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NITROGEN RESPONSE OF THE RICE PLANT IN RELATION TO INHERENT CHARACTERISTICS OF THREE SOIL SERIES IN MUDA*

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Keywords: Nitrogen, rice, cation exchange capacity.

RINGKASAN

Kajian-kajian mengenai kesanbalas pokok padi kepada nitrogen bersabit dengan ciri-ciri semulajadi tanah telah dijalankan pada tanah-tanah bersiri Chengai, Tualang dan Hutan di kawasan Pengairan Muda. Potensi semulajadi siri-siri tanah itu untuk memberikan hasil padi boleh dikaitkan dengan kandungan tanah liat dan keupayaan tukaran kation (C.E.C.) mereka. Ciri-ciri ini juga nampaknya ada kaitan dengan kedapatan kandungan nitrogen semulajadi bagi sesuatu tanah serta baja nitrogen yang dibubuh. Bagi tanah dalam siri Chengai, kandungan tanah liat dan C.E.C. yang lebih tinggi boleh menyebabkan penahanan dan seterusnya penggunaan nitrogen yang lebih baik oleh pokok padi untuk memberikan lebih banyak hasil bijian berbanding dengan tanah-tanah dalam siri Tualang dan Hutan. Walaubagaimanapun pemerhatian telah menunjukkan bahawa secara umum kecekapan penggunaan nitrogen yang lebih baik adalah didapati pada paras nitrogen yang lebih rendah dan pada tanah-tanah yang secara bandingannya kurang subur.

INTRODUCTION

The padi soils of the Kedah/Perlis coastal plain have been classified into five classes and sixteen series (SOO, 1972). A study of the productivity potential of the soil classes based on the crop cutting survey carried out by the Statistics Department did not indicate any definite pattern of yield between the different soil classes (JOSEPH and SAMY, 1974). Fertilizer trials with padi varieties Ria, Bahagia and Jaya carried out from 1967 to 1974 have clearly demonstrated that the yield of padi without the application of fertilizer and the yield potential with the application of fertilizer did not conform to the soil classes (JOSEPH and SAMY, 1974). Fertilizer recommendations for Muda Scheme Area (within the Kedah/Perlis coastal plain) have in the past attempted to associate with the soil classes but recent recommendations by MARDI have been based on the actual response in yield of the padi crop to fertilizers on different soil series.

The soil series of the Muda Scheme Area can serve as a good basis for the demarcation of soils. Studies are currently being conducted to understand the variation in the yield potential and response to fertilizer in the different soil series. This paper reports on the studies conducted on the nitrogen response of the rice plant in relation to the inherent soil characteristics of three selected soil series in the Muda Scheme Area.

MATERIALS AND METHODS

Fertilizer trials were laid down in three varying soil series – Chengai, Tualang and Hutan soil series in the Muda Scheme Area. The major physical and chemical characteristics of the three soil series are given in *Table 1*. The rice varieties used were Ria, Sri Malaysia II and Bahagia. The nitrogen levels studied were control (no nitrogen application), 40 kg/ha, 80 kg/ha, 120 kg/ha and 160 kg/ha. Urea (36% N) was used as the source of nitrogen. A basal application of phosphate at 60 kg/ha as Christmas Island Rock Phosphate (36% P_2O_5) and potassium at 30 kg/ha as Muriate of Potash (60% K_2O) was applied to all the plots. A split plot design with varieties as the main plots and nitrogen appli-

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TABLE 1: DESCRIPTION OF THE SOIL IN THE EXPERIMENTAL SITES

Soil Characteristics	Location		
	Batu 13 Jalan Sungai Petani	Hutan Kampong	Alor Cik Kendu
a) Soil Series	Chengai	Tualang	Hutan
b) Mechanical Analysis			
Clay (%)	75	60	41
Silt (%)	20	30	18
Fine sand (%)	4	9	37
Coarse sand (%)	1	1	4
c) pH			
(Air-dry soil – 1: 2.5)	4.8	4.5	4.8
d) Chemical Analysis			
Organic matter (%)	3.4	2.8	4.3
Carbon (%)	2.0	1.5	2.5
Total Nitrogen (%)	0.19	0.16	0.20
Ammonical nitrogen (ppm)	70	90	90
C/N ratio	10	9	12
Potassium (ppm) (0.5N acetic acid)	63	53	127
Phosphorus (ppm) (0.1N NaOH soln.)	96	168	23
C.E.C. (meq/10 g soil)	32	19	17

cation as sub-plots was used with four replications.

Planting and Maintenance

At the nursery stage the cultural practices included the applications of 1 kg Ammophos to every 46.5m^2 nursery area and 0.5 kg of Urea as top-dressing at two weeks after seeding.

Field cultivation was by tractor and the date of planting was as practised in the locality. The plot size was six metres by six metres. Twenty-five days old seedlings were transplanted at two seedlings per hill with the planting distance of 20 cm by 20 cm for Ria, 25 cm by 25 cm for Sri Malaysia II and 30 cm by 30 cm for Bahagia. Hand weeding was carried out three weeks after transplanting. Pest control measures included the application of carbamate (Sevin 85) at 1.5 kg a.i./ha as protection against leafhoppers in the nursery and endosulfan (Thiodan 5% granules) at the rate of 1.75 kg a.i./ha at 10 days, 35 days and 60 days after transplanting in the field plots for protection against stem borers.

Harvesting

The whole plot was harvested after discarding two guard rows and after recording the number of missing, damaged hills or off-type plants. The grains were sun-dried to

14% moisture content, winnowed and weighed.

Soil, Foliar and Grain Analysis

Soil sampling consisted of a composite sample taken at 0 to 15 cm depth from each location, for mechanical and complete chemical analysis of the soil. Another set of soil samples from each treatment plot was taken at 0 to 15 cm depth at five points at random and mixed together. The samples were taken just before transplanting of the trial and at harvest. The soil samples were analysed for ammonical nitrogen content.

The foliar analysis for nitrogen content was carried out on four sample hills taken at harvest from each treatment plot. The nitrogen content of grain was determined from grain samples taken from each plot at harvest.

RESULTS AND DISCUSSION

Response in Grain Yield to Nitrogen Application

The response in grain yield to nitrogen application in rice varieties Ria, Sri Malaysia II and Bahagian is graphically illustrated in *Figure 1*. There were significant responses in grain yield to nitrogen application in all the rice varieties in the different soil series. There was a highly significant increase in yield in all the varieties with the very high levels of nitrogen (120 and 160 kg/ha) in comparison with the low levels (40 and 80 kg/ha). A comparison between 40 and 80 kg/ha nitrogen indicated a significant increase in yield at 80 kg/ha nitrogen in rice varieties Ria and Bahagia. There was no significant difference in grain yield between 120 and 160 kg/ha nitrogen in the different soil series. Rice varieties Ria and Sri Malaysia II had a

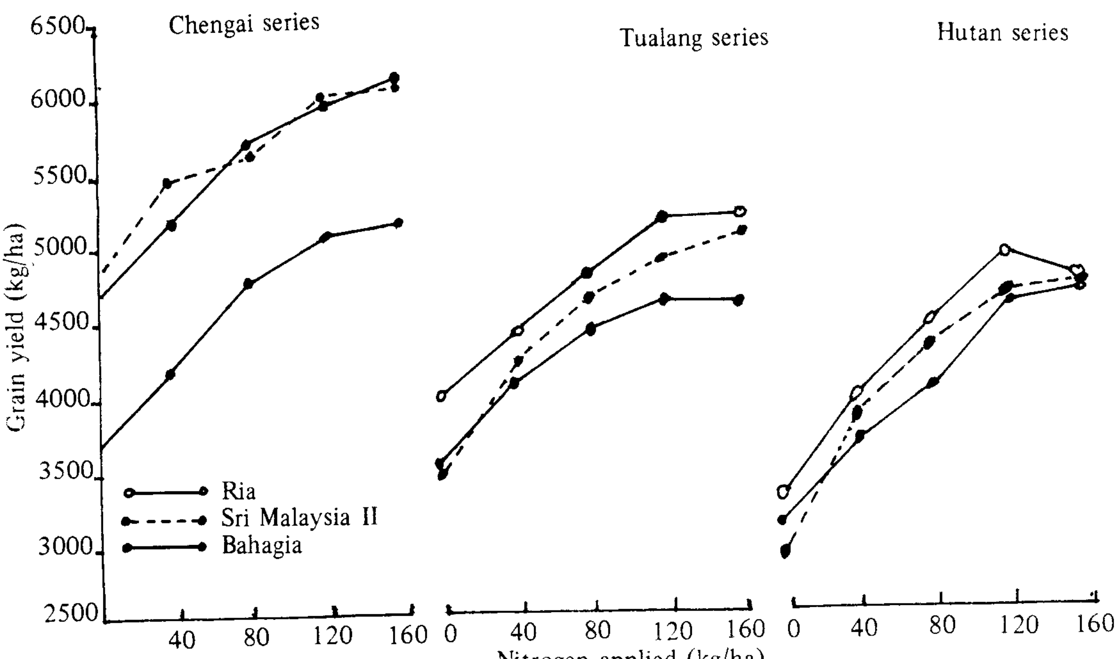

Figure 1: Response in grain yield of the rice varieties at various levels of nitrogen application.

higher yield trend than Bahagia in all the soils and this difference would be due to the inherent yield potential of the varieties.

It was observed in the three rice varieties that a relatively higher grain yield was obtained in Chengai soil series followed by Tualang and Hutan soil series. The varietal and the location mean grain yield are tabulated in *Table 2*.

The difference in grain yield in the three soil series can be related to the inherent

TABLE 2: VARIETAL AND LOCATION MEAN GRAIN YIELD

Rice varieties	Mean grain yield (kg/ha)		
	Chengai series	Tualang series	Hutan series
Ria	5504	4682	4205
Sri Malaysia II	5579	4446	4025
Bahagia	4569	4250	3976
Location mean	5217	4459	4069
Soil characteristics:			
Clay (%)	75	60	41
C.E.C. (meq/100 g soil)	32	19	17

soil characteristics. KYUMA KAWAGUCHI (1972) from a study of the soil fertility evaluation of Peninsular Malaysia rice soil have assigned some 60% of the variance in rice yield to three fertility constituents, i.e. inherent potentiality of the soil, available phosphorus and available nitrogen. In the study it was observed that where the clay content and cation exchange capacity (C.E.C.) of the soil was high as in the Chengai soil series, a relatively higher grain yield was obtained while with a lower clay content and C.E.C. as in Tualang and Hutan soil series, the grain yield progressively declined *(Table 2)*. PURUSHOTHAMAN and JOSEPH (1975) have shown a decrease in NH_3 loss in Chengai soil in comparison to Tualang soil because of the higher C.E.C. in the former. NOMMIK and WARLIN (1960) claimed that on soils with more than 50% clay, the risks of NH_3 volatilisation was small, possibly due to the higher C.E.C. at higher clay contents. In the study, the inherent potentiality for grain yield in the three soil series can be related to the clay content and C.E.C. of the soil. In Chengai soil series the higher clay content and C.E.C. could cause a better retention and therefore utilization of nitrogen by the rice plant in comparison to Tualang and Hutan series.

Nitrogen Uptake by Rice Plant in the Different Soil Series

The relationship between the application of various levels of nitrogen and plant uptake of nitrogen in Chengai, Tualang and Hutan soil series is graphically illustrated in *Figure 2.* The total nitrogen uptake by the rice plant is linearly related to the fertilizer levels over the full application range. In this study where Y is the amount of total nitrogen utilized by plants and X is the amount of nitrogen applied, the portion of the ascending straight line extrapolated to Y = O would give the amount of nitrogen present in the unfertilized soil having an availability equivalent to that of the applied fertilizer. In the study, the extrapolated soil nitrogen values obtained were 180 kg/ha in Chengai soil series. The relatively higher nitrogen content obtained in Chengai soil series followed by Tualang and Hutan soil series could be related to the inherent characteristics of the soil, i.e. clay content and C.E.C. of the soil. On this basis it could be said that Chengai soil series is relatively the most fertile soil followed by Tualang and Hutan soil series and this was clearly demonstrated by the grain yield and nitrogen response pattern of rice plant in these soils.

The amount of nitrogen in the rice plant at harvest in the control treatment (no nitrogen application) would be the amount of available nitrogen in the soil. KANAPATHY (1976) has reported that this would be the best assessment of available soil nitrogen as the plant itself is the extracting agent. The average nitrogen uptake by rice

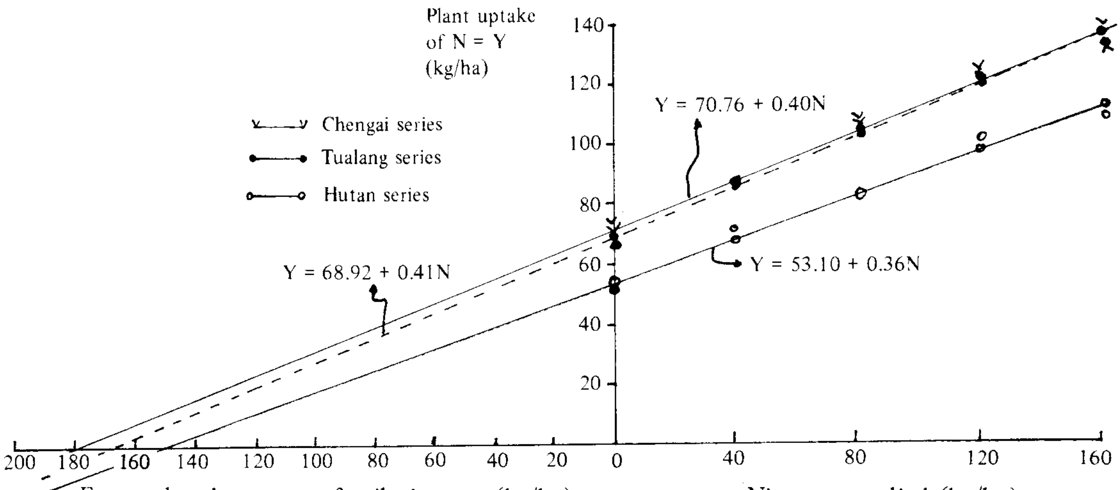

Figure 2: Relationship between various levels of nitrogen applied and plant uptake of nitrogen.

varieties in the control plots were 69.2 kg/ha in Chengai series, 67.7 kg/ha in Tualang series and 50.0 kg/ha in Hutan series. These values represent the inherent available soil nitrogen and they again clearly indicate the relative fertility of the three soils series. Rice soil fertility can be regarded in a narrow sense as the nitrogen supplying capacity of the soil (KOYAMA, 1971).

There was an increase in nitrogen recovery at harvest in the three rice varieties with increasing levels of nitrogen application as shown in *Figure 3.* This however, is related to the soil series and is determined by the inherent available nitrogen in the soil. The nitrogen uptake by rice plant is derived from the native soil nitrogen as well as the applied nitrogen. TAKAHASI (1964) has reported that the rice plant usually utilizes more of the native soil nitrogen than the applied nitrogen. Several researchers have reported that with an increase in the amount of applied nitrogen added to soils there is usually an increase in the amount of soil nitrogen in the harvested plant (WALKER *et al.,* 1956; STEWART *et al.,* 1963; LEGG and ALLISON, 1967). BROADBENT (1965) has ascribed this to the 'priming effect', that is, the stimulating effect of inorganic nitrogen on the mineralization of organic soil nitrogen. KOYAMA (1971) has reported that this might be caused by the stimulated root growth as a result of added nitrogen which would then increase the volume of soil exploited by the plant.

The relationship between nitrogen uptake by plant and the grain yield in the three soil series is graphically illustrated in *Figure 4.* There was generally a significant linear response in grain yield with nitrogen uptake by the rice plant. In Tualang series in rice varieties Sri Malaysia II and Bahagia and in Hutan series in rice variety Sri Malaysia II there was a quadratic response significant at 5% level, indicating a diminishing grain yield at high levels of nitrogen uptake. The reasons for this are not very clear. However, it is evident that with a higher nitrogen uptake by the rice plant, a higher grain yield is obtained in Chengai soil series followed by the Tualang and Hutan soil series.

Productive Efficiency of Nitrogen

The fertilizer use efficiency in kilograms grain per kilogram nitrogen applied at the various rates and time of application in rice varieties Ria, Sri Malaysia II and Bahagia in the three soil series is given in *Table 3.* It was interesting to note that

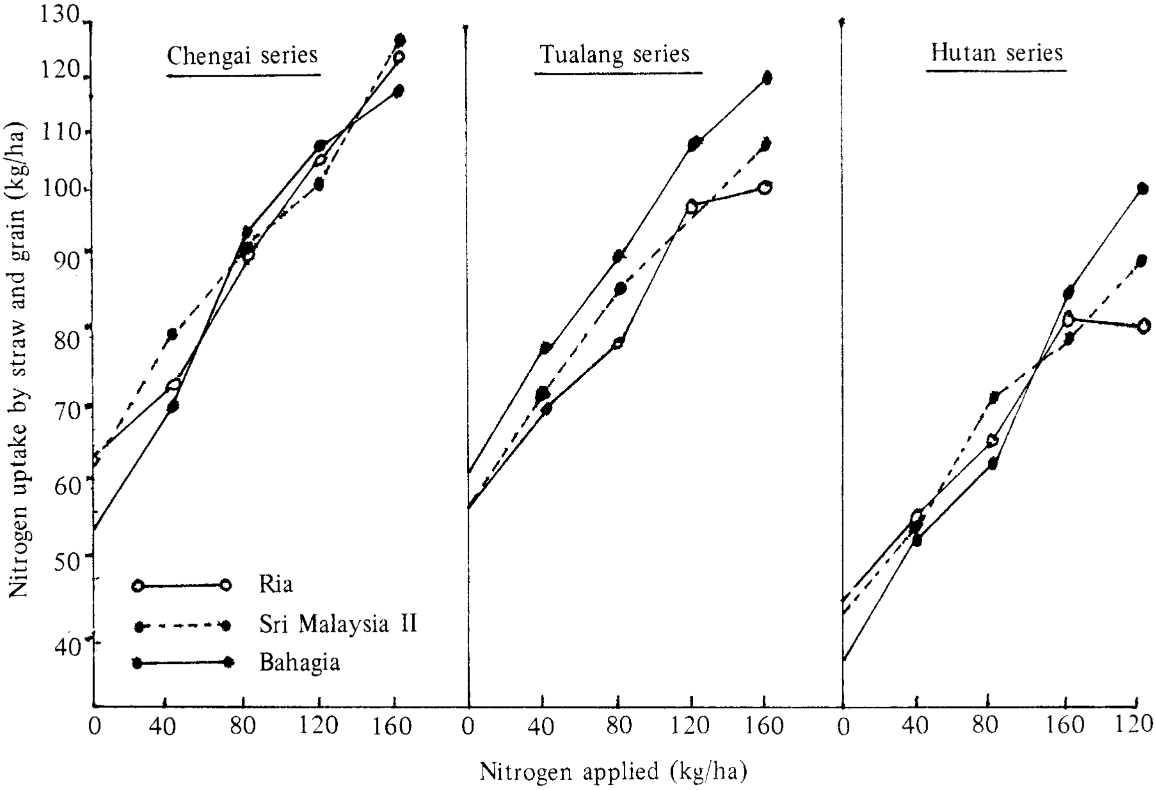

Figure 3: Nitrogen uptake by the rice plant (straw and grain).

generally a higher nitrogen use efficiency was obtained at the lower levels of nitrogen and in the relatively poorer soils. There is a better response to nitrogen in the relatively poor soil series (Hutan series) although this does not result in a higher grain yield than in the Chengai and Tualang series *(Figure 1)*. This would merely indicate that in Hutan soil series, with a relatively lower inherent available soil nitrogen, more of the applied fertilizer nitrogen may be utilized by the rice plant. Rice variety Sri Malaysia II tends to have a slightly higher nitrogen use efficiency than Ria and Bahagia in the three soil series. This could be due to varietal differences between the rice varieties.

TABLE 3: NITROGEN USE EFFICIENCY IN KILOGRAMS GRAIN PER KILOGRAM NITROGEN APPLIED

Nitrogen level* (kg/ha)	Chengai series			Tualang series			Hutan series		
	Ria	SMII	Bah	Ria	SMII	Bah	Ria	SMII	Bah
40	13.0	20.0	18.0	19.1	24.1	19.1	23.9	26.7	14.3
80	13.9	12.2	15.9	12.3	18.9	13.6	17.3	20.2	14.6
120	12.4	13.1	14.1	12.4	16.9	10.3	13.3	16.2	16.4
160	10.9	8.8	10.8	9.7	13.1	8.1	10.0	11.3	7.5

* Applied at basal and panicle initiation stage
SMII : Sri Malaysia II
Bah : Bahagia

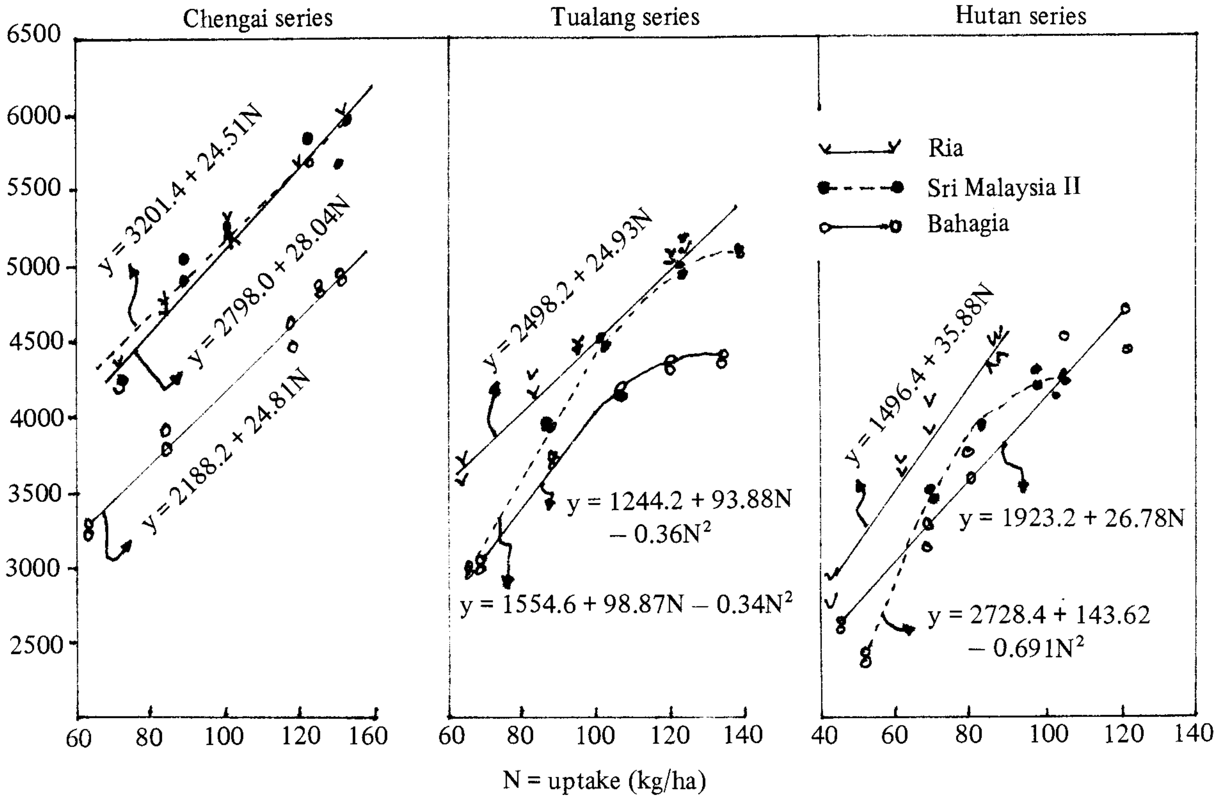

Figure 4: Relationship between nitrogen uptake and grain yield.

CONCLUSION

The inherent potentiality of rice grain yield in the different soil series of the Muda Scheme Area can be related to the inherent properties of the soil, particularly to the clay content and C.E.C. These soil characteristics also seem to relate to the inherent available nitrogen content of the soil and the response pattern to applied nitrogen fertilizer. Nitrogen application in the relatively more fertile soils, which have a higher clay content, C.E.C. and soil nitrogen content, are able to give higher responses in grain yield of rice plant.

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SUMMARY

The studies on the nitrogen response of the rice plant in relation to the inherent soil characteristics were conducted in the Chengai, Tualang and Hutan soil series in the Muda Scheme Area. The inherent potentiality for grain yield in the three soil series can be related to the clay content and C.E.C. of the soil. These characteristics also seem to relate to the inherent available nitrogen content of the soil and the response to applied nitrogen fertilizer. In Chengai soil series the higher clay content and C.E.C. could cause a better retention and therefore utilization of nitrogen by the rice plant for a higher grain yield in comparison to Tualang and Hutan series. It was however observed that generally a higher nitrogen use efficiency was obtained at the lower levels of nitrogen and in the relativel poorer soils.

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