Nitrogen Nutrition of Some Local Rice Varieties Grown without Fertilizer on Acid Sulphate Soil Area in South Kalimantan

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ABSTRACT

Nitrogen Nutrition of Some Local Rice Varieties Grown without Fertilizer on Acid Sulphate Soil Area in South Kalimantan (E. Purnomo, T. Hasegawa, Y. Hashidoko, P. J. Saputra and M. Osaki): Banjarese farmers in South Kalimantan apply a very minimum nitrogen (N) fertilizer in growing local rice. This practice has been adopted for many years. Yet, the grain yield level at farmers' field is not necessary low. Nitrogen sources for the crop are questioned. This study only focuses on measuring net N mineralization in association with N uptake. Three rice varieties at four sites in rice growing area of South Kalimantan are grown. The net N accumulation in soil and water, plant top biomass, N concentration of plant tissue and N uptake were measured on monthly basis. The results showed that all rice varieties grown in the 4 locations took up more N than from N mineralized from the organic matter. The higher N in the crop indicates that there are other sources of N for the local rice such as N fixed by microorganisms.

Keywords: N content, N mineralization, N uptake, plant top biomass

INTRODUCTION

One third of South Kalimantan area is wetland. The wetland areas can be found both in the inland and near the coastal area. Acid sulphate soil is the main soil type that lies in near coastal area. Most farmers in this area grow rice. Due to the acidic condition, high iron (Fe) and aluminium (Al) concentrations and unpredictable water level not all rice varieties can be grown in this area (Hasegawa *et al*., 2001).

Under such condition, farmers grow local rice varieties to cope with the severe soil condition. The local rice varieties are not only tolerant to the low pH, high Fe and Al concentration but also taller to avoid flooding In addition, the local rice varieties are less responsive to fertilizer application compared to modern rice varieties (Hasegawa *et al*., 2004).

Interestingly, the farmers only use a small amount of N fertiliser during the seedling preparation and never apply fertilizer after last transplanting. This practice has been done for many years (25-100 years). Inspite of the fact that minimum fertilizers are used, the grain yield level at farmers' paddock is not necessary low. Survey work of Hasegawa *et al*. (2004) of 60 paddocks in this area, grain yields averaged 2.6 t ha^{-1} and 10% of the paddocks studied exceede 4 t ha^{-1}. The present study aimed to estimate the amount N from the soil and water and to compare with the N uptake by crop.

MATERIALS AND METHODS

Study Site

The experiment was conducted at four sites, these were Tambak Sirang (03° 26' 29''S, 114° 35' 27''E), Malintang (03° 26' 27''S; 114° 37' 50''E), Balandean (03° 10' 13''S; 144° 36' 06''E) and Handil Manarap (03° 21' 59''S, 114° 39' 44''E). The soils at Tambak Sirang and Balandean sites are considered as gleysols, while at Malintang and Handil Manarap are alluvial soils.

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Table 1. Selected soil properties (value ± standard error).

Soil properties*)	Location			
	Tambak Sirang	Malintang	Balandean	Handil Manarap
pH (H_2O)[1]	4.3 ± 0.2 (very acid)	4.4 ± 0.1 (very acid)	3.6 ± 0.0 (very acid)	4.3 ± 0.2 (very acid)
Org. N (%)[2]	1.4 ± 0.3 (very high)	1.2 ± 0.3 (very high)	1.7 ± 0.1 (very high)	1.1 ± 0.2 (very high)
Org. C (%)[3]	11 ± 0.5 (very high)	5.4 ± 0.4 (very high)	11 ± 0.8 (very high)	7.1 ± 1 (very high)
EC (□S cm^{-1})[4]	251 ± 63	36 ± 1.8	204 ± 9	94 ± 9

*) Procedure of measurements are described in [1]McLean (1982); [2]Bremner and Mulvaney (1982); [3]Yeomans and Bremner (1988); [4]directly measured in the field.

Cultivation System

The selected sites (paddocks) were grown with 3 local rice varieties, namely, Bayar Pahit, Pandak and Siam Unus. A multi transplanting system in preparing the seedlings. The multi transplanting system included seedling stage in early October 2002, followed by the first transplanting in December 2002, in the second transplanting in January 2003 and finally, last transplanting (planting) in early April 2003. Report on such unique culture pratice were explained in more detail in Hasegawa *et al.* (2004).

Paddock Preparation

Approximately a month prior to planting paddocks were prepared. To prepare the paddock, weeds were cut using special hand hoe (tajak) and led the weeds to decompose. Before planting the un-decomposed weeds were dragged to the edge of the paddock. No fertilizer was applied during the growing season.

Selected Soil Properties

The soil samples were collected from a depth of 25 cm from 3 replicates within the area of each paddock and were obtained from the first sampling period. The soil from each replicate was air-dried, ground to less than 2 mm and stored prior to analysis. The selected soil properties are shown in Table 1

Experimental Procedures

The N mineralisation and N uptake were measured through out the growing season (17 April – 21 August 2003. Nitrogen mineralisation was measured by inserting 2 poly vinyl chloride (PVC) tubes (internal diameter of 10 cm) into 25 cm depth. The arrangement of the tubes is shown in Figure 1.

Approximately the first tube was excavated on the same day and the other tube was kept in the field for one month with the lid on. After excavating the tubes, mineral N (NH_4^+ + NO_3^-) was determined. Details of the procedures were explained elsewhere (Purnomo *et al.*, 2000). These activities were repeated three times for each paddock. The N mineralisation measurement was carried out in every a month interval through out the growing season.

In each sampling period, plant top biomass was also sampled. The plant samples were randomly taking from 3 hills out of 15 hills around the tube. The plant tops were washed, oven dried 70 °C, ground and determined their N content.

Soil and Plant Analysis

Accumulation of N in soil and water were determined using a set PVC tube inserted to soil within the crop row (Fig. 1.). The ammonium (NH_4^+) and nitrate (NO_3^-) concentrations of soil at the beginning of *in situ* incubation (T_0) or at the of 30 days incubation (T_f) were determined following extraction of approximately 40 g of fresh soil in 200 mL of 1 *M* KCl for 1 hour. The NH_4^+ and NO_3^- concentration in the extract was measured colorimetrically using methods described in Kempers and Zweers (1986) and in Yang *et al.* (1998), respectively.

Sampling of plant top and soil were carried out every month. For each paddock there was three replicates. For the plant sampling, 3 x 5 hills were

Figure 1. PVC tubes arrangement in the field.

was sampled by cutting the plant 1 cm above the ground. The plant samples were weighted, sub-sampled, ground to pass 0.5 mm screen. The N content of the plant material was determined by digesting the plant material using kjeldahl reagent. The N content in the digest was measured by distillation.

Calculation and Data Analysis

Nitrogen mineralisation for each *in situ* incubation period was calculated using a formula:

$$\text{N mineralisation} = [\text{N mineral}]_{Tf} - [\text{N mineral}]_{T0}$$

Variations of data obtained were shown using standard error of 3 means.

RESULTS AND DISCUSSION

Soil Properties

The selected soil properties of the four locations use for the experiment are shown in Table 1. In all paddocks, the soil pHs are very acid. Therefore, in this are modern rice variety is not suitable to grow.

Biomass Production

Biomass production of the three rice varieties in four paddocks is shown in Figure 2. It is important to note that despite no fertilizer application after planting, there were rapid increases of biomass production up to flowering stage. A similar trend was also observed by Purnomo *et al.* (2006[a]). In general, biomass of the plant tops less at Tambak Sirang and Balandean paddocks than the other two paddocks. This relates to the soil condition, especially the EC readings of the previous two paddocks are higher than the other ones.

The biomass productions were determined by the rice variety grown, the paddock and the plant age. At the early stage (22/5), the plant tops biomass were the same for all rice varieties used in the four locations. The effects of rice variety and location occurred at the flowering and afterward.

At Tambak Sirang (Figure 2a), biomass of Bayar Pahit variety was lower than of Siam Unus and Pandak, at flowering. At maturity stage (21/8 and 26/8), there was a decrease in plant top biomass. The decrease was much clearer for Siam Unus variety. A similar patterns was also observed at Balandean paddock (Figure 2c). Except that, Pandak variety had lower biomass on sampling date of 26/9. At Manarap paddock, it was found that there was a rapid decrease in plant top biomass after flowering. However, the decrease of biomass after flowering was not observed at Handil Manarap paddock. The decrease of biomass is due to defoliation that occurs as plant become older.

N Content

The course of N contents of in the plant top tissue in the growing are demonstrated in Figure 3. In general, the N content increased toward the maturity. The increase of N content is related to the decrease in plant top biomass. It was also observed there was a decrease in N content. This occurred for all rice varieties at Tambang Sirang and Pandak Variety at Malintang.

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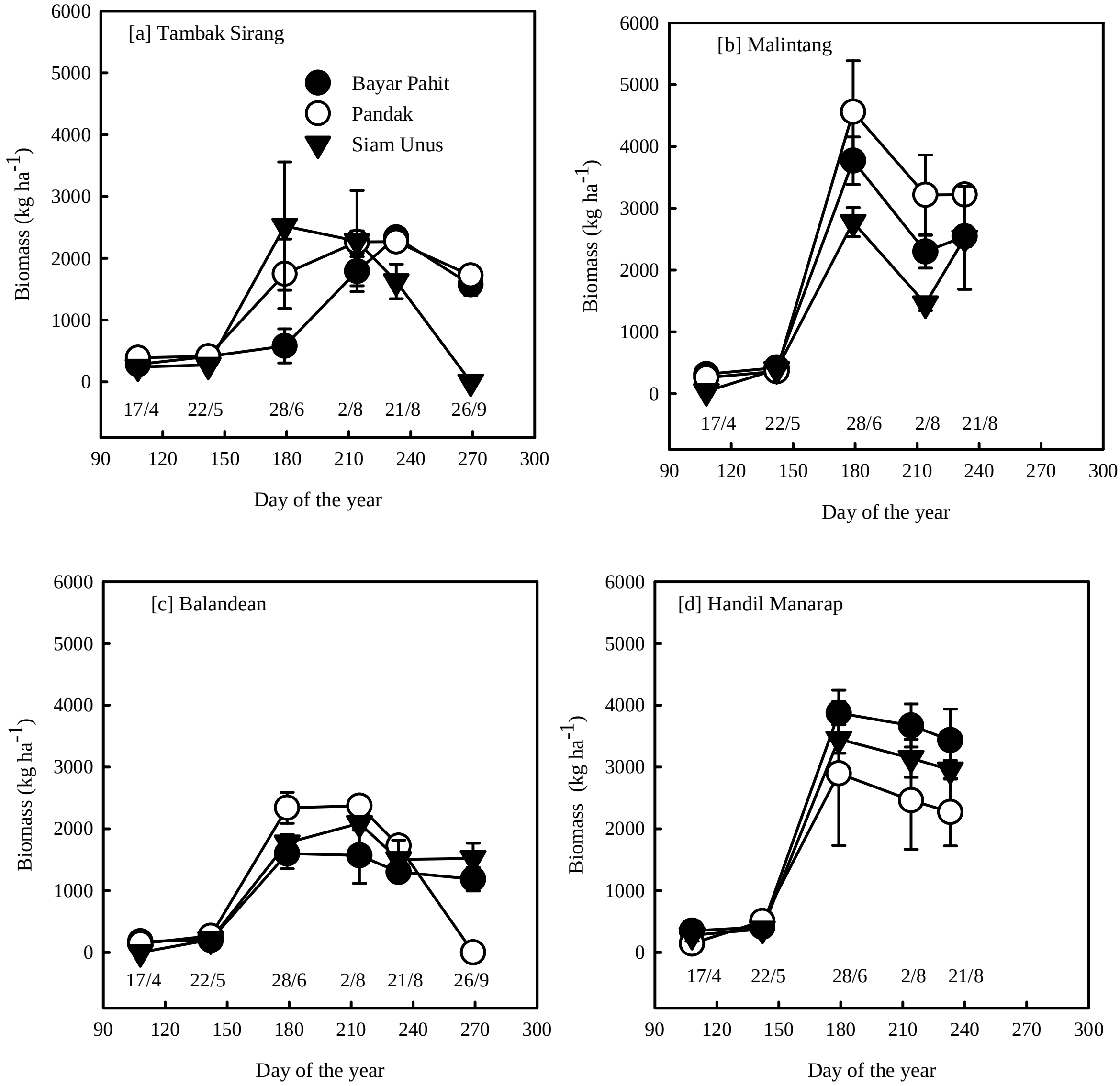

Figure 2. Plant top biomass through out the growing season. Bars indicate standard error.

.According Doberman and Fairhust (2000) informed that critical level of N deficiency for modern rice varieties was less that 2.0 at flowering stage. In our study, only for Siam Unus at Malintang paddock had N content above the 2% level. At other paddocks were below the 2% level. Up till now, there is no information for critical level of N deficiency for local rice.

N Mineralization

The course of N mineralisation at all paddocks are shown in Figure 4. In a growing season, the N mineralised at Tambak Sirang was higher than at Handil Manarap Baladean and Malintang. It was noticed that at Tambak Sirang the N mineralised ranged 9.7 - 15.15 kg N ha^{-1} compared to 2.7 – 5.47; 3.86-4.56 or 7.2 – 9.47 kg N ha^{-1} for Balandean, Malintang or Handil Manarap paddocks, respectively.

N Uptake

The N uptakes patterns (Figure 4) by all rice varieties were generally similar to biomass pattern. Before the flowering stage, N from the soil was adequate to satisfy the plant demand. However, at flowering stage and afterward, the N taken up by plants exceeded the N from mineralisation of N organic. This result was supported Purnomo *et al.* (2006[a]). It is suggested that the rest of N taken up by

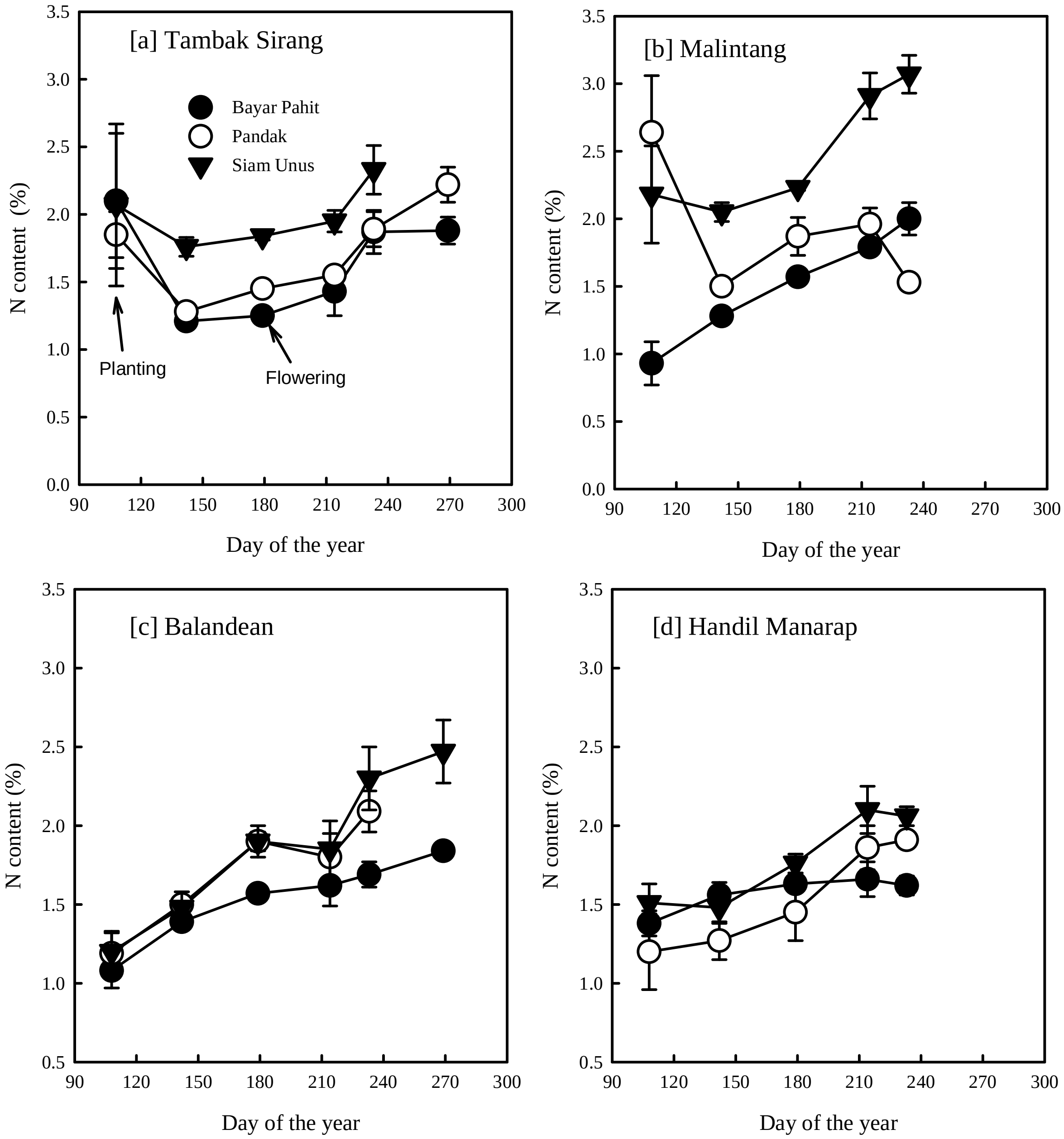

Figure 3. Nitrogen content in the plant top through out the growing season. Bars indicate standard error.

the plant is obtained from the activity N fixing bacteria anchored on the rhizoplane the local rice varieties. Some works of Hashidoko *et al*. (2002) Purnomo *et al*. (2006[b]) and Su *et al*. (2007) had found the N fixing bacteria such *Spingomonas* sp. and *Bulkoderia* sp. anchored in the rhizosphere of the local rice.

CONCLUSION

It can be concluded that in spite of no fertiliser application, the local rice varieties produced a significant biomass. It also pointed out that in general, N contents in the plant top tissue were below the critical for N deficiency for modern rice variety. There was a gap of knowledge on whether the critical level figure of N (<2%) is applicable for local rice. It was observed that at flowering stage, the N uptake by all local rice varieties were higher than the soil could contribute. It is suggested there is a role of N fixing bacteria in supplying N for the plant.

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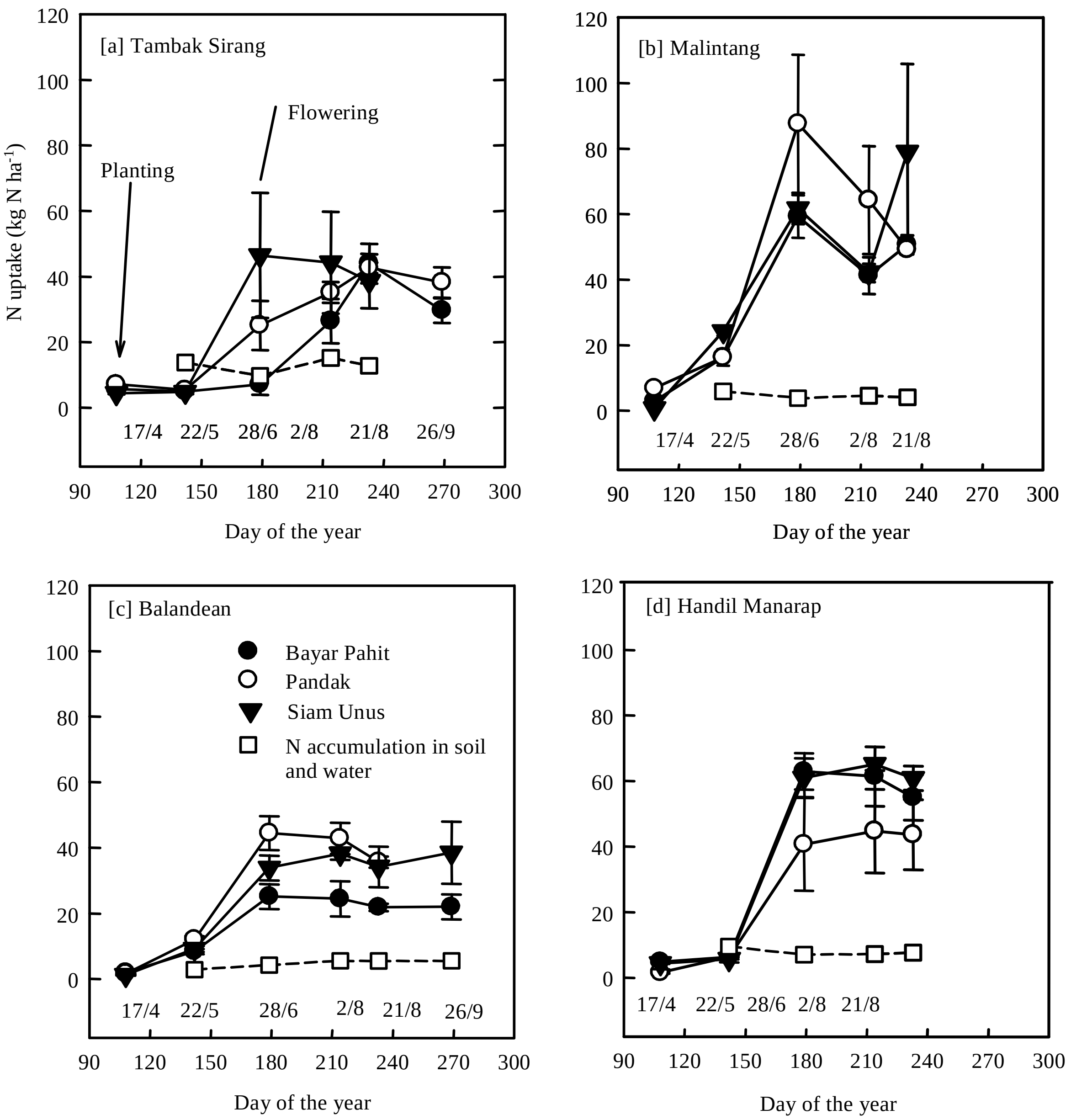

Figure 4. N uptake and accumulation of N in soil and water in a growing season. Bars indicate standard error.

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