

RESPONSE OF IRRIGATED LOWLAND RICE TO ADDITION OF N, P AND K FERTILIZERS IN NON-CALCIC BROWN SOILS

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ABSTRACT

Experiments were conducted on Non-calcic Brown soils at Aralaganwila to study the response of rice to the addition of nitrogen, phosphorus and potassium. Response to addition of nitrogen was observed in all the seasons from yala 1987 to maha 1989/90. Grain yield function attained its maximum at a nitrogen rate of 170.6 kg N/ha for the 3 1/2 month variety. Despite the significant response to the addition of nitrogen, rice showed a low agronomic efficiency for this nutrient in this soil. Grain yield response to the addition of phosphorus was significant only in the second season. No response to the addition of potassium was observed during the two consecutive seasons studied.

KEY WORDS: Agronomic efficiency, Fertilizer response, Non-calcic Brown soil, Rice (*Oryza sativa*)

INTRODUCTION

System 'B' of the Mahaweli River Development Scheme lies on either side of Maduru Oya in the eastern dry zone of Sri Lanka. The most agriculturally significant feature of this region would perhaps be the presence of a large extent of coarse-textured soils. Non-calcic Brown (NCB) soils and soils on old alluvium are the most prominent great soil groups which are coarse textured. It has been estimated that at least 50,834 ha of lowland sandy soils are present in system 'B' and 62% of this is NCB soils (Acres, 1980).

The available information regarding this particular soil group showed its inferior chemical fertility status. It has been reported that the cation exchange capacity of this soil is < 10 meq/100 g in addition to its low organic matter content (Acres, 1980). Mapa and Bodhinayaka (1988) reported the percolation rate of these soils to be as high as 7 cm/hr. Therefore a greater degree of nutrient loss is anticipated in these soils especially under rice-rice cropping sequence. Nitrogen (N)

fertilization has been identified as a key input in rice production. Agronomic efficiency (AE) or the yield increase of grain per unit of applied N is considered to be one of the most important criteria for evaluating fertilizer recommendation for rice (Bouldin, 1986). The performance of applied N is known to depend on the source and the management of fertilizer in a given environment. The objectives of this study were to examine the response of rice to added N, P and K fertilizers and to determine the AE of the chemical N applied to NCB soils in a rice-rice cropping sequence.

MATERIALS AND METHODS

Two field experiments were conducted in Galwewa series of NCB soils at the Regional Agricultural Research Centre, Aralaganwila to study the response of rice to the addition of N, P and K.

First field experiment was conducted during yala 1987 and maha 1987/88 to study the response of rice to the addition of N and K. Some of the important soils properties of the experimental site are given in Table 1. Experimental design was a randomized complete

Table 1. Soil characteristics of the experimental sites

| <i>Property</i> | <i>Site 1</i> | <i>Site 2</i> |
|-------------------------|---------------|---------------|
| pH (1:1 water) | 5.8 | 6.8 |
| Organic matter (%) | 0.2 | 0.3 |
| Exch. K (meq/100g) | 0.03 | 0.06 |
| Available P Olsen (ppm) | 4.5 | 5.0 |
| Total N (%) | 0.043 | 0.047 |
| CEC (meq / 100g) | 4.52 | 4.13 |
| Texture | LS | LS |

LS = Loamy sand; Site 1 - For NK response experiment;
Site 2 - For N and P response experiment

block of a 4×5 factorial with four replicates. Tested N levels varied from 0 to 150 kg N/ha in 50 kg N/ha increments while K levels varied from 0 to 80 kg K/ha in 20 kg K/ha increments. Phosphorus was added to all plots in the basal mixture at the rate of 25 kg P/ha.

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Plot size was 3.5 m × 3.2 m and Bg 350 (3 1/2 month rice variety) was transplanted after 21 days in the nursery with the spacing of 20 cm × 15 cm at 2 plants per hill.

Second field experiment was designed to examine the response of rice to addition of P and also to higher levels of N exceeding the highest level used in the previous experiment. This experiment was conducted in yala 1989 and maha 1989/90. Soil characteristics of the site are given in Table 1. In this experiment, N levels tested varied from 0 to 225 kg N/ha in 45 kg N/ha increments and P levels from 0 to 50 kg P/ha in 12.5 kg P/ha increments. Experimental design was a randomized complete block with four replicates. To all the N levels tested, P and K were added at the rates of 25 kg P/ha and 40 kg K/ha. Nitrogen and K were added at the rates of 90 kg N/ha and 40 kg K/ha to all the P levels tested. Twenty-one day old Bg 94-1 (3 1/2 month rice variety) seedlings were planted at the spacing of 20 cm × 15 cm at 2 plants per hill in plots of size 3.5 m × 4.0 m.

For both experiments conducted, N was applied in the form of urea, P in the form of triple superphosphate and K in the form of muriate of potash. Plots were irrigated whenever necessary to maintain a standing water level of around 2.5 cm. Rotary weeder was used in controlling weeds and recommended cultural practices were followed in crop management.

Number of plants at maximum tillering was determined by taking 10 randomly selected hills/plot at five weeks after planting. Number of panicles/hill was also determined by taking 10 randomly selected hills/plot one week before harvesting. Rice was harvested eliminating one border row surrounding each plot and the grain yield was recorded at 14% moisture content.

RESULTS AND DISCUSSION

Response to nitrogen

Results of both experiments showed a marked response to the addition of N (Fig. 1 and Table 2). Grain yield data of all four seasons were combined in a regression model (Fig. 1) which showed

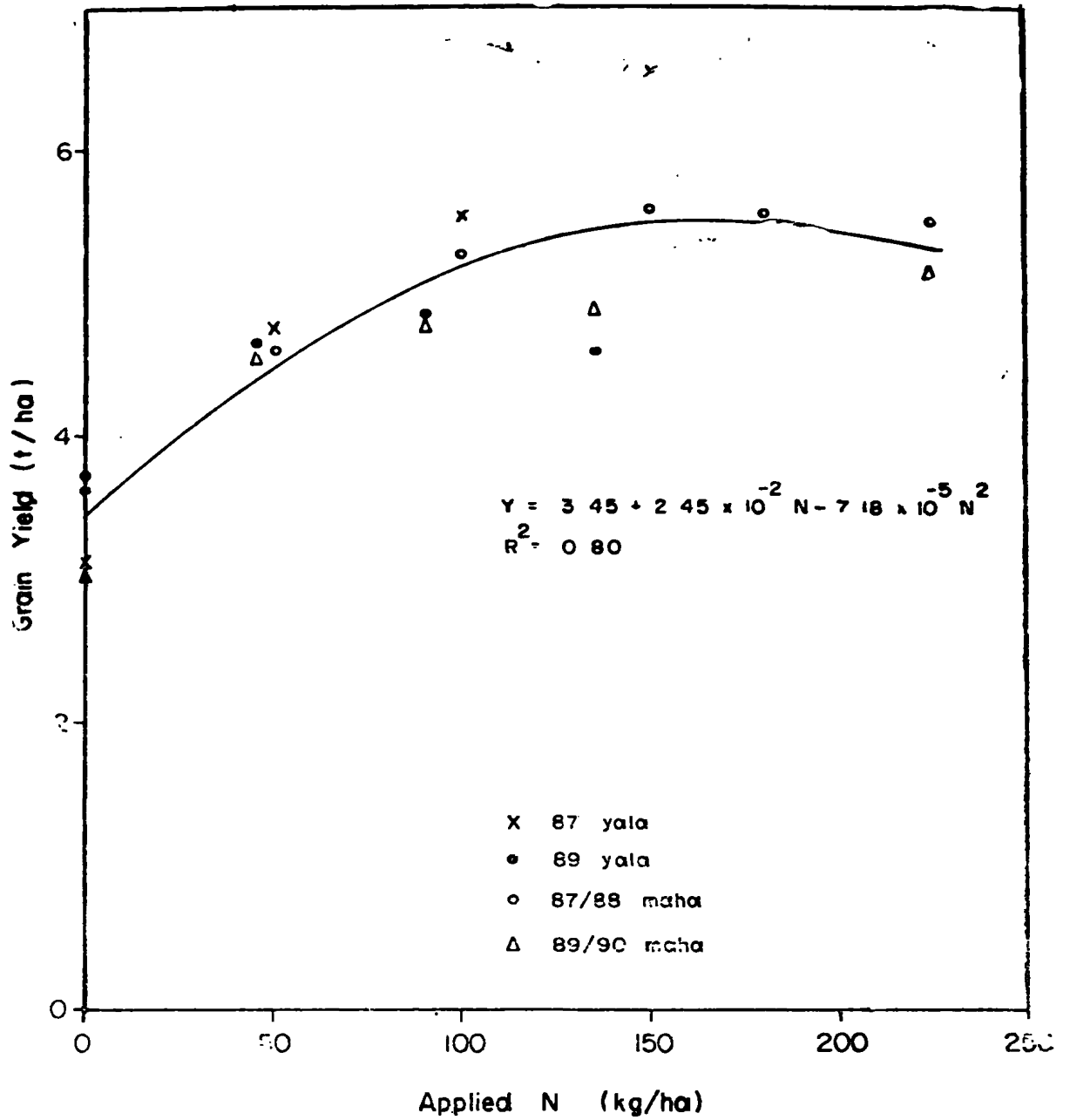


Fig. 1. Grain yield response to applied N

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Table 2. Grain yield response to addition of N

| <i>Season</i> | <i>Relationship</i> | <i>Correlation coefficient</i> |
|---------------|--------------------------------------|--------------------------------|
| yala 87 | $GY = 3.34 + 0.022 N$ | 0.99** |
| maha 87/88 | $GY = 3.86 + 0.012 N$ | 0.98** |
| yala 89 | $GY = 3.94 + 0.008 N$ | 0.89* |
| maha 89/90 | $GY = 3.22 + 0.024 N - 0.000068 N^2$ | 0.95** |

GY = Grain yield, t/ha; N = kg N/ha; * Significant at 5 % level;
 ** Significant at 1 % level

that grain yield increase diminished as the N level increased. According to this model the yield function attained its maximum at the N level of 170.6 kg N/ha. Kandiah (1989) reported that rice yield attained its maximum at 120 kg N/ha in the same soil group.

If the price of one kg of urea is Rs. 9.75 and the price of one ton of paddy is Rs. 6100, then the economic optimum level of N was calculated to be 148.2 kg N/ha, provided that farmer has no other additional costs incurred due to the increase in the rate of N application. Thus an increase in the present recommended level of application (100 kg N/ha) would give higher returns to the farmer.

The addition of N had mainly increased the number of panicles (Table 3). This increase must have contributed to increase in yield. However it was observed that there was an increase in non-productive tiller production with the increase in N rate.

Agronomic efficiency (AE) of applied N

Table 4 shows the AE of applied N in yala 89 and maha 89/90 seasons. The overall efficiency was much lower compared to that observed for Grumusols (Yogaratham, 1987). Kandiah (1989) also observed a low AE of N in NCB soil. It has been reported that a 50 kg grain increase per unit of N applied is ideal for rice (Bouldin, 1986). AE decreases when N level increases. Low AE of applied N in this soil could be attributed to the high degree of N losses. Coarse texture and the need for frequent irrigation in these soils may create conditions for high degree of leaching losses. Kendaragama (1989) observed a loss of 15—17 kg N/ha by leaching alone in his

Table 3. Tillers and panicles as affected by N levels

| <i>N level</i> (kg/ha) | <i>Tillers/hill</i> | | <i>Panicles/hill</i> | |
|---------------------------|---------------------|-------------------|----------------------|-------------------|
| | <i>yala 89</i> | <i>maha 89/90</i> | <i>yala 89</i> | <i>maha 89/90</i> |
| 0 | 5.7 e | 9.0 b | 5.4 c | 7.2 b |
| 45 | 6.8 d | 11.7 a | 6.0 bc | 8.1 ab |
| 90 | 7.3 cd | 12.7 a | 6.4 abc | 8.2 ab |
| 135 | 7.7 bc | 11.1 ab | 6.5 ab | 8.0 ab |
| 180 | 8.2 b | 12.6 a | 7.4 a | 8.8 a |
| 225 | 9.8 a | 13.8 a | 7.0 ab | 9.2 a |
| CV (%) | 4.0 | 5.7 | 4.9 | 5.2 |

Means followed by the same letter in any column are not significantly different at 5% level according to DMRT

Table 4. Agronomic efficiency (AE) of applied N in grain production

| <i>N level</i> (kg/ha) | <i>AE of applied N (kg grain/kg N)</i> | | |
|---------------------------|--|-------------------|-------------|
| | <i>yala 89</i> | <i>maha 89/90</i> | <i>mean</i> |
| 45 | 23.04 | 32.96 | 28.00 |
| 90 | 13.86 | 18.94 | 16.40 |
| 135 | 10.98 | 13.58 | 12.28 |
| 180 | 10.74 | 13.83 | 12.29 |
| 225 | 8.44 | 9.27 | 8.86 |

lysimeter studies on the same soil group. Loss of N by the process of NH_3 volatilization is another mechanism of N loss. High flood water pH levels and high wind velocities which prevail in the area are two conducive factors favouring this mechanism. Therefore it would be more beneficial to seek ways of increasing the AE of applied N than increasing the rate of N applied in order to increase rice yields.

Response to potassium

Results showed that the addition of K was not effective in increasing rice yields significantly (Table 5). However, Balasuriya *et al.*, (1977) and Kandiah (1989) reported response to the addition on K in NCB soils. Kendaragama (1988) reported a loss of 17 kg K/ha/season

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Table 5. Grain yield response to the addition of K

| <i>K level</i> (kgK/ha) | <i>Grain yield (t/ha)</i> | |
|----------------------------|---------------------------|-------------------|
| | <i>yala 87</i> | <i>maha 87/88</i> |
| 0 | 4.83 | 4.41 |
| 20 | 4.72 | 4.79 |
| 40 | 4.71 | 5.31 |
| 60 | 4.97 | 5.21 |
| 80 | 5.12 | 4.81 |
| CV (%) | 18.9 | 16.5 |
| LSD | NS | NS |

NS = not significant

from the root zone of rice and a gain of 23.5 kg K/ha/season, from irrigation water. Preliminary work (Acres, 1980) indicated the presence of 2:1 type clays in these soils which can be expected to play a significant role in the release and fixation of K in these soils. These point to the need to carry out long term studies to understand the fate of applied K in these soils.

Response to phosphorus

Content of Olsen P in these soils was observed to be low (Table 1). Grain yield data in the first season (Table 6) did not show a significant yield response to added P. However the number of panicles/hill was significantly affected by the addition of P. Grain yield data in the following season (Table 6) showed response to added P. This yield increase was more than that for the N and there was no significant yield increase beyond 37.5 kg P/ha (Table 6). Kandiah (1989) also reported a response to the addition of P in the same soil and considered 15—30 kg P/ha as adequate. Therefore P may be a critical element, limiting rice yield in these soils. However, an understanding of the P sorption and release characteristics of the soils in the region would be more useful in determining the P requirement.

Table 6. Response of rice to addition of P

| <i>P</i> level (kg P/ha) | <i>Tillers/hill</i> | | <i>Panicles/hill</i> | | <i>Grain yield (t/ha)</i> | |
|-----------------------------|---------------------|-------------------|----------------------|-------------------|---------------------------|-------------------|
| | <i>yala 89</i> | <i>maha 89/90</i> | <i>yala 89</i> | <i>maha 89/90</i> | <i>yala 89</i> | <i>maha 89/90</i> |
| 0 | 7.3 a | 10.3 a | 5.9 b | 7.2 b | 4.76 a | 4.41 b |
| 12.5 | 7.0 a | 11.1 a | 6.1 b | 8.6 a | 4.82 a | 4.43 b |
| 25.0 | 7.3 a | 12.7 a | 6.4 ab | 8.2 ab | 4.86 a | 4.75 b |
| 37.5 | 7.8 a | 12.8 a | 7.4 a | 8.6 a | 5.49 a | 6.31 a |
| 50.0 | 7.5 a | 11.7 a | 6.9 ab | 9.0 a | 5.37 a | 6.49 a |

Means followed by the same letter in any column are not significantly different at 5% level by DMRT

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CONCLUSIONS

Results of these experiments showed a very clear response to the addition of N and the possibility of increasing the present recommended level of N from 100 kg N/ha to 140 kg N/ha. However the greater degree of N leaching reported and the possibility of high NH_3 volatilization losses seem to suggest that increasing the present rate of N may not be a satisfactory approach to obtain higher yields; instead it would be more beneficial to find ways of increasing the efficiency of N utilization. The lack of response to K in NCB soil indicates the need for long term studies in order to assess the contribution of other sources of K in this soil. Phosphorus seemed to be a critical element limiting yields in the NCB soil. However, more information on P sorption and release characteristics is needed to understand the importance of P fertilization in the NCB soil.

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