

The Effects of Mungbean Residue on Growth and Yield of Direct-Seeded Rice in Rice-Mungbean Mixed Cropping in Flooded Soil

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Abstract

The greenhouse experiment was conducted at the Field Crop Station Department of Plant Science and Agriculture Resource Khon Kaen University in 2002. The objective of this study was to investigate the effect of mungbean residue from flooding at different growth stages on growth and yield of direct-seeded rice. A completely randomized design was used. The treatments comprised of (i) sole rice, (ii) rice-mungbean mixed cropping and flooding at vegetative stage of mungbean, (iii) rice-mungbean mixed cropping and flooding at flowering growth stage of mungbean, and (iv) rice-mungbean mixed cropping and flooding at pod filling growth stage of mungbean. The results showed that mungbean residue had significant effects on heights, tiller numbers, and grain yields of rice at harvest. Rice-mungbean mixed cropping and flooded mungbeans at flowering growth stage gave the highest grain yield. However, the yield was not significantly different from that obtained from the rice-mungbean mixed cropping and flooding at mungbean vegetative growth stage and sole rice pot.

Keywords: Direct seeding, growth stage, mungbean residue, nitrogen, rice grain yield

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Introduction

In the Northeast Thailand, the rainfed lowland ecosystem occupies 91 percent of the total area of rice production. Most of lowland rice in the rainfed areas is planted by transplanting. But in some provinces, where drought regularly occur in early rainy season, or in cases where farmers have large plots of land, direct seeding by dry seed will be used in planting (Sumita and Ando, 2001).

An increase in rice production depends mainly on fertilization. However, many farmers cannot afford the high costs of chemical fertilizers, so very limited amounts of fertilizer are typically applied to rice and not enough to increase yield. Moreover, chemical fertilizers are easily lost from soil because of low soil organic matter. Animal manure is used to increase soil organic matter, but it has inherent problems in its limited availability on farms. The use of green manure to increase soil fertility and crop productivity has received high attention from researchers during the last two or three decades (MacRae and Mehuys, 1985). Leguminous species have been the best candidates among plant species because they can fix atmospheric nitrogen by symbiotic nitrogen fixation (Naire et al., 1979), and nitrogen is beneficial to succeeding crops after the incorporation of green manure. John et al. (1992) and Akanvou et al. (2002) reported that the incorporation of the leguminous crop increased grain yield and N nutrition of the subsequent rice crop.

In northeast Thailand, growing of short-season legumes, like mungbean, planted with the first rains in May, and later incorporated into

the soil as green manure before the rice is transplanted in July, may be a possible alternative. However, for direct-seeded rice it is not practical because rice will be seeded during early rainy season in May - June. Late planting is not feasible, because rice fields will be flooded. Therefore, mungbean and rice can be mixed and planted at the same time in the early rainy season in May - June. Mungbeans will die when subjected to waterlogging in July - August, and become useful green manure fertilizer for rice. During periods when soil is saturated, severe oxygen deficiency can develop rapidly in the roots, causing root death and subsequent death of the entire plant (Geisler, 1965; Herrera and Zandstra, 1979).

Since the rainfall patterns in Northeast Thailand vary year by year, the timing of flooding period can not be specified accurately. Therefore, the objective of this study was to investigate the effects of mungbean residue at different growth stages on growth and yield of direct-seeded rice in flooded soil under greenhouse conditions.

Materials and Methods

A pot experiment was carried out at the Department of Plant Science and Agricultural Resources, Khon Kaen University in 2002. The soil used was collected from 0 cm to 30 cm soil depths of a paddy field in Ban Khok Sri village, Maung District, Khon Kaen Province. The soil is sandy loam with pH 4.5 (1:2.5 w/v water), organic matter 0.75 % (Walkley and Black, 1934), total N 0.034 % (Kjeldahl method, Bremner, 1960), extractable P 2.0 mg/kg (Bray II, Bray and Kurtz, 1945), and extractable K 33 mg/kg (1 N

ammoniumacetate pH 7 extraction, Schollerger and Simmon, 1945). The soils were dried, ground and filled in cement pots with 1 m in diameter and 0.5 m in depth, and leveled off 10 cm below the top of the pot.

A completely randomized design with three replications was used. There were four treatments; (i) sole rice, (ii) rice-mungbean mixed cropping and flooding at vegetative growth stage of mungbean (25 days after seeding), (iii) rice-mungbean mixed cropping and flooding at flowering stage of mungbean, and (iv) rice-mungbean mixed cropping and flooding at pod-filling stage of mungbean.

Rice seeds of cultivar 'KDML105' were seeded into the soil at 5 cm depths, with spacing of 20 cm by 20 cm, of four to five seeds per hill. The 'Chainat 72' mungbean variety, with four to five seeds was sown at a 2 cm to 3 cm depth. Rice and mungbean were planted at the same date. At 10 days after seeding, rice and mungbean were thinned to three and two plants per hill, leaving the plant population of 750,000 and 500,000 plant per ha, respectively. Basal chemical fertilizer grade 16-16-8 ($N-P_2O_5-K_2O$) was applied at the rate of 156 kg/ha at 15 days after seeding. Plants were irrigated as necessary to prevent water stress during growth periods before flooding treatment was applied. Flooding started at 25, 35 and 55 days after seeding, respectively. Mungbean samples for total top dry weight were taken from two randomly selected plants before being subjected to flooding. Samples were oven dried, weighed after exposure to a constant temperature of 80°C for two to three days, and ground for Kjeldahl nitrogen analysis.

Plant height and tiller number were measured at 30 and 60 days after seeding (DAS) and at panicle initiation (PI). Plant height was measured from ground level to the highest leaf or panicle in each pot. Leaf area was measured from a randomly selected plant, in a hill of each pot by an automatic area meter (Model No. AAC-400, Hayashi Denko Co., Ltd. Japan). Total top dry weight was recorded from a randomly selected hill (three plants) at 30 and 60 DAS and at PI. Samples for total top dry weight and N content were oven dried, weighed after exposure to a constant temperature of 80°C for two to three days, and ground for nitrogen analysis using the Kjeldahl method (Bremner, 1960).

Prior to harvest, panicle numbers were counted from six random hills. Twenty panicles were taken at random from the samples, and total grains were separated into filled and unfilled grains. Thousand grain weight was determined from the filled grains. Grain yield was taken from six randomly selected hills of each pot at 14 % moisture content.

Data were subjected to analysis of variance (ANOVA). Least significant difference (LSD) was used to compare mean differences (Gomez and Gomez, 1984).

Results

Mungbean residues and N accumulation

Mungbeans produced aboveground residues of 17.16, 25.78 and 28.25 g per pot (1,430, 2,185 and 2,355 kg/ha dry weight) when being subjected to flooding at 25 days after seeding, flowering stage and pod filling stage,

respectively. The aboveground nitrogen accumulation of mungbean residues returned to the soil were 0.51, 0.78 and 1.25 gN per pot (42.75, 65.0 and 104.5 kg/ha) when being flooded at 25 days after seeding, flowering stage and pod filling stage respectively.

Effects of mungbean residues on rice growth

Mungbean residue increased plant height of rice at 60 DAS and at PI. However, only

mungbean residue at flowering stage was significantly higher than sole rice pot (Table 1). Also mungbean residue increased tiller number of rice at PI except mungbean residue at flowering stage (Table 2). Consequently, leaf area per rice plant at PI was increased in rice-mungbean cropping (Table 3). Also mungbean residue increased above ground dry weight at all growth stage although there was not significant (Fig. 1).

Table 1 Height of rice as influenced by mungbean residues at different growth stages of 30, 60 days after seeding (DAS) and at panicle initiation (PI).

Treatment	Height (cm)		
	30 DAS	60 DAS	PI
1. Sole rice	35.0	50.0b/ ¹	61.3b
2. Rice-mungbean (FV)	35.0	55.3ab	75.3b
3. Rice-mungbean (FF)	32.6	66.0a	76.6a
4. Rice-mungbean (FP)	36.6	59.3ab	64.0ab
F-test	ns	*	*
C.V. (%)	24.89	13.67	10.57

FV=Flooded at vegetative, FF=Flooded at flowering, FP=Flooded at pod filling

ns-not significant

significantly different at $P < 0.05$

1/ = Means followed by the same letter in a column were not significantly different by LSD 0.05.

Table 2 Tiller number of rice as influenced by mungbean residues at different growth stages of 30, 60 days after seeding (DAS) and at panicle initiation (PI).

Treatment	Tiller number per hill		
	30 DAS	60 DAS	PI
1. Sole rice	4.00	9.00	12.00a ^{1/}
2. Rice-mungbean (FV)	3.66	8.00	12.33a
3. Rice-mungbean (FF)	5.00	8.33	11.00b
4. Rice-mungbean (FP)	5.00	8.00	12.33a
F-test	ns	ns	*
C.V. (%)	20.67	16.25	3.43

FV=Flooded at vegetative, FF=Flooded at flowering, FP=Flooded at pod filling

ns-not significant

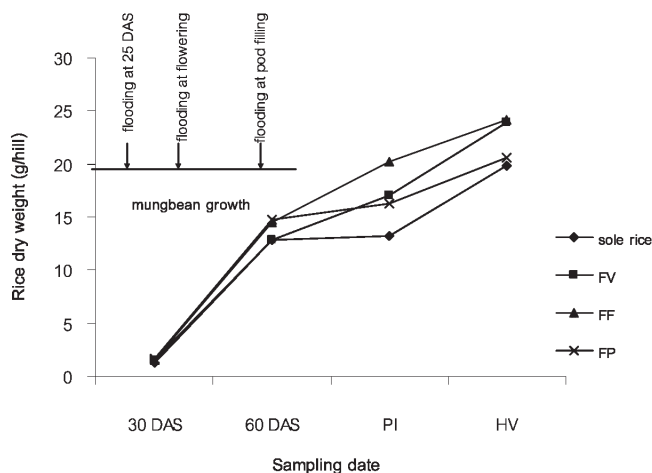
significantly different at $P < 0.05$

1/ = Means followed by the same letter in a column were not significantly different by LSD 0.05.

Table 3 Leaf area of rice as influenced by mungbean residues at growth stages of 60 days after seeding (DAS) and at panicle initiation (PI).

Treatment	Leaf area (cm ² /hill)	
	60 DAS	PI
1. Sole rice	5,614.00	18,132.33
2. Rice-mungbean (FV)	3,258.33	33,331.67
3. Rice-mungbean (FF)	5,466.00	32,705.00
4. Rice-mungbean (FP)	4,817.00	30,097.33
F-test	ns	ns
C.V. (%)	47.08	24.90

FV=Flooded at vegetative, FF=Flooded at flowering, FP=Flooded at pod filling
ns-not significant



FV=Flooded at vegetative, FF=Flooded at flowering, FP=Flooded at pod filling

Fig. 1 Above ground dry weight of rice as influenced by mungbean residues at different growth stages of 30, 60 days after seeding (DAS), at panicle initiation (PI) and at harvest stage (HV).

Effects of mungbean residues on nitrogen uptake in rice

Rice N uptake was not significantly affected by mungbean residue at 30 and 60 DAS, at PI or at harvest. However, rice-mungbean mixed cropping tends to give higher N uptake than pure

rice cropping at all growth stages. At 30 and 60 DAS and at harvest, the highest N uptake was obtained with rice-mungbean mixed cropping when soil was flooded at mungbean pod filling stage. But at PI, it is obtained with rice-mungbean mixed cropping when soil is flooded at mungbean flowering stage (Fig. 2).

Table 4 Grain yield and yield components of rice as influenced by mungbean residues at different growth stages.

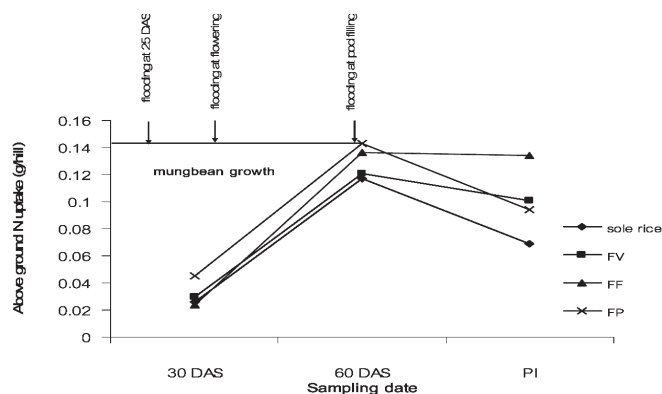
Treatments	Panicle number/ hill	Number of filled grain/panicle	unfill grain (%)	1,000 grains weight (g)	Yield (g/hill) ^{1/}
1. Sole rice	9.72	59.55	36.31	23.607	13.33ab
2. Rice-mungbean (FV)	8.17	85.53	13.40	25.130	17.28ab
3. Rice-mungbean (FF)	9.22	75.03	18.40	25.310	17.93a
4. Rice-mungbean (FP)	8.16	70.55	13.26	23.663	12.21b
F-test	ns	ns	ns	ns	*
C.V. (%)	11.08	24.63	26.74	4.39	18.13

FV=Flooded at vegetative, FF=Flooded at flowering, FP=Flooded at pod filling

ns-not significant

significantly different at $P < 0.05$

1/ = Means followed by the same letter in a column were not significantly different by LSD 0.05



FV=Flooded at vegetative, FF=Flooded at flowering, FP=Flooded at pod filling

Fig. 2 Effect of mungbean residues at different growth stages on nitrogen uptake (gN/hill) of rice at 30 and 60 days after seeding (DAS) and at panicle initiation (PI).

Effects of mungbean residues on rice yield and yield components

Mungbean residue had significant effects on grain yield. The maximum grain yield was obtained in rice-mungbean mixed cropping when soil was flooded at the mungbean flowering stage (Table 4). The lowest grain yield was obtained in rice-mungbean mixed cropping when soil was

flooded at the mungbean pod filling stage. Rice-mungbean mixed cropping and flooding at 25 DAS, and at flowering stages, produced rice grain yield 23 % and 27 % over pure (sole) rice. Mungbean residues had no effect on panicle number per plant, number of filled grains, percentage of unfilled grains and 1,000 grain weight (Table 4).

Discussion

In the present study, mungbean residues in rice-mungbean mixed cropping had significant effects on rice yield. The maximum grain yield was obtained in rice-mungbean mixed cropping when mungbeans were flooded at flowering stage. The lowest grain yield was found when mungbeans were flooded at the pod filling growth stage. However, there was no significant difference in rice yield between rice-mungbean mixed cropping when flooding at flowering or at 25 DAS growth stage. This was due to a higher N uptake in rice-mungbean mixed cropping with flooding at flowering stage, especially at 60 DAS and at PI.

In this study root nodule nitrogen fixing was not determined. There are many reports that nodule numbers in mungbeans peak at flowering stage (Poehlman, 1991; Phoomthaisong et al., 2003). In addition, aboveground nitrogen accumulation of mungbean return in the soil in rice-mungbean mixed cropping with flooding at flowering stage was higher than that of rice-mungbean mixed cropping with flooding at vegetative growth stage (25 DAS). In the case of rice-mungbean mixed cropping when mungbeans were flooded at the pod filling stage, however, aboveground nitrogen accumulation of mungbean return to the soil was higher than that of crop flooding at flowering stage. Rice yield was the lowest, though. This was due to relatively late flooding treatment. There was longer competition for light and nutrients between the mungbean and rice crops. In addition, mungbean residues provided to the rice crop from flooding are quite late for rice growth.

In the present study, rice-mungbean mixed cropping with mungbean flooding at 25 DAS and at the flowering stage did not show significant increases in rice yield over sole rice pots. However, rice yield increased 23 % and 27 % in rice-mungbean cropping when mungbeans were flooded at 25 DAS and at flowering stages, respectively. This was due to mungbean residue providing higher N for rice crops, especially at panicle initiation growth stage. De Datta (1981) and Hasegawa et al. (1994) stated that rice requires N at panicle stage for increased spikelet numbers, which is the potential number of grains per panicle (IPI, 1993). 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.

The current results show that rice-mungbean mixed cropping improves rice grain yield. Therefore, the use of mungbean residue under water level control conditions is a viable alternative for farmers. However, the field study still needs confirmation of the current results.

Acknowledgment

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