Research article

Alternative Cropping Systems for North-West Cambodia

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Abstract A field research program commenced in north-west (NW) Cambodia in 2012 to test the feasibility of including a dry season crop for this upland area, increasing the cropping intensity from 2 to 3 crops per year. Dual purpose crop options that can be harvested for fresh forage or silage in the event of crop failure due to drought will also be evaluated. Forest clearing after 1998 has been followed by the expansion of upland cropping in NW Cambodia. Major threats to sustainable agricultural production in the region are: (a) rapid soil degradation, soil fertility decline, loss of crop diversity; and (b) poverty and lack of income diversity for small-holder farmers. Access to improved agricultural technologies could provide solutions to these problems. Current farmer practice involves growing two crops per year, with an early wet season crop (March-June) and followed by a main wet season crop (July-October). Land is ploughed after the main wet season crop or left fallow from November to February. Due to high rainfall in NW Cambodia in September and October, there is significant residual water remaining in the soil after the wet season that could be exploited by crops rather than weeds as it currently is. The risk of growing dry season crops would be reduced if tillage was eliminated and surface crop residues were retained to conserve soil water. Small-holder farmers in NW Cambodia struggle to cover household expenses with crop income. Annual gross margins from growing two crops of maize (USD 874/ha) are declining and farmers are turning to cassava (USD 1,066/ha) to increase income and reduce labour costs. Replacing early wet season maize with peanut is more profitable (USD 1,447/ha); moreover adding dry season sunflower into the peanut-maize rotation to grow three crops per year could return a gross margin of USD 1,888/ha.

Keywords upland cropping systems, land use efficiency, maize, sunflower, Cambodia

INTRODUCTION

North-West Cambodia has seen rapid expansion of rainfed upland cropping as a result of large-scale land clearing since the end of the Khmer Rouge civil war in 1998. Unfortunately this development has been associated with excessive cultivation and burning of crop residue which has led to rapid soil fertility decline and soil erosion. The Australian Centre for International Agricultural Research (ACIAR) has funded research since 2003 to address these problems and to develop more sustainable upland cropping systems for NW Cambodia.

CROPPING SYSTEMS TRENDS

The rapid expansion of maize and cassava area, which began in 2006, has led to a loss of crop diversity in the region (Fig. 1, Fig. 2). Maize yields are declining as soil fertility declines and this may be one of the reasons why farmers have begun to increase the area of cassava at the expense of maize (Fig. 2). The expansion of cassava could also be due to the need for less labour and opportunity for household members to earn off-farm income.

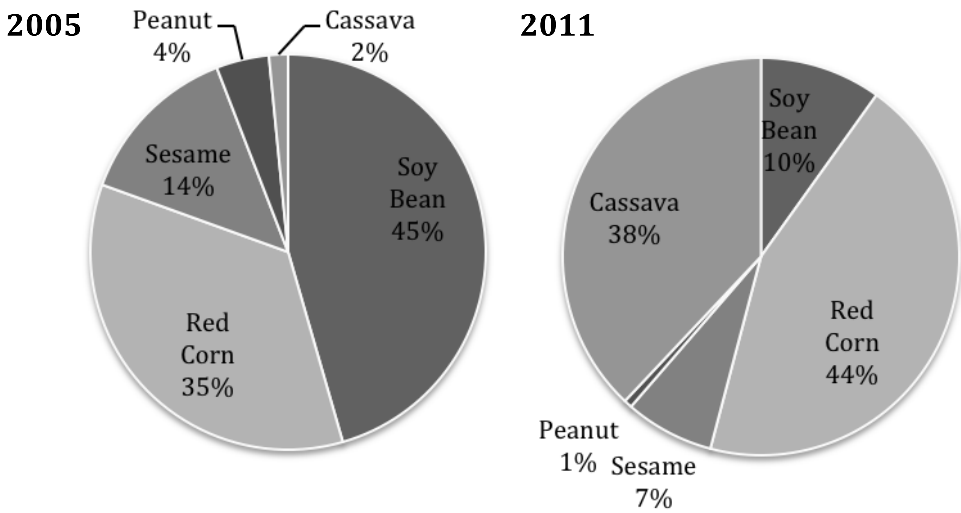

Fig. 1 Cropping trends in Battambang Province based on area of production
(Data source: pers comm. Battambang Provincial Department of Agriculture)

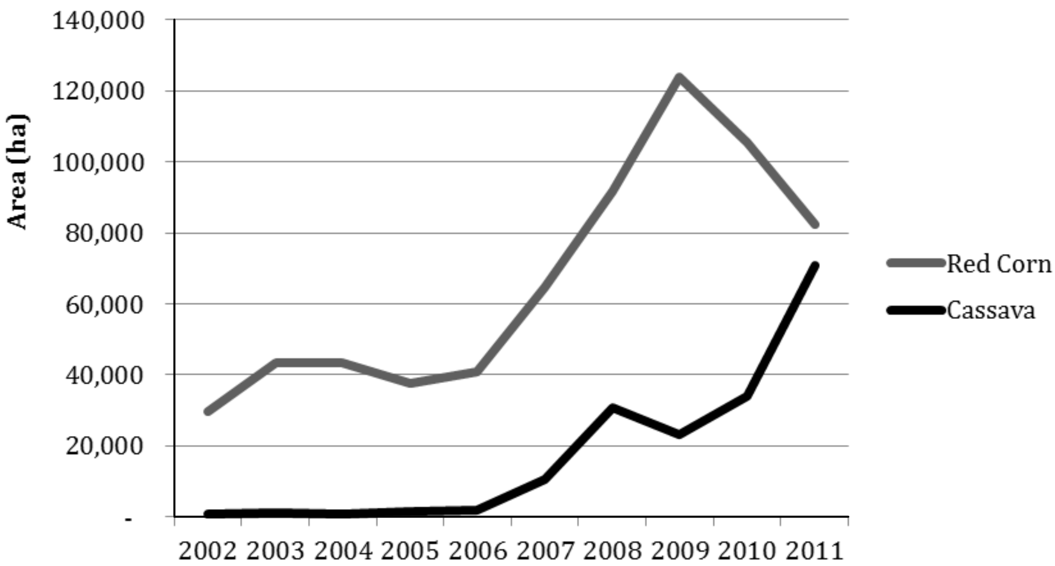

Fig. 2 Trends in the area of red corn and cassava in Battambang Province
Data source: Battambang Provincial Department of Agriculture

CLIMATE AND SOIL

NW Cambodia has a monsoonal climate with a rainy season between May and October and a distinct dry season between November and March (Fig. 3). The average annual rainfall at Battambang is 1,247 mm with 101mm, 391mm and 755 mm falling in the dry season (DS), early wet season (EWS) and main wet season (MWS) respectively.

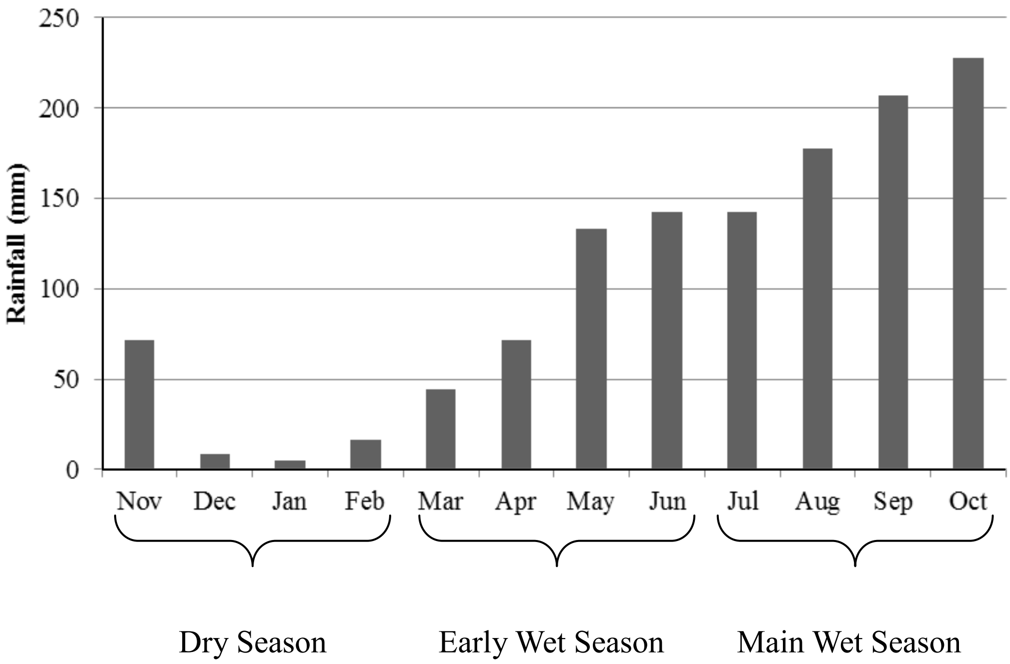

Fig. 3 Average seasonal rainfall distribution at Battambang Town
(Data source: Battambang Office, Ministry of Water Resources and Meteorology)

The average temperature at Battambang is 28.0 ^oC. April is the warmest month with an average maximum temperature of 36.1 ^oC and December the coolest with an average minimum temperature of 19.7 ^oC. Average relative humidity at Battambang is 80% rising to 86% in September-October and falling to 72% in March.

The main soils where upland crops are grown in NW Cambodia are known locally as Kampong Siem (Vertosol) and Labanseak (Ferrosol) (White et al., 1997). The Kampong Siem soils are black self-mulching clays and the Labanseak are red friable clay-loams. Martin et al. (2005) reported analyses for 25 ferrosols and 25 vertosols in crop fields in Ratanak Mondul District, Battambang Province. On average, the vertosols are higher in organic carbon and total nitrogen and have higher pH than the ferrosols (Table 1). These clay and clay-loam soils have the capacity to retain significant quantities of plant-available water in dry periods between rainfall events.

Table 1 Organic carbon, total nitrogen and pH (0-15cm) of ferrosols and vertosols in Ratanak Mondul District, Battambang

Soil	Organic carbon (%)	Total nitrogen (%)	pH (water)
Ferosol	2.07 (1.36-3.81)	0.176 (0.115-0.258)	5.5 (5.0-6.0)
Vertosol	2.46 (1.45-4.50)	0.181 (0.105-0.342)	6.5 (5.0-8.0)

Data source: Martin et al. 2005

ALTERNATIVE CROP OPTIONS

The main crops grown in the early wet season (March-June) include sesame, maize, mungbean and peanut, while the principal crops grown in the main wet season (July-October) are maize and soybean. Cassava is grown over a 12 month period.

There is potential for drought tolerant crops such as sunflower and sorghum to be grown during the dry season (November - February) on residual soil moisture after harvest of the main wet season maize crop, especially if the dry season crop could be sown at the end of October (Fig. 3). The success of the dry season crop is likely to be enhanced by no-till seeding into chopped maize residue to better retain residual soil water from the main wet season rains.

Inclusion of a dry season crop allows the potential for three crops to be grown during the year compared to the current practice of growing one (cassava) or two crops per year: early wet season (March - June) and main wet season (July - October) (Fig. 4). The three crop option is only possible if tillage is eliminated between crops to conserve soil moisture and enable timeliness of operations.

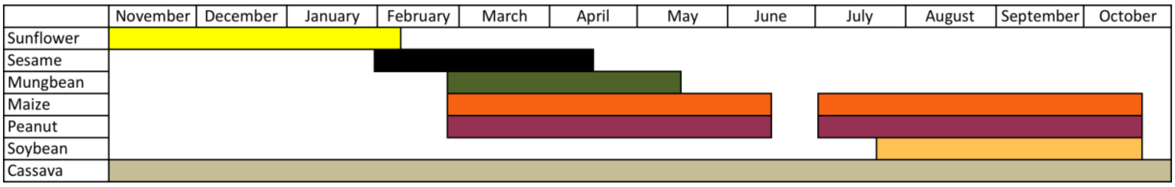

Fig. 4 Current upland crop calendar for NW Cambodia incorporating proposed dry season sunflower (*Data source: pers comm. B. Martin*)

Technically both mungbean and soybean can be grown in the early and main wet seasons. However, soybean is not drought tolerant and can fail in the early wet season. Mungbean crops often fail in the main wet season because of fungal infection of the pods in the humid conditions. Therefore it is recommended mungbean be planted only in the early wet season and soybean in the main wet season. Sesame is best grown in the early wet season to avoid attack from the sesame webworm (*Antigastra* spp.)

Apart from the problems of soil degradation and lack of crop diversity, maize and cassava fields in NW Cambodia are being invaded by tall grass weeds such as *Sorghum halepense* (Johnson grass), *Sorghum bicolor* (wild sorghum) and *Pennisetum polystachyon* (mission grass). If left uncontrolled after maize harvest, these grasses continue to grow throughout the dry season and consume the residual soil moisture from the main wet season rains. This gives a strong indication that there is sufficient residual soil moisture to grow a dry season crop. Farmers in this region have already experimented successfully with growing sunflower and sorghum in the dry season.

A challenge for introducing the dry season crop option is to successfully manage the maize crop residues and weeds at harvest without losing valuable soil water. A maize stalk chopper and a no-till planter have been imported from the USA to enable small plot replicated on farm trials of direct seeding of the dry season crop into the maize/weed residue. This will require chopping of the maize stalks and killing the weeds with a broad-spectrum herbicide (glyphosate) before direct seeding the dry season crop. As part of research for a PhD and the afore mentioned ACIAR project, trials with this system focusing on crop sequencing, cropping intensity and effects of maize residue as a mulch under a no till farming system will commence in 2013 in collaboration with farmers. Until the machinery is ready to use, trials will be hand planted following no till farming principles.

The important elements that a resilient crop sequence in NW Cambodia could include are:

1. A 'grass' crop such as maize which can provide sufficient residues to maintain ground cover mulch through the annual crop cycle;
2. A legume crop such as mungbean, peanut or soybean that can increase soil nitrogen fertility through fixation of atmospheric nitrogen; and
3. Other crop species such as sunflower or sesame to help to break disease, insect and weed cycles.

ECONOMIC ANALYSIS

In Battambang Province in 2011, maize and cassava were the dominant crops grown. Gross margins have been calculated for cassava, maize, peanut and soybean based on interviews with farmers in Samlout/Pailin in 2010/11 as part of the ACIAR project ASEM/2010/049 (Table 2). In this case, crop gross margins are calculated (on a per hectare basis) as the gross income from the crop less the variable costs incurred in achieving it, such as seed, fertilizer, in-crop weed control and harvesting costs. The potential gross margin for sunflower was calculated based on yield estimates and prices from Thailand and the prices being aligned with those for soybean.

Table 2 Gross margin sensitivity for cassava, maize, peanut, soybean and sunflower

Cassava fresh tuber.

Yield (kg/ha)	Price (USD/t)		
	USD32	USD64	USD95
20,000	USD77	USD711	USD1,345
30,000	USD115	USD1,066	USD2,017
40,000	USD154	USD1,422	USD2,690

Maize on cob

Yield (kg/ha)	Price (USD/t)		
	USD127	USD159	USD191
3,000	USD76	USD171	USD265
4,500	USD280	USD437	USD595
7,000	USD483	USD704	USD925

Peanut in shell

Yield (kg/ha)	Price (USD/t)		
	USD604	USD762	USD921
1,000	USD123	USD273	USD423
2,000	USD710	USD1,010	USD1,310
3,000	USD1,297	USD1,747	USD2,197

Soybean kernel

Yield (kg/ha)	Price (USD/t)		
	USD400	USD450	USD500
1,000	USD128	USD178	USD228
2,000	USD468	USD568	USD668
3,000	USD807	USD957	USD1,107

Dry season sunflower (low input, estimated)

Yield (kg/ha)	Price (USD/t)		
	USD400	USD450	USD 500
750	USD89	USD126	USD164
1,500	USD378	USD453	USD528
2,250	USD668	USD780	USD893

Data source: Anon. (2012)

Table 3 Gross margin comparison for cassava, maize, peanut, soybean and sunflower

Crop sequence	Average Annual Gross Margin (USD/ha)
Maize-Maize	USD874
Cassava	USD1,066
Peanut-Maize	USD1,447
Sunflower-Maize-Soybean	USD1,458
Sunflower-Peanut-Maize	USD1,888

Data source: pers comm. K. Kynal 2010, University of Battambang students 2011

Table 3 shows the comparison of potential average annual gross margins (using the average yields and prices) between the crop sequences under evaluation. At a first glance, farmers seem to be justified in switching from maize-maize to cassava as the gross margin for cassava is higher based on average yields and prices (Table 3). However, ACIAR research in Samlout/Pailin between 2008 and 2012 has shown that peanut can be a very profitable crop. A peanut-maize sequence could give a much higher gross margin than maize-maize or cassava. The peanut-maize sequence is also a better option to maintain soil fertility.

The addition of dry season sunflower to the peanut-maize cropping sequence would give an estimated annual gross margin of USD1,888, which is more than double that for maize-maize and almost double that for cassava. Another rotation option is sunflower-maize-soybean which is a good rotation option agronomically but might be less profitable than sunflower-peanut-maize (Table 3). However, this assumes relative crop prices remain the same. A disadvantage of the sunflower-maize-soybean option is that there is very little crop residue remaining after the soybean crop and there would be less ground cover for the dry season crop.

An important marketing consideration for sunflower, as with other crop species, is that the maturity of the NW Cambodian crop does not coincide with the harvest timing of the same crop species in Thailand. Lopburi Province is the main sunflower production area in Thailand. The peak monthly rainfall is September for Lopburi and October for Battambang so it is expected that the Cambodian crop would be planted one month later than the bulk of the Thai crop. Battambang also receives marginally more dry season rain (101 mm) than Lopburi (70 mm) meaning that dry season sunflower production might be safer in NW Cambodia compared to Thailand.

The average yield of sunflower under rainfed conditions in Australia is around 1,700 kg/ha with a realistic range from 700 to 2,400 kg/ha (Serafin et al., 2011). It is expected that dry season sunflower in Battambang Province could average up to 1,500 kg/ha. If the area of sunflower in Battambang Province expanded to 50,000 ha then the potential production would be at least 50,000 tonnes of sunflower seed per annum assuming a more conservative average yield of 1,000 kg/ha.

CONCLUSION

The current upland cropping system in north west Cambodia is facing many challenges including a loss in crop diversity, declining soil fertility, extensive soil erosion and continued deforestation. Soil characterisation in this region is not well determined but soils are generally inherently fertile, friable, well-structured soils, which if managed in a sustainable manner could greatly assist in alleviating rural poverty. Research is ongoing into sustainable cropping systems for this region. This research will provide the basic information required to improve soil management and water-use efficiency in upland areas of NW Cambodia. It will also develop 'response cropping' planting guidelines to reduce the risk of crop failure due to drought and demonstrate to farmers alternative cropping options on their land. The research will also identify the most suitable dual purpose crops that can be harvested for fresh forage or silage in the event of crop failure due to drought.

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