Research article

Peanut Yield and Changes of Soil properties by Intercropping in Upland Cropping Systems of Southeast Cambodia

TARA PIN*
University of Heng Samrin Thbongkhmum, Thbongkhmum, Cambodia
Email: pintara30@gmail.com

KONGKEA PHAN
Faculty of Science and Technology, International University, Phnom Penh, Cambodia

VANNARO PIN
University of Heng Samrin Thbongkhmum, Thbongkhmum, Cambodia

OEUN HORN
Faculty of Agriculture, Chea Sim University of Kamchaymear, Cambodia

JOHN M. SCHILLER
School of Agriculture and Food Sciences, University of Queensland, Australia

Received 21 December 2015 Accepted 21 October 2016 (*Corresponding Author)

Abstract Successive monocropping with cassava in upland areas of Cambodia has led to a progressive decline in soil fertility. The aim of the present study was to investigate the change of soil properties and examine the growth and yield of peanut in intercropping cultivation in the upland cropping systems of Cambodia. Seven intercropping treatments were studied: T1 (cassava + mungbean + fertilizer rotation with fallowing); T2 (cassava + peanut + fertilizer rotation with fallowing); T3 (cassava + fertilizer rotation with fallowing); T4 (cassava + no fertilizer); T5 (mungbean + fertilizer rotation with cassava + mungbean + no fertilizer); T6 (peanut + fertilizer rotation with cassava + peanut + no fertilizer) and T7 (stylo + fertilizer rotation with cassava + no fertilizer) were designed and conducted in the fields of farmers in Prey Veng and Svay Rieng provinces. Field data indicated that peanut yield increased in the order of: T2 > T7 > T1 > T6 > T5 > T3 > T4. Analysis revealed there were significant differences in peanut yield among all seven treatments, with the yield of T4 being significantly lower than that of T2 and T7. The mean of the peanut yields were greater than 2.1t h^{-1} for all treatments. The total N, K and phosphate of the pre-treatment analysis did not significantly differ from those of the post-treatment analysis. This study suggests that intercropping cultivation could provide a sustainable harvestable yield of peanut in the upland cropping system in Cambodia.

Keywords peanut, intercropping, upland cropping system, Cambodia

INTRODUCTION

The challenges of farmers in improving upland farming systems in Cambodia were identified, in which soil fertility was one of the main challenges in agricultural production systems in Cambodia (Chan et al., 2009). Soil factors affecting crop suitability for upland crops in Cambodia have been documented (Seng et al., 2009). Previous studies revealed that upland areas are widespread throughout Cambodia, thus there was a considerable scope in developing upland crops and cropping technologies in Cambodia (Seng et al., 2011). The continuous mono-cropping particularly with cassava in 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 at the same time improve the incomes of rural households, which are almost 100% dependent on agriculture. Important upland crops in Cambodia are maize, rubber, soybean, mungbean, cassava, sesame, peanut and sugarcane (Bell et al. 2005). Inter-cropping is one of the options available for more sustainable agricultural production systems. 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.

Some farmers have reported that soil fertility shown a significant decline in areas with a history of cassava cropping because smallholder producers like them are unable to afford commercial fertilizers to replace the nutrients removed by successive cassava cultivation. In this study, a number of different 'systems of production' are being evaluated on the Prey Khmer soils in Prey Veng and Svay Rieng provinces. Crop growth and yield performance, together with issues of soil fertility sustainability, from different combinations of maize and cassava with selected legumes were investigated.

OBJECTIVE

The objectives of the present study are to (1) examine growth and yield of peanut in intercropping cultivation in the upland cropping system of Cambodia and (2) investigate the changes in soil chemical and physical properties after intercropping cultivation.

METHODOLOGY

This study was carried out in Prey Veng and Svay Rieng provinces which are located in the Southeastern Cambodia (Fig. 1). Prey Veng is located on the east bank of the Mekong River and is one of the largest rice producing regions in Cambodia and other crops while Svay Rieng is located on Cambodia's South-Eastern border with Vietnam, 125km from Phnom Penh capital.

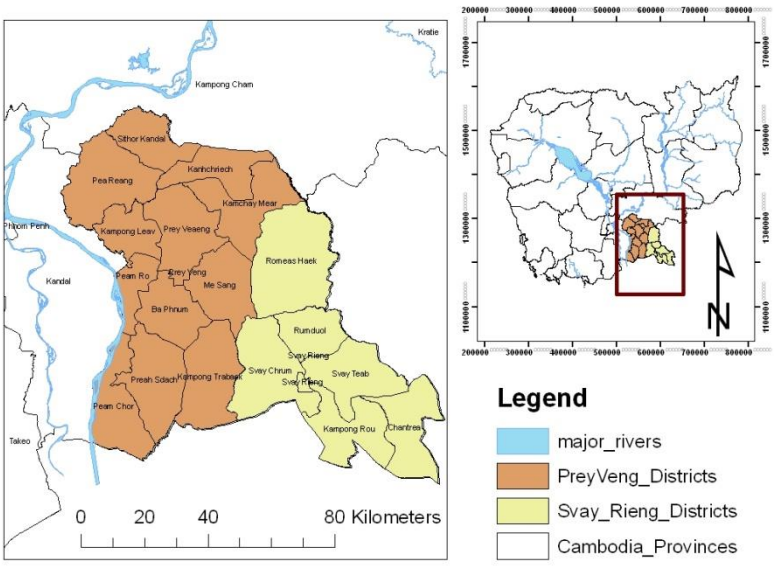

Fig. 1 Map of the study areas

Field trials of intercropping cultivation of peanut were conducted in eight basic production systems (7m × 10m) of farmers in the study areas of Prey Veng (n = 4) and Svay Rieng (n = 4) provinces. The detailed design of field trials is presented in Table 1. The plant height (cm), weight per hill (g), number of fruit per hill, grain weight per 100 seeds (g), peanut yield per hectare (t h^{-1}) were determined. Concurrently, soil samples were collected before and after each treatment, to determine soil properties and the changes in total C, organic C, N, P_2O_5, Ca, Mg, Na, K and exchangeable acidity (pH_{KCl}) and actual acidity (pH_{H2O}).

Table 1 Summary of intercropping of peanut cultivation in the upland cropping system in Prey Veng and Svay Rieng provinces

Treatment	2014		2015	
	EWS	LWS	EWS	LWS
T1	CS+MB+F	–	PN+F	–
T2	CS+PN+F	–	PN+F	–
T3	CS+F	–	PN+F	–
T4	CS-F	–	PN+F	–
T5	MB+F	CS+MB-F	PN+F	–
T6	PN+F	CS+PN-F	PN+F	–
T7	Stylo+F	CS-F	PN+F	–

EWS, early wet season; LWS, late wet season; MZ, maize; SB, soybean; MB, mung bean; CS, cassava; PN, peanut; +F, fertilizer application; -F, No fertilizer application

All statistical data analyses were employed using SPSS for Windows (Version 16.0). One-way ANOVA test was applied to verify the differences in plant height, weight per hill, number of fruit per hill, peanut yield among all treatments. Paired samples *t* testing was performed to certify the differences in soil pH, total C, organic C, total N, P_2O_5, K, Ca, Mg and Na between pre-treatment and post-treatment of each treatment. Significance is considered in a circumstance where $p < 0.05$.

RESULTS AND DISCUSSION

Peanut Yield

A summary of growth and yield of intercropping cultivation of peanut are presented in Table 2. The comparisons revealed that there were no significant difference in plant height at flowering and harvesting stages among all treatments (One-way ANOVA, $p > 0.05$). However, there were significant differences in weight per hill of peanut among all treatment (One-way ANOVA, $p < 0.05$). The weight per hill of T2 was significantly higher than that of T3, T4, T5 and T6 using post hoc Tukey HSD test ($p < 0.05$). Likewise, the number of fruit per hill significantly differed among all treatments (One-way ANOVA, $p < 0.05$). The post hoc Tukey HSD test revealed that number of fruit per hill of T2 was significantly greater than that of T3, T4, T5 and T6 ($p < 0.05$). Grain weights per 100 seeds were significantly different among all treatment (One-way ANOVA, $p < 0.05$). A previous study on field crop productivity in relation to soil properties revealed that peanut was the most reliable crop with successful establishment in the early wet season and harvestable yield at 80% of sites (Seng et al., 2011). The present study showed that peanut yield increased in an order of T2 > T7 > T1 > T6 > T5 > T3 > T4. A comparison revealed that there were significant differences in peanut yield among all treatments (One-way ANOVA, $F(6, 49) = 3.18$, $p = 0.01$). Post hoc Tukey HSD test indicated that peanut yield of T4 was significantly lower than that of T2 and T7 ($p < 0.05$). According to Seng et al (2011), peanut yield was between 2.1 to 3.4t h^{-1} on Kampong Siem soils. Peanut yield of the present

study (Table 2) was comparable to that of Kampong Siem soil. Peanut yield varied with site and season in which about 43% of peanut crops yielded 1.5t h^{-1} or less (Seng et al., 2011). The mean of peanut yield in all treatments in the present study were greater than 2.1t h^{-1}. These data suggested that intercropping cultivation could provide a harvestable yield of peanut in the upland cropping system of Cambodia.

Soil chemical and physical properties before and after intercropping are presented in Table 3. The soil texture that applied to soil sample was determined using the triangle (Brady and Weil, 2007). Soil particle analysis revealed that field soils were sandy loam. A comparison revealed that there were no significant differences between total C of pre-treatment and post-treatment in all treatment; however, the total C of post-treatment was significant lower than that of pre-treatment of T6 (Paired samples *t* test, $p < 0.05$). Likewise, organic C of pre-treatment and post-treatment of all treatments, except T6 ($p = 0.013$), are not significantly different (Paired samples *t* test, $p > 0.05$). There were not significant differences in total N and phosphate between pre-treatment and post-treatment in all treatments (Paired samples t test, $p > 0.05$).

Table 2 Plant growth and crop yield after intercropping in the upland cropping systems of Prey Veng and Svay Rieng provinces

Treatment	Statistics	Plant height at flowering (cm)	Plant height at harvesting (cm)	Weight/Hill (g)	Number of fruit/Hill	Weight/ 100 seeds (g)	Yield (th^{-1})
T1	Mean	13.01	40.40	48.90	46.48	171.85	2.47
	SD	2.35	8.58	5.95	2.83	5.97	0.33
T2	Mean	13.88	39.40	52.80	50.20	177.88	2.72
	SD	2.68	7.06	6.58	3.50	3.76	0.38
T3	Mean	13.65	40.88	42.68	42.23	165.43	2.31
	SD	2.97	6.97	4.52	3.51	5.03	0.41
T4	Mean	11.69	38.08	40.93	40.53	161.86	2.12
	SD	1.72	8.49	4.88	4.20	9.74	0.38
T5	Mean	11.17	37.48	43.50	42.73	170.80	2.39
	SD	0.96	9.09	5.44	3.92	6.11	0.20
T6	Mean	12.18	35.68	44.15	43.85	171.75	2.44
	SD	2.40	10.41	5.06	4.63	7.40	0.29
T7	Mean	11.61	38.15	50.65	48.08	177.58	2.69
	SD	3.30	8.76	5.32	2.23	6.33	0.30

S.D, standard deviation

Further analysis revealed that soil Ca levels of pre-treatment did not significantly differ from that of the post-treatment in all treatments (Paired samples t test, $p > 0.05$). However, soil Mg and Na levels of post-treatment of T5, T6 and T7 was significantly lower than those of pre-treatment (Paired samples t test, $p < 0.05$). A comparison indicated that there were no significant differences in soil K levels of pre-treatment and post-treatment in all treatment (Paired samples *t* test, $p > 0.05$). Concurrently, the exchangeable pH and actual pH of soil in the pre-treatment did not significantly differ from those the post-treatment (Paired samples *t* test, $p > 0.05$).

Table 3 Mean values of the chemical and physical properties of soils before (n = 8) and after (n = 8) intercropping

				Pre-treatment					
Treatment	C	Org C	N	P_2O_5	Ca	Mg	Na	K	pH
T1	10.32	1.77	1.18	144.25	3.40	1.40	0.12	0.16	4.73
T2	10.32	1.77	1.18	144.25	3.40	1.40	0.12	0.16	4.73
T3	10.32	1.77	1.18	144.25	3.40	1.40	0.12	0.16	4.73
T4	10.32	1.77	1.18	144.25	3.40	1.40	0.12	0.16	4.73
T5	10.32	1.77	1.18	144.25	3.40	1.40	0.12	0.16	4.73
T6	10.32	1.77	1.18	144.25	3.40	1.40	0.12	0.16	4.73
T7	10.32	1.77	1.18	144.25	3.40	1.40	0.12	0.16	4.73
				Post-treatment					
T1	9.04	1.55	0.93	145.88	4.06	1.49	0.11	0.18	4.78
T2	9.04	1.55	0.95	142.63	2.71	1.24	0.11	0.17	4.70
T3	8.92	1.51	0.94	156.63	2.69	1.24	0.11	0.17	4.49
T4	9.49	1.63	0.95	146.13	2.70	1.20	0.12	0.16	4.55
T5	9.62	1.65	0.94	143.13	2.79	1.11	0.09	0.17	4.59
T6	7.78	1.33	0.88	150.63	2.74	1.15	0.08	0.17	4.58
T7	9.53	1.63	1.09	139.75	3.08	1.22	0.11	0.16	4.76

C, Org C, N, P2O5, Ca, Mg, Na, K in mg kg^{-1}

CONCLUSION

Intercropping of peanut cultivation has been successfully implemented in the upland cropping system of Prey Veng and Svay Rieng provinces. Field data revealed that there were not significant differences in peanut height at flowering and harvesting stages among all treatments. However, weight per hill, number of fruit per hill and 100 grain weight significantly differed among the treatments. Peanut yield increased in the order of T2 > T7 > T1 > T6 > T5 > T3 > T4. The mean of peanut yield were greater than 2.1t h^{-1} in all treatments. There were no significant differences in total N, phosphate, and K before and after intercropping cultivation. This study suggests that intercropping could provide a harvestable sustainable yield of peanut in the upland cropping systems of southeast Cambodia.

ACKNOWLEDGEMENTS

Authors would like to thank OAE and DOA advisors and student volunteers attached to Chea Sim University of Kamchaymear (CSUK) for their valuable field assistance. This study was financially supported by World Bank through HEQCIP project of the Directorate General of Higher Education, Ministry of Education, Youth and Sport of Cambodia Government.

REFERENCES

Bell, R.W., Seng, V., Schoknecht, N., Vance, W. and Hin, S. 2005. Assessing land suitability for crop diversification in Cambodia. In Proceedings of the Land Resource Assessment Forum, held at CARDI, 23-26 September 2004, Cambodia.

Brady, N.C. and Weil, R.R. 2007. The nature and properties of soils. 14th Ed. Prentice Hall.

Chan, P., Bob, M., Bob, F., Ung, S., Pol, C. and Pin, T. 2009. Farmer's challenge in improving upland farming systems in Cambodia. Cambodian Journal of Agriculture, 9 (1-2), 8-23.

Seng, V., Bell, R.W., Hin, S., Schoknecht, N., Vance W. and White, P.F. 2009. Soil factors affecting crop suitability for upland crops in Cambodia. Cambodian Journal of Agriculture, 9 (1-2), 24-37.

Seng, V., Bell, R.W., Hin, S. and Touch, V. 2011. Field crop productivity in relation soil properties in Basaltic soils of eastern Cambodia. Cambodian Journal of Agriculture, 10 (1-2), 5-19.