kg ha<sup>-1</sup> respectively. Application of 250 kg of charred rice husk and one ton of green manure were made after the second ploughing as additional materials. Charred rice husk was to supplement silica and green manure was used as a organic nutrient

source. Both rice straw and cattle manure additions were continued at the same rates as before. A dramatic increase in yield was obtained.

With the success at the two locations, more number of sites were selected to repeat the demonstrations. The increase of N was carried out from the first season but the increment of P and K were introduced from the second season. Many locations had high yields, thus it was necessary to introduce other nutrients like S, Mg and Zn fertilizers with the basal application depending on the location. Sulphur as  $\text{SO}_4\text{-S}$  at  $10\text{kg ha}^{-1}$  in ammonium sulphate was added to give 50% of the recommended N at the basal together with urea to total  $20\text{ kg N ha}^{-1}$ . Kieserite was added at the rate of  $3.0\text{ kg ha}^{-1}$  MgO and zinc sulphate at  $1\text{ kg ha}^{-1}$  of ZnO was added as additional nutrients. Fields receiving these treatments continued to yield  $10\text{ t ha}^{-1}$  and new demonstrations receiving combined applications of all the nutrients together with organic manure gave higher yields.

Soil samples were taken from selected sites before crop establishment in the first season and the following seasons to monitor the content of organic carbon, pH, available P and exchangeable K. In some locations leaf samples before PI stage from the flag leaf was taken for analysis of NPK.

In these demonstrations the plant population was increased by a closer spacing of  $10\text{ cm} \times 10\text{ cm}$  for transplanted rice and the seed rate was increased to  $150\text{ kg}$  from  $100\text{ kg ha}^{-1}$  for a seeded crop. Cultivars of 3.5 month and 4.0 month age classes were used. Crop cutting surveys and total plot harvesting were carried out to determine yield. Farmer's were made to keep records of all inputs and operation costs. Certain agronomic parameters of tiller count, panicle number per hill and spikelet count per panicle were recorded. Farmer's were provided with NPK fertilizers for four seasons and money to obtain cow dung was provided in the first season. Most farmer cooperators are continuing these demonstrations beyond the fourth season. Farmers' with high management ability high quality seeds were provided from the breeding stations of Batalagoda and Ambalantota.

In an effort to extend the concept of obtaining high yields beyond  $10\text{ t ha}^{-1}$  from the first season the package of treatments carried out are:

a. Plant nutrients

- i. N:P:K at rates ( $\text{kg ha}^{-1}$ ) of  $140\text{ kg N}$ ,  $25\text{ kg of P}$  in TSP and  $62\text{ kg of K}$  in MOP in two splits of 60% at basal and 40% with the second top dressing of urea.
- ii. The quantity of N was split on the basis of the fertilizer recommendations of 1996. The basal N had 50% N in

ammonium sulphate and balance in urea. The leaf color was taken as an indicator of N requirement of the plant. Split application of N was done to match this requirement and to maintain colour at a uniform rate throughout the growth period.

- iii. Zinc oxide at  $1.0 \text{ kg ha}^{-1}$  in zinc sulphate and MgO at  $3.0 \text{ kg ha}^{-1}$  in kieserite, to be added with the materials used in the basal dressing.
- iv. Organic manures
  - a. 5 t of rotted cow dung \ FYM or  $2.5 \text{ t poultry litter ha}^{-1}$
  - b. 10 t of rice straw  $\text{ha}^{-1}$
  - c. 625 kg of charred rice husk  $\text{ha}^{-1}$
  - d. 2.5 t of green manure  $\text{ha}^{-1}$
- b. Spacing at 10cm x 10 cm.
- c. Cultivars of BG and AT of 3.5 month and 4.0 month age classes.

This was tested at Handapanagala and Okkampitiya in the Moneragala district.

## RESULTS OF FARMER FIELD EXPERIMENTS ON FERTILIZER APPLICATION

### Testing of 1990 revision of fertilizer recommendations

Results are grouped according to three main agro ecological regions of the Low Country Dry and Intermediate zones (LCDZ and LCIZ), Low Country Wet Zone (LCWZ) and the Mid and Up Country Wet and Intermediate Zones (MC|UC, WZ|IZ), due to the different rates of NPK applied based on the 1990 revision.

Results of demonstrations carried out during *maha* seasons of 1990/1991, 1991/1992 and 1993/1994 and the *yala* seasons of 1991,92 and 93 are given (table 1). These results were recorded from nine districts and three Mahaweli systems. Results show that 1980 recommendation gives a marginal increase over the 1990 recommendations during both *maha* and *yala* seasons. Similar results are available for LCWZ and the mid country wet and the intermediate zones. But based on the value cost ratio it is shown that to use the 1990 recommendation is more profitable due to the reduced quantities of fertilizers used.

**Table 1. Yields obtained using the 1980 and 1990 fertilizer recommendations**

AER	No. Dem. Season		Yield by treatments ( $t\ ha^{-1}$ )			VCR	
	maha	yYala	000	111	222	111	222
LCDZIZ	304	-	3.1	5.0	5.2	5.3	4.1
	-	27	3.0	5.5	6.0	6.9	5.9
LCWZ	114	-	2.6	4.2	4.3	6.2	4.4
		07	3.0	4.4	4.3	5.5	3.4
MCWZIZ	76	-	3.2	4.1	4.5	3.5	2.7
UCWZIZ		15	2.7	4.2	4.4	5.8	3.6

Treatments: 000 Check plot; 111 1990 Fertilizer recommendation; 222 1980 Fertilizer recommendation

### Application time of basal fertilizers

Results available from four locations are given in table 2. Application before leveling gives better results. Farmers are accustomed to apply basal applications before seeding to leave the fertilizers at the surface, although covering it is better.

**Table 2. Yield ( $t\ ha^{-1}$ ) obtained in relation to application of basal fertilizers at different operational times**

Location	T1	T2	T3	T4
System C	4.6	4.0	4.4	4.0
Matale	5.9	5.3	5.6	5.0
Kurunegala	5.2	4.4	6.0	5.2
Kegalle	5.0	5.3	5.8	5.1

Treatments: T1: Basal application before second ploughing; T2: Basal application before puddling; T3: Basal application before leveling; T4: Basal application after leveling.

### Benefits of applying different rates and urea treatment of rice straw

Testing of this recommendation was done in two *maha* seasons. Table 3 gives the yields obtained in each plot.

**Table 3. Yields obtained using different rates and urea treatment of rice straw**

Season	T1	T2	T3	T4	T5	T6
Maha 1990/1991	4.2	5.5	5.2	5.1	5.1	4.7
Maha 1991/1992	4.1	4.6	4.5	5.2	4.7	4.8

Treatments: i. NPK; ii NPK +  $4\ t\ ha^{-1}$  straw treated with urea; iii NPK +  $4\ t\ ha^{-1}$  straw not treated with urea; iv. NP +  $4\ t\ ha^{-1}$  straw treated with urea; v. NPK +  $2\ t\ ha^{-1}$  straw treated with urea; vi. NPK +  $2\ t\ ha^{-1}$  straw not treated with urea.

Results show that addition of rice straw with chemical fertilizers is beneficial. There is not much benefit in treating rice straw before application

as far as the yields are concerned. Using four tons of rice straw does not have an advantage over two tons per ha in the short run.

### Substitution of K by recycling of rice straw

The 0.1 ha demonstrations were carried out in 12 districts of the LCDZ/IZ, six districts of the LCWZ and five districts of the MCWZ/IZ for four seasons of *maha* 1995/1996, *yala* 1996, *maha* 1996/1997 and *yala* 1997. The average yield obtained in each season is given (table 4)

**Table 4. Rice yields with straw applied to substitute K fertilizer**

AER	No. Dem.	Season and Yield ( $t\ ha^{-1}$ )			
		<i>maha</i> 1995/1996	<i>yala</i> 1996	<i>maha</i> 1996/1997	<i>yala</i> 1997
LCDZ /IZ	148	5.2	5.3	5.2	5.2
LCWZ	121	3.5	3.2	3.5	4.0
MCWZ/IZ	78	4.6	3.8	4.3	4.7

The average yields obtained with straw application was comparable with the fertilizer added potassium as shown in the first series of demonstrations.

### Application of high rates of N in well managed rice fields.

The demonstrations carried out in the districts of Polonnaruwa, Hambantota and System H Kalawewa shows a slight increase in yields after the addition of  $20\ kg\ N\ ha^{-1}$  (table 5).

**Table 5. Yield obtained with high N under good management.**

District	Season	No. locations	Treatments and yield t ha <sup>-1</sup>			
			maha	90\91	111	222
Polonnaruwa	maha 1990/1991	06	3.1		6.2	7.0
	yala 1991	05	3.2		5.0	5.3
Hambantota	maha 1990/1991	06	2.8		5.2	5.4
Kalawewa	maha 1990/1991	05	3.3		5.6	6.1

Treatments (kg ha<sup>-1</sup>): 000: Check plot; 111 N: 100, P: 11 and K: 16; 222 N: 120, P: 11 and K: 16

Applying higher levels of N have benefited yield in all locations. However, it was observed that senescence of mature leaves, was faster in plots receiving higher rates of N.

### The combined organic and inorganic applications of fertilizer demonstrations (IPNS)

#### i. Direct application of rice straw and application of sulfur

Application of rice straw with the full complement of NPK fertilizers were beneficial at both rates of NPK. There is an increase in yield after application of sulphur (table 6)

**Table 6. Application of rice straw and gypsum as a source of sulfur.**

District	Season	Yield by treatments (t ha <sup>-1</sup> )						
		T0	T0+ St	T1	T1+St	T2	T2+ St	T2+ Gyp.
Ampara	maha 1989\1990	2.9	3.2	4.8	4.9	4.4	4.5	5.3
	yala 1990	3.1	3.2	5.0	5.1	4.4	4.7	5.0
Polonn.	maha 1989\1990	2.9	2.7	4.4	4.6	4.4	4.6	4.8
	yala 1990	2.8	3.2	4.5	5.0	5.6	4.9	4.8
Sys. H	Maha 1989\1990	3.2	3.4	5.8	6.2	6.5	6.7	6.8
Sys. C	Maha 1989\1990	-	-	5.6	6.1	6.2	6.1	6.9
	Yala 1990	-	-	6.0	6.2	6.6	6.8	6.8

Treatments T0 :N 0, P<sub>2</sub>O<sub>5</sub> 0, K<sub>2</sub>O 0; T0 + St:N 0, P<sub>2</sub>O<sub>5</sub> 0, K<sub>2</sub>O 0 + Rice straw at 3 t ha<sup>-1</sup>; T1N 86, P<sub>2</sub>O<sub>5</sub> 56, K<sub>2</sub>O 45; T1 + St N 86, P<sub>2</sub>O<sub>5</sub> 56, K<sub>2</sub>O 45 + Rice straw; T2 N 100, P<sub>2</sub>O<sub>5</sub> 75, K<sub>2</sub>O 60; T2 + St : N 100, P<sub>2</sub>O<sub>5</sub> 75, K<sub>2</sub>O 60 + Rice straw; T2 + Gyp: N 100, P<sub>2</sub>O<sub>5</sub> 75, K<sub>2</sub>O 60 + 30 kg Gypsum

## ii. Combined use of organic and inorganic fertilizers

Results of two seasons application shows that application of poultry litter is better than the application of rice straw or green manure when combined with recommended rates of inorganic fertilizers (table 7).

**Table 7. Combined organic and inorganic fertilizer demonstrations in rice.**

<i>Location</i>	<i>Season</i>	<i>T1</i>	<i>T2</i>	<i>T3</i>	<i>T4</i>	<i>T5</i>	<i>T6</i>
Endanduwawa	<i>maha 91\92</i>	2.2	3.2	3.0	3.8	4.2	3.6
	<i>yala 92</i>	2.4	4.2	3.8	4.8	6.2	4.8
Alapalawala	<i>maha 91\92</i>	2.0	3.0	2.6	3.2	4.1	3.6
	<i>yala 92</i>	3.0	3.8	4.1	5.2	5.3	4.9
Aludeniya	<i>maha 91\92</i>	1.2	2.6	2.8	2.9	3.9	3.2
	<i>yala 92</i>	3.1	3.6	4.2	5.3	4.8	4.8

Treatments : T1 : Control; T2: NPK (1990 Recc.); T3: NP ; T4: NP+ Straw  
T5: NPK + 2.5 t poultry manure ha<sup>-1</sup> ; T6: NPK + 5.0 t green manure ha<sup>-1</sup>

## iii. IPNS large scale demonstrations

Demonstrations carried over a period of four seasons were common in most places. Some farmers continue to keep the level of management high and obtain yields exceeding 10 t ha<sup>-1</sup>. Table 8 shows the results of some of the demonstrations scattered over the dry and intermediate zones of the country.

**Table 8a. Grain yield of combined application of inorganic and organic fertilizers at different locations**

<i>Location</i>	<i>Grain yield (t ha<sup>-1</sup>)</i>							
	<i>maha 1995/1996</i>	<i>yala 1996</i>	<i>maha 1996/1997</i>	<i>yala 1997</i>	<i>maha 1997/1998</i>	<i>yala 1998</i>	<i>maha 1998/1999</i>	<i>yala 1999</i>
Tabbowa	6.2	10.1	6.7	9.4	-	-	-	-
Minipe	6.6	8.1	6.5	7.8	-	-	-	-
Mapakadawewa	-	-	8.2	10.2	9.8	10.2	10.5	10.2
Ampara (Uhana)	-	-	5.3	7.3	8.2	8.6	-	-
Polonnaruwa (H'goda)	-	-	7.1	7.7	8.2	8.1	-	-
Hambantota Yoda-kandiya	-	-	5.1	6.1	6.3	7.2	9.6	-

**Table 8b. Grain yield of combined application of inorganic and organic fertilizers at different locations**

Locations	Grain yield ( $t\ ha^{-1}$ )				
	<i>yala</i> 1998	<i>maha</i> 1998\1999	<i>yala</i> 1999	<i>maha</i> 1999\2000	<i>yala</i> 2000
Moneragala					
Okkampitiya					
i.	8.6	8.2	-	8.8	-
ii.	8.2	9.5	-	9.2	10.3
Handapanagala					
i.	7.2	9.6	10.1	-	10.2
ii	-	-	-	-	10.1
Polonnaruwa (H'goda)	-	8.5	10.7	8.1	NH*

NH: Not harvested

Results indicates the following types of possibilities

- (a). The build up of nutrients over one to two seasons from the initial application of organic inorganic combination is necessary to produce a yield of over  $10\ t\ ha^{-1}$
- (b). Addition of combined application of plant nutrients of sulphur, zinc and magnesium with the other combinations can give a  $10\ t\ ha^{-1}$  yield in the first season itself
- (c). Application of organic – inorganic combinations can sustain high yields in spite of high removal rates

The extension of the successful IPNS demonstrations were handled through three approaches.

- (a). The introduction of the *yaya* Demonstration program began in the *yala* 1996. Here 23 farmers cultivating 46 acres (17.4 ha) of rice paddy in the Siyambalanduwa irrigation settlement scheme were organized to do a *yaya* demonstration with recommended rates of inorganic fertilizers given on credit. The credit was arranged between the Department of Agriculture (DOA) and the Ceylon Fertilizer Corporation (CFC). Fertilizer worth of Rs. 43000.00 were given to the farmers on credit which was fully recovered by the end of the season. This gave an impetus to push the *yaya* demonstration program under most irrigation settlement schemes that has resulted in an over all annual turn over of Rs. 200 m worth of fertilizer material being used in the *yaya* program.

- (b). The IPNS demonstrations demanded a regular supply of cow dung FYM to be added to the rice paddies. To encourage farmers to collect money was provided to purchase materials to construct collection pits in cattle sheds.
- (c). The success of the IPNS demonstration demanded the DOA to give a separate recommendation for the *yaya* demonstration farmers where rates above that of the 1996 revision are given.
- (d). Farmers who have used additional plant nutrients of zinc sulphate and magnesium sulphate along with the package of practices are confident of the benefits and are eager to use them regularly to obtain the 10 t ha<sup>-1</sup> yield.

### CONCLUSIONS AND RECOMMENDATIONS

The following conclusion can be given based on the past farmer field experiments on fertilizer application.

- (a) The fertilizer recommendations given by the 1990 revision is not capable of obtaining yields beyond 5-6.0 t ha<sup>-1</sup> even under good management in farmers fields.
- (b) The IPNS package has the capacity to enhance soil fertility and farmers who practice it could obtain high yields.
- (c) Obtaining high yields is possible throughout the dry and intermediate low country regions under assured water supply.
- (d) As there is a response to S, Zn and Mg, their application should be included in recommendations in the dry and intermediate zones.
- (e) Many 4 and 3.5 month cultivars originating from Batalagoda and Ambalantota rice breeding stations have the potential of giving yields of over 10 t ha<sup>-1</sup> under IPNS with good management.
- (f) Profitable rice production should aim at reducing the production cost of a kilogram of rice rather than attempting to reduce the cost of production by reducing the recommended amounts of inputs.
- (g) A comprehensive program to push higher level of rice production needs the integration of animal husbandry into rice farming systems. A concerted effort is necessary to achieve this.
- (h) Small scale industry to supply organic manure, charred rice husk and other organic materials could enhance rice yields as it is believed at

higher levels of production rice too is comparable to the production of other high value crops.

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### REFERENCES

- Anon. 1990. Fertilizer recommendations for rice. Department of Agriculture
- Deb, D.L. 1992. Development of soil and plant analytical methods for micro nutrients and sulfur. Field Doc. No. 11, FAO Fertilizer Project.
- Dissanayake, S.T., A. Willekens and M. Reznia. (1993). Fertilizer demonstrations on rice and subsidiary crops. Field doc. No. 15, FAO Fertilizer Project.
- Dissanayake, S.T. (2000). Increasing Rice yields through Integrated Plant Nutrition Systems (IPNS) to face the new millennium. Proc. of International Seminar on Sustaining Paddy Soil Fertility. 24-27 April 2000. Manila, Philippines.
- Dissanayake, S.T. and S.Wirasinghe. 1992. Promotion of the efficient use of fertilizers; the experience of the plot demonstration program. Proc. Of the national seminar on fertilizer use in agricultural development of Sri Lanka, 28-29 Oct. 1992,Peradeniya
- FAO. 1990. Integrated plant nutrition systems. State of the art. Commission on Fertilizers;Eleventh session,Rome: p 4-6.
- Seneviratne, R. 1992. Basis for fertilizer recommendations; present and future. Proc. of the National Seminar on Fertilizer use in Agricultural Development of Sri Lanka, 28 - 29, October 1992 , Peradeniya.