Research article

Soil Amendments for Maize Cultivation by Crop Rotations in Upland Cropping Systems of Southeast Cambodia

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Abstract A study was made of the importance of crop rotations on the growth and yield of maize in upland cropping systems of Cambodia. Maize (MZ) was grown continuously and in two-year rotations with cassava (CS), soybean (SB), mung bean (MB) and peanut (PN). Six different rotations T1, T2, T3, T4, T5 and T6 were designed and studied in the upland cropping systems in the provinces of Prey Veng and Svay Rieng in southeastern Cambodia. Mono-cropping with maize (T0) was used as the control treatment in the study. The study was undertaken in the period 2013 to 2015. The field experiments revealed an increase in crop yields in the order of T1 > T2 > T3 > T5 > T6. There was no significant difference in crop yield between T4 and the control (T0) treatment. The analysis of soils data revealed that there were no significant differences in soil nitrogen and phosphate levels pre-treatment and post–treatment in each of the rotations (paired samples t test, $p > 0.05$). However, post-treatment potassium levels were significantly lower than the pre-treatment levels in all cropping rotations ($p < 0.05$) except T0. The results of the study suggest that the maize-legume rotation is the most promising crop rotation for yield improvement in the upland cropping systems in southeast Cambodia.

Keywords maize, crop rotation, upland cropping system, Cambodia

INTRODUCTION

It is Cambodian government policy to encourage crop diversification (i.e. to grow cash crops other than rice), especially in non-rice upland agro-ecological systems (Chan et al, 2009). Cambodian farmers, extension workers and researchers, are less familiar with crop rotations than with mono-cropping, as the focus of the research has been on cassava cultivation for many years on the same land. Cassava production is also perceived to degrade soil fertility. This is also a major contributing factor to the relatively low cassava yields in areas where cassava has been cropped over many years. Maintaining soil fertility is one of the main challenges in agricultural production systems in Cambodia. Intercropping is one of the options available for more sustainable agricultural production systems.

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Other benefits of intercropping include, spreading of risk (relative to single cropping), improved weed management, and reduced incidence of insect pest and disease damage. The Government of the 3rd Constitution has adopted a development strategy which is partly based on crop intensification and diversification (MAFF, 2007). Most farmers in the provinces of Prey Veng and Svay Rieng have tried to intensify agricultural production through mono-cropping of cassava, reflecting the high demand for this crop in commercial markets. However, this cropping intensification has been done with little knowledge of procedures or technologies for maintaining soil fertility.

Soil fertility (and therefore crop yields) has shown a significant decline in areas with a long history of cassava cropping, as smallholder producers are unable to afford commercial fertilizers to replace the nutrients removed by successive cassava crops. To date, mono crops in Cambodia are generally low yielding, with little knowledge and financial information available on the best management practices for soil fertility maintenance in mono cropping systems, and often unsuitable are being grown. Attention to the agronomic aspects of rotation crops, especially soybean and mungbean is required. Growers need agronomic advice which will reduce the risk of degradation in soil fertility (Chan et al., 2009). To enhance food security and sustainable livelihoods, improvements are needed in agricultural techniques for enhancing production in upland rural areas of Prey Veng and Svay Rieng Provinces of Cambodia. A combination of poor soils and a dependence on non-irrigated agricultural production are the basis of low agricultural production and high levels of poverty in Prey Veng and Svay Rieng Provinces.

OBJECTIVE

The goal of this project was to use an on-farm, farmer participatory approach to study a range of potential agricultural technologies for enhancing and sustaining agricultural production and incomes in Prey Veng and Svay Rieng Provinces. The main objectives of the study were to: (1) determine the promising crop rotation options for improving fertility and food crop production of the Prey Khmer soil group in upland cropping system of Prey Veng and Svay Rieng provinces; and (2) investigate the changes in soil chemical and physical properties after crop rotations.

METHODOLOGY

The study was carried out in Prey Veng and Svay Rieng provinces which are located in the Southeastern part of Cambodia (Fig. 1). The continuous mono-cropping particularly with cassava in these upland areas has led to a progressive decline in soil fertility. There is an urgent need to identify alternative agricultural production options capable of economically improving both the soils and production, while the same time improving incomes of rural households which are almost 100% dependent on agriculture.

Six different treatments (combinations of maize (MZ), cassava (CS), mungbean (MB), soybean (SB) and peanut (PN)) T1 (SB-MZ-MB-MZ), T2 (PN-MZ-SB-MZ), T3 (MB-MZ-PN-MZ), T4 (CS-CS-CS-MZ), T5 (CS-MB-PN-MZ) and T6 (CS-SB-PN-MZ) were designed to investigate on the growth performance and crop yield of maize in eight basic production systems (7m × 10m) in the study areas of Prey Veng (n = 4) and Svay Rieng (n = 4) provinces. The mono-cropping of maize was used as a control in the present study. Field trials were conducted in the field of farmers and carried out at appropriate times throughout the growing seasons. The Proposed cropping treatments and timetable of cropping activities are summarized in Table 1. The plant height (cm), the number of ear per plant, ear length (cm), ear size (cm), weight (g) per ear and maize yield (dwt) per hectare (t/h) were measured before the next cycle of ration. Concurrently, soil samples were collected at depth of 10-30cm before and after each treatment to determine soil properties and measure the changes in their total C, organic C, N, P_2O_5, Ca, Mg, Na, K and exchangeable acidity (pH_{KCl}) and actual acidity (pH_{H2O}).

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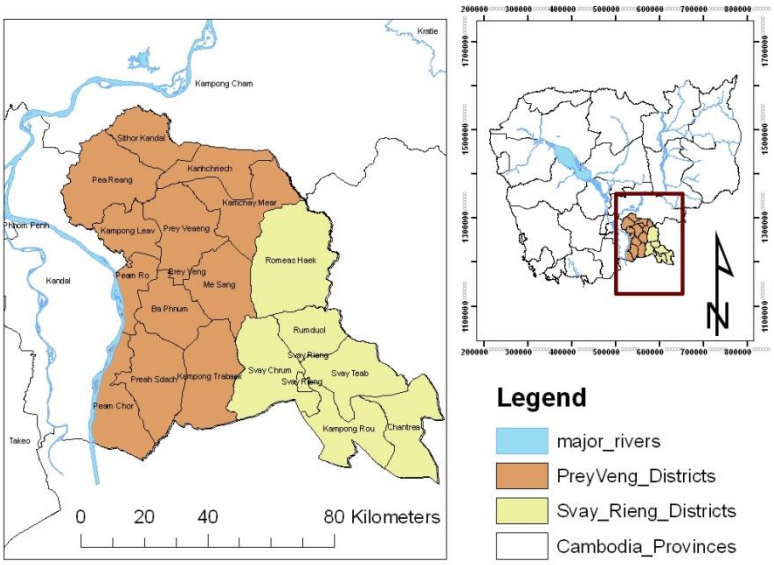

Fig. 1 Map of the study areas

Table 1 Summary of crop rotations in the upland cropping system in Prey Veng and Svay Rieng provinces

Treatment	2013		2014		2015	
	EWS	LWS	EWS	LWS	EWS	LWS
T0	-	MZ+F	MZ+F	MZ+F	MZ+F	-
T1	-	SB+F	MZ+F	MB+F	MZ+F	-
T2	-	PN+F	MZ+F	SB+F	MZ+F	-
T3	-	MB+F	MZ+F	PN+F	MZ+F	-
T4	-	CS+F	CS+F	CS+F	MZ+F	-
T5	-	CS+F	MB+F	PN+F	MZ+F	-
T6	-	CS+F	SB+F	PN+F	MZ+F	-

EWS, early wet season; LWS, late wet season; MZ, maize; SB, soybean; MB, mungbean; CS, cassava; PN, peanut; +F, fertilizer application

All statistical analyses were performed using SPSS for Windows (Version 16.0). The t-test was applied to verify significant differences in the growth performance and crop yield between the six treatment methods with a control and differences in the growth performance and production yield between the two study areas. One way ANOVA was applied to verify the differences in the growth performance and crop yields among the six rotation designs. Paired samples *t* test was applied to verify the difference of soil physical and chemical properties before and after treatment. The significance was considered in a circumstance where $p < 0.05$.

RESULTS AND DISCUSSION

Plant height (cm), number of ear per plant, and yield per hectare (t/h) of maize after crop rotation are presented in Table 2. A comparison revealed that there were no significant differences in plant height of control (T0) with each treatment (t-test, $p > 0.05$). However, there was a significant difference in number of ear per plant among all treatments (One-way ANOVA, $F(6, 49) = 12.11$, $p < 0.01$). Post-

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