Development of sustainable legume production in rice-based farming systems in Cambodia

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Abstract

Lowland rice production is the dominant agricultural enterprise in Cambodia, traditionally grown as a single crop over the wet season, with land remaining fallow over the dry season. Development of a farming system where legumes are produced in the dry season following wet season rice, poses numerous constraints. These include: poor soil quality characteristic of lowland rice soils, provision and maintenance of adequate soil moisture over the dry season, and management of a novel crop for traditional rice farmers. A series of experiments were conducted from 2007 to 2010 to evaluate a number of production variables on two legume crops, mungbean and peanut, sown post-wet season rice. In lighter soils where legumes appear suitable for growth, soil-stored water from the wet season is not sufficient to grow legume crops, and supplementary irrigation water is required. Comparison between three bed configurations using gravity fed irrigation, and the traditional watering can method, found that flood irrigation on flat beds could improve yields, and farmers preferred this method over the labour intensive hand-watering method, although water use increased. Use of rice straw as mulch reduced weed growth and promoted legume growth, and increased water use efficiency. Future work will need to determine the most efficient bed configuration to facilitate irrigation and to optimise plant population, and to evaluate specific irrigation scheduling on the amount and timing of water required, in different soil types for more sustainable rice based dry season legume farming systems.

Key Words

mungbean, mulch, lowland, double cropping

Introduction

Rice is, and will remain, the most important crop in terms of area in many Asian countries including Cambodia. Over 90 % of rice in Cambodia is produced in the lowlands (under paddy conditions with bunds to store free water) and over 80% of this is grown under rainfed conditions in the wet season. Increasingly, as farmers meet their subsistence rice requirements, they explore new avenues to increase family/ farm income, including intensification, sometimes with supplementary irrigation, and diversification with higher value crops. The use of a short season early maturing rice variety before the main wet season rice crop is a major innovation that has made double rice cropping possible in Cambodia (Mak 2001). Many farmers now grow two crops of rice and are increasing family income by 37 and 25% in two provinces studied recently (Chea *et al.* 2004). However, there is little diversification to other crops even though the duration of the wet season in Cambodia provides more opportunity than in neighbouring Laos or NE Thailand to develop multiple cropping in lowlands. One of the priority issues for agricultural development is diversification of rice-based systems to increase farmer income. Short season legumes may be suitable to grow after rice. We have conducted a number of experiments over the last 3 years to determine suitability of growing a legume crop after rice harvesting in lowlands, and identified that coarse-textured soils are more suitable than heavy soils, and also peanuts and mungbean are more suitable than soybean (Seng *et al.* 2008).

In other areas of south-East Asia, conservation agriculture practices are utilized for double cropping in rice based lowland systems (Kirchhof *et al.* 2000). In some cases planting machines are used to save labour, and crop residues in the field are utilized to conserve soil moisture, prevent weed growth and reduce soil erosion. Results of a set of experiments are shown in this paper as an example of our efforts to improve legume yield after rice harvesting in Cambodia. This set of experiments conducted at 4 locations in 2008/09 dry season examined the effect of mulching (use of rice straw), planting method (manual vs seed drill) and tillage method (conventional vs no-tillage) on mungbean growth and yield. Another set of experiments (not reported here) were conducted including those to determine the amount and frequency of irrigation water requirement, fertilizer requirement, bed-configuration and plant density, and adapted genotypes of mungbean, peanuts and soybean. Results of these experiments and on-farm demonstration activities were used to analyze the profitability of growing legume after rice in lowlands.

Methods

The mungbean experiments were conducted after rice harvesting, from December 2008 to April 2009 under rain-fed lowland conditions at four locations (Takeo, Kampong Cham, Kampong Thom and Preah Vihear provinces). The experiments were carried out to test two tillage treatments under two planting methods with or without mulch with three replications. A split-split plot design was used in the trials; the tillage treatment was assigned as the main plot, planting method was sub plot and mulching was sub-sub plot. Plot size was 12 m^2 and the total plot number was 24, total experimental area being approximate 690m^2.

The tillage practices evaluated were no-tillage and conventional tillage. The no-tillage plots were not ploughed and glyphosate at rate of 2.5 L ha^{-1} applied 10 days before planting. The conventional tillage plots were ploughed two times by using tractor with seven disc plough, the depth ranging from 15 to 20 cm, with the first plough immediately after rice harvesting and second plough one day before the planting.

Planting method treatments were manual and seeding machine methods. In both methods row spacing was 40 cm, and the seed rate was 20 kg ha^{-1} with expected established plant density of approximately 200,000 plants ha^{-1}. In the manual method, 3 cm deep holes were made with a stick at 30 cm intervals and seed was placed in the hole. The hole was then pressed by foot. The planting machine was adjusted to make similar plant spacing of 30 cm and press wheel was attached to improve soil-seed contact.

In the mulch treatment, rice straws were collected from nearby paddy fields and applied at the rate of 1500 kg ha^{-1}. Nutrient composition of the mulch was not determined.

Weeds were controlled mainly by hand-weeding at 20 days and subsequently at 45 days after crop emergence. The fertilizer applied rate was 90-26-25 kg/ha (NPK) (Urea-124kg/ha, DAP- 95kg/ha and KCl- 37 kg/ha).

Soil moisture content was determined at planting and post harvest. The percentage of residue cover after seedbed preparation was visually estimated. Plants emergence was counted at 15 days after crop emergence. Grain was harvested three times due to the indeterminate maturity of the mungbean crop. At the final harvest weeds were also collected and dry weight determined. Rainfall, soil temperature and atmospheric humidity were measured at each location.

Statistical analysis was conducted using IRRISTAT 5.0 for each location and for all locations combined, to determine significance of main treatment effects and their interaction effects.

Results

On average, mulching of rice straw at 1.5 t/ha increased crop establishment from 72 to 83%, reduced weed biomass at harvest from 163 to 123 kg/ha and increased mungbean yield from 228 to 332 kg/ha (Table 1). These effects were generally consistent across the four locations, although there was significant location by mulch interaction effect on yield and weed biomass. The effect of mulch on grain yield was significant at p=0.05 at 3 of the 4 locations, with only a small mulch effect at Takeo resulting in significant interaction effect. Mulch was effective in conserving soil moisture, and even at maturity the mulched area had 1 % higher soil moisture content. On the other hand, planting method and tillage method appeared to have had little effect. The fact that the seed drill produced very similar establishment, weed biomass and grain yield to the hand planting is encouraging in that the use of a planter can save the labour cost. Only in one location did no-till produced higher yield.

Table1. Effects of mulching at different locations on mungbean seedling emergence, weed biomass and mungbean grain yield in lowlands after rice in Cambodia

Location	Emergence (%)		Weed biomass (kg/ha)		Grain yield (kg/ha)	
	Mulching	No-mulch	Mulching	No-mulch	Mulching	No-mulch
Takeo	83.5	73.9	115	232	459	421
Kampong Cham	84.3	70.7	318	370	302	168
Kampong Thom	83.2	72.6	21	40	360	203
Preah Vihea	81.1	71.5	37	11	209	117
Mean	83.0	72.2	123	163	332	228
LSD at 5% (interaction)	ns		17**		57*	

For the irrigation water requirement, a series of experiments were conducted to determine optimum irrigation frequency and amount of water required for mungbean and peanuts in two dry seasons. The mungbean results from one experiment indicate that irrigation is required every 3 days or so when watering can is used. In one of the experiments, water use efficiency of mungbean was found to be around 1.9-2.4 kg/ha/mm which is at the lower end of WUE commonly found in Australia. The common practice of hand watering was found to be labour intensive, often resulting in under-watering for mungbean and peanuts, and we have successfully developed furrow and flood irrigation methods in 2009/10DS. One of the key findings was that legume roots are shallow in lowlands, and water extraction was limited to the top 20 cm or so depending on the depth of hard pan. With the rather coarse textured nature of the lowland soil used in growing legumes, accessible stored water is limited, and thus the legume crops need to be irrigated frequently.

Conclusion

During the course of research, we have realized the importance of water availability on legume growth in lowlands. While the soil water stored at the end of the rice cycle may be available to the non-rice crops, the amount is generally small because of the limited soil depth that the legume crops can explore. Thus, it is essential that the farms have access to a supplementary irrigation source. We have found that the use of tube wells and on-farm storage ponds can provide sufficient supplementary irrigation to grow legumes successfully.

From the results of experiments and economic analyses, we developed the best bet technologies for growing mungbean and peanuts. The documents describing them were distributed and discussed with Provincial Department of Agriculture officers in two provinces. In 2009/10 dry season, these PDA established 20 demonstration farms where mungbean, peanuts as well as tomatoes were grown as per our best bet technologies. Some farmers produced very good crops of mungbean and peanuts, and farmers who attended one of the field days we conducted recently, were interested in growing these crops in the near future. A large proportion of farmers who were formally interviewed indicated that growing mungbean and peanuts were less risky than vegetable crops, because of large price fluctuation in the latter.

There are however, a few key areas where research is required to improve the profitability of growing legume after rice in lowlands. Important areas are development of no-tillage system and sound fertilizer management system.

Use of furrow/bed system is essential particularly for mungbean in some areas where ponding of water causes a major adverse effect on crop growth. This system has improved crop establishment and facilitated development of a furrow irrigation system. There are prototypes of a bedmaker available that will produce furrows/beds, and this will greatly improve labour productivity. The use of such implement needs to be tested with farmers for possible further improvement and assessing the likelihood of adoption of the furrow/bedmaker. This system needs to be compared with the no-till flood irrigation systems where operational costs will be small but requires careful management of the land from the rice cropping phase.

We have also noted that particularly ICRISAT peanut lines produced a large number of pods but some were empty and often the kernels were small. This is likely to be associated with Ca deficiency, but we would need to test this in the field. Similarly when water is fully provided in the pot experiment, chemical fertilizer application increased legume growth greatly (Cheth et al 2010). The effect of chemical fertilizer including Ca and lime on growth of mungbean and peanuts needs to be tested in the field.

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