SEED PRODUCTION POTENTIAL AND PARTICIPATORY VEGETATIVE PROPAGATION OF *ARACHIS PINTOI* IN DIFFERENT ENVIRONMENTS IN NORTHERN THAILAND

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Abstract
Arachis pintoi is a perennial, stoloniferous legume that forms an excellent ground cover for erosion and weed control, contributes to soil improvement, and is a high quality feed for livestock, withstanding heavy grazing or cutting. This paper investigates the potential of *Arachis pintoi* for seed production at three different altitudes in northern Thailand on 2-year old plots. Seed yield and 100-seed weight were particularly low at low altitude; germination of fresh seed was high at the high-altitude site. Seed yields of up to 470 g m^{-2} were measured at medium altitude.

Seed production data is complemented by a study on participatory, farmer-led vegetative propagation of *Arachis pintoi* in Mae Sa Mai, an ethnic minority community in Chiang Mai province. Farmers had been introduced to the new cover crop during a field day organized on the experimental plots (medium-altitude site) where they received vegetative material for testing. In establishing their own experiments with *Arachis pintoi* in their hillside orchards, farmers were surprisingly creative. They received field books for continuous monitoring and evaluation of the experiments. Results suggest that involving farmers in early stages of the development process of new soil conservation technologies is crucial for identifying farmers' constraints, particularly as regards labour demand.

Additional Keywords: tropical legumes, soil cover, germination, farmer-managed experiments

Introduction
In the hillsides of northern Thailand, erosion and soil fertility depletion are among the major constraints to sustainable production of fruit orchards, an emerging land use system in that area. Cover legumes adapted to low-fertility soils are seen as a promising option for soil erosion and weed control, soil improvement and, at the same time, as potential forage plants in smallholder hillside orchards. *Arachis pintoi*, a stoloniferous perennial legume, can be an excellent ground cover for weed control and soil improvement under fruit trees and erosion control on slopes. It forms a dense green carpet with a mass of yellow flowers, is a high quality feed for livestock and can withstand heavy grazing or cutting (Kerridge and Hardy, 1994). This paper examines the potential of seed production (under experimental site conditions) and of vegetative propagation (in farmer-managed experiments) for *Arachis pintoi*.

Materials and Methods
Field sites
A species x environment interaction study was established at three sites of contrasting altitudes in the area of Chiang Mai city, Chiang Mai province, Northern Thailand. Characteristics of the experimental sites are given in Table 1. Whereas the Mae Hia experimental station of Chiang Mai University (CMU) is representative of lowlands with longan orchards, Mae Sa Mai represents the area where litchis and the highland CMU Chang Khian station where plums and apricots are grown. Farmers' experiments were carried out in the medium altitude site in Mae Sa Mai where most farmers grow litchi and, to a lesser extent, tangerine and jackfruit.

Experimental details
Plots (8 m x 3 m) had been established in 2001 with *Arachis pintoi* cv. Amarillo by seeding; experimental layout was RCB with 3 replicates. With the objective to ensure plant establishment and near maximum growth, half of each plot received a low (100 kg ha^{-1}) and high (300 kg ha^{-1}) fertilization dose, respectively. We used a N-P_2O_5-K_2O compound fertilizer (12-24-12). After six months, *A. pintoi* had formed a dense soil cover. In 2002 and 2003, plots were cut repeatedly. Seed production was determined in December 2003 at all three experimental sites. For this, in six 0.5 m x 0.5 m samples $plot^{-1}$ aerial plant parts were cut and the soil, together with underground plant parts (roots, pegs and pods), was excavated down to a depth of 15 cm. Pods were separated from soil by sieving,

hand-separated from roots and carefully detached from pegs, washed and air-dried. Seed yield and 100-seed weight were measured as seed in pod; germination was determined within two weeks after seed sampling.

Table 1. Location, climate and soil of the three study sites in Chiang Mai province, northern Thailand

Site	Location			Climate		
	Lat (N)	**Long** (E)	**Altitude** (m.a.s.l.)	**Rainfall[1]** (mm)	**Temp[1]** (°C)	**Dry season** (no. of months)
CMU Mae Hia Station	18°45′	98°56′	340	1539	23.2	6
Mae Sa Mai	18°51′	98°52′	850	1354	22.5	4
CMU Chang Khian Station	18°51′	98°49′	1100	2495	19.8	4

Site	Soil chemical characteristics						
	pH	**OM[2]** (%)	**N** (%)	**P[3]** (ppm)	**K[4]** (ppm)	**Ca[4]** (ppm)	**Mg[4]** (ppm)
CMU Mae Hia Station	5.3	1.16	0.06	5	45	585	92
Mae Sa Mai	4.9	3.09	0.14	5	312	561	115
CMU Chang Khian Station	5.1	1.58	0.07	150	93	374	14

Site	Soil physical characteristics				
	Sand (%)	**Silt** (%)	**Clay** (%)	**Texture**	**Bulk density** ($g\ cm^{-3}$)
CMU Mae Hia Station	60.3	22.7	16.9	Sandy loam	1.54
Mae Sa Mai	46.2	12.6	41	Sandy clay	1.26
CMU Chang Khian Station	43.9	14	42	Sandy loam	1.58

[1] mean annual; [2] organic matter; [3] Bray II; [4] NH_4 OAc extractable base

Farmers' experiments with vegetative propagation of *Arachis pintoi* were initiated by a presentation on June 18, 2003 for around 40 male and female farmers of the Hmong ethnic minority community of Ban Mae Sa Mai who were interested in the results of two-year field experiments with fourteen different leguminous plants at the medium altitude experimental site. The participants got actively involved in discussions on potential benefits and risks of growing cover crops in their litchi orchards. The presentation was followed up by a field day on June 25, 2003, in which seven farmers participated who were particularly interested in *Arachis pintoi* and its potential as animal feed and ground cover in fruit orchards (see Figure 1).

Figure 1. Introduction to *Arachis pintoi* during a field day in Mae Sa Mai

Six farmers finally decided to test the cover legume in their own orchards. Researchers gave a short instruction into the techniques of vegetative propagation and distributed plastic bags with stolons from the Mae Hia and Chiang Khian experimental sites based on individual demand of the farmers. The experiments were entirely farmer-managed and jointly monitored by farmers and researchers. Farmers decided on location and size of the experimental plots and were responsible for planting and maintenance (weeding, fertilizing). Planting densities of 50 x 50 cm were recommended by the researcher, but most farmers varied the planting densities according to their own judgement. The researchers distributed field books to the farmers for regular recording of labor and other inputs. As some of the farmers were illiterate, a research assistant helped in keeping the field book. Cover density of *Arachis* in the experimental plots was monitored in monthly intervals during a five-month establishment phase by the researchers.

In experimenting with *Arachis* in their hillside orchards, farmers were surprisingly creative. Some created their own experimental designs, such as varying weed management prior to stolon planting and comparing effects of different light intensities. The experimental capacities of farmers in these trials confirm findings of other authors suggesting that farmers' experimentation has a much more formal character than often expected by scientists, and that combining station-based experiments and farmer-managed trials can provide valuable synergetic effects (cf. Van Veldhuizen *et al*., 1997; Sumberg *et al*., 2003).

Results and Discussion

Seed production under experimental site conditions

As Table 2 shows, both seed yield and 100-seed weight were lowest at the low-altitude Mae Hia station and highest at Mae Sa Mai (medium altitude). Except for Chang Khian station, there was no fertilization effect. Germination of fresh seed, which could not be determined for Mae Hia station samples, was surprisingly low at Mae Sai Mai. Yields of up to 470 g m^{-2} (equivalent to 4.7 t ha^{-1}) are in line with data reported in literature as are the tendency to produce higher yields at higher altitudes and the 100 seed weight range of 13-18 g (Ferguson, 1994). Environmental effects on germination of freshly harvested seed have, however, not yet been reported.

Table 2. *Arachis pintoi* seed production with different fertilizer application levels at three experimental sites

	Chang Khian station			Mae Sa Mai			Mae Hia station		
Fert. level*	Yield (g m^{-2})	100-seed weight (g)	Germination (%)	Yield (gm^{-2})	100-seed weight (g)	Germination (%)	Yield (g m^{-2})	100-seed weight (g)	Germination (%)
Low	322.2	15.71	63	335.9	18.18	26	18.5	13.53	n.a.
High	76.0	14.54	73	473.4	18.30	17	10.4	12.53	n.a.
Mean	*199.1*	*15.13*	*68*	*404.7*	*18.24*	*21.5*	*14.5*	*13.03*	*n.a.*

*Fert. level = fertilizer level

Vegetative propagation in farmer-managed experiments

Data on vegetative propagation could be recorded on experimental plots of five farmers. One member of the initial group of six experimental farmers abandoned the experiment after a few weeks due to lack of time for maintenance of the plot. One farmer (plot B) subdivided his plot into one part that was treated with herbicides prior to planting *Arachis* (plot B_H) and one part that was hand-weeded before planting (plot B_N).

Table 3. Cover densities of *Arachis pintoi* in farmers' fields in Mae Sa Mai (August – December 2003)

Farmers' plot A Ground cover (month, %)						Farmers' plot B_H* Ground cover (month, %)						Farmers' plot B_N** Ground cover (month, %)					
% slope	1	2	3	4	5	% slope	1	2	3	4	5	% slope	1	2	3	4	5
31	12	61.6	70.8	80	60	33	6	9.4	13.2	13.2	10	33	10	34.8	30.8	30	25
Farmers' plot C Ground cover (month, %)						**Farmers' plot D Ground cover (month, %)**						**Farmers' plot E Ground cover (month, %)**					
% slope	1	2	3	4	5	% slope	1	2	3	4	5	% slope	1	2	3	4	5
40	12	50.4	68	90	70	25	5.2	30.4	19.2	18	16	45	20	43.5	70.4	20 †	25.3

* B_H = herbicide use prior to planting, ** B_N = no herbicides prior to planting, † herbicide effect

Data on cover densities suggest a high variation of ground cover during the establishment phase of *Arachis pintoi* (Table 3). Steepness of slope did not have a significant effect on achieving a high cover density. Farmers reported various problems in the first months, such as adverse effects caused by periods of drought, insect pests and weed competition, the latter particularly after using fertilizer. Sensitivity to drought is indicated by the fact that cover densities dropped slightly in all plots at the beginning of the dry season (December). A lack of tolerance to herbicide use prior to planting and during the establishment phase that could be observed in the farmers' experiments (plot B_H and plot E) needs further confirmation in controlled experiments. Labour input turned out to be a decisive factor in establishing *Arachis* (Table 4). Farmers who frequently weeded their plot (see plots A and C in Table 3) achieved the highest cover densities of *Arachis*. In the case of two farmers, weeding time interfered with other economic activities, such as growing vegetables and working off-farm.

Table 4. Total field size, size of experimental plot and labour input during the establishment phase for *Arachis pintoi* in farmers' fields (July – October 2003)

Farmers' plot*	Total field size (ha)	Size of *Arachis* plot (m^2)	% of total field area planted with Arachis	Weeding (man days ha^{-1})	Total labor (man days ha^{-1})
Plot A	2.4	400	0.02	0.32	3.10
Plot B**	1.12	800	0.07	0.40	1.40
Plot C	1.6	48	0.003	2.67	5.46
Plot D	0.24	400	0.16	0.24	0.96
Average	*1.34*	*412*	*0.063*	*0.91*	*2.73*
Standard deviation	*0.94*	*322.89*	*0.061*	*1.18*	*1.89*

* no data for plot E available, ** parts with and without herbicide use combined

Table 4 shows that farmers were cautious in determining the size of the experimental plots. None of them designated an area of more than one percent of the total field size for the experiment. Rivas and Holmann (2000) reported similar observations from early adopters in Caquetá, Colombia. Apart from planting, weeding was the most time-consuming activity during the establishment phase.

Conclusions

Medium and higher altitudes in Northern Thailand are favourable environments for seed production of *Arachis pintoi*, at least on sandy soils. Potential yields in the region are very high and, once it becomes a widely accepted cover legume in the region, seed production of this species could well contribute to generation of aggregated-value based rural income. The influence of environmental conditions on germination rate and/or seed dormancy warrants further investigations.

The adoption of multi-purpose cover crops is a complex and slow process (cf. Rivas and Holmann, 2000; Wünscher *et al*., 2002). Farmers have to invest a considerable amount of time into the establishment of a crop whose direct benefits accrue mostly in the long term. As cover crops like *Arachis pintoi* can provide substantial indirect benefits for downstream users in terms of reducing erosion and preventing landslides, temporary subsidies to support the establishment phase of the crops may be justified.

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