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Mungbean (*Vigna radiata* L.) Residue and Nitrogen Rate Affected Growth and Yield of Direct Seeded Rice (*Oryza sativa* L.) In Rainfed Riceland

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Abstract: An experiment was conducted in a farmer's field in Ban Muong village, Muang district in Khon Kaen province in 2003. The objective of this study was to investigate the effect of mungbean (*Vigna radiata* L.) residue and nitrogen rates (0, 30 and 60 kg N ha^{-1}) on growth and yield of direct seeded rice (*Oryza sativa* L.) in rainfed riceland. The results showed that mungbean residue had no effect on tiller number, leaf area index and total top dry weight of rice in rice-mungbean intercropping or sole rice cropping. Also, mungbean residue had no significant effect on panicle number m^{-2}, spikelets number per panicle, 1,000 grain weight, percentage filled grain, harvest index or grain yield However, mungbean residue tendes to increase rice grain yield over sole rice by 0.33 t ha^{-1}(13 %) with had no nitrogen application. Rice grain yield was significantly affected by nitrogen rates. The highest rice grain yield (2.7 t ha^{-1}) was obtained with a nitrogen rate of 30 kg N ha^{-1}. Nitrogen fertilizer application at a rate of 60 kg N ha^{-1} decreased grain yield, when compared with 30 kg N ha^{-1}.

Key words: Cropping system, direct seeded rice, mungbean residue, N rates

INTRODUCTION

Rainfed lowland rice is often transplanted, but because of the labor scarcity in the last decade, many farmers have changed from transplanting to direct seeding of rice. Because of reduced water requirement in a paddy field, direct seeding can be used to establish the crop earlier and hence can utilize early rainfall for plant growth (Saley and Bhuiyan, 1995). Early planting by direct seeding can result in early maturity and, as a result, the crop may escape late-season drought, a common problem for rainfed lowland rice (Fukai and Cooper, 1995).

Farmers in northeast Thailand have already adopted dry direct seeding by broadcasting seeds after plough tillage as a counter measure when rainfall is insufficient for transplantation (Sumita and Ando, 2001). However, yields are generally low due to problems accompanied with direct seeding, where emergence of weeds is the most noxious factor hampering the growth of rice. Moreover, sandy soil in these areas is poor in both physical and chemical properties. The nutrients which clearly limit the growth of rice plants in northeast Thailand soils are nitrogen and phosphorus (Suriya-Arunroj *et al*., 2000). Low water availability and low soil fertility are recognized as the major constraints to production (Wade *et al*., 1999).

To improve the availability of soil nutrients for rice crops, some farmers apply animal compost during the dry fallow period, but the amounts available at their farms are often less than 2 t ha^{-1}. Another strategy, which is more often adopted, is the use of N chemical fertilizer during the rice growing period. However, this alternative is risky, as loss of N by leaching and denitrification in a poorly controlled water regime of these rice cropping systems can be substantial and may reduce income and harm the environment (Singh and Sekhon, 1979; Schröder *et al*., 1998; Xing *et al*., 2002; Crews and Peoples, 2004; Janssen, 2005). Introducing legumes into the existing cropping systems seems to be a logical approach. Legumes are widely known through their abilities to fix atmosphere nitrogen when living in symbiosis with rhizobium bacteria. The usefulness of legume green manures in maintaining or building-up soil fertility has long been recognized (Singh *et al*., 1986; Chapman and Myers, 1987; Sharma *et al*., 1995).

According to Diallo and Johnson (1997), weed infestation continues to be a serious problem in dry-seeded rice. Aerobic soil conditions and dry-tillage

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practices, besides alternate wetting and drying conditions, are conducive for germination and growth of highly competitive weeds, causing grain yield losses of 50 to 91% (Elliot *et al*., 1984; Fujisaka *et al*., 1993). Crop residues such as mulch may selectively provide weed suppression through their physical presence on the soil surface (Teosdale *et al*., 1991; Thorup-Kristensen *et al*., 2003). Very little weed growth occurs under mulch, as mulch prevents penetration of light or excludes the certain wavelengths of light needed for weed seedlings to grow (Ossom *et al*., 2001). Ramakrishna *et al*. (2006) stated that straw mulch was effective on suppressing weed infestation and different mulching materials showed different effects on soil temperature. This is due to mulch ability to prevent soil water evaporation, retaining soil moisture.

Mungbean (*Vigna radiata* L.) is a grain legume crop widely grown in the tropics as an intercrop, particularly with cereals. Aggarwal and Garrity (1987) stated that nitrogen benefit is experienced by a rice crop when intercropped with a grain legume. This increase in N availability might be due to N transfer from the legume to the cereal, or to the greater soil volume. Direct seeded rice is commonly planted by the farmers in the early rainy season. Mungbean residue as green manure cannot be grown before rice and incorporated into the soil. Rice and mungbean must be grown at the same time as intercropping. Mungbeans will die when subjected to waterlogging in July-August and become useful green manure fertilizer for rice. Because of mungbean susceptible for waterlogging and mungbean residues have C:N ratio 16:1 (Das *et al*., 1993) and therefore tend to release N and decompose rapidly. Therefore, the objective of this study was to investigate the effect of mungbean residue and nitrogen rates on growth and yield of direct seeded rice in rainfed riceland.

MATERIALS AND METHODS

The field experiment was conducted in a farmer's field in Ban Muong of Muang district, Khon Kaen province (16°26N', 102°50E') in Thailand during May to November 2003. Annual rainfall is 1,090.8 mm, distributing almost solely during the cropping period (June to November). Rainfall is high in August and September and declined to nil in November of that year (data not shown). The texture of soil is loamy sand with a pH of 5.0 (1:2.5 w/v water), organic matter content of 0.48% (Walkley and Black, 1934), total N of 0.033% (Kjeldahl method, Bremner, 1960), extractable P of 2.5 ppm (Bray II extraction, Bray and Kurtz, 1945) and extractable K of 30 ppm (1 N ammoniumacetate pH 7 extraction, Schollerger and Simmon, 1945).

A split plot design was used with two rice cropping patterns as main plots (sole rice and rice-mungbean intercropping as green manure) and three nitrogen rates as sub plots (0, 30 and 60 kg N ha^{-1}). The size of the individual plots was 6×4 m with four replications. The experimental area was ploughed twice at moist soil conditions. A paddy bund was constructed around the small plot. At final land preparation, rice seed of variety RD6 was drilled into rows spaced 25 cm apart at a seed rate of 125 kg ha^{-1}. The Chainat 72 mungbean, with 4-5 seeds per hole, were sown with plant spacing of 20 cm. Rice and mungbean were planted at the same time (8 June 2003). The concentration of NH_4^+ and NO_3^- nitrogen fractions in 0-20 cm soil cores of the rice rhizosphere was colorimetrically determined at 30 and 60 days after seeding, at panicle initiation and at harvest.

The mungbean crop was thinned to two plants per hole leaving the plant population of 400,000 plants ha^{-1}. A basal application of phosphorus and potassium fertilizers was applied at the rate of 25 kg P_2O_5 ha^{-1} and 12.5 kg K_2O ha^{-1} at ten days after seeding. Nitrogen fertilizer was applied twice, once at ten days after planting (60%) and the other 40% at panicle initiation of testing rates. Parathion was sprayed onto the crop at 30 and 60 days after seeding to control rice blast disease. Furadan was used on the crops at ten days after seeding to control insects. Hand weeding occurred twice, at 30 and 60 days after seeding.

In general, mungbean crop was waterlogged and killed, providing residue as green manure before flowering. In this year, rainfall was insufficient to accumulate surface water in the paddy field. Therefore, the mungbean crop was cut by hand sickle and recessed into the soil to reduce crop competition from rice.

Rainfall and air temperature were recorded during the growing season. Observation wells of perforated PVC tubing were installed at 1.5 m soil depth. Water table depth was measured weekly from the soil surface to water level, at the beginning until harvest. The soil moisture content (percentage by weight) at 0-15 and 15-30 cm down were determined by gravimetric procedure (if the paddy field had no standing water). The Field Capacity (FC) and Permanent Wilting Point (PWP) were measured water retention on undisturbed soil core at 0.03 and 1.5 MPa soil water potential by pressure plate apparatus at 0-15 and 15-30 cm soil depths.

Rice data: Tiller number and leaf area index were recorded from a randomly selected square meter area at 30 and 60 Days After Seeding (DAS) and at Panicle Initiation (PI). The leaf area was measured with an automatic area meter (Model No. AAC-400, Hayashi Denko Co., Ltd. Japan). The leaf area index was computed as the leaf area divided by the land area. Samples for total top dry weight and N content were taken from a randomly selected square metre at 30 and 60 DAS and at panicle initiation outside the harvest area. Samples were oven dried and weighed after being subjected to a constant temperature of 80°C for two to three days. The number of panicles was counted from 1 m^2 at harvest. Twenty panicles were randomly taken from this area in the sample area and grains were separated into filled and unfilled grains. The 1,000 grain weight was determined from the filled grains. Grain yield was taken from 8 m^2 meters of each plot and expressed as ton per hectare (t ha^{-1}) at 14% moisture content. Harvest Index (HI) was calculated as [weight of dry filled seeds/(weight of stem + leaves + seeds)]. From the grain yield sample, a small sub sample was collected, oven-dried and ground for nitrogen analysis by the kjeldahl method.

Mungbean data: Samples of total top dry weight were taken from the plants grown in a randomly selected square metre area at 45 days after planting. Samples were oven dried and weighed after being heated at a constant temperature of 80°C for two to three days and ground for kjeldah nitrogen analysis. The data was subjected to analysis of variance (ANOVA) and Duncan's Multiple Range Test (DMRT) was used to compare treatment means when the F-test was significant.

RESULTS

Water table depth and soil moisture content: During the mungbean growth, the water table depth ranged from 140 to 44 cm below the soil surface and the soil water content of the 0-15 and 15-30 cm soil layer was at least 7.15 and 8.31 g 100 g^{-1}. At the mungbean cutting date, the water table was at least 30 cm below the soil surface. Standing water occurs at rice flowering stage for two weeks. Its maximum height above the soil surface reached 32 cm during September, corresponding to the stage of rice flowering (Fig. 1). Soil moisture content at 0-15 and 15-30 cm depths was mostly maintained in the available ranges (between field capacity and permanent wilting point level) during the entire mungbean growing period (Fig. 2). The results indicate that the mungbean plant received adequate soil moisture throughout the growing period. In the present study, the maximum and minimum air temperature ranged from 29.7 to 36.3°C and 16.5 to 25.2°C during the growth period. It was noted that maximum temperature was generally over 30°C during the period.

Mungbean residues: Mungbean residue at 45 days after seeding produced 873, 1,048 and 891 kg ha^{-1} dry weight, which contained 25.11, 36.83 and 25.66 kg N ha^{-1} when N was applied to rice at 0, 30 and 60 kg N ha^{-1}, respectively.

Rice growth:

Tiller number: Mungbean residue had no significant effect on tiller number of rice at 30 and 60 Days after Seeding (DAS) and at Panicle Initiation (PI), but N rates had significant effect on tiller number at 60 DAS and at PI. The highest tiller number was obtained with N application at a rate of 60 kg N ha^{-1} (Table 1). There was an interaction effect between mungbean residue and N rate on tiller number at 60 DAS and at PI, indicating that the response to mungbean residue from N rate was not

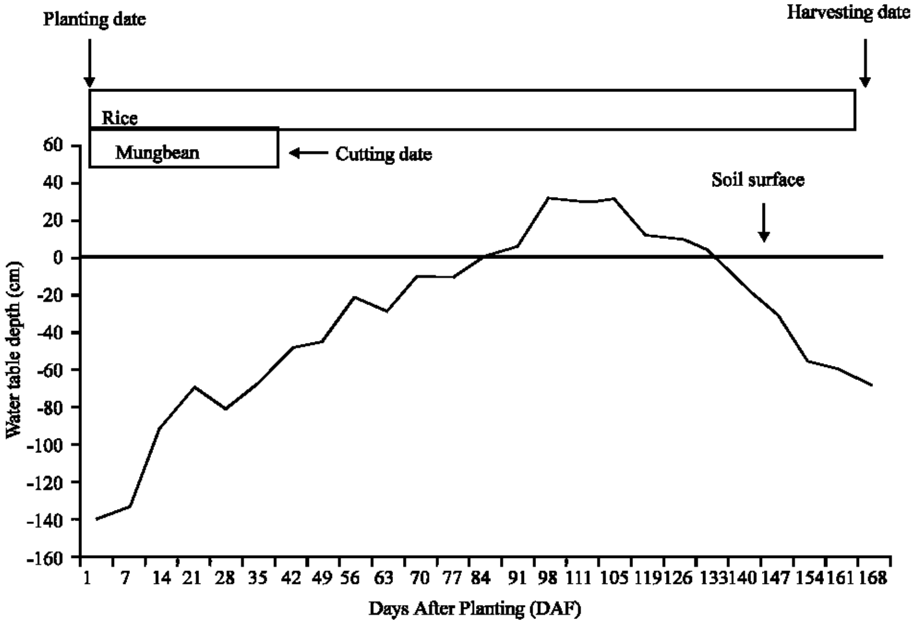

Fig. 1: Water table levels below and above soil surface during the growing season

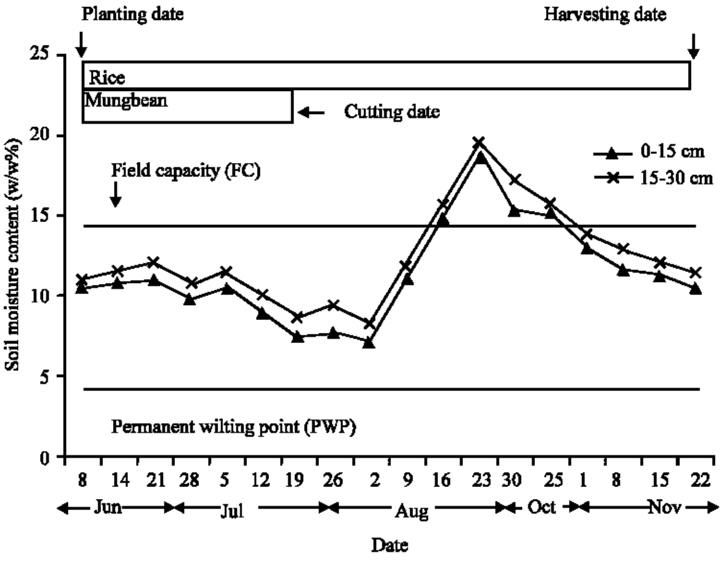

Fig. 2: Average soil moisture content at 0-15 and 15-30 cm depth during the growing season

Table 1: Tiller number of rice as influenced by mungbean residue and N rates at 30 and 60 DAS and at PI

	Tiller (No. m^{-2})		
Treatments	30 DAS	60 DAS$^{1/}$	PI
Mungbean residue			
Sole rice	164.41	270.41	168.83
Rice+mungbean	147.66	193.91	154.83
F-test	NS	NS	NS
N rates (kg N ha^{-1})			
0 (N0)	139.00	167.75b	129.25b
30 (N1)	169.00	248.75ab	162.62ab
60 (N2)	160.12	280.00a	193.62a
F-test	NS	*	*
Interaction			
Sole rice+N0	143.00	186.00bc	123.75b
Sole rice+N1	184.25	319.00a	174.25ab
Sole rice+N2	166.00	306.25ab	208.50a
Rice+Mungbean+N0	135.00	149.25c	134.75ab
Rice+Mungbean+N1	153.75	178.50c	151.00ab
Rice+Mungbean+N2	154.25	253.75abc	178.75ab
F-test	NS	**	**

*: Significant at $p<0.05$, **: Significant at $p<0.01$, NS: Non Significant $^{1/}$, Means followed by the same letter(s) at the same column were not significantly different by Duncan's Multiple Range Test (DMRT)

Table 2: LAI of rice as influenced by mungbean residue and N rates at 30 and 60 DAS and at PI

	LAI		
Treatments	30 DAS	60 DAS	PI
Mungbean residue			
Sole rice	1.040	2.339	2.877
Rice+mungbean	1.034	2.102	2.473
F-test	NS	NS	NS
N rates (kg N ha^{-1})			
0 (N0)	1.017	1.924b	2.218
30 (N1)	1.046	2.288ab	2.559
60 (N2)	1.058	2.450a	3.247
F-test	NS	**	NS

*: Significant at $p<0.05$, **: Significant at $p<0.01$, NS: Non Significant, Means followed by the same letter(s) at the same column were not significantly different by Duncan's Multiple Range Test (DMRT)

Table 3: Above ground dry weight of rice as influenced by mungbean residue and N rates at 30 and 60 DAS, at PI and at harvest stage

	Above ground dry weight (t ha^{-1})			
Treatments	30 DAS	60 DAS	PI	Harvest stage (straw)
Mungbean residue				
Sole rice	0.085	0.73	1.78	3.70
Rice+mungbean	0.075	0.50	1.54	2.99
F-test	NS	NS	NS	NS
N rates (kg N ha^{-1})				
0 (N0)	0.065b	0.37b	1.07b	3.31
30 (N1)	0.088a	0.72a	2.09a	3.44
60 (N2)	0.086a	0.74a	1.84ab	3.28
F-test	*	**	*	NS

*: Significant at $p<0.05$, **: Significant at $p<0.01$, NS: Non Significant, Means followed by the same letter(s) at the same column were not significantly different by Duncan's Multiple Range Test (DMRT)

consistent. This was mainly due to a greater reduced tiller number with nitrogen application in rice-mungbean intercropping as green manure.

Leaf Area Index (LAI): The LAI of the rice was not significantly affected by mungbean residue at 30 and 60 DAS and at PI. There was significant difference in LAI among the N rates only at 60 DAS. The highest LAI was obtained with N application at a rate of 60 kg N ha^{-1} (Table 2). There was no interaction effect between mungbean residues and N rates.

Total top dry weight: Mungbean residues had no significant effect on total top dry weight of rice, but N rates affected dry matter at 30 and 60 DAS and at PI. The highest dry matter was obtained with N application of 30 kg N ha^{-1} (Table 3). There was no interaction effect between mungbean residue and N rate.

Inorganic N: Mungbean residue had no significant effect on inorganic N (NH_4^+, NO_3^-) in rice rhizosphere, but N rate affected inorganic N in rice rhizosphere at 30 DAS. The highest inorganic N was obtained with 60 kg N ha^{-1} (Table 4). The interaction effect of mungbean residue by N rate on inorganic N in rice rhizosphere was only at 30 DAS, indicating that the response to mungbean residue by N rate was not consistent. This was mainly due to a greater reduction in inorganic N with nitrogen application in rice-mungbean intercropping as green manure.

N concentration of rice: N concentration in leaves and stems of rice was not significantly affected by mungbean residue. There was significant different in N concentration in leaves among the N rates at 30 DAS and in stems at 30 DAS and at PI. The highest N concentration in leaves and stems was obtained at 30 and 60 kg N ha^{-1} N application (Table 5). There was an interaction effect between mungbean residues and N rates on N

Table 4: Inorganic N in top soil as influenced by mungbean residue and N rates at 30 and 60 DAS, at PI and at harvest stage

	NH_4^+ and NO_3^- (ppm)			
Treatments	30 DAS	60 DAS	PI	Harvest stage
Mungbean residue				
Sole rice	27.68	12.37	13.62	174.12
Rice+mungbean	22.29	15.15	13.18	174.26
F-test	NS	NS	NS	NS
N rates (kg N ha^{-1})				
0 (N0)	11.93b	15.86	13.52	173.85
30 (N1)	22.78b	12.31	12.80	174.94
60 (N2)	40.24a	13.11	13.89	172.28
F-test	**	NS	NS	NS
Interaction				
Sole rice+N0	10.17c	13.53	13.47	172.85
Sole rice+N1	29.63abc	13.15	12.28	176.04
Sole rice+N2	43.23a	10.42	15.12	173.48
Rice+Mungbean+N0	13.68c	18.20	13.57	174.85
Rice+Mungbean+N1	15.94bc	11.46	13.32	173.84
Rice+Mungbean+N2	37.24ab	15.80	12.66	171.08
F-test	**	NS	NS	NS

**: Significant at p<0.01, NS: Non Significant; Means followed by the same letter(s) at the same column were not significantly different by Duncan's Multiple Range Test (DMRT)

Table 5: N concentration of rice as influenced by mungbean residue and N rates at 30 and 60 DAS and at PI

	N concentration in leaf (%)			N concentration in stem (%)		
Treatments	30 DAS $^{1/}$	60 DAS	PI	30 DAS	60 DAS	PI
Mungbean residue						
Sole rice	4.56	2.51	1.64	2.92	1.18	0.56
Rice+mungbean	4.34	2.38	1.70	2.89	1.13	0.61
F-test	NS	NS	NS	NS	NS	NS
N rates (kg N ha^{-1})						
0 (N0)	3.78b	2.22	1.66	2.06b	1.17	0.56b
30 (N1)	4.85a	2.52	1.62	3.21a	1.11	0.53b
60 (N2)	4.71ab	2.58	1.74	3.44a	1.18	0.66a
F-test	**	NS	NS	**	NS	*
Interaction						
Sole rice+N0	4.11ab	2.31ab	1.59	2.06b	1.32a	0.58b
Sole rice+N1	5.00a	2.61a	1.64	3.30a	1.12ab	0.51b
Sole rice+N2	4.56a	2.60a	1.69	3.41a	1.11ab	0.59b
Rice+Mungbean+N0	3.45b	2.13b	1.73	2.07b	1.02b	0.55b
Rice+Mungbean+N1	4.70a	2.42ab	1.59	3.13a	1.11ab	0.55b
Rice+Mungbean+N2	4.85a	2.57ab	1.78	3.47a	1.26ab	0.73a
F-test	**	*	NS	**	*	**

*: Significant at p<0.05, **: Significant at p<0.01, NS: Non Significant; Means followed by the same letter(s) at the same column were not significantly different by Duncan's Multiple Range Test (DMRT)

Table 6: Grain yields and its components, harvest index and N concentration in rice grain as influenced by mungbean residue and N rates

Treatments	Panicle No. m^2	Spikelet No. panicle	1,000 grains weight (g)	Filled grain (%)	Harvest index	Yield (t ha^{-1})	Grain total N (%)
Mungbean residue							
Sole rice	161.58	102.33	25.50	91.29	0.41	2.18	1.00
Rice+mungbean	149.83	112.43	25.58	91.19	0.46	2.51	0.95
F-test	NS	NS	NS	NS	NS	NS	NS
N rates (kg N ha^{-1})							
0 (N0)	126.87b$^{1/}$	105.90	26.28	92.52	0.44	1.91b	0.96
30 (N1)	155.25ab	111.73	25.29	91.27	0.46	2.73a	0.94
60 (N2)	185.00a	104.51	25.05	89.94	0.41	2.39ab	1.02
F-test	*	NS	NS	NS	NS	*	NS
Interaction							
Sole rice+N0	126.75	97.34	26.99	92.52	0.41bc	2.86b	0.94
Sole rice+N1	176.50	103.56	25.22	91.50	0.44bc	4.03ab	0.94
Sole rice+N2	181.50	106.08	24.28	89.84	0.39c	2.85b	1.11
Rice+Mungbean+N0	127.00	114.46	25.56	92.51	0.47ab	3.25ab	0.98
Rice+Mungbean+N1	134.00	119.91	25.35	91.03	0.49a	4.72a	0.95
Rice+Mungbean+N2	188.50	102.94	25.83	90.03	0.43abc	4.08ab	0.92
F-test	NS	NS	NS	NS	**	**	NS

*: Significant at p<0.05, **: Significant at p<0.01, NS: Non Significant; Means followed by the same letter(s) at the same column were not significantly different by Duncan's Multiple Range Test (DMRT)

concentration in leaves at 30 and 60 DAS and in stems at 30 and 60 DAS and at PI, indicating that the response from mungbean residues to N rates was not consistent. This was mainly due to a greater reduction of N concentration with nitrogen application in rice-mungbean intercropping as green manure.

Rice grain yield and yield components: Mungbean residue had no significant effect on panicle number m^{-2}, spikelets per panicle, 1,000 grain weight, percentage filled grain or Harvest Index (HI) (Table 6). N rate had no significant effect on spikelet number per panicle, 1,000 grain weight, percentage filled grain or HI, but did affect panicle number m^{-2}. The highest panicle number m^{-2} was observed with N application at 60 kg N ha^{-1}. There was an interaction effect between mungbean residues and N rates on HI.

Grain yield did not show statistically significant difference between sole rice and rice-mungbean intercropping as green manure, but N rates did affect grain yield. The highest grain yield was obtained with N application at a rate of 30 kg N ha^{-1}. There was an interaction effect between mungbean residue and N rate, indicating that the response from mungbean residue to N rate was inconsistent. This was mainly due to a greater reduction in rice grain yield with nitrogen application in rice-mungbean intercropping as green manure.

DISCUSSION

The mungbean above ground residue contributed 873-1,048 kg ha^{-1} dry weight containing nitrogen of 25-37 kg N ha^{-1} which was considered rather low mungbean residue as well as N accumulation return to the soil. This was due to poor soil fertility (0.48% OM, 0.03% N, 2.5 ppm P, 30 ppm K), low soil pH and the coarse texture of the soil. The mungbeans received starter N fertilizer at the same time as the rice. Under rainfed conditions of northeast Thailand, mungbean green manure and mungbean residue (mungbeans grown to maturity with their pods removed) produced 1.1 and 3.8 t ha^{-1}, containing 21 and 55 kg N ha^{-1} (Suriyakup *et al*., unpublished). Phoomthaisong *et al*. (2003) reported that at 45 day after seeding, mungbean cultivar ‘CN 72’ produced 1.8 t ha^{-1} dry weight, containing 52 kg N ha^{-1}. The root nodule nitrogen fixing, however, was not determined in this study. Phoomthaisong *et al*. (2003) observed that mungbeans fixed N_2 35-50 kg N ha^{-1} and nodule numbers and dry weight of the beans peaked early (at 45 days) and sharply declined thereafter. The highest nodule number per plant was obtained with mungbean cultivar CN72 (84 nodules $plant^{-1}$).

Mungbean residue had no effect on growth (tiller number, LAI and total top dry weight) (Table 1- 3) or grain yield of rice in rice-mungbean intercropping, like green manure and sole rice cropping. However, rice-mungbean intercropping as green manure tends to increase 13% grain yield over sole rice (Table 6). This is due to a higher spikelet number per panicle. De Datta (1981) and Hasegawa *et al*. (1994) stated that rice required N at panicle stage for an increased spikelet number, which is the potential number of grains per panicle (IPI, 1993). As shown in the concentration of N in the leaves and stems of rice, it is higher in rice-mungbean intercropping than in sole rice at panicle initiation (Table 5). In this study, mungbean crops were cut and covered on the soil surface between rice rows, accompanied with low soil moisture content at the cutting date (Fig. 2). This may have resulted in low rates of mungbean residue decomposition. Promsakha na Sakonnakhon *et al*. (2005) observed that groundnut incorporation into the soil had a higher decomposition, microbial biomass N and total recovery rate than with surface application. This is due to stover application, which when incorporated into the soil increases the surface area of groundnut residues for microbial attack, over and above surface application. Moreover, mungbean residue covered on the soil surface may be lost by ammonia volatilization (Janzen and McGinn, 1991).

In some case the mungbean residue have been effective, like Aggarwal *et al*. (1992) reported that rice-mungbean intercropping systems increased N uptake and grain yield over sole rice plantations due to the increased soil volume for N extraction and increased aerial space after mungbean harvest. In addition, Singh *et al*. (1986) found that maize intercropped with soybean and blackgram increased NO_3^- and NH_4^+ concentration and population of active bacteria in the maize rhizosphere. The rate of decomposition of plant material is influenced by the microbial population of the soil, degree of incorporation into the soil, the amount added (Ladd *et al*., 1983), its chemical composition (especially C:N ratio), particle size, soil temperature and moisture status, oxygen supply, pH and presence of inorganic nutrient (Alexander, 1977). Plant residues with high C:N ratio (say >30:1) are likely to decomposed slowly with initial net immobilization of N, whereas residues with a smaller C:N ratio are likely to decompose more rapidly with a net mineralization of N occurring right from the beginning. Legume residues commonly have C:N ratio less than 30:1 and therefore tend to release N and decompose rapidly.

In the present study, the response of grain yield to N application was significant, resulting in the increase of up to 30 kg Nha^{-1} over the control. N application at

30 kg N ha^{-1} to the rice-mung bean intercropping increased rice yield by 0.64 t ha^{-1} (14%) over sole rice. Nitrogen fertilizer application at the rate of 60 kg N ha^{-1} gave lower grain yield than that of N application at a rate of 30 kg N ha^{-1}, due to it's lower in filled grain. Dobermann and Fairhurst (2002) observed that excessive N can increase the number of sterile grains and thus can decrease the number of filled grains per panicle. In the present experiment, the rice crop received N from chemical fertilizer application and that slowly released from mungbean residues.

Our study suggest that mungbean residue due to cutting at flowering stage had no significant effect on growth and yield of direct-seeded rice. This was due to flooding condition did not occur during mungbean flowering stage in the present experiment. Therefore, an alternative way to increase the potential benefit of mungbean residue intercropped with rice would be recommend this cropping system to irrigated area where the water level can control or rainfed area where shallow water table below soil surface observed in dry season.

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REFERENCES

Aggarwal, P.K. and D.P. Garrity, 1987. Intercropping of legumes to contribute nitrogen in low-input upland rice-base cropping systems. International Symposium on Nutrient Management for Food Crop Production in Tropical Farming Systems.

Aggarwal, P.K., D.P. Garrity, S.P. Liboon and R.A. Morris, 1992. Resource use and plant interactions in a rice-mungbean intercrop. Agron. J., 84: 71-78.

Alexander, M., 1977. Introduction to Soil Microbiology. 2nd Edn., John Wiley and Sons, New York.

Bray, R.H. and L.T. Kurtz, 1945. Determination of total organic and available form of phosphorus in soil. Soil Sci., 59: 39-45.

Bremner, J.M., 1960. Determination of nitrogen in soil by the Kjeldahl method. J. Agric. Sci., 55: 1-23.

Chapman, A.L. and R.J.K. Myers, 1987. Nitrogen contributed by grain legumes to rice grown in rotation on the Cununurra soils of the Ord irrigation Area, Western Australia. Aust. J. Exp. Agric., 27: 155-163.

Crews, T.E. and M.B. Peoples, 2004. Legume versus fertilizer sources of nitrogen: Ecological tradeoffs and human needs. Agric. Ecosyst. Environ., 102: 279-297.

Das, S.K., G. Subba Reddy, K.L. Sharma, K.P.R. Vittal, B. Venkateswarlu, M. Narayana Reddy and Y.V.R. Reddy, 1993. Prediction of nitrogen availability in soil after crop residue incorporation. Fertil. Res., 34: 209-215.

De Datta, S.K., 1981. Principles and Practices of Rice Production. John Wiley and Sons, New York.

Diallo, S. and D.E. Johnson, 1997. Les Adventices du Riz Irrigue´ Et Leur Controle. In: Irrigated Rice in the Sahel. Mie´zan, K.M., M.C.S. Wopereis, M. Dingkuhn, J. Deckers and T.F. Randolph (Eds.), Prospects for Sustainable Development. West Africa Rice Development Association, 01 BP 2551 Bouake´, Coˆte d'Ivoire, pp: 311-327.

Dobermann, A. and Fairhurst, 2002. Rice Nutrient Disorders and Nutrient Management. Oxford Graphic Printers Pte Ltd.

Elliot, P.C., D.C. Navarez, D.B. Estario and K. Moody, 1984. Determining suitable weed control practices for dry-seeded rice. Philipp. J. Weed Sci., 11: 70-82.

Fujisaka, S., K. Moody and K. Ingram, 1993. A descriptive study of farming practices for dry seeded rainfed lowland rice in India, Indonesia and Myanmar. Agric. Ecosyst. Environ., 45: 115-128.

Fukai, S. and M. Cooper, 1995. Development of drought-resistant cultivars using physio-morphological traits in rice. Field Crops Res., 40: 67-86.

Hasegawa, T., Y. Koroda, N.G. Seligman and T. Horie, 1994. Response of spikelet number to plant nitrogen concentration and dry weight in paddy rice. Agron. J., 86: 673-676.

IPI., 1993. Fertilizer for High Yield Rice. Bull. 3, 3rd revised Edn., International Potash Institute, Basel, Switzerland.

Janssen, B.H., 2005. Agriculture and the nitrogen cycle, assessing the impact of fertilizer use on food production and the environment. Book Review; Geoderma (In Press).

Janzen, H.H. and S.M. McGinn, 1991. Volatile loss of nitrogen during decomposition of legume green manure. Soil Biol. Biochem., 23: 291-297.

Ladd, J.N., M. Amato, R.B. Jackson and J.H.A. Butler, 1983. Utilization by wheat crops of nitrogen from legume residues decomposing in soil in the field. Soil Biol. Biochem., 15: 231-238.

Ossom, E.M., P.F. Pace, R.L. Rhykerd and C.L. Rhykerd, 2001. Effect of mulch on weed infestation, soil temperature, nutrient concentration and tuber yield in *Ipomoea batatus* (L.) Lam. In Papua New Guinea. Trop. Agric. Trinidad, 78: 144-151.

Phoomthaisong, J., B. Toomsan, V. Limpinuntana, G. Cadisch and A. Patanothai, 2003. Attributes affecting residual benefits of N_2-fixing mungbean and groundnut cultivars. Biol. Fertil. Soils, 39: 16-24.

Promsakha na Sakonnakhon, S., B. Toomsan, G. Cadisch, E.M. Baggs, P. Vitayakon, V. Limpinuntana, S. Jogloy and A. Patanothai, 2005. Dry season groundnut stover management practices determine nitrogen cycling efficiency and subsequent maize yields. Plant and Soil, 272: 183-199.

Ramakrishna, A., H.M. Tamb, S.P. Wani and T.D. Long, 2006. Effect of mulch on soil temperature, moisture, weed infestation and yield of groundnut in northern Vietnam. Field Crops Res., 95: 115-125.

Saley, A.F.M. and S.I. Bhuiyan, 1995. Crop and rain water management strategies for increasing productivity of rainfed lowland rice systems. Agric. Syst., 49: 259-276.

Schollerger, C.J. and R.H. Simmon, 1945. Determinate of exchange capacity and exchangeable bases in soil-ammonium acetate method. Soil Sci., 59: 39-45.

Schröder, J.J., J.J. Neeteson, J.C.M. Withagen and I.G.A.M. Noij, 1998. Effects of N application on agronomic and environmental parameters in silage maize production on sandy soils. Field Crops Res., 58: 55-67.

Sharma, S.N., R. Prasad and S. Singh, 1995. The role of mungbean residues and *Sesbania aculeata* green manure in the nitrogen economy of rice-wheat cropping system. Plant and Soil, 172: 123-129.

Singh, B. and G.S. Sekhon, 1979. Nitrate pollution of groundwater from farm use of nitrogen fertilizers. A review. Agric. Environ., 4: 207-225.

Singh, B., P.P. Singh and K.P.P. Nair, 1986. Effect of legume intercropping on enrichment of soil nitrogen, bacterial activity and productivity of associated maize crops. Exp. Agric., 22: 339-344.

Sumita, T. and M. Ando, 2001. Economy of direct seeding of rice in Northeast Thailand and its future direction. JIRCAS Working Report No. 30, pp: 147-149.

Suriya-Aunroj, D., P. Chaiwat, S. Fukai and P. Blamey, 2000. Identification nutrients limiting rice growth in soil of northeast Thailand under water-limiting and non-limiting conditions. Thai Agric. Res. J., 18: 246-258.

Teosdale, J.R., C.E. Beste and W.E. Potts, 1991. Response of weeds to tillage and cover crop residues. Weed Sci., 39: 195-199.

Thorup-Kristensen, K., J. Magid and L.S. Jensen, 2003. Catch crops and green manures as biological tools in nitrogen management in temperate zones. Adv. Agron., 79: 227-302.

Wade, L.J., S.T. Amarante, A. Olea, D. Harnpichitvitaya, K. Naklang, A. Wihardjaka, S.S. Sengar, M.A. Mazid, G. Singh and C.G. McLaren, 1999. Nutrient requirements in rainfed lowland rice. Field Crop Res., 64: 91-107.

Walkley, A. and I.A. Black, 1934. An examination of dichromate method for determining soil organic matter and proposed modification of the chromic acid titration method. Soil Sci., 37: 29-38.

Xing, G.X., Y.C. Cao, S.L. Shi, G.Q. Sun, L.J. Du and J.G. Zhu, 2002. Denitrification in underground saturated soil in a rice paddy region. Soil Biol. Biochem., 34: 1593-1598.