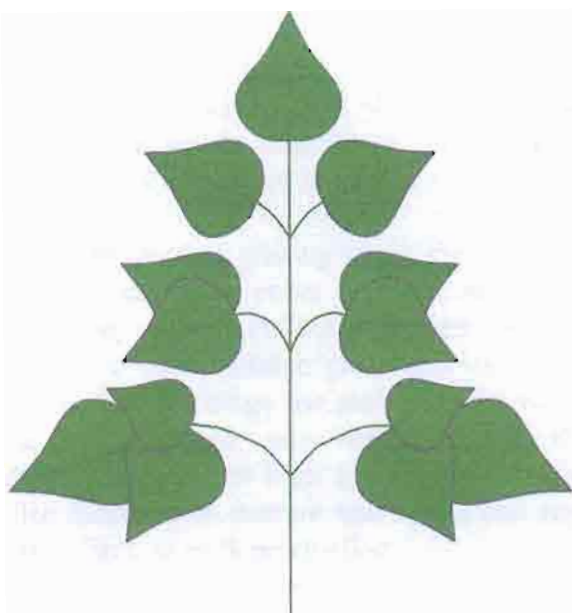


6.6 เพื่อส่งเสริมมหาวิทยาลัยอุบลราชธานีให้เป็นศูนย์กลางความเป็นเลิศทางพืชอาหารสัตว์ต่อไป โดยผ่านการตีพิมพ์ผลงานในวารสารนานาชาติ การประชุมวิชาการ การฝึกอบรม งานวันเกษตร และสื่อสารมวลชน

วัตถุประสงค์ข้อนี้ประสบความสำเร็จ กล่าวคือได้มีการตีพิมพ์ผลงานวิชาการในวารสารนานาชาติจำนวน 8 เรื่อง และในการประชุมวิชาการจำนวน 4 เรื่อง ตลอดจนมีการจัดการฝึกอบรมเกษตรกรในเรื่องการผลิตพืชอาหารสัตว์ รวมทั้งมีการตีพิมพ์บทความเกี่ยวกับกิจกรรมของโครงการในหนังสือ พิมพ์ในระดับท้องถิ่นและระดับประเทศ

7. สรุปโดยรวม

ในภาพรวมสามารถกล่าวได้ว่าโครงการประสบความสำเร็จเป็นอย่างดีที่สามารถทำงานวิจัยประยุกต์ และผลงานที่ได้สามารถส่งผ่านไปยังผู้ใช้ได้ค่อนข้างรวดเร็วโดยผ่านทางเอกสารและสิ่งตีพิมพ์ รวมทั้งโดยการจำหน่ายเมล็ดพันธุ์ที่โครงการและเกษตรกรผลิตได้ไปยังตลาดทั้งภายในและภายนอกประเทศ



Dairy Cattle Feeding Systems
using Perennial Pastures for
Farmers in Northeast Thailand

Final Report

November 1 2002 to October 31 2005

Faculty of Agriculture

Ubon Ratchathani University

Abstract

The Thailand Research Fund project, '**Dairy cattle feeding systems using perennial pastures for farmers in Northeast Thailand,**' was conducted at the Faculty of Agriculture, Ubon Ratchathani University from November 2002 to October 2005.

In a series of milk production grazing trials, the project demonstrated that it is possible to successfully graze dairy cows on pastures day and night in Thailand, without additional feeding of concentrate supplements. Signal grass and Ubon paspalum were found to be both suitable grass species for dairy production. Ubon paspalum does have low quality forage but makes up for this by producing high dry matter yields and a high leaf:stem ratio which is very digestible. Signal grass maintains good quality and produces high crude protein yields all year round. The project also found that Ubon stylo pasture and silage can replace concentrate feeds without any significant effect on milk production.

Research by the project on different *Brachiaria* species showed that in the dry season, without irrigation, new *Brachiaria* species, Toledo, Marandu, Mulato II and Mulato, produce significantly more dry matter than ruzi on upland soils. Ruzi is the most commonly grown grass in Thailand, but the project showed that the above species are better than ruzi on upland soils, particularly in the dry season. In the 2004-5 dry season, many ruzi plants died, whereas both Mulato and Mulato II remained green and productive.

Studies on stylo legumes showed that Ubon and Tha Phra have superior dry matter production compared to Hamata, particularly in the dry season. This is because Ubon and Tha Phra are perennials and stay green and productive throughout the year, whereas Hamata is a biennial and dries off and dies in the dry season. The forage quality of Hamata was generally better in the wet season because it had new fresh growth from new seedlings. However, in the dry season, the quality of Hamata decreased rapidly as it dried and died in contrast to the quality of Ubon and Tha Phra which remained fresh and green. In the dry season, Ubon and Tha Phra stylos produced 2-3 times more dry matter than grasses. Both these cultivars should be grown more in Thailand for dry season forage.

The project showed that good quality silage production can be made from Ubon paspalum and Ubon stylo in plastic drums. Additives do not have to be applied and the grass does not have to be chopped if the drum is well-sealed and air-tight.

The method of placing nylon bags over the seed heads to collect seed produced the highest seed yields of Mulato and Mulato II. However, seed yields of Mulato and Mulato II were much lower than ruzi. Mulato and Mulato II grew good quality forage before closing the fields for seed production. Cutting monthly until July in first year crops and August in second year crops produced high dry matter yields of high quality leaf content for feeding to animals. Farmers can therefore feed Mulato and Mulato II to their animals, 7-8 months of the year and, close for seed for 4-5 months (July or August to December). Planting with tillers as early as possible in the wet season will enable farmers to get both forage and seed in the same year.

Studies on seed storage found that Mulato seed can be safely stored in ordinary rooms for short periods (up to 8 months) but for long-term storage, cool storage is recommended. For long-term storage, plastic and nylon bags maintain seed germinations better than paper bags.

Ubon stylo was found to be a very prolific seeder, producing up to 150 kg/rai, which was nearly 3 times the seed yields produced by Tha Phra stylo. Cutting stylo

seed crops at the beginning of September produced more seed than not cutting or cutting later.

The project's village seed production programme was very successful with high quality seed produced of Ubon paspalum and Ubon stylo. Ubon paspalum and Ubon stylo were found to be lucrative cash crops and relatively easy crops to harvest seed. The farmers now average over 100 kgs/rai, with some farmers producing 150 kgs/rai. Demand for Ubon paspalum seed in Thailand is currently very high, as it is the best grass for wet soils. The project has started to develop a market for Ubon paspalum and Ubon stylo seed in South America. 3000 kgs of seed of both species have been ordered for export to Central and South America in 2006.

The project undertook a joint venture with a Mexican Seed company to produce Mulato II seed by village farmers. Over 2000 kgs of seed were produced in the first year and 1500 kgs exported to USA. However, in 2005 only 1292 kgs of seed were produced by village farmers. This project has been difficult for the farmers because of low seed yields.

The project supported 1 researcher to undertake field research for her Masters thesis on 'The effect on silage quality from different methods of ensiling'.

Twelve papers were written and published during the 3 year phase of the project. The project maintained a high scientific output, both nationally and internationally.

Final Report to the Thailand Research Fund

1. Project

Dairy cattle feeding systems using perennial pastures for farmers in Northeast Thailand

2. Project Leader Dr. Michael Hare

Research Associates

Dr. Kungwan Thummasaeng
Dr. Worapong Suriyapat
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Mr. Kittipat Saiprasert
Miss Pataraporn Tatsapong
Miss Areerat Lunpha

3. Period of report

November 1, 2002 to October 31, 2005.

4. Project research results

4.1 Milk production grazing trials

The project conducted six milk production grazing trials on the Ubon Ratchathani University farm during the research period.

Methods

Trial 1 This trial commenced on November 11, 2002 and finished on March 3, 2003. There were 3 grazing treatments [Ubon paspalum (10 rai), signal grass (10 rai) and Jarra digit (11 rai)] and 6 cows per treatment. The pastures were fenced into 1 rai paddocks and the cows rotationally grazed around the paddocks every 3-7 days depending on pasture growth.

The trial was divided into two 8 week periods. Data was analysed for 7 weeks in each period, with the first week of each period an adjustment period. At the end of period 1, the cows were re-randomised for period 2.

During the trial the cows were fed concentrate at a rate of 1 kg concentrate per 2.5 kg milk produced. The fields were irrigated once a week and 25 kg/rai NPK (15:15:15) applied every 45 days.

Data collection Before each paddock was grazed, 8 x 0.25 m² quadrats were cut from each paddock, weighed fresh and divided into leaves and stems for dry weight and nutrient analysis. Milk yields per cow were measured twice a day and samples taken for quality testing. For milk data statistical analysis, the cows were regarded as replications and for pasture data analysis there were 6 replications.

Trial 2 This trial commenced on March 9, 2003 and finished on April 13, 2003. There were 2 grazing treatments and 6 cows per treatment:

Treatment 1 Signal grass (11.8 rai- 6 paddocks, Stocking rate 1.96 rai per cow).

Treatment 2 Signal grass and Ubon stylo (4 rai of each species – 8 rai-8 paddocks. Stocking rate 1.33 rai per cow). The cows grazed signal grass during the day and Ubon stylo during the evening and night.

Data was analysed from the whole 5 week trial period. During the trial the cows were fed concentrate at a rate of 1 kg concentrate per 4 kg milk produced. The fields were irrigated once a week and 25 kg/rai NPK (15:15:15) applied every 45 days.

Data collection Before each paddock was grazed, 8 x 0.25 m² quadrats were cut from each paddock, weighed fresh and divided into leaves and stems for dry weight and nutrient analysis. Milk yields per cow were measured twice a day and samples taken for quality testing. For milk data statistical analysis, the cows were regarded as replications.

Trial 3 This trial was for 8 weeks, commencing on August 21, 2003 and finished on October 16, 2003. There was a two week adjustment period (August 7 to August 20) before the trial commenced. There were 3 treatments and 4 cows per treatment (Cows regarded as replications):

Treatment 1. Grass and concentrate. Grazed 6 rai of signal grass divided into 1 rai paddocks, and receiving concentrate (4 litres milk per 1 kg concentrate; 4:1) at milking time.

Treatment 2. Grass and legume with no concentrate. Grazed 3 rai of signal grass during the day and 3 rai of Ubon stylo at night, divided into 1 rai paddocks, and no concentrate.

Treatment 3. Grass, legume and concentrate. Grazed 3 rai of signal grass and 3 rai of Ubon stylo, divided into 1 rai paddocks. Cows grazed signal during the day and stylo at night and received concentrate (4:1) at milking time.

Cows in each treatment were rotationally grazed around the 6 rai of pastures, moving to a new paddock every 2-4 days.

Data collection Before each paddock was grazed, 8 x 0.25 m² quadrats were cut from each paddock, weighed fresh and divided into leaves and stems for dry weight and nutrient analysis. Milk yields per cow were measured twice a day and samples taken for quality testing.

Trial 4 The trial was for 8 weeks, commencing on October 27, 2003 and finished on December 22, 2003. There was a 10 day adjustment period (October 16 to October 26), before the trial commenced. There were 2 treatments and 6 cows per treatment.

Treatment 1. Grass and concentrate. Grazed 8 rai of signal grass and received concentrate (4 litres milk per 1 kg concentrate; 4:1) at milking time.

Treatment 2. Grass and legume with no concentrate. Grazed 4 rai of signal grass during the day and 4 rai of Ubon stylo at night.

Cows in each treatment rotationally grazed around their pastures, moving to a new paddock every 2-4 days.

Data collection Before each paddock was grazed, 8 x 0.25 m² quadrats were cut from each paddock, weighed fresh and divided into leaves and stems for dry weight and nutrient analysis. Milk yields per cow were measured twice a day and samples taken for quality testing. For milk data statistical analysis, the cows were regarded as replications.

Trial 5 The trial was to compare the effects of concentrate feed and Ubon stylo silage supplementation to dairy cows. The experiment had 2 treatments; T 1) Cows were grazed in Ubon paspalum grass pasture during day and night time and concentrate feeds were supplemented during milking time at the rate of 1 kg per 4 kg milk produced; T 2) Cows were grazed in Ubon paspalum grass pasture during day time and cows were confined in the yard during the night with Ubon stylo silage supplemented *ad libitum*.

The trial was in RCBD with 6 replications. It commenced on September 9, 2004 and finished on October 29, 2004. A 2 week preliminary period was followed by a 6 week period of data collection. Body weight change, body condition score, milk yields and milk composition were measured.

Results

Trial 1 In period 1, cows grazing signal grass produced more milk/cow/day, 12 and 8% respectively, than cows grazing Ubon paspalum and Jarra digit (Table 1). In period 2, cows grazing Ubon paspalum produced more milk/cow/day, 10 and 11% respectively, than cows grazing signal grass and Jarra digit. Cows grazing signal grass in both periods produced milk with higher protein and lower lactose than cows grazing Ubon paspalum and Jarra digit (Table 1). Grazing different pastures produced no differences in milk SNF but in period 1, milk fat levels were lower from cows grazing Jarra digit.

Milk production per rai was 11% higher on signal grass pastures compared to the other pastures in period 1 but in period 2, milk production on Ubon paspalum pastures was 9 and 22% higher respectively, compared to milk production from signal and Jarra digit pastures.

Table 1 Effect of grazing 3 pasture grasses on milk yield and milk quality (Trial 1).

Period 1 (November 18, 2002 - January 6, 2003)						
Treatment	Milk yield (kg/cow/day)	Milk yield (kg/rai/week)	Milk fat (%)	Milk protein (%)	Milk lactose (%)	Milk SNF (%)
Ubon paspalum	15.75 c	66	4.41 a	2.84 b	4.92 a	8.50 a
Signal	17.60 a	74	4.27 ab	2.99 a	4.74 b	8.52 a
Jarra digit	16.34 b	66	4.20 b	2.82 b	4.89 a	8.45 a
Period 2 (January 13, 2003 - March 3, 2003)						
Ubon paspalum	15.80 a	66	4.25 a	2.97 c	4.89 a	8.57 a
Signal	14.37 b	60	4.24 a	3.06 a	4.75 b	8.55 a
Jarra digit	14.17 b	54	4.17 a	3.01 b	4.87 a	8.62 a

In a column, means followed by a common letter are not significantly different at the 5% level by Duncan's Multiple Range Test.

In both periods, Jarra digit produced significantly lower pasture dry matter yields than the other 2 species. Crude protein levels in Jarra digit were double the levels in Ubon paspalum (Table 2) and levels in signal grass were intermediate between the 2 species. Ubon paspalum produced significantly higher leaf:stem ratios than the other 2 species in both periods.

High milk production yields from cows grazing signal grass in period 1 were probably due to the higher crude protein yields in the pastures. However, in period 2, despite producing higher crude protein yields, milk production from signal grass was not as high as Ubon paspalum. Ubon paspalum pastures are very leafy (>80%) and even though crude protein levels are low, the high proportion of leaf results in high digestibility. Ubon paspalum compensates for low crude protein levels by producing high yields of digestible leaf. This is in contrast to Jarra digit, which even though produced very high crude protein levels in both stems and leaves, produced significantly lower dry matter yields. Cows grazing Jarra digit had to be rotated every 2-3 days.

Table 2 Dry matter yields, proportions of stem and leaf and crude protein yields in 3 pasture species prior to being grazed by dairy cows (Trial 1).

Period 1 (November 18, 2002 - January 6, 2003)						
Treatment	Total dry matter yield (kg/ha)	% stem fresh weight	% leaf fresh weight	CP % stem	CP % leaf	CP yield (kg/ha)
Ubon paspalum	3628 a	18 c	82 a	5.9 c	10.4 c	345 a
Signal	2970 a	42 a	58 c	9.4 b	15.0 b	375 a
Jarra digit	1608 b	34 b	66 b	12.9 a	18.4 a	268 b
Period 2 (January 13, 2003 - March 3, 2003)						
Ubon paspalum	2268 a	17 c	83 a	3.9 c	8.2 c	175 b
Signal	2114 a	40 a	60 c	7.5 b	12.7 b	224 a
Jarra digit	1170 b	31 b	69 b	10.3 a	16.4 a	170 b

In a column, means followed by a common letter are not significantly different at the 5% level by Duncan's Multiple Range Test.



Plate 1 Dairy cows grazing Jarra digit (foreground) and signal grass (background) at Ubon Ratchathani University (Trial 1).

Trial 2 Milk yields per cow were 7% higher from cows grazing signal only compared to cows on signal plus Ubon stylo (Table 3). However, the grass and legume treatment had a higher stocking rate (1.33 vs 1.96 rai/cow) and milk yield/rai/week was 38% higher on the grass + legume pastures compared to grass only pastures. This trial was a preliminary trial to study the effects of grazing grass and legume pastures on dairy cow milk production. More detailed research was undertaken in Trials 3 & 4.

Table 3 Effect of grazing signal grass and signal grass plus Ubon stylo on milk yield and milk quality (Trial 2).

Treatment	Milk yield (kg/cow/day)	Milk yield (kg/rai/week)	Milk fat (%)	Milk protein (%)	Milk lactose (%)	Milk SNF (%)
Signal grass	13.67	48.65	4.00	3.12	4.80	8.65
Signal + Ubon stylo	12.79	67.15	4.14	2.97	4.72	8.44

Trial 3 There were no significant differences in milk production between the 3 treatments (Table 4). There was no advantage in terms of total milk production in providing cows with concentrate. Milk lactose and SNF were 7 and 6% higher, respectively, in the milk produced from cows grazing signal and stylo and receiving concentrate compared to cows grazing signal and stylo with no concentrate. However, there were no significant differences in milk fat and protein among the 3 treatments.

Table 4 Effect of 3 grazing treatments on milk yield and milk quality (Trial 3).

Treatment	Milk yield (kg/cow/day)	Milk yield (kg/rai/week)	Milk fat (%)	Milk protein (%)	Milk lactose (%)	Milk SNF (%)
Signal + conc.	16.3 a	75.9	4.34 a	2.77 a	5.05 ab	8.52 ab
Signal + stylo	16.2 a	75.3	4.15 a	2.64 a	4.83 b	8.19 b
Signal + stylo + conc.	15.8 a	73.6	4.22 a	2.81 a	5.16 a	8.68 a

In a column, means followed by a common letter are not significantly different at the 5% level by Duncan's Multiple Range Test.

Dry matter in the signal grass fields before each grazing averaged 2384 kg/ha with a leaf:stem ratio of 46:54. Ubon stylo fields averaged 1990 kg/ha DM before each grazing.

Trial 4 There were no significant differences in milk production and milk quality between the 2 treatments (Table 5). There was no advantage in terms of milk production and milk quality in feeding cows with concentrate.

Dry matter in the signal grass fields before each grazing, from October to December, averaged 1389 kg/ha with a leaf:stem ratio of 43:57. Ubon stylo fields averaged 2518 kg/ha DM before each grazing during the same period.

Data from Trial 3 and Trial 4 shows that for medium-producing cows in Thailand, it is not necessary to supplement concentrates if good grass and legume pastures are available.

Table 5 Effect of 2 grazing treatments on milk yield and milk quality (Trial 4).

Treatment	Milk yield (kg/cow/day)	Milk yield (kg/rai/week)	Milk fat (%)	Milk protein (%)	Milk lactose (%)	Milk SNF (%)
Signal + conc.	13.3	69.6	4.7	3.0	4.9	8.5
Signal + stylo	12.9	67.6	4.8	3.0	4.8	8.5
F test	ns	ns	ns	ns	ns	ns

Trial 5 The results found that body weight of cows that received concentrate did not change while the cows received legume silage lost 8 kg of body weight which equivalent to 0.11 kg/d (Table 6). However, when consideration for body condition score is taken into account (BCS), they got 3 in both groups (8 points system), which is rather lean.

Milk yields were similar in both groups (11-12 kg/h/d, Table 3). Milk fat and protein were similar but milk lactose and solid-not fat of cows that received legume silage were slightly lower than cows that received concentrate.

Ubon paspalum pasture produced 261 kg/rai/ from 1 grazing cycle. Leaf : Stem ratio was 34:66. The amount of supplemented feed intake was 3.0 kg for concentrate and 2.7 kg DM for legume silage.

Table 6 Average body weight change, milk yield and milk constituents of dairy cows received concentrated feed and legume silage supplementation.

	T 1		T 2	
	Concentrate		Legume silage	
Parameters	Mean	± SD	Mean	± SD
Body weight change				
Initial weight, kg	458	32	490	27
Final weight, kg	458	32	482	24
Average daily gain, kg	0		0.11	
Body condition score	3		3	
Milk yield and milk constituents				
Milk yield, kg/d	11.95	1.93	11.17	2.61
Fat corrected milk, kg/d	12.40	2.26	11.47	1.62
% Fat	4.23	0.53	4.30	0.80
% Protein	2.84	0.12	2.86	0.43
% Lactose	4.80	0.36	4.60	0.34
% Solid not fat	8.37	0.26	8.21	0.56

Conclusion

In Trial 1, the project has demonstrated that it is possible to successfully graze dairy cows on pastures day and night in Thailand. Signal grass and Ubon paspalum are both suitable grass species for dairy production. Ubon paspalum does have low quality forage but makes up for this by producing high dry matter yields and a high leaf:stem ratio which is very digestible. Signal grass maintains good quality and produces high crude protein yields all year round. Even though Jarra digit is a very high quality grass, low dry matter production lowers milk production per rai.

Full details of Trials 3 & 4 were published in the attached paper in the appendix.

Thummasaeng, K., Hare, M. and Tasapong, P. 2004 A study on dairy cows grazing signal grass pasture, with or without legume and concentrate feed supplementation. *Proceedings of the 3rd Southern Animal Science Conference, Prince of Songkhla University, Thailand.* 85-93.

In Trials 3 & 4, the project showed that it is possible to successfully graze dairy cows on grass and legume pastures in Thailand, all day and all night, without concentrate, in both the wet and dry seasons. If farmers have well-fertilised grass and legume pastures it is not necessary to supply medium-producing cows with concentrate in Thailand. However, irrigation is necessary in the dry season to keep forages green and leafy.

Legume silage can replace concentrate feeds without any significant effect on milk production



Plate 2 Dairy cows grazing Ubon stylo pastures at Ubon Ratchathani University (Trial 3).

4.2 Village dairy farmer forage system projects

Project 1 The objective of this project was to improve forage production of interested dairy farmers in two cooperatives, **Baan Kaset Pattana Cooperative, Ubon Ratchathani** and **Nong Hai Dairy Cooperative, Sisaket**.

In March, 2003, a one day training seminar on forage production for these farmers was held at Ubon Ratchathani University. During the wet season, May-October, 2003, the farmers purchased forage seed and established pastures. They were visited every 3 weeks during the wet season.

Baan Kaset Pattana Cooperative, Ubon Ratchathani

At the end of the 2003 wet season the number of dairy cattle and pasture area of the farmers participating in the project were recorded. (Tables 7 & 8).

Most of farmers were taking care of their pastures and animals well, except one farmer (Mr Khai) who does not properly manage his pastures. The pastures are over utilized (cut too frequently and without fertiliser) and consequently his cows are in poor condition. The 7 farmers have 46 dairy cows, but approximately 30% are dry so that only 33 cows are currently being milked. The average milk yield is 10 kg/head/day, which is similar to the national Thailand average.

Table 7 Number of dairy cattle and milk yield at Kaset Pattana village, Ubon Ratchathani.

Farmer	No. of cattle			Total milk yield kg/day	Remarks
	Cow	Heifer	Calf		
1. Mr. Khai	4	-	3	40	Lean
2. Mr. Cheusak	6	3	5	40	Good condition
3. Mr. Pravej	8	-	3	65	Good condition
4. Mr. Utid	9	-	3	45	Good condition
5. Mr. Wichein	6	-	2	50	Good condition
6. Mrs. Wilaiwan	9	-	5	45	Good condition
7. Mr. Sawat	4	1	2	45	Good condition
Total	46	4	23	330	

Table 8 Pasture species and area grown by farmers at Kaset Pattana village, Ubon Ratchathani.

Farmer	Ubon paspalum	Signal	Ruzi	Purple guinea	Stylo	Remark
1. Mr. Khai	2	-	1	1	-	Poor
2. Mr. Cheusak	4	1	-	3	-	Good
3. Mr. Pravej*	-	-	2	6	1	Good
4. Mr. Utid	1	1	1	6	-	Good
5. Mr. Wichein*	1	-	2	6	-	Good
6. Mrs. Wilaiwan	9	-	-	-	1	Good
7. Mr. Sawat	-	-	-	4	-	Good
Total	17	2	6	26	2	

* Two farmers grew small areas of Mulato (100 m² each)

However, this group of farmers had a major problem of selling milk in 2003. The cooperative was paying them very late and only paying them part payments. After 4-6 months they still had not received the full price for their milk. The farmers did not have enough cash flow to buy concentrated feed for feeding supplementation to their cows. The result was that the cows did not produce milk as high as their potential.

The late payments got worse in 2004 and as such, most have the farmers were discouraged from improving their pastures. By the middle of 2004, most of the farmers had given up dairy farming and had sold their cows.

The project could not continue with working on pasture management with these farmers as they were no longer dairy farming and therefore this programme stopped in 2004.

Nong Hai Dairy Cooperative, Sisaket

Each farmer in the cooperative owns 8-12 dairy cows but only grow 1-3 rai of pasture per farm and as such do not produce enough fresh grass. Rice straw is the main source of roughage all year round, with a high proportion of concentrate used (1 kg concentrate to 1 kg milk). This is 4 times the amount we currently use with the project cows at the university (4:1). The price of concentrated feed is 6-8 baht/kg, depending on crude protein content. Farmers spent a lot of money to buy concentrated feed.

The project tried to convince the farmers to increase the use of good quality forages instead of using rice straw, in order to lower the amount of concentrate used and lower milk production costs. Farmers can either increase their own pasture area or set up a group of neighboring pasture producing farmers to supply fresh grass for them. Farmers seem to agree with these approaches but none of them are responding. They told us that they have not enough land to grow more pasture and could not find pasture producing farmers to join their business.

The project was unable to make any progress in improving pastures in 2002 and 2003 and consequently the programme with the Sisaket farmers stopped in 2004.

Project 2 The objective of this project was to improve forage production of interested dairy farmers in one dairy cooperative, **Trakarn-Kudkhaopun Cooperative, Ubon Ratchathani**, by workshops and practical training. Three workshops and practical were held with the detail as follows:

1 May 14, 2004. A workshop was held at Trakarn-Kudkhaopun Cooperative for forage producing farmers. Twenty farmers attended the workshop. The topics were as follows;

Time	Contents/Activities	Lecturer
08.30 – 09.00	Registration.	
09.00 – 11.00	Background and objectives of the project. The importance of forage for dairy farming	Dr. Kungwan
11.00 – 12.00	The establishment and management of forage crops.	Mr. Prapon
13.00 - 16.00	Practical field work on sowing seed.	Mr. Kittipat Miss Puan Miss Areerat



Plate 3 Farmers attending practical training in pasture seed establishment

2 June 12, 2004. A workshop was held at Trakarn-Kudkhaopun Vocational College for dairy farmers. Twenty six farmers attended the workshop. The topics were as follows;

Time	Contents/Activities	Lecturer
08.30 – 09.00	Registration.	
09.00 – 11.00	Feeding management for dairy cows.	Dr. Kungwan
11.00 – 12.00	Dairy cow diseases and farm sanitation.	Dr. Somchai
13.00 - 16.00	Practical field work on body condition scoring and inspection of animal health.	Dr. Kungwan Dr. Somchai Mr. Kittipat

3 August 28, 2004. A workshop was held at Ubon Ratchathani University for dairy farmers. Thirty two farmers attended the workshop. The topics were as follows;

Time	Contents/Activities	Lecturer
08.30 – 09.00	Registration.	
09.00 – 10.00	Feeding management for dairy cows.	Dr. Kungwan
10.00 – 11.00	Herd health management.	Dr. Somchai
11.00-12.00	The problems of cow fertility and how to deal with this problem.	Dr. Narintorn
13.00 - 16.00	Practical field work and a study tour on field and laboratory facilities.	Dr. Kungwan Miss Puan

During the 2004 wet season, the farmers belonging to the **Trakarn-Kudkhaopun Cooperative** were visited regularly and interviewed about their dairy cow and forage management.

Many farmers were not successful in establishing good pastures. They sowed their pastures very late in the season because they could hire tractors to plough the land. These tractors were too busy ploughing land for rice planting. By the time the seed was sown it was late July-early August, the period of heavy rainfall. A combination of poor land preparation, weeds and waterlogging resulted in very poor seed germination and establishment. Subsequently most of the pasture fields got smothered in weeds. The farmers also refused to apply fertilizer and so the establishing pasture plants were very unhealthy.

Even after receiving training, the dairy farmers at the **Trakarn-Kudkhaopun Cooperative** were not able to plant good pastures. In 2005 they were not interested in getting any advice from our project. This group of farmers also faced the same problem of milk marketing as the farmers in the Baan Kaset Pattana Cooperative. The problem of selling their milk discouraged the farmers and they lost money in their dairy cow business.

Most of these farmers have stopped milking cows and sold their cows to try and reduce their debt with the banks.

Conclusion The village dairy farmer forage system projects were not successful, with nearly all farmers in the three cooperatives failing to grow good pastures.

4.3 *Brachiaria* evaluation

4.3.1 Trial 1 *Brachiaria* species in northeast Thailand: dry matter yields and seed production.

Full details of this research are in the attached published paper in the appendix.

Hare, M.D., Tatsapong, P., Lunpha, A. and Wongpichet, K. 2005 *Brachiaria* species in north-east Thailand: dry matter yields and seed production. *Tropical Grasslands*, 39: 99-106.

Methods

Two field experiments were conducted in from 2001-2003 on the university farm to compare dry matter yields and seed production of *Brachiaria ruziziensis* (ruzi grass; common Thailand type), *B. decumbens* (common signal grass cv. Basilisk), *B. decumbens* (CIAT 26297), *B. brizantha* cv. Marandu (CIAT 6780) and *B. brizantha* (CIAT 6387).

Results

Marandu, Basilisk and CIAT 6387 produced 50%, 46% and 43%, respectively, more dry matter than ruzi grass over 3 dry seasons. In addition, during the research period (2000-2002), Marandu and CIAT 6387 produced in excess of 30% more leaf dry matter than ruzi grass. CIAT 26297 produced similar dry matter yields to ruzi grass but produced the highest leaf crude protein concentrations of all the trial cultivars.

Basilisk produced the greatest number of inflorescences in 2001 followed by CIAT 6387 and ruzi grass, while in 2002, ruzi grass produced 76% and 150% more inflorescences, respectively, than Basilisk and CIAT 6387. Both Marandu and CIAT 26297 produced very few inflorescences in either year. Ruzi grass produced 30 and 80 kg/ha in the two years, while the other species produced negligible amounts of seed.

The failure of Basilisk in particular to produce adequate quantities of good seed was attributed primarily to failure of either or both seed set and caryopsis maturation.

4.3.2 Trial 2 *Brachiaria* evaluation

Objective

The hypothesis of this research is that there are more productive grasses than the main commonly grown grasses in Thailand. The objective of the research was to compare wet and dry season forage production of new grass species with the 3 main species currently grown in Thailand, ruzi, Purple guinea and Ubon paspalum.

Methods

The trial was planted on May 12, 2003. Seven grasses (Ruzi, signal, Marandu brizantha, Mulato hybrid brachiaria, Toledo brizantha, Ubon paspalum and Purple guinea) were planted in a RCBD with 5 replications. Ruzi, Ubon paspalum and Purple guinea were sown by seed and signal, Marandu, Mulato and Toledo planted with tillers.

Details of field crop management are in Table 9.

At each sampling cut, the forage was cut 5 cm from ground level, weighed fresh, and a 300 gram subsample sorted into leaves and stems and dried at 70C for 48 hours to determine dry weight. The subsample was analysed for crude protein, ADF and NDF levels. After each sampling cut, the remaining herbage in the plots were also cut to 5 cm from ground level and removed.

Table 9 Details of field crop management of *Brachiaria* evaluation trial.

Field cultivation	Ploughing x 2, discing x 1, harrowing x 1
Plot size	8 x 5 m
Sowing date	May 12, 2003
No. of sampling cut quadrats/plot	Six x 0.25m ²
Sampling cuts	
First wet season	Jul. 21, Sep. 9 & Oct. 30, 2003
First dry season	Jan. 8 & Apr. 26, 2004
Second wet season	Jun. 9, Aug. 3, Sep. 15 & Oct. 28, 2004
Second dry season	Apr. 25, 2005
Third wet season	Jun. 9, Jul. 25, Sep. 16 & Oct 31 ,2005
Fertiliser	
At sowing	200 kg/ha (32 kg/rai) NPK (15:15:15)
After every second cut	200 kg/ha (32 kg/rai) NPK (15:15:15)
	2003 Jul. 21 & Oct. 30
	2004 Apr. 26, Aug. 3 & Oct. 28
	2005 Apr. 25, Jul 25 & Oct 31

Results

In the first wet season, Toledo produced significantly more total dry matter than the other grass species, and, in particular, 70%, 90% and 173% more total dry matter, respectively, than ruzi, Ubon paspalum and Purple guinea (Table 10). Mulato produced 30%, 48% and 111% more total dry matter respectively than ruzi, Ubon paspalum and Purple guinea in the first wet season.

In the first dry season, Toledo, Mulato and Marandu, produced approximately twice the total dry matter produced by ruzi, Ubon paspalum and Purple guinea (Table 10).

There were no significant differences in total dry matter in the second wet season. In the second dry season, Mulato produced 3 times the amount of total dry matter than ruzi.

In the third wet season, Toledo produced significantly more total dry matter than all other species except for Purple guinea (Table 10). Ubon paspalum produced significantly less total and stem dry matter than all other species in the third wet season.

Ruzi produced the lowest amount of leaf matter compared to other species in all seasons except in the third wet season where Ubon paspalum produced similar leaf dry matter to ruzi (Table 11). Toledo and Mulato produced more leaf dry matter than ruzi, signal and purple guinea in the first wet and dry seasons. In the second wet season, Purple guinea, Ubon paspalum and Toledo produced significantly more leaf dry matter than ruzi. In the second dry season, leaf dry matter of ruzi was significantly less than Mulato, Marandu, Toledo and Purple guinea. Toledo and Purple guinea produced significantly more leaf dry matter than other species in the third wet season.

Ubon paspalum and Purple guinea produced significantly less stem dry matter than all the *Brachiaria* species in the first wet season and dry seasons and, except for Marandu, also in the second wet season (Table 12). In the second dry season, all species had similar amounts of stem dry matter.

Table 10 Total dry matter of 7 grass species.

Species	Total dry matter				
	Wet season 2003	Dry season 2003-2004	Wet season 2004	Dry season 2004-2005	Wet season 2005
	(kg/ha)				
Ruzi	8883	1104	7899	409	7925
Signal	9279	1859	8339	817	9882
Marandu	9873	2302	8741	990	9080
Mulato	11671	2558	9488	1235	9363
Toledo	15105	2657	11041	834	12543
Ubon paspalum	7875	1649	9099	689	5049
Purple guinea	5527	1255	10419	803	11250
LSD (P<0.05)	2431	732	ns	538	2032

Table 11 Leaf dry matter of 7 grass species.

Species	Leaf dry matter				
	Wet season 2003	Dry season 2003-2004	Wet season 2004	Dry season 2004-2005	Wet season 2005
	(kg/ha)				
Ruzi	4455	940	4550	319	4184
Signal	4241	1421	4865	616	5382
Marandu	5627	1812	5855	840	6136
Mulato	6304	2011	6243	945	5850
Toledo	8779	2065	7592	730	8297
Ubon paspalum	6091	1477	7084	595	3600
Purple guinea	4181	1131	7969	703	8221
LSD (P<0.05)	1415	571	1825	348	1197

Table 12 Stem dry matter of 7 grass species.

Species	Stem dry matter				
	Wet season 2003	Dry season 2003-2004	Wet season 2004	Dry season 2004-2005	Wet season 2005
	(kg/ha)				
Ruzi	4428	164	3349	90	3741
Signal	5038	438	3474	201	4500
Marandu	4246	490	2886	150	2944
Mulato	5367	547	3245	290	3513
Toledo	6326	592	3449	104	4246
Ubon paspalum	1784	172	2015	94	1449
Purple guinea	1346	124	2450	100	3029
LSD (P<0.05)	1365	224	708	ns	936

Ruzi had the highest leaf crude protein concentrations of all the species in the first three seasons, being significantly higher than all other species in the first dry and second wet season (Table 13). Throughout the trial, Ubon paspalum had significantly lower leaf crude protein concentrations than all the other species. Mulato and signal produced the highest stem crude protein concentrations in the first wet season (Table 13). In the following seasons, stem crude protein concentrations were similar for all

species, except for Ubon paspalum, which had significantly lower concentrations of stem crude protein than the other species.

Ruzi had significantly lower ADF and NDF concentrations than other species in the first three seasons (Tables 14 and 15). In the second dry season, ADF concentrations in ruzi, Ubon paspalum and Purple guinea were significantly higher than in other species.

Table 13 Crude protein concentrations in leaf (L) and stem (S) of 7 grass species.

Species	Crude protein									
	Wet season 2003		Dry season 2003-2004		Wet season 2004		Dry season 2004-2005		Wet season 2005	
	L	S	L	S	L	S	L	S	L	S
	(%)									
Ruzi	11.2	6.7	15.3	7.7	11.3	7.6	10.7	7.0	12.3	6.8
Signal	10.5	8.9	12.9	7.7	9.9	6.9	9.9	7.3	9.5	5.4
Marandu	11.7	7.8	11.7	7.8	9.3	6.6	11.1	7.5	9.1	5.5
Mulato	10.6	8.3	10.8	7.7	9.3	6.2	9.8	7.6	11.5	6.4
Toledo	9.9	6.9	12.6	7.8	9.1	6.0	11.6	8.9	8.9	5.2
Ubon paspalum	8.5	5.6	7.3	4.6	8.0	4.9	5.8	5.0	8.7	5.7
Purple guinea	9.4	6.8	12.5	8.4	9.5	5.4	11.8	8.7	10.0	5.4
LSD (P<0.05)	1.3	1.5	2.1	1.6	0.9	0.8	1.8	1.6	ns	ns

Table 14 Acid detergent fibre (ADF) concentrations in leaf (L) and stem (S) of 7 grass species.

Species	ADF									
	Wet season 2003		Dry season 2003-2004		Wet season 2004		Dry season 2004-2005		Wet season 2005	
	L	S	L	S	L	S	L	S	L	S
	(%)									
Ruzi	28.7	38.4	26.3	33.4	29.5	35.8	38.1	45.3	29.2	37.6
Signal	29.4	37.1	28.5	36.4	30.8	38.5	34.8	40.8	30.6	44.5
Marandu	31.0	37.4	31.2	36.1	32.5	36.8	34.7	40.0	32.7	37.4
Mulato	30.9	38.2	28.8	33.5	32.2	37.4	32.9	38.1	32.7	36.9
Toledo	34.2	39.0	32.0	37.2	35.0	38.6	35.7	39.8	35.4	40.2
Ubon paspalum	36.6	38.3	35.3	32.0	38.4	37.9	45.5	44.0	35.4	36.5
Purple guinea	38.0	41.2	35.6	39.5	40.1	43.7	41.2	46.6	38.8	43.2
LSD (P<0.05)	1.3	1.6	1.3	2.3	1.5	1.3	3.3	2.9	0.7	1.4

Conclusion

In general, new brachiaria species, Toledo, signal, Marandu and Mulato, were more productive than ruzi, particularly in the dry season. Wet season production of ruzi was similar to these species in the first two wet seasons but by the third wet season ruzi dry matter production was lower than these new brachiaria species. Ubon paspalum was found to be not suitable for growing on upland dry soils. It is more suited to low-lying wet soils. Production of Purple guinea was similar to the new brachiaria species and better than ruzi in the second and third years.

These trials have found that for long-term perennial pastures in Thailand on upland soils, ruzi is not as productive as new brachiaria species and Purple guinea.

Table 15 Neutral detergent fibre (NDF) concentrations in leaf (L) and stem (S) of 7 grass species.

Species	NDF									
	Wet season 2003		Dry season 2003-2004		Wet season 2004		Dry season 2004-2005		Wet season 2005	
	L	S	L	S	L	S	L	S	L	S
	(%)									
Ruzi	55.8	67.3	53.4	64.3	60.2	67.5	59.6	68.6	56.8	67.1
Signal	57.1	64.6	57.4	67.6	63.6	67.6	60.8	69.4	60.6	75.0
Marandu	61.1	68.0	62.0	68.5	67.0	69.1	61.1	68.7	61.5	68.5
Mulato	57.2	65.7	55.9	64.6	64.0	68.1	58.4	64.2	60.5	64.8
Toledo	63.3	66.7	61.1	66.9	65.4	67.2	61.2	66.4	63.4	69.8
Ubon paspalum	64.0	68.6	62.3	63.2	65.5	68.0	68.6	71.1	63.4	69.0
Purple guinea	65.3	70.6	65.3	69.1	66.7	69.7	64.7	67.6	67.2	73.0
LSD (P<0.05)	1.4	2.1	2.3	2.0	1.6	1.1	2.1	1.7	1.1	1.0

4.3.2 Trial 3 Hybrid Brachiaria evaluation with other Brachiaria cultivars

Objective

The hypothesis of this research is that new hybrid brachiaria cultivars are more productive grasses than other commercial cultivars of Brachiaria, in particular ruzi, the most commonly grown forage grass in Thailand. In order to prove the hypothesis, the objective of this trial was to compare the forage growth and quality of two hybrid Brachiaria cultivars (Mulato and Mulato II) with other commercial cultivars of Brachiaria.

Methods

The trial was planted at 2 sites; Ubon Ratchathani University (UBU) (May 10, 2004) and the Land Development Centre (LDC) (May 11, 2004), which was 10 km from the university on the road to Amphur Phibun. At both sites, 6 grasses (Mulato, Mulato II, signal, Marandu, Toledo and ruzi) were planted in a RCBD with 5 replications. Details of field crop management are in Table 16.

Table 16 Details of field crop management of the hybrid Brachiaria evaluation trial.

Field cultivation	Ploughing x 2, discing x 1, harrowing x 1
Plot size	5 x 5 m
Sowing date	May 10, 2004 UBU. May 11, 2004 LDC
Sowing method	By seed
Establishment plant counts	4 weeks after seed sowing; 4 x 0.25m ² quadrats/ plot
Sampling cuts	Six x 0.25m ² quadrats/plot
First wet season	UBU Jul. 12, Aug. 25, Oct. 11, 2004 LDC Jul. 13, Aug. 26, Oct. 12, 2004
First dry season	UBU Apr. 26, 2005; LDC Apr. 28, 2005
Second wet season	UBU Jun. 13, Jul. 29, Aug. 14, Oct. 26, 2005 LDC Jun 10, Jul. 28, Aug. 15, Oct. 27, 2005
Fertiliser	
At sowing	200 kg/ha (32 kg/rai) NPK (15:15:15)
After every sampling cut	200 kg/ha (32 kg/rai) NPK (15:15:15)

All cultivars were sown at a seeding rate of 10 kg/ha adjusted to 100% germination. The seeds were tested for germination immediately before sowing (Table 17).

Table 17 Germination % and seed sowing rate of *Brachiaria* cultivars

Cultivar	Germination %	Sowing rate (kg/ha)
Mulato	34	29.4
Mulato II	26	38.5
Signal	15	66.6
Marandu	71	14.1
Toledo	72	13.9
Ruzi	60	16.7

At each sampling cut, the forage was cut 5 cm from ground level, weighed fresh, and a 300 gram subsample sorted into leaves and stems and dried at 70°C for 48 hours to determine dry weight. The subsample was analysed for crude protein, ADF and NDF levels. After each sampling cut, the remaining herbage in the plots were also cut to 5 cm from ground level and removed.



Plate 4 Harvesting brachiaria species at the Land Development Centre trial site.

Results

Plant populations at 4 weeks after sowing varied significantly, with signal having the highest plant density and Mulato the lowest (Table 18). Mulato II had significantly higher plant density than Mulato at both sites. All cultivars had higher plant populations at the LDC site than at the UBU site.

Table 18 Plant populations of 6 *Brachiaria* cultivars 4 weeks after sowing.

Cultivar	Plants/m ²	
	UBU	LDC
Mulato	25.2	67.6
Mulato II	118.8	221.0
Signal	268.0	285.0
Marandu	88.8	99.8
Toledo	67.6	102.8
Ruzi	88.6	149.4
LSD (P<0.05)	48.1	55.5

In the first wet season of establishment at UBU, both Mulato and Mulato II produced significantly less total dry matter than signal, ruzi and Toledo and in the second wet season, Toledo produced significantly more total dry matter than all the other species which produced similar yields (Table 19). At LDC there were no significant differences in total dry matter production between all *Brachiaria* cultivars in the first and second wet seasons.

In the first dry season at both sites, Mulato produced significantly more total dry matter in the dry season than all the other *brachiaria* cultivars (Table 19). Ruzi grass had significantly less total dry matter than all the other cultivars in the first dry season.

In the both wet seasons, Toledo produced more leaf dry matter than the other cultivars at UBU (Table 20). At LDC in the first wet season, Toledo and Mulato II produced more leaf dry matter than ruzi and in the second wet season all species, except signal, produced more leaf dry matter than ruzi. In the first dry season, Mulato produced significantly more leaf dry matter at both sites than all the other *brachiaria* cultivars (Table 20). Ruzi had significantly less leaf than all the other cultivars in the first dry season at both sites.

Ruzi and signal produced significantly higher stem yields than the other cultivars at UBU and Mulato II, Marandu and Toledo at LDC in the first wet season (Table 21). In the first dry season, Mulato and signal produced more stem dry matter than other cultivars at UBU and Mulato produced more stem dry matter than other cultivars at LDC. In the second wet season, there were no significant differences in stem dry matter between species at both sites.

Table 19 Total dry matter production of 6 *Brachiaria* cultivars

Cultivar	Total dry matter					
	UBU			LDC		
	Wet 2004	Dry 2004-05	Wet 2005	Wet 2004	Dry 2004-05	Wet 2005
	(kg /ha)					
Mulato	7445	1219	13648	9947	1539	9543
Mulato II	8601	828	11605	9041	673	9667
Signal	10161	806	11198	10437	544	8605
Marandu	8966	775	10233	9131	658	9950
Toledo	11212	750	23083	9990	701	9263
Ruzi	11021	336	11907	10529	322	7237
LSD (P<0.05)	1474	206	9031	ns	203	ns

Table 20 Leaf production of 6 *Brachiaria* cultivars

Cultivar	Leaf dry matter(kg/ha)					
	UBU			LDC		
	Wet 2004	Dry 2004-05	Wet 2005	Wet 2004	Dry 2004-05	Wet 2005
	(kg /ha)					
Mulato	4241	1004	8533	5791	1268	6252
Mulato II	6009	692	7978	6352	581	6936
Signal	5092	581	6188	5540	389	5013
Marandu	5520	621	6360	5709	546	6614
Toledo	7691	616	10558	6617	584	6294
Ruzi	5417	243	6160	5059	252	3894
LSD (P<0.05)	797	155	707	884	159	1538

Table 21 Stem dry matter production of 6 *Brachiaria* cultivars

Cultivar	Stem dry matter					
	UBU			LDC		
	Wet 2004	Dry 2004-05	Wet 2005	Wet 2004	Dry 2004-05	Wet 2005
	(kg /ha)					
Mulato	3214	215	5116	4156	271	3291
Mulato II	2592	136	3627	2689	92	2731
Signal	5069	225	5010	4897	155	3592
Marandu	3446	154	3873	3422	112	3336
Toledo	3521	134	12524	3373	117	2970
Ruzi	5604	92	5746	5470	70	3342
LSD (P<0.05)	705	77	ns	1102	60	ns

In the first wet season at both sites, Mulato had significantly higher leaf and stem crude protein concentrations than the other cultivars (Table 22). In the first dry season, leaf crude protein concentrations of ruzi at UBU were significantly higher than other cultivars but at LDC, Toledo had higher leaf crude protein concentrations than ruzi. Signal had significantly lower leaf crude protein concentrations than other cultivars during the first dry season at LDC (Table 22). Stem crude protein concentrations during the first dry season were similar for all cultivars at UBU but at LDC, stem crude protein concentrations of Mulato were significantly higher than concentrations in signal and ruzi.

Toledo had significantly higher leaf ADF concentrations than the other cultivars in the first wet season at both sites (Table 23). In the first wet season, stem ADF concentrations in Mulato and Mulato II were significantly lower than other cultivars at UBU and lower than Toledo and ruzi at LDC. In the first dry season, leaf ADF concentrations were similar for all cultivars at UBU, however, at LDC, leaf ADF concentrations in Mulato were similar to Mulato II but significantly lower than the other cultivars.

Leaf NDF concentrations of Mulato in the first wet season were significantly lower than concentrations in signal, Marandu and Toledo but similar to concentrations in Mulato II and ruzi at both sites (Table 24). Mulato and Mulato II leaf NDF concentrations in the dry season were significantly lower than other species at LDC but at UBU concentrations were similar for all species except for ruzi which had

significantly lower leaf NDF concentrations (Table 24). Stem NDF concentrations of Mulato in the first wet and dry seasons were significantly lower than other cultivars at both sites (Table 24), except for Mulato II, which had similar concentrations to Mulato at UBU (wet season) and at LDC (dry season).

Table 22 Crude protein concentrations in leaf (L) and stem (S) of 6 *Brachiaria* cultivars.

Cultivar	Crude protein concentrations											
	UBU						LDC					
	Wet 2004		Dry 2004-05		Wet 2005		Wet 2004		Dry 2004-05		Wet 2005	
	L	S	L	S	L	S	L	S	L	S	L	S
	(%)											
Mulato	13.8	9.2	16.1	15.9	9.0	4.9	14.2	10.5	14.7	13.1	9.0	4.3
Mulato II	11.8	7.7	18.5	13.3	9.5	5.5	12.1	8.7	15.2	10.5	9.3	4.5
Signal	11.3	7.0	17.8	14.2	9.8	6.2	11.4	8.8	11.8	9.4	10.4	4.9
Marandu	10.1	6.4	19.3	15.6	8.8	4.8	11.4	7.9	16.0	11.3	9.3	4.8
Toledo	9.4	5.9	19.7	14.1	8.3	5.1	10.9	7.8	17.1	11.8	9.8	5.7
Ruzi	10.2	5.8	22.1	14.4	9.9	5.0	12.2	8.0	14.2	8.7	12.4	7.0
LSD (P<0.05)	1.2	0.9	2.5	ns	0.8	0.7	1.4	1.5	2.7	2.9	1.0	1.1

Table 23 Acid detergent fibre (ADF) concentrations in leaf (L) and stem (S) of 6 *Brachiaria* cultivars.

Cultivar	ADF											
	UBU						LDC					
	Wet 2004		Dry 2004-05		Wet 2005		Wet 2004		Dry 2004-05		Wet 2005	
	L	S	L	S	L	S	L	S	L	S	L	S
	(%)											
Mulato	31.7	41.8	29.7	33.7	34.5	42.3	31.2	37.6	28.5	33.1	33.2	42.5
Mulato II	32.9	41.9	29.4	35.5	32.2	41.3	32.1	39.1	29.8	34.5	32.3	40.7
Signal	31.8	46.0	28.7	33.2	30.7	43.9	30.2	39.6	31.4	37.7	30.7	44.4
Marandu	35.1	43.5	29.8	33.7	34.7	43.0	32.7	39.0	32.4	37.1	33.5	40.9
Toledo	37.8	45.2	29.3	34.3	38.6	43.9	35.2	40.5	31.3	36.9	35.3	42.2
Ruzi	32.2	43.9	28.9	35.7	31.6	43.8	30.3	41.0	31.8	40.2	29.5	40.7
LSD (P<0.05)	0.9	1.3	ns	1.3	2.2	ns	0.9	1.6	2.1	1.7	1.4	1.4

Conclusion

This research has shown that, in general, the new *brachiaria* cultivars are more productive than ruzi, particularly in the dry season. These new cultivars produced 3-4 times the amount of dry season forage than ruzi.

Table 24 Neutral detergent fibre (NDF) concentrations in leaf (L) and stem (S) of 6 *Brachiaria* cultivars.

Cultivar	NDF											
	UBU						LDC					
	Wet 2004		Dry 2004-05		Wet 2005		Wet 2004		Dry 2004-05		Wet 2005	
	L	S	L	S	L	S	L	S	L	S	L	S
	(%)											
Mulato	60.3	69.0	54.4	59.4	62.8	73.6	58.8	64.4	53.3	61.3	62.8	70.0
Mulato II	61.1	68.4	53.2	62.8	63.4	73.7	60.6	66.8	53.9	62.3	63.1	70.5
Signal	63.2	75.6	54.6	63.4	63.9	77.1	62.0	68.0	58.0	67.5	61.5	73.0
Marandu	66.3	71.8	54.8	59.7	67.3	75.7	63.4	67.6	56.3	63.8	65.7	71.2
Toledo	67.5	72.0	53.2	61.8	68.3	75.4	64.6	68.6	56.3	64.4	65.3	71.9
Ruzi	61.9	71.8	46.7	60.9	60.1	73.8	59.6	67.1	56.7	66.9	57.2	68.4
LSD (P<0.05)	2.3	1.5	1.0	1.4	1.5	0.9	2.0	2.0	2.0	1.8	1.1	1.0

4.4 *Stylosanthes* evaluation

Objective

The hypothesis of this research is that there are more productive stylo accessions than the main commonly grown hamata stylo Thailand. The objective of the research was to compare wet and dry season forage production of new stylo accessions with the main accession, hamata stylo, currently grown in Thailand.

Methods

The trial was sown at the university with five stylo accessions (Hamata, Tha Phra, Ubon, ATF 3309 and Seca) sown in a RCBD with 6 replications. Details of field managed are detailed in Table 25.

Table 25 Details of field crop management of *Stylosanthes* evaluation trial.

Field cultivation	Ploughing x 2, disking x 1, harrowing x 1
Plot size	8 x 5 m
Sowing date	May 16, 2003
Sowing method	By seed
Establishment plant counts	6 weeks after seed sowing; 4 x 0.25m ² quadrats/ plot
Sampling cuts	8 x 0.25m ² quadrats/plot
First wet season	Aug. 20 & Oct. 29, 2003
First dry season	Feb. 20 & Apr. 28, 2004
Second wet season	Jun. 28, Aug. 30 & Oct. 29, 2004
Second dry season	Mar. 4 & Apr. 25, 2005
Third wet season	Jun. 29, Aug. 29, & Oct 28, 2005
Fertiliser	
At sowing	20 kg/ha P, 50 kg/ha K, 20 kg/ha S
After cutting	20 kg/ha P, 50 kg/ha K, 20 kg/ha S
	2003 Aug. 20 & Oct. 30
	2004 Apr. 28, Aug. 30 & Oct. 29
	2005 Apr. 25 & Aug 29

The seeds were tested for germination immediately before sowing (Table 26) and all accessions were sown at a seeding rate of 10 kg/ha adjusted to 100% germination. The exception was Seca. We only had 200 grams of seed sent up from

Australia and even though the germination of this seed was very low we could not increase the sowing rate.

Table 26 Germination (%) and sowing rate (kg/ha) of 5 stylo accessions

Accessions	Germination	Sowing rate
Hamata	45	22
Tha Phra	45	22
Ubon	82	12
ATF 3309	77	13
Seca	23	5

At each sampling cut, the herbage was cut 10 cm from ground level, weighed fresh and sorted into stylo accessions and weeds. A 300 g stylo subsample was taken and dried at 70C for 48 hours to determine dry weight. The subsample was analysed for crude protein, ADF and NDF levels. After each sampling cut, the remaining herbage in the plots was also cut to 10 cm from ground level and removed.

Results

All stylo accessions, except Seca, established well, particularly Ubon, which had significantly more plants/m² than the other accessions (Table 27). The low plant numbers of Seca were a reflection of the low seed germination.

Tha Phra produced significantly more dry matter than Hamata, ATF 3309 and Seca and similar yields to Ubon stylo in the first wet season (Table 27). Weeds, mainly *Zornia spp.*, constituted 80% of the herbage in the Seca plots in the first wet season.

Dry matter yields of Tha Phra and Ubon were significantly higher than the other accessions in all the following seasons, except for ATF 3309 in the third wet season, which produced similar yields (Table 27). Seca and Hamata were the lowest producing accessions in all seasons.

Table 27 Plant counts 6 weeks after sowing and total dry matter production of 5 stylo accessions.

Accession	Plant counts	Total dry matter				
		Wet 2003	Dry 2003-04	Wet 2004	Dry 2004-05	Wet 2005
	(no/m ²)	(kg/ha)				
Hamata	253	5580	2800	8336	536.3	4280
Tha Phra	306	7746	5863	14423	3718.2	10638
Ubon	381	6993	5857	14899	3458.8	10673
ATF 3309	264	5521	4363	12692	2724.3	8963
Seca	46	1443	3293	9035	1562.3	4738
LSD (P<0.05)	62	1816	1282	1380	555.7	1896

Crude protein concentrations of Hamata were significantly higher than Ubon, ATF 3308 and Seca in the first and third wet seasons and all accessions in the second wet season (Table 28). However, in the dry season, hamata stylo crude protein concentrations were lower than the other accessions. Crude protein concentrations

were, on average, 10-20% higher in the wet season compared to concentrations in the dry season.

Hamata had significantly lower ADF concentrations in the second wet season than Tha Phra, Ubon and ATF 3308 but in the first wet season Seca ADF concentrations were significantly lower than Hamata, Ubon and Tha Phra (Table 29). In the dry season, Hamata ADF concentrations were, on average, higher than the other accessions.

Hamata NDF concentrations were significantly lower than other accessions in the wet season, except for Seca which had similar concentrations to Hamata (Table 30). ATF 3308 and Seca had significantly lower NDF concentrations than Tha Phra and Ubon in the second dry season.

Table 28 Crude protein concentrations of 5 stylo accessions.

Accession	Crude protein				
	Wet 2003	Dry 2003-04	Wet 2004	Dry 2004-05	Wet 2005
	(%)				
Hamata	20.0	12.4	20.9	12.6	22.1
Tha Phra	19.2	14.3	19.6	15.5	22.0
Ubon	18.4	14.5	19.7	16.4	20.9
ATF 3309	18.2	13.9	19.4	14.9	20.8
Seca	17.1	13.2	16.9	14.1	19.6
LSD (P<0.05)	1.2	ns	1.1	1.2	1.0

Table 29 Acid detergent fibre (ADF) concentrations of 5 stylo accessions.

Accession	ADF				
	Wet 2003	Dry 2003-04	Wet 2004	Dry 2004-05	Wet 2005
	(%)				
Hamata	34.2	45.0	30.8	44.7	31.7
Tha Phra	34.3	42.2	36.3	43.2	33.7
Ubon	33.9	41.7	35.1	41.7	35.6
ATF 3309	32.9	38.8	33.5	41.5	33.8
Seca	32.8	42.8	34.2	42.7	33.3
LSD (P<0.05)	1.0	2.5	1.8	2.4	0.8

Conclusion

The results show that Ubon and Tha Phra have far superior dry matter production than Hamata, particularly in the dry season. This is because Ubon and Tha Phra are perennials and stay green and productive throughout the year, whereas Hamata is a biennial and dries off and dies in the dry season. The forage quality of Hamata is generally better in the wet season because it has new fresh growth from new seedlings. However, in the dry season, the quality of Hamata decreases rapidly as it dries and dies in contrast to the quality of Ubon and Tha Phra which remains good.

Seca dry matter production was less than Ubon and Tha Phra dry matter production and, generally better or similar to Hamata.

Ubon and Tha Phra produce excellent quality dry matter in the dry season, which, on average is 2-3 times the production from grasses. Both these accessions should be grown more in Thailand for dry season forage.

Table 30 Neutral detergent fibre (NDF) concentrations of 5 stylo accessions.

Accession	NDF				
	Wet 2003	Dry 2003-04	Wet 2004	Dry 2004-05	Wet 2005
	(%)				
Hamata	42.0	53.8	40.9	53.3	32.5
Tha Phra	43.7	52.7	46.6	54.2	38.2
Ubon	46.6	55.0	43.4	54.1	44.2
ATF 3309	44.4	50.9	43.0	50.4	35.5
Seca	43.3	52.9	41.3	49.5	35.5
LSD (P<0.05)	1.5	ns	2.7	3.5	0.7

**Plate 5** Ubon stylo growing well in the wet season

4.5 Grass and legume silage production for smallholder dairy farmers

The following trials were part of Miss Areerat Lunpha's Masterate thesis work..

4.5.1 Trial 1. Study of forage moisture content of Ubon paspalum on silage quality.

Objective To find out the suitable moisture content of Ubon paspalum before ensiling in plastic drums.

Methods

The trial commenced on November 7, 2003 in CRD with 4 replications. The treatments were; T1) < 60, T 2) 60-68, T 3) 69-75 and T 4) > 75 % moisture contents of Ubon paspalum.

Silage samples were taken from the upper, the middle and the bottom part of the container and thoroughly mixed. Sub samples were analyzed for dry matter, crude protein, ash, neutral detergent fiber (NDF) and acid detergent fiber (ADF).

Results

The results show that moisture contents in grass before ensiling had no effect on crude protein and total ash in the silage (Table 31). Silage pH were higher in the lower moisture content grass with the similar trend of dry matter content in silage. On the other hand, the NDF and ADF were lower in the lower moisture content grass.

Table 31 pH and chemical composition in Ubon paspalum grass silage at different moisture contents in grass before ensiling.

Moisture contents before ensiling	pH	DM	CP	Total ash	NDF	ADF
----- % DM -----						
60%	5.16a	57.76a	8.46a	9.12ab	62.28bc	35.77b
65%	5.26a	54.57a	8.45a	8.23b	61.62c	35.26b
70%	4.31b	43.41b	8.42a	8.64ab	65.15ab	38.79a
>75%	4.48b	17.52c	8.03a	9.46a	67.05a	40.83a

In a column, means followed by the same letter is not significantly different at 5% by Duncan's Multiple Range Test

Conclusion

The most suitable moisture content of Ubon paspalum before ensiling should be between 69-75%. With moisture contents higher than 75%, too much dry matter was lost after ensiling.

4.5.2 Trial 2. Study of ensiling time on silage quality of Ubon paspalum.

Objective To find out the most suitable duration time for making good silage from Ubon paspalum.

Methods

The trial commenced on July 23, 2004 in CRD with 4 replications. The treatments were 1, 2, 3, 4 weeks, 3 and 6 months ensiling of Ubon paspalum.

Silage samples were taken from the upper, the middle and the bottom part of the container and thoroughly mixed. Sub samples were analyzed for dry matter, crude protein, ash, neutral detergent fiber (NDF) and acid detergent fiber (ADF).

Results

The results shown that duration of ensiling had no effect on silage pH. The 3 and 6 months storage periods, however, lowered crude protein and increased the fiber contents (Table 32).

Conclusion

The duration interval for ensiling Ubon paspalum in plastic drums should be at least 2 weeks in order for pH to become constant. After 3 months ensiling, the dry matter and crude protein of Ubon paspalum silage decreases.

Table 32 pH and chemical composition in Ubon paspalum grass silage at different ensiling times.

Time	pH	DM	CP	Total ash	NDF	ADF
----- % DM -----						
1 weeks	4.79a	20.28a	9.64ab	10.45a	63.16bc	39.37b
2 weeks	4.57ab	20.62a	10.06a	10.12a	62.06cd	38.72bc
3 weeks	4.56ab	20.96a	9.78a	8.70b	60.96d	37.90c
4 weeks	4.66ab	20.71a	9.23b	10.11a	61.39d	39.85b
3 months	4.61ab	20.47a	7.84c	8.47b	64.81a	41.42a
6 months	4.52b	19.13b	8.09c	9.26ab	63.82ab	42.48a

In a column, means followed by the same letter is not significantly different at 5% by Duncan's Multiple Range Test

4.5.3 Trial 3. Study of kind and amount of additives for making silage.

Objective To find out the type and quantity of additives to mix in grass and legume to make silage in plastic drums.

Methods

The trial commenced on July 23, 2004 in CRD with 4 replications. Plant materials were Ubon paspalum grass and the mixture of Ubon stylo and Cavalcade legume. The treatments were cassava meal or molasses were mixed with the plants at the rate of 0, 3, 6 and 9 % fresh basis.

Silage samples were taken from the upper, the middle and the bottom part of the container and thoroughly mixed. Sub samples were analyzed for dry matter, crude protein, ash, neutral detergent fiber (NDF) and acid detergent fiber (ADF).

Results

Dry matter content in Ubon paspalum grass silage increased as cassava meal and molasses were added (Table 33). Silage pH was lower when cassava meal was added, with the lowest in the 9% cassava meal silage. Molasses tended to lower pH lower than that of cassava meal. Crude protein concentrations were not affected by the addition of cassava or molasses. The addition of molasses increased total ash but lowered ADF content.

In legume silage, the addition of both additives lowered silage pH. Molasses was more effective than cassava meal (Table 34). Dry matter content increased when additives were added. Crude protein concentration did not change but NDF and ADF levels decreased. This may be because of the dilution effect rather than the fermentation effects.

Conclusion

Using cassava and molasses at any level of supplementation in grass and legume silage will improve silage quality. However, molasses at 3% supplementation tended to produce better quality silage and this level of supplementation is recommended when making silage in plastic drums.

Table 33 pH and chemical composition in Ubon paspalum grass silage at different kinds and level of silage additive.

Additives	pH	DM	CP	Total ash	NDF	ADF
----- % DM-----						
0%	4.48a	17.72c	10.09a	9.45bc	60.37a	38.62a
Cassava 3%	4.22b	19.50b	10.18a	8.80bc	60.87a	35.97b
6%	4.20b	20.79b	9.64a	9.44bc	57.83a	33.58c
9%	3.99c	24.05a	8.17b	7.65c	50.24b	29.92d
Molasses 3%	3.91cd	19.44b	10.50a	14.12a	54.92ab	38.99a
6%	3.81d	20.42b	9.58a	11.10b	55.27ab	35.05bc
9%	3.75d	19.65b	10.78a	10.51b	57.16a	34.33bc

In a column, means followed by the same letter is not significantly different at 5% by Duncan's Multiple Range Test

Table 34 pH and chemical composition in legume (Ubon stylo + Cavalcade) silage at different kinds and level of silage additives

Additives	pH	DM	CP	Total ash	NDF	ADF
----- % DM-----						
0%	4.76a	15.69d	15.31a	19.05a	51.04a	44.38a
Cassava 3%	4.25b	19.99c	14.56a	15.91c	46.28b	38.99bc
6%	4.15bc	22.14b	14.90a	13.05d	42.34b	35.80c
9%	4.11c	23.73a	14.97a	13.31d	43.02b	36.83bc
Molasses 3%	3.82d	16.91d	15.31a	18.27ab	45.62b	39.55b
6%	3.79d	19.50c	15.17a	18.22ab	45.01b	38.00bc
9%	3.79d	20.51c	14.95a	16.55bc	44.59b	36.36bc

In a column, means followed by the same letter is not significantly different at 5% by Duncan's Multiple Range Test

4.5.4 Trial 4 Study of chopped vs. unchopped grass and vacuumed vs. unvacuumed containers.

Objective To compare the effects of chopping and vacuuming on the quality of Ubon paspalum silage made in plastic drums and plastic bags.

Methods

The trial commenced on July 23, 2004 in CRD with 4 replications. Treatments were; T 1) chopped grass and air sucked, T 2) chopped grass and no air sucked, T 3) no chopped grass and air sucked and T 4) no chopped grass and no air sucked.

Silage samples were taken from the upper, the middle and the bottom part of the container and thoroughly mixed. Sub samples were analyzed for dry matter, crude protein, ash, neutral detergent fiber (NDF) and acid detergent fiber (ADF).

Results

The non chopped grass lost a significant amount of dry matter content in grass silage ensiled in the drum (Table 35) but chopping vs unchopped silage were not significantly different on other parameters.

The results found that the non chopped grass lost 5-6% dry matter content and also lower in total ash content (Table 36). Other parameters were not affected by air sucking.

Table 35 pH and chemical composition in chopped and non chopped grass silage in plastic drums.

Treatment	pH	DM	CP	Total ash	NDF	ADF
----- %DM-----						
Chopped	4.73a	22.04a	9.17a	12.06a	64.31a	42.80a
Non chopped	4.75a	16.10b	8.88a	7.84b	65.37a	42.81a

In a column, means followed by the same letter is not significantly different at 5% by Duncan's Multiple Range Test

Table 36 pH and chemical composition of the combination of chopping and air suction in plastic bag grass silage.

Treatment	pH	DM	CP	Total ash	NDF	ADF
----- % DM-----						
C & NS	4.84a	21.16a	9.32a	10.48a	66.23a	42.47b
C & S	4.86a	19.55ab	8.88a	11.48a	64.61a	44.35ab
NC & NS	4.85a	15.48b	9.04a	7.85b	66.70a	45.77a
NC & S	4.76b	16.39b	9.12a	7.56b	66.24a	43.73ab

In a column, means followed by the same letter is not significantly different at 5% by Duncan's Multiple Range Test

C = Chopped, S = Suction, NS = Non chopped, NS = Non suction

Conclusion

Chopping and vacuuming produced better quality silage than not chopping and not vacuuming.

4.5.5 Trial 5. Study of grass: legume ratio for making silage.

Objective To find out if mixing grass and legume together will improve silage quality.

Methods

The trial commenced on July 23, 2004 in CRD with 4 replications. The ratios of legume and grass were; T 1) 100:0, T 2) 75:25, T 3) 50:50, T 4) 25:75 and T 5) 0:100. Molasses was mixed to the plant at 3% fresh basis and the ensiling time was 3 weeks.

Silage samples were taken from the upper, the middle and the bottom part of the container and thoroughly mixed. Sub samples were analyzed for dry matter, crude protein, ash, neutral detergent fiber (NDF) and acid detergent fiber (ADF).

Results

Silage pH did not change as the ratio of legume and silage changed (Table 37). The concentration of dry matter, crude protein, total ash and ADF decreased as the ratio of legume decreased.

Conclusion

Dry matter and crude protein increase as the proportion of legume in grass silage increases. 50-100% legume can successfully make good silage.

Table 37 pH and chemical composition of different ratios of legume and grass silage.

Legume:Grass	pH	DM	CP	Total ash	NDF	ADF
----- % DM -----						
100:0	3.74a	33.18ab	13.77a	9.99a	57.59b	45.82a
75:25	3.91a	34.29a	13.64a	9.08b	60.22ab	46.02a
50:50	3.95a	32.40b	12.82b	9.37b	59.96ab	41.19b
25:75	3.90a	30.72c	10.99c	9.05b	62.38a	41.45b
0:100	4.02a	29.82c	10.22d	9.00b	60.61ab	36.72c

In a column, means followed by the same letter is not significantly different at 5% by Duncan's Multiple Range Test

**Plate 6** Silage in plastic bags (foreground) and plastic drums (background).

4.6 Seed production research

4.6.1 Effect of closing date on seed production of Mulato and Mulato II hybrid brachiaria.

Objective

The hypothesis of this research is that strategic defoliation in the wet season will increase seed yields of Mulato and Mulato II by decreasing lodging and increasing flowering and seed-set. The objective of the research was to cut seed crops at monthly intervals during the wet season to find out what time is the best for the last closing cut for seed production.

Trial 1 Effect of closing date on seed production of Mulato

Methods

Two field trials were conducted on the university farm in 2003 and 2004. Both trials were in the same Mulato field planted in May 2002 with plants spaced at 50 x 50 cm. The trials were identical in a randomized complete block design of 5 replications and 5 final closing cut treatments: May 3, June 3, July 3, August 3, September 3, 2003

and 2004. At each closing date, all plots that were not closed were cut 5 cm from ground level as follows:

1. May final cut. One cut only.
2. June final cut. Two cuts in May and June.
3. July final cut. Three cuts in May, June and July.
4. August final cut. Four cuts in May, June, July and August.
5. September final cut. Five cuts in May, June, July, August and September.

Each plot measured 4 m x 5 m. At each sampling cut, 3 rows x 2 m in length were cut, weighed fresh, and a 300 gram subsample sorted into leaves and stems and dried at 70°C for 48 hours to determine dry weight. The subsample was analysed for crude protein. Fertiliser was applied after cutting every 60 days in 2003 (160 kg/ha NPK 15:15:15) and every 30 days in 2004 (200 kg/ha NPK 15:15:15).

At peak anthesis, all inflorescences in a fixed quadrat of 3 rows x 2 m in length, were counted and 20 inflorescences taken from just outside this area for reproductive analysis. All racemes were counted on each inflorescence and spikelets per raceme were counted from 3 racemes per inflorescence, taken from the top, middle and bottom of each inflorescence. Seed was harvested in 2003 from the fixed quadrat by tying the inflorescences in living sheaves and gently knocking the seed into bags each day. In 2004, nylon bags were tied over the living sheaves and the seed allowed to fall naturally into the bags. Seed was collected from the bags once a week.

Seed was dried slowly on top of trays inside a laboratory and then cleaned through hand screens and a South Dakota seed blower. Following cleaning, seed yields were corrected to 10% seed moisture content.

Results

Closing plots in September produced significantly more dry matter (stem, leaf and total DM) than plots closed in June and July (Table 38). Crude protein concentrations were not significantly different.

Table 38 Effect of Mulato final closing cut date on dry matter yields and crude protein.

Final closing cut date	Stem DM (kg/ha)	Stem CP (%)	Leaf DM (kg/ha)	Leaf CP (%)	Total DM (kg/ha)
2003					
June	262	12.0	918	15.3	1180
July	547	8.2	1738	12.7	2285
August	1054	9.1	2952	12.4	4006
September	1344	8.2	3599	11.8	4943
LSD (P<0.05)	168	1.5	423	1.7	564
2004					
June	442	10.3	1123	12.6	1565
July	504	10.0	1424	13.4	1928
August	933	10.1	2439	13.2	3372
September	1224	12.2	3151	15.3	4375
LSD (P<0.05)	553	ns	1040	ns	1584

Closing at the beginning of July and August produced, respectively, the highest seed yields in 2004 and 2003, though in 2004 there were no significant differences between July and August closing (Table 39). Closing in May or September significantly reduced seed yields compared to other closing dates

Closing in August in 2003 significantly increased the number of inflorescences and number of seeds (Table 39). Inflorescence numbers in 2004 were significantly reduced by closing in May and September. Spikelets/raceme were significantly reduced by cutting in August and September 2003 and July to September 2004 compared to cutting earlier.

Table 39 Effect of Mulato final closing cut date on seed yield components and seed yield.

Final Closing cut date	Inflorescences /m ²	Racemes /inflorescence	Spikelets /raceme	Seeds/ m ²	Seed yield (kg/ha)	TSW (g)
2003						
May	220	4.1	28.6	189	16.9	8.50
June	223	4.0	28.3	253	22.5	8.84
July	233	3.9	29.4	312	28.1	8.48
August	302	3.0	25.3	441	39.4	8.68
September	31	2.9	23.9	56	5.0	7.90
LSD (P<0.05)	45	0.25	2.37	93.7	8.4	0.44
2004						
May	284	3.0	38.6	583	51.6	8.77
June	389	4.6	34.6	1000	91.0	9.01
July	411	4.8	29.4	1516	140.5	9.32
August	445	4.8	28.4	1360	122.0	8.87
September	120	4.2	28.6	169	14.2	8.45
LSD (P<0.05)	111	0.72	0.97	427	40.5	0.56

Trial 2 Effect of closing date on seed production of Mulato and Mulato II hybrid brachiaria

This trial was a RCBD with 2 factors and 4 replications. The factors were 2 cultivars (Mulato and Mulato II) and 4 closing date cuts.

2004 no cutting after planting (control), July 6, August 6, and September 6

2005 May 13 (control), July 1, August 1 and September 1.

2004 The trial was planted on May 6, 2004. The field was previously planted in Cavalcade and Ubon stylo and was ploughed and disced into a fine seed bed in April, 2004. The 2 cultivars were tested for germination (Mulato 34% and Mulato II 26%) and sown at a rate of 3.1 kg/ha. The seeds were sown in rows in shallow holes (2 cm depth) 1 m apart, and 50 cm apart in the row. Fertiliser (200 kg/ha NPK 15:15:15) was applied at sowing and at monthly intervals thereafter until September. Plots measured 4 x 5 m.

At each sampling cut, 3 rows x 2 m in length were cut, weighed fresh, and a 300 gram subsample sorted into leaves and stems and dried at 70C for 48 hours to determine dry weight. The subsample was analysed for crude protein. Each plot was only cut once at the time of closing.

At peak anthesis, all inflorescences in a fixed quadrat of 3 rows x 2 m in length, were counted and 20 inflorescences taken from just outside this area for reproductive analysis. All racemes were counted on each inflorescence and spikelets per raceme were counted from 3 racemes per inflorescence, taken from the top, middle and bottom of each inflorescence. Nylon bags were tied over the inflorescences ('living

sheaves”) and the seed allowed to fall naturally into the bags. Seed was collected from the bags once a week.

Seed was dried slowly on top of trays inside a laboratory and then cleaned through hand screens and a South Dakota seed blower. Following cleaning, seed yields were corrected to 10% seed moisture content.

2005 After harvest in December 2004, all the plots were cut to 5 cm from ground level and allowed to grow until May 2005. On May 13, 2005 all plots were cut to 5 cm from ground level and closing date treatments applied to the same plots as in 2004.

Fertiliser was not applied in May but was applied (200 kg/ha NPK 15:15:15) at monthly intervals from June to September.

At each closing date, all plots that were not closed were cut 5 cm from ground level as follows:

- 1 June final cut. One cut only.
- 2 July final cut. Two cuts in June and July.
- 3 August final cut. Three cuts in June, July and August.
- 4 September final cut. Four cuts in June, July, August and September.

Measurements for dry matter, seed yields and seed yield components were identical to the previous year.

Results

There were no significant differences in dry matter yields (leaf, stem, total DM) between Mulato and Mulato II, except in 2005, when Mulato produced more stem dry matter than Mulato II. In 2004, Mulato produced significantly higher crude protein levels than Mulato II (Table 40).

September closed seed crops produced the highest dry matter yields at closing. In 2004, because September crops were left to grow all through the wet season their quality was lower than the other treatments, whereas, in 2005, they were cut monthly, from June onwards, and their quality was higher than other treatments. (Table 41).

Table 40 Dry matter yields and crude protein concentrations of hybrid *Brachiaria* seed crops at closing for seed production.

Cultivar	Total DM (kg/ha)	Stem DM (kg/ha)	Leaf DM (kg/ha)	Stem CP (%)	Leaf CP (%)
2004					
Mulato	3793	1822	1971	13.3	17.5
Mulato II	4576	2337	2239	9.9	14.6
LSD (P<0.05)	ns	ns	ns	1.7	1.5
2005					
Mulato	3795	1453	2342	7.5	11.7
Mulato II	3730	1180	2550	7.7	11.0
LSD (P<0.05)	ns	254	ns	ns	ns

Table 41 Effect of closing date on dry matter yields and crude protein concentrations of hybrid *Brachiaria* seed crops

Final closing cut date	Total DM (kg/ha)	Stem DM (kg/ha)	Leaf DM (kg/ha)	Stem CP (%)	Leaf CP (%)
2004					
July	224	36	188	16.0	17.7
August	2857	1254	1603	10.6	16.5
September	9471	4949	4522	8.2	14.0
LSD (P<0.05)	2032	1305	779	2.1	1.8
2005					
July	2366	936	1431	6.3	8.2
August	4083	1444	2639	8.0	12.5
September	4838	1571	3266	8.5	13.3
LSD (P<0.05)	664	311	362	1.6	1.0

Table 42 Effect of closing date on Mulato and Mulato II reproductive components of seed yield

Final closing cut date	Inflorescences/m ²		Racemes/inflorescence		Spikelets/racemce	
2004	Mulato	Mulato II	Mulato	Mulato II	Mulato	Mulato II
Control	299	175	6.3	6.0	42.8	35.8
July	330	186	6.0	5.5	37.3	33.5
August	278	159	5.8	5.0	35.0	28.0
September	152	3	4.8	-	35.0	-
LSD (P<0.05)	88.9		0.55		4.1	
2005	Mulato	Mulato II	Mulato	Mulato II	Mulato	Mulato II
Control	218	131	4.9	5.1	36.3	46.3
July	344	200	5.1	4.8	46.7	32.5
August	279	173	5.1	4.3	32.0	26.0
September	84	-	3.6	-	24.7	-
LSD (P<0.05)	55.5		0.33		1.6	

Table 43 Effect of closing date on Mulato and Mulato II seed yields

Final closing cut date	Seeds/m ²		Seed yield (kg/ha)		TSW (g)	
2004	Mulato	Mulato II	Mulato	Mulato II	Mulato	Mulato II
Control	1608	3009	149	232	9.4	7.7
July	1746	3374	161	258	9.2	7.6
August	1392	924	119	76	8.6	6.8
September	783	-	65	-	8.3	-
LSD (P<0.05)	1078		83.3		1.5	
2005	Mulato	Mulato II	Mulato	Mulato II	Mulato	Mulato II
Control	95	1129	9	98	9.5	8.6
July	306	855	30	71	9.9	8.3
August	265	1021	26	85	9.7	8.3
September	50	-	4	-	8.7	-
LSD (P<0.05)	302		26.8		0.3	

Mulato produced significantly more inflorescences, racemes and spikelets than Mulato II and heavier seed (Table 42). But Mulato produced a large portion of light-immature seeds which were removed at seed cleaning.

There were no significant differences between Mulato and Mulato II seed viability, 81.8 and 75.4%, respectively (TZ test).

The highest seed yield of Mulato II (258 kg/ha) was 60% higher than the highest seed yield of Mulato (161 kg/ha) (Table 43). The best closing time for good seed yields in both cultivars was at the beginning of July. Mulato II seed yields were significantly reduced by later closing, with no seed at all from closing in September.

Mulato had much lower economical spikelet site utilization % (SSU%) than Mulato II. SSU is best determined using the formula:

$$\text{SSU}\% = \frac{\text{seed yield/m}^2}{\text{Inflorescences/m}^2 \times \text{TSW/1000} \times \text{spikelets per inflorescence}} \times 100$$

Using this formula and data from the above study, we found that the best treatment for both cultivars (July closing) produced SSU of 9.9% for Mulato II and 2.34% for Mulato. Both figures are very low when compared to temperate grasses which are in the range of 20 to 30 % and even up to 60% in some species.

Conclusion

The results from these trials show that Mulato and Mulato II can produce good quality forage before closing the fields for seed production. Cutting monthly until July in first year crops and August in second year crops will produce high dry matter yields of high quality leaf content for feeding to animals. Farmers can therefore feed Mulato to their animals, 7-8 months of the year and, close for seed for 4-5 months (July or August to December).

Seed yields in 2004 were far greater than yields in 2003 because of applying fertilizer every 30 days instead of every 60 days.



Plate 7 Mulato II seed plots cut and uncut in August 2005

4.6.2 Effect of method and time of planting on seed production of Mulato and Mulato II hybrid brachiaria.

Objectives

The hypothesis of this research is that Mulato seed crops established by planting tillers produce more seed than crops established by seed and early established crops produce more seed than crops planted late. The objective was to compare seed sowing with planting tillers at different times during the wet season and the effects on Mulato seed production.

Trial 1 Effect of time of seed planting on seed production of Mulato

Methods

This field trial was a randomized complete block design of 5 replications and 4 seed planting dates: May 6, June 6 and August 6, 2003. Seeds at 5 kg/ha were planted at spacings of 50 cm x 50 cm in well-cultivated plots measuring 4 m x 5 m. To increase seed germination to 70 %, seeds were scarified in sulphuric acid for 10 minutes, washed in running cold water and dried before planting. Fertilizer (15-15-15) at the rate of 160 kg/ha was applied to each new plot at sowing and again on September 20, 2003. Only the May planting treatments were cut to 10 cm above ground level on August 1 and dry matter measured and crude protein concentrations analysed.

At peak anthesis, all inflorescences in a fixed quadrat of 1 m x 2 m were counted and 20 inflorescences taken from just outside this area for reproductive analysis. All racemes were counted on each inflorescence and spikelets per raceme were counted from 3 racemes per inflorescence, taken from the top, middle and bottom of each inflorescence. Seeds were harvested from within the fixed quadrat by tying the inflorescences in living sheaves and gently knocking the seed into bags each day.

Seed was dried slowly on top of trays inside a laboratory and then cleaned through hand screens and a South Dakota seed blower. Following cleaning, seed yields were corrected to 10% seed moisture content.

Results

Planting with seeds in May and June produced significantly higher Mulato seed yields than from planting in July (Table 44). Mulato planted with seeds in August did not flower and produce seed. Early seed planting significantly increased the number of inflorescences.

Only the May planted plots were cut in August (Table 45) because the other plots were too short for cutting. Because May sown plots were cut in August, they had significantly less harvest stubble than June and July planted plots (Table 46). June planted plots produced significantly more total harvest stubble dry matter than May and July planted plots. Time of planting seed had no significant effect on crude protein concentrations in the harvest stubble (Table 46).

Conclusion

Mulato seed crops will produce more seed if seeds are planted early, May and June, in the wet season. Seed crops planted in May can be cut in July for forage production, which is an additional benefit for farmers in Thailand. The quality of the forage stubble after harvest is superior to that of rice stubble.

Table 44 Effect of time of planting Mulato seed on seed yields and seed yield components

Seed planting time	Inflorescences /m ²	Racemes /inflorescence	Spikelets /raceme	Seeds/m ²	Seed yield (kg/ha)	TSW (g)
May	360	3.7	31.7	1043	90.6	8.64
June	315	4.6	36.5	959	81.3	8.44
July	258	5.2	36.2	708	59.4	8.30
August	-	-	-	-	-	-
LSD(P<0.05)	47	0.72	3.33	229	21.8	ns

Table 45 Dry matter yields and crude protein concentrations of Mulato seed crops planted with seed in May and cut in August.

Seed planting time	Total DM (kg/ha)	Stem DM (kg/ha)	Leaf DM (kg/ha)	Stem CP (%)	Leaf CP (%)
May	9263	4750	4513	6.0	11.8

Table 46 Effect of time of seed planting of Mulato on dry matter yields and crude protein concentrations in harvest stubble.

Seed planting time	Stem DM (kg/ha)	Stem CP (%)	Leaf DM (kg/ha)	Leaf CP (%)	Total DM (kg/ha)
May	12084	2.4	5460	4.6	17544
June	18236	2.8	6581	5.7	24817
July	16157	2.8	4879	5.6	21036
LSD (P<0.05)	2374	ns	1116	ns	2778

Trial 2 Effect of time of tiller planting on seed production of Mulato**Methods**

This field trial was a randomized complete block design of 5 replications and 4 tiller planting dates: May 16, June 16, July 16 and August 16, 2003. Tillers with roots were divided from one-year old Mulato plants, dug from an adjacent field and planted at spacings of 50 cm x 50 cm in well-cultivated plots measuring 3 m x 5 m. Fertilizer (15-15-15) at the rate of 160 kg/ha was applied to each new plot at sowing and again on September 20, 2003. May and June planting treatments were cut to 10 cm above ground level on August 1 and dry matter measured and crude protein concentrations analysed.

At peak anthesis, all inflorescences in a fixed quadrat of 1m x 2 m were counted and 20 inflorescences taken from just outside this area for reproductive analysis. All racemes were counted on each inflorescence and spikelets per raceme were counted from 3 racemes per inflorescence, taken from the top, middle and bottom of each inflorescence. Seeds were harvested from within the fixed quadrat by tying the inflorescences in living sheaves and gently knocking the seed into bags each day.

Seed was dried slowly on top of trays inside a laboratory and then cleaned through hand screens and a South Dakota seed blower. Following cleaning, seed yields were corrected to 10% seed moisture content.

Results

There were no significant differences in seed yield and numbers of seeds between planting tillers in May, June and July which were significantly higher than

yields from August planted plots (Table 47). May and June planted plots produced significantly more inflorescences than later planted plots. However, plots planted later in the wet season, July and August, produced more spikelets and racemes than earlier planted plots.

Mulato seed crops planted in May and June produced good quality forage when cut at the beginning of August, but forage yields from May plots were approximately four times greater (Table 48). Plots planted in May, June and July produced significantly more harvest stubble total and stem dry matter than plots planted in August (Table 49). Crude protein concentrations were similar in all plots.

Conclusion

Mulato seed crops can be planted with tillers one month later than crops established with seed (July vs June). Planting with tillers produced 60% greater seed yields than by planting with seeds.

Table 47 Effect of time of planting Mulato tillers on seed yields and seed yield components.

Tiller planting time	Inflorescences /m ²	Racemes /inflorescence	Spikelets /raceme	Seeds/m ²	Seed yield (kg/ha)	TSW (g)
May	407	4.0	32.4	1772	147.5	8.66
June	443	4.5	35.1	1606	143.8	8.92
July	256	5.1	36.0	1459	128.9	8.78
August	219	4.9	36.6	875	76.3	8.72
LSD (P<0.05)	15	0.35	2.78	367	34.3	ns

Table 48 Dry matter yields and crude protein concentrations of Mulato seed crops planted with tillers in May and June and cut in August.

Tiller planting time	Total DM (kg/ha)	Stem DM (kg/ha)	Leaf DM (kg/ha)	Stem CP (%)	Leaf CP (%)
May	6551	3288	3263	8.2	13.0
June	1794	713	1081	12.0	15.9

Table 49 Effect of time of planting tillers of Mulato on dry matter yields and crude protein in harvest stubble.

Tiller planting time	Stem DM (kg/ha)	Stem CP (%)	Leaf DM (kg/ha)	Leaf CP (%)	Total DM (kg/ha)
May	14817	3.2	4591	5.3	19428
June	15875	2.6	4811	4.8	20686
July	15712	2.7	4180	4.9	19892
August	11643	2.2	4617	4.7	16260
LSD(P<0.05)	1072	ns	ns	ns	2789

Trial 3 Effect of method and time of planting on seed production of Mulato

Methods

This field trial was a randomized complete block design of 4 replications, 4 times of planting (May 4, June 4, July 2, and August 4, 2004) and 2 methods of planting (planting by seed and planting with rooted tillers). Plot size was 4 m x 4 m. Tillers and seed were planted into well-cultivated soil in rows 1 m apart and 50 cm apart in the row. For the seed plantings, about 5 seeds were planted in each hole.

Rooted tillers were divided from 1 year-old Mulato plants dug from an adjacent field. Fertilizer (15-15-15) at the rate of 200 kg/ha was applied to each new plot at planting and at the beginning of each month until September.

Closing dry matter cuts (2 m x 3 rows) were taken 10 cm above ground level from May plots planted with tillers on July 2 and from all May and June planted plots on August 4, 2004. Dry matter yields were measured and crude protein concentrations analysed.

At peak anthesis, all inflorescences in a fixed quadrat of 2 m x 3 rows were counted and 20 inflorescences taken from just outside this area for reproductive analysis. All racemes were counted on each inflorescence and spikelets per raceme were counted from 3 racemes per inflorescence, taken from the top, middle and bottom of each inflorescence. Seeds were harvested from within the fixed quadrat by tying the inflorescences in living sheaves and gently knocking the seed into bags each day.

Seed was dried slowly on top of trays inside a laboratory and then cleaned through hand screens and a South Dakota seed blower. Following cleaning, seed yields were corrected to 10% seed moisture content.

Results

There were no significant differences in seed yields from seed crops planted at the beginning of May to the beginning of August (Table 50). Planting with tillers produced higher seed yields than seed sowing (Table 50).

Conclusion

In order for farmers to get both forage and seed in the same year, we would recommend seed crops to be planted with tillers as early as possible in the wet season, in order to produce a strong rooting system, tiller out and produce forage for feeding livestock before closing.

Table 50 Effect of method and time of planting Mulato on seed yields and seed yield components.

Method of planting	Inflorescences /m ²	Racemes /inflorescence	Spikelets /raceme	Seeds/m ²	Seed yield (kg/ha)	TSW (g)
Seed	190	5.4	35.4	654	57.3	8.57
Tillers	220	5.4	34.8	1370	123.5	8.93
LSD (P<0.05)	ns	ns	ns	306	28.2	ns
Time of planting						
May	247	4.6	33.9	1084	96.2	8.84
June	224	5.0	33.6	990	88.4	8.73
July	217	5.9	35.1	1048	94.5	8.78
August	134	6.0	37.8	925	82.4	8.64
LSD (P<0.05)	57	0.49	1.91	ns	ns	ns

Trial 4 Effect of time of planting tillers on seed production of Mulato II

Methods

This field trial was a randomized complete block design of 5 replications and 7 tiller planting dates: May 16, June 1, June 16, July 1, July 15, August 1 and August 16, 2005. Tillers with roots were divided from one-year old Mulato II plants dug from

an adjacent field and planted at spacings of 1 m x 50 cm in well-cultivated plots measuring 6 m x 5 m.

NPK fertilizer (15-15-15) at the rate of 200 kg/ha was applied to plots planted in May, June and July on August 1 and to August-planted plots on September 1, 2005. All plots received Urea (20 kg/ha) on October 6, 2005.

On August 1, 2005, closing date cuts (2 m x 3 rows) were taken 5' cm above ground level from plots planted in May, June and July 1 and dry matter measured and crude protein concentrations analysed. July 15 plots were too small to take samples but were trimmed to 5 cm above ground level on August 1. Plots planted on August 1 and August 16 were not cut before seed harvest.

At peak anthesis, all inflorescences in a fixed quadrat of 1m x 2 m were counted and 20 inflorescences taken from just outside this area for reproductive analysis. All racemes were counted on each inflorescence and spikelets per raceme were counted from 3 racemes per inflorescence, taken from the top, middle and bottom of each inflorescence. Seeds were harvested from within the fixed quadrat by tying the inflorescences in living sheaves and gently knocking the seed into bags each day.

Seed was dried slowly on top of trays inside a laboratory and then cleaned through hand screens and a South Dakota seed blower. Following cleaning, seed yields were corrected to 10% seed moisture content.

Results

Planting tillers from June onwards, significantly reduced Mulato II seed yields compared to planting in May (Table 51). Inflorescences numbers were significantly reduced when planting was delayed every two weeks and raceme and spikelet numbers were reduced when tillers were planted from mid-July onwards.

Table 51 Effect time of planting Mulato II on seed yields and seed yield components.

Time of planting	Inflorescences /m ²	Racemes /inflorescence	Spikelets /raceme	Seed yield (kg/ha)	TSW (g)
May 16	163	4.7	35.0	117	8.58
June 1	138	5.2	34.6	93	8.55
June 16	122	5.3	34.0	67	8.65
July 1	104	5.0	32.7	46	8.54
July 15	59	2.8	25.5	21	8.42
August 1	23	2.7	21.9	5	6.43
August 16	-	-	-	-	-
LSD (P<0.05)	28	0.7	6.4	22	1.80

Conclusion

In order for farmers to get both forage and high seed yields in the same year, we would recommend Mulato II seed crops to be planted with tillers as early as possible in the wet season, May, in order to produce a strong rooting system, tiller out and produce forage for feeding livestock before closing. Early-planted Mulato II seed crops produce more inflorescences, racemes and spikelets which produce more seed than late-planted seed crops.

4.6.3 Effect of seed harvesting methods on seed yield and seed quality of Mulato and Mulato II.

Objective

The hypothesis of this research is that the method of collecting seed in nylon bags tied over seed heads will produce higher seed yields and better seed quality than other hand-harvesting methods.

The objective was to compare seed production from nylon bag collection with the common method used by farmers in Thailand of knocking seed heads and the method used in Brazil of sweeping seed from the ground.

Trial 1 Effect of seed harvesting methods on seed yield and seed quality of Mulato

Methods

Two field trials were conducted in 2003 and 2004.

2003 Pre-trial preparation began by cutting a second year Mulato research area on June 16 and a second cut on August 2, 2003. The field was planted with tillers in 50 cm x 50 cm spacings. NPK fertilizer (15-15-15) at the rate of 160 kg/ha was applied after each cut and again on September 20.

2004 Pre-trial preparation in an adjacent field began by cutting a second year Mulato research area on June 3 and August 4 to 5 cm above ground level and applying NPK (15-15-15) fertiliser (200 kg/ha) on June 3, July 3, August 3, September 3, 2004. The field was planted with tillers in 50 cm x 50 cm spacings.

The trial in both years was a RCBD with 4 replications and 5 treatments and each plot measured 4 x 5 m. Treatments were

- 1) flower heads tied up and knocked every day,
- 2) flower heads tied up and knocked every two days,
- 3) flower heads tied up and knocked every three days,
- 4) flower heads covered up with a nylon bag and fallen seed collected every seven days from the bag
- 5) Seed allowed to fall on to the ground and then swept up.

Seeds were harvested from the whole plots and then dried slowly on top of trays inside a laboratory before cleaning through hand screens and a South Dakota seed blower. Following cleaning, seed yields were corrected to 10% seed moisture content.

Data collection included seed yield, seed weight and seed viability (tetrazolium tests TZ).

Results

The method of placing nylon bags over the seed heads to collect seed produced the highest seed yields in both years (Table 52). In 2003, the nylon bag yield was significantly higher than the second best method of daily knocking (70% more). In 2004, even though the yields from nylon bags and daily knocking were not significantly different, the nylon bags yields were 20% higher than daily knocking.

Knocking produced significantly more seed than sweeping from the ground in 2004 but not in 2003.

There were no significant differences in seed viability among harvesting methods in 2003 but in 2004, seed knocked every 2 days had significantly lower viability than seed harvested by other methods.

Table 52 Effect of harvesting method on Mulato seed yields and seed viability

Harvest method	Seed yield (kg/ha)	TSW (g)	Seed viability (%)
2003			
Knocking daily	49.4	8.50	68.6
Knocking every 2 days	40.6	8.73	71.6
Knocking every 3 days	47.5	8.78	72.4
Nylon bag	83.8	8.55	74.5
Swept from ground	42.5	7.99	70.3
LSD P<0.05	18.6	ns	ns
2004			
Knocking daily	168.6	8.43	79.8
Knocking every 2 days	123.9	8.13	68.8
Knocking every 3 days	146.3	8.75	75.8
Nylon bag	202.5	8.40	77.0
Swept from ground	75.7	8.89	76.0
LSD P<0.05	48.5	ns	6.64

Trial 2 Effect of seed harvesting methods on seed yield and seed quality of Mulato II

Methods

Mulato II tillers were planted at spacings of 1 m x 50 cm on May 31, 2005. On August 2, the field was cut to 5 cm above ground level. Fertiliser was applied on August 2 (NPK 15-15-15 200 kg/ha) and on October 6 (Urea 20kg/ha).

The trial was a RCBD with 4 replications and 5 treatments and each plot measured 4 x 5 m. Treatments were

- 1) flower heads tied up and knocked once every day,
- 2) flower heads tied up and knocked twice day,
- 3) flower heads tied up and knocked every two days,
- 4) flower heads covered up with a nylon bag and fallen seed collected every seven days from the bag
- 5) Seed allowed to fall on to the ground and then swept up.

Seeds were harvested from the whole plots and then dried slowly on top of trays inside a laboratory before cleaning through hand screens and a South Dakota seed blower. Following cleaning, seed yields were corrected to 10% seed moisture content.

Data collection included seed yield, seed weight and seed viability (tetrazolium tests TZ).

Results

The method of placing nylon bags over the seed heads to collect seed produced the highest seed yield (Table 53). The nylon bag yield was significantly higher than the second best method of twice daily knocking (88% more). There were no significant differences among seed yields of the three methods of knocking. Sweeping seed from the ground produced the lowest seed yields, the lightest seed and the seed with the lowest viability (Table 53).

Conclusion

The method of nylon bag collection produced the most seed in all trials. However, farmers think that the cost of bags are expensive and therefore knocking the seedheads once a day is the most appropriate method for them. The South American method of ground sweeping fallen seed appears not suitable for Thailand.

Table 53 Effect of harvesting method on Mulato II seed yields and seed viability

Harvest method	Seed yield (kg/ha)	TSW (g)	Seed viability (%)
Knocking once daily	230.2	8.79	92.0
Knocking twice daily	271.2	8.68	92.0
Knocking every 2 days	254.6	8.94	89.3
Nylon bag	509.4	9.03	90.5
Swept from ground	87.3	8.20	84.0
LSD P<0.05	73.2	0.38	5.8

**Plate 8** The nylon bag method of harvesting Mulato II seed

4.6.4 Effect of storage time on breaking seed dormancy of *Brachiaria ruziziensis* x *B. brizantha* cv Mulato.

Objective

The hypothesis of this trial is that seed dormancy in Mulato is short-lived and can be broken with length of storage. The objective was to compare seed germinations of Mulato seed stored for varying lengths of time, in different storage rooms and in different storage bags to see which storage type is best for Mulato seed.

Methods

The trial was a factorial trial with 3 replications, 2 storage rooms (ambient and cool) and 3 bag types (nylon, plastic and paper). Mulato seed harvested in November 2003, was divided into 20 g lots and placed in bags and storage rooms on January 13, 2004. Germination prior to seed storage was 30%.

Every 2 months, seeds were tested for germination. At each test, 120 seeds from each bag were soaked for 10 minutes in H_2SO_4 , washed in running cold water and dried. 100 seeds were then put in petri dishes on top of paper with KNO_3 (0.2%) and placed in a germination cabinet at 25°C, 16 hours dark and 35°C, 8 hours light.

Germination counts were taken at 7, 14 and 21 days. Distilled water was added to the dishes if needed.

Results

Storage room conditions significantly affected seed germination of Mulato seed after two months storage (Table 54). The germination of seed stored at ambient temperatures was significantly higher than seed stored in the cool room (RH 40% 10°C) after 2, 4 and 6 months storage. After 8 months storage, there was no significant difference in seed germination between the two rooms. However, the germination of seed stored at ambient temperatures decreased by 13.5%.

After 10 months storage, seed stored in the cool room was significantly higher in germination than seed stored at ambient temperatures. The germination of seed stored in the cool room increased after 10 months storage but the germination of seed stored at ambient temperatures decreased until no seed germinated after 20 months of storage (Table 54).

Bag type did not affect seed germination until 18 months of storage (Table 54) when seeds stored in paper bags were significantly lower in germination than seeds stored in nylon bags. After 20 months storage, seeds stored in paper bags were significantly lower in germination than seeds stored in both nylon and plastic bags

Conclusion

Embryo dormancy in Mulato seed appears to be more quickly broken when stored at ambient temperatures than when stored in cool conditions. Seed germinates more quickly but then deteriorates more quickly.

It appears that Mulato seed can be safely stored in ordinary rooms for short periods (up to 8 months) but for long-term storage, cool storage is recommended. In addition, for long-term storage, plastic and nylon bags maintain seed germinations better than paper bags.

If Mulato seed is harvested in the dry season and then used in the following wet season, storing in ordinary rooms is okay. But if seed is not used in the first wet season after harvest, it should be stored in a cool room in plastic or nylon bags.

This trial will continue for one more year.

Table 54 Effect of seed storage on seed germination of Mulato.

Time of storage	Storage Room		Significance
	Cool	Ordinary	
	(%)		
2 months	33.8	67.7	**
4 months	54.2	78.4	**
6 months	67.8	75.2	*
8 months	65.3	61.7	ns
10 months	73.8	61.6	**
12 months	73.6	58.2	*
14 months	80.9	46.4	**
16 months	70.2	31.9	**
18 months	76.7	12.7	**
20 months	74.0	0	**

Table 55 Effect of bag type on seed germination of Mulato seed stored in a cool room.

Time of storage	Nylon bag	Paper bag	Plastic bag	LSD (P<0.05)
	Germination (%)			
18 months	83.0	71.3	75.7	5.0
20 months	80.7	62.0	79.3	6.5

4.6.5 Effect of cultivar and time of closing on stylo (*Stylosanthes guianensis*) seed production.

Objective

The hypothesis of this trial is that the multi-line Ubon stylo produces more seed than the single line Tha Phra stylo. The objective was to compare seed yields of Ubon and Tha Phra stylo and to compare final closing cuts on stylo seed yields.

Methods

Two field trials were conducted

Trial 1 2004 This trial was a factorial trial with 5 replications, 2 cultivars (Ubon and Tha Phra stylo) and 3 final closing date cuts-control (no cutting from planting until seed harvest), September final closing cut and October final closing cut.

The trial was planted on June 11, 2004. The field was previously planted in Mulato and was ploughed and disced into a fine seed bed in April and May, 2004. The 2 cultivars were tested for germination (Ubon stylo 67% and Tha Phra stylo 47%) and sown at a rate of 5 kg/ha (adjusted for germination Ubon 7.5 kg/ha; Tha Phra 10.6 kg/ha). The seeds were broadcast sown into plots measuring 3m x 3m (1m walkways between plots) and raked into the soil. Fertiliser (K 50 kg/ha, P 20 kg/ha, S 20 kg/ha) was applied at sowing and again in October.

At each closing date (September 1 and October 1), 4 x 0.25m² quadrats were cut 10 cm above the ground and weighed fresh. A 300 g subsample was taken for dry weight and quality analysis. The remaining herbage in the plots sampled was cut to 10 cm above ground level and the herbage removed.

Plots were harvested from February 21st-23rd 2005. At harvest, the herbage was beaten with sticks to make all remaining seed fall to the ground and then all the herbage in each plot was cut and removed. Each plot was swept with brooms and the collected material sieved through screens and winnowed to separate out the stylo seed. The seed was further cleaned in the laboratory and a purity test was done on each seed lot. Seed yields were corrected to 10% seed moisture and 100% pure seed.

Trial 2 2005 This trial was a factorial trial with 5 replications, 2 cultivars (Ubon and Tha Phra stylo) and 3 final closing date cuts-control (no cutting from planting until seed harvest), October final closing cut and November final closing cut.

The trial was planted on June 28, 2005 in the same plots for the previous trial in 2004. The plots were hand-cultivated into a fine seed bed prior to seed sowing. The 2 cultivars were tested for germination (Ubon stylo 50% and Tha Phra stylo 30%) and sown at a rate of 5 kg/ha (adjusted for germination Ubon 10 kg/ha; Tha Phra 16.6 kg/ha). The seeds were broadcast sown into plots and raked into the soil. Fertiliser (K 50 kg/ha, P 20 kg/ha, S 20 kg/ha) was applied at sowing and again in October.

At each closing date (October 1 and November 1), 4 x 0.25m² quadrats were cut 10 cm above the ground and weighed fresh. A 300 g subsample was taken for dry weight and quality analysis. The remaining herbage in the plots sampled was cut to 10 cm above ground level and the herbage removed.

Seed is expected to be harvested in February 2006.

Results

In 2004, Ubon stylo produced significantly more dry matter than Tha Phra stylo at closing for seed production but this forage was 1% lower in crude protein content compared to Tha Phra stylo (Table 56). Final closing cutting in October produced 3 times more forage, with significantly lower crude protein concentrations, than final closing cutting in September.

In addition to producing more forage, Ubon stylo produced nearly 3 times the seed yields than those produced by Tha Phra stylo (Table 57). However, the thousand seed weight (TSW) of Ubon stylo seed was lower than Tha Phra stylo seed. Final closing cut had no significant effect on seed yields but seed crops cut in September had twice the seed yields of crops cut in October and 50% more seed than plots not cut.

Conclusion

Ubon stylo produces more seed than Tha Phra stylo and cutting the seed crop at the beginning of September produces more seed than not cutting or cutting later.

Table 56 Forage dry matter production and quality at time of closing stylo crops

Cultivar	DM (kg/ha)	CP (%)
Ubon stylo	2561.5	21.3
Tha phra stylo	2113.7	22.4
LSD (P<0.05)	352.7	0.80
Time of final closing cut		
September	1053.6	22.4
October	3621.6	21.3
LSD (P<0.05)	352.7	0.80

Table 57 Effect of cultivar and time of closing on seed yields and seed weight of stylo

Cultivar	Seed yield (kg/rai) ¹	Seed yield (kg/ha) ¹	TSW (g) ¹
Ubon stylo	153.4	958.6	2.50
Tha Phra stylo	58.4	365.0	2.59
LSD (P<0.05)	68.0	425.0	0.06
Time of final closing cut			
Control	98.9	618.1	2.60
September	147.3	920.6	2.53
October	72.5	453.1	2.50
LSD (P<0.05)	ns	ns	0.08

¹ Corrected to 10% seed moisture content

4.7 Seed production by village farmers

4.7.1 Ubon paspalum village seed production

Objective

The main objective of this research was to show that seed production of Ubon paspalum can be successfully done by smallholder village farmers. A secondary objective was to have high quality forage seed available for sale to livestock farmers in Thailand.

Methods

Smallholder village farmers at Bark Kud Waay village signed contracts with the project at the beginning of each wet season to produce and sell seed at a set price. The

farmers divided tillers from old Ubon paspalum plants and planted these new tillers in cultivated fields in May and June each wet season.

Project staff visited the farmers and seed fields every month until seed harvest in October. At seed harvest, the farmers tied the seed heads into living sheaves and knocked the seed out in trays every day. Seed was dried slowly in the shade for 3 days and then sun-dried for 1-2 days before cleaning.

In early November each year the project purchased the seed in the village and paid out cash the same day. Only seed that reached Grade A quality was purchased.

Results

Ubon paspalum seed was successfully produced by farmers at Bark Kud Waay village in Warin Chamrab district every year (Table 58). Over 3 years a total of 12,320 kgs of seed were produced and 985,600 baht paid in cash to the farmers.

Table 58 Ubon paspalum village seed production

Year	No of farmers	Quota per farmer (kgs)	Amount of seed (kgs)	Amount of money paid (baht)
2003	22	250	5,500	440,000
2004	22	100	2,200	176,000
2005	42	110	4,620	369,600
Total			12,320	985,600

Demand for Ubon paspalum seed was very high throughout Thailand as more and more farmers realized that Ubon paspalum was the best grass for low-lying wet soils (Table 59). They also realized that good pastures are important for their cattle. 12,315 kgs of Ubon paspalum seed were sold from 2003 to 2005.

Grupo Papalotla has ordered 3,000 kgs of the 2005 harvest to be exported in March 2006 to Mexico. We are hoping to develop an export market for Ubon paspalum seed as this will allow seed production to increase as the local Thailand is limited.

Table 59 Seed sales of Ubon paspalum

Region	Amount of seed sold (kg)		
	2003	2004	2005
North	22	36	30
Northeast	2,798	3,573	4,570
Central	212	226	521
East	34	-	-
South	13	40	240
Total	3,079	3,875	5,361

Conclusion

Farmers find Ubon paspalum a relatively easy crop to harvest seed. The farmers now average over 100 kgs/rai (625 kgs/ha), with some farmers producing 150 kgs/rai (938 kgs/ha). Demand for Ubon paspalum seed is currently very high, as it is the best grass for wet soils.

Ubon paspalum



Plate 9 Harvesting Ubon paspalum seed at Bark Kud Waay village

4.7.2 Mulato II village seed production

Objective

The main objective of this research was to show that seed production of a new forage species for export can be successfully done by smallholder village farmers.

Methods

A Memorandum of Understanding was signed on April 27, 2004 between the project and a Mexican seed company, Grupo Papalotla, to produce seed of Mulato II for export to Central and South America. Grupo Papalotla guaranteed to buy all clean seed at 125 baht/kg, with a purity not less than 95%, a moisture content below 10% and seed viability of more than 70% (TZ test).

Smallholder village farmers signed contracts with the project at the beginning of each wet season to produce and sell all Mulato II seed produced at 125 baht/kg. Each farmer received a seed production brochure and 0.5 kg of seed to plant a seed nursery. Seedlings were transplanted in cultivated fields in May and June each wet season in rows 1 m x 50 cm apart.

Project staff visited the farmers and seed fields every month until seed harvest in November. At seed harvest, the farmers tied the seed heads into living sheaves and knocked the seed out in trays every day. Seed was dried slowly in the shade for 3 days and then sun-dried for 1-2 days before cleaning.

In December each year, the project purchased the seed in the village and paid out cash the same day. Only seed that reached the above Grade A standards was purchased.

The project recleaned the seed again at the university and packaged the seed for export overseas.

Results

In 2004, 2,070 kgs of high quality seed (7.3 % moisture, 99.9% purity and 83% viability TZ test) were produced by 60 farmers in Bark Kud Waay village. Another 23 kgs were produced by 3 farmers in Nam Yuen district.

1,500 kgs were exported in March 2005 to Grupo Papalotla, Miami, USA and the remaining seed used by the project for seed production and pasture research in Thailand.

In 2005, only 1292 kgs of seed were produced by 127 farmers even though contracts were signed by 1052 farmers in Ubon Ratchathani, Amnart Charoen and Sisaket provinces (Table 60).

Table 60 Mulato II village farmer seed production in 2005

Village No.	Village	District	No. of farmers	
			Signed contracts	Harvested seed
Ubon province				
1	Bark Kud Waay	Warin Chamrab	44	32
2	Tangsaay	Warin Chamrab	21	10
3	Naa Muang	Muang	10	1
4	Sawang	Sumrong	31	2
5	Nong HuaNg	Sumrong	5	0
6	Naa Yia	Naa Yia	16	2
7	Baa Khaa	Sawangwirarong	51	2
8	Hua Kharm	Sawangwirarong	26	2
9	Somsaart	Det Udom	45	3
10	Kudpratay	Det Udom	41	5
11	Kaeng	Det Udom	51	0
12	NongBuk	LaoSuaKuk	40	8
13	Sarangming	Muangsaamsip	20	4
14	Tumyai	Muangsaamsip	80	0
15	NongHai	Phibun	40	5
16	Nonokkalug+NaaCharoen	Phibun	40	1
17	Hylatung	Trakaan	18	0
18	Nonasawang	Trakan	25	4
19	Khawbun	Kudkhawbun	55	7
20	Kangudomneua	Kudkhawbun	20	0
21	Nosawang	Kudkhawbun	65	0
22	Nikhomlumkhomnoy	Sirinthon	12	2
23	Kawkalang	Buntharik	28	5
24	Bukchareon	Buntharik	10	3
25	Somprarad	Buntharik	12	1
26	Naataanneua	Khemarat	24	1
27	Barksaeng	Naataan	28	6
Sisaket province				
28	Nongkaew	Kanthararom	34	7
Amnart province				
29	Nonanamtang	Muang	75	7
30	Naatae	Muang	23	5
31	Naawiang	Saenangnitom	62	2
Total			1052	127

Only 12% of the farmers harvested seed and the reasons for the low amount of seed harvested and the small number of farmers harvesting are as follows:

1 Many new farmers only wanted free seed for pastures. They cut the Mulato II forage and did not close for seed production.

2 Many farmers planted seed nurseries but did not transplant to fields because they did not have sufficient arable land.

3 Many farmers transplanted into very low land which became waterlogged in August-September causing the Mulato II plants to die.

4 Some farmers just left the seed in the bags in their house and did not plant a nursery.

5 At harvest time, some farmers were too busy harvesting rice to harvest Mulato II seed.

6 Many fields were planted under trees and Mulato II did not produce many seed heads because of shade.

However, the successful farmers are producing good seed and next year, 2006, we will have more success. We also have to train the farmers more in the dry season on site selection and seed crop management. In 2006, we will concentrate Mulato II seed production in the villages that were successful in 2005.



Plate 10 Harvesting Mulato II seed at Bark Kud Waay village

4.7.3 Ubon stylo seed production

Objective

The main objective of this research was to show that seed production of a new forage legume species can be successfully done by smallholder village farmers. The goal was to have seed of the forage legume Ubon stylo, available to livestock farmers in Thailand.

Methods

Smallholder village farmers in Bark Kud Way village, Warin Chamrab district, Ubon Ratchathani province, signed contracts with the project at the beginning of each wet season to produce and sell all Ubon stylo seed produced at 100 baht/kg. Each farmer received 0.5 kg of seed to plant their seed fields. Seed was directly sown into raised seed beds, 1 m apart, in June-July each year.

Project staff visited the farmers and seed fields every month until seed harvest in January. At seed harvest, the farmers allowed nearly all the seed to fall to the

ground and then beat any remaining seed out of the seed heads with sticks. The vegetation was cut to ground level and removed. Seed was swept from the ground and cleaned by the farmers in the field.

In February each year, the project purchased the seed in the village and paid out cash the same day. The seed was then scarified through a rice thresher at the university to remove soil and seed coats to improve seed purity and seed germination.

Results

Farmers produced more than 150 kg/rai of seed each year. Seed harvesting is a dirty and dusty job as the seed has to be swept from the ground and cleaned through screens in the field. However, with the high seed yields, the farmers find Ubon stylo seed production to be a lucrative cash crop (Table 61).

Table 61 Ubon stylo village seed production

Year	No of farmers	Amount of seed (kgs)	Amount of money paid (baht)
2003	4	541	54,100
2004	2	651	65,100
2005	10	2,070	207,00
Total		3,262	326,200

In 2005, 1,800 kgs of seed were exported in March to Grupo Papalotla, Miami, USA. Grupo Papalotla then sold this seed in 10 countries in Central and south America.

In 2005, contracts were signed by 15 farmers in Bark Kud Waay village on March 21st, 2005 to produce seed in February 2006 for 100 baht/kg. Farmers can produce as much seed as they like without any quota. We are expecting about 4,000 kgs of seed and Grupo Papalotla has already ordered 3,000 kgs of this seed to be exported to Mexico. We are hoping to develop an export market for Ubon stylo seed as this will allow seed production to increase as the local market in Thailand is limited.



Plate 11 Harvesting Ubon stylo seed at Bark Kud Waay village

5 Important project research and development conclusions over the last 3 years

5.1 Papers

Twelve papers were written and published during the 3 year phase of the project. The project maintained a high scientific output, both nationally and internationally.

- 1 Hare, M.D., Kaewkunya, C., Tatsapong, P. and Saengkham, M. 2003 Evaluation of forage legumes and grasses on seasonally waterlogged sites in north-east Thailand *Tropical Grasslands*, 37: 20-32. (Appendix 1).
- 2 Thummasaeng, K., Hare, M., Lunpha, A. and Suriyajantratong, W. 2003 Dairy cow milk production from 3 different tropical grasses under grazing. *Agricultural Journal* 39 No. 3: 58-63. (Appendix 2).
- 3 Wongsri, M., Suwangumjai, T., Choksawat, C., Thummaseang, K. and Hare, M.D. 2003 Productivity of Brahman and Thai native cows grazing *Paspalum atratum* cv. Ubon pastures in Thailand. In: *Department of Livestock Development Annual Report, 2003, Animal Breeding and Farm Management Section*. pp 132-140 (Department of Livestock Development, Thailand). (Appendix 3).
- 4 Thummasaeng, K., Hare, M. and Tasapong, P. 2004 A study on dairy cows grazing signal grass pasture, with or without legume and concentrate feed supplementation. *Proceedings of the 3rd Southern Animal Science Conference, Prince of Songkhla University, Thailand*. 85-93. (Appendix 4).
- 5 Hare, M.D., Gruben, I.E., Tatsapong P, Lunpha, A., Saengkkham, M. and Wongpichet, K. 2004 Inter-row planting of legumes to improve the crude protein concentration in *Paspalum atratum* cv. Ubon pastures in north-east Thailand. *Tropical Grasslands*, 38: 167 - 177. (Appendix 5).
- 6 Hare, M.D and Horne, P. M. 2004 Forage seeds for promoting animal production in Asia. *APSA Technical Report No. 41*. (The Asia & Pacific Seed Association, Bangkok, Thailand). (Appendix 6).
- 7 Phaikaew, C., Nakamane, G., Pholsen, P. and Hare, M.D. 2004 Seed production of hybrid Mulato in Thailand. *Pasture Newsletter* 9 (3): 28-29 (Department of Livestock Development, Thailand). (Appendix 7).
- 8 Hare, M.D., Tatsapong, P., Lunpha, A. and Wongpichet, K. 2004 Effect of plant spacing, cutting and nitrogen on establishment and production of *Digitaria milanjiana* cv. Jarra in north-east Thailand. *Tropical Grasslands*, 38: 217-226. (Appendix 8).
- 9 Hare, M.D., Saengkham, M., Tatsapong, P., Wongpichet, K. and Tudsri, S. 2004 Waterlogging tolerance of some tropical pasture grasses. *Tropical Grasslands*, 38: 227-233. (Appendix 9).
- 10 Hare, M.D., Tatsapong, P., Lunpha, A. and Wongpichet, K. 2005 *Brachiaria* species in north-east Thailand: dry matter yields and seed production. *Tropical Grasslands*, 39: 99-106. (Appendix 10).
- 11 Phaikaew, C., Nakamane, G. and Hare, M. 2005 Seed production of new hybrid *Brachiarias* in Thailand. (Southeast Asia Feed Research and Development Network). *Seafarad Newsletter* 15, 15. (Appendix 11).

- 12 Phaikaew, C. and Hare, M.D. 2005 Stylo Adoption in Thailand: three decades of progress. In: O'Mara, P., Wilkins, R.J., Marnett, L., Lovett, D.K., Rogers, P.A.M. and T.M. Boland, T.M. (eds). *Proceedings of the XX International Grassland Congress*. Wageningen Academic Publishers, The Netherlands. pp. 323. (Appendix 12).

5.2 Graduate thesis

The project supported 2 researchers to undertake field research for their Masters thesis. One researcher withdrew from her studies and the other researcher completed her studies. Miss Areerat Lunpha conducted her research at Ubon Ratchathani University. The abstract is included in Appendix 13.

Lunpha, A. 2005 The effect of silage quality after ensiling in small containers. Master of Science thesis, Department of Animal Science, Faculty of Agriculture, Ubon Ratchathani University. 142 pp (Appendix 13).

5.3 Milk production grazing trials

The project demonstrated that it is possible to successfully graze dairy cows on pastures day and night in Thailand. Signal grass and Ubon paspalum are both suitable grass species for dairy production. Ubon paspalum does have low quality forage but makes up for this by producing high dry matter yields and a high leaf:stem ratio which is very digestible. Signal grass maintains good quality and produces high crude protein yields all year round. Even though Jarra digit is a very high quality grass, low dry matter production lowers milk production per rai.

The project showed that it is possible to successfully graze dairy cows on grass and legume pastures in Thailand, all day and all night, without concentrate, in both the wet and dry seasons. If farmers have well-fertilised grass and legume pastures it is not necessary to supply medium-producing cows with concentrate in Thailand. However, irrigation is necessary in the dry season to keep forages green and leafy.

The project also found that Ubon stylo legume silage can replace concentrate feeds without any significant effect on milk production.

5.4 *Brachiaria* evaluation

Research by the project on different *Brachiaria* species showed that in the dry season, without irrigation, new *Brachiaria* species, Toledo, Marandu, Mulato II and Mulato, produce significantly more dry matter than ruzi on upland soils. Ruzi is the most commonly grown grass in Thailand, but the project has shown that the above species are better than ruzi on upland soils, particularly in the dry season. In the 2004-5 dry season, many ruzi plants died, whereas both Mulato and Mulato II remained green and productive.

5.5 *Stylosanthes* evaluation

The project showed that Ubon and Tha Phra have superior dry matter production compared to Hamata, particularly in the dry season. This is because Ubon and Tha Phra are perennials and stay green and productive throughout the year, whereas Hamata is a biennial and dries off and dies in the dry season. The forage quality of Hamata is generally better in the wet season because it has new fresh growth from new seedlings. However, in the dry season, the quality of Hamata decreases rapidly as it dries and dies in contrast to the quality of Ubon and Tha Phra which remain good.

Ubon and Tha Phra produce excellent quality dry matter in the dry season, which, on average is 2-3 times the production from grasses. Both these accessions should be grown more in Thailand for dry season forage.

5.6 Silage production for smallholder dairy farmers

The project showed that good quality silage production can be made from Ubon paspalum in plastic drums. Additives do not have to be applied and the grass does not have to be chopped if the drum is well-sealed and air-tight.

5.7 Seed production research

The results showed that Mulato and Mulato II can produce good quality forage before closing the fields for seed production. Cutting monthly until July in first year crops and August in second year crops will produce high dry matter yields of high quality leaf content for feeding to animals. Farmers can therefore feed Mulato to their animals, 7-8 months of the year and, close for seed for 4-5 months (July or August to December). In order for farmers to get both forage and seed in the same year, we would recommend seed crops to be planted with tillers as early as possible in the wet season, in order to produce a strong rooting system, tiller out and produce forage for feeding livestock before closing.

The method of placing nylon bags over the seed heads to collect seed produced the highest seed yields. However, seed yields of Mulato and Mulato II are much lower than ruzi. Mulato seed can be safely stored in ordinary rooms for short periods (up to 8 months) but for long-term storage, cool storage is recommended. For long-term storage, plastic and nylon bags maintain seed germinations better than paper bags.

The project found that Ubon stylo is a very prolific seeder, producing up to 150 kg/rai, which is nearly 3 times the seed yields produced by Tha Phra stylo. Cutting stylo seed crops at the beginning of September produces more seed than not cutting or cutting later.

5.8 Seed production by village farmers

Farmers find Ubon paspalum and Ubon stylo lucrative cash crops and relatively easy crops to harvest seed. The farmers now average over 100 kgs/rai, with some farmers producing 150 kgs/rai. Demand for Ubon paspalum seed in Thailand is currently very high, as it is the best grass for wet soils. The project is trying to develop a market for Ubon paspalum and Ubon stylo seed in South America. 3000 kgs of seed of both species has been ordered for export to Central and South America in 2006.

The project undertook a joint venture with a Mexican Seed company to produce Mulato II seed by village farmers. Over 2000 kgs of seed were produced in the first year and 1500 kgs exported to USA. This project has been difficult for the farmers because of low seed yields.

6 Were the objectives of this project achieved?

In the project proposal submitted to the Thailand Research Fund for approval in 2002, there were 6 main project objectives.

6.1 To demonstrate through field research that dairy cows grazing good perennial grass and legume pastures can produce milk yields that are economically better than other management systems.

This objective was achieved because the project proved that it is possible to successfully graze dairy cows on grass and legume pastures in Thailand, all day and all night, without concentrate, in both the wet and dry seasons. This system was proven to be economically better than the grass-concentrate feeding system currently used by the majority of dairy farmers in Thailand.

6.2 To assist and improve smallholder dairy production in Ubon Ratchathani and neighbouring provinces and to formulate and demonstrate economical perennial pasture systems that are suitable for dairy farmers.

This objective was not achieved with nearly all farmers in the 3 cooperatives that the project worked with in Ubon Ratchathani and Sisaket provinces failing to grow good pastures. The main reason for the failure of this objective was the economic management problems within the cooperatives. For many months dairy farmers were not paid for their milk and because of this they had no incentive or money to grow pastures.

The project concluded that dairy production in these two provinces is still in its infancy and until the cooperatives become better organized and managed, farmers will not improve their pastures.

6.3 To evaluate lines of *Brachiaria* and *Stylosanthes* species for dairy farmers on upland sandy soils in Thailand.

This objective was achieved, with new brachiaria and stylo cultivars proving to be better, respectively, than ruzi and hamata stylo currently used by dairy farmers in Thailand. Use of new brachiaria and stylo cultivars will significantly increase dry season pasture production.

6.4 Develop seed production of the best *Brachiaria* and *Stylosanthes* species into long term cash crops for farmers.

This objective was achieved, with farmers successfully planting Mulato II and Ubon stylo for seed production. Both species are developing into long-term cash crops for farmers as overseas markets are created in Central and South America.

6.5 Develop simple silage-making methods from grasses and legumes for smallholder farmers.

This objective was achieved, with research showing that good quality silage production can be made from Ubon paspalum and Ubon stylo in plastic drums. This method can be used by smallholder farmers to make silage in the wet season for feeding to their livestock in the dry season.

6.6 Further promote Ubon Ratchathani University as a centre of pasture excellence through international publications, conferences, training, field days and the mass media.

This objective was achieved with 8 international publications, 4 conference papers, training of farmers in pasture production and articles on the project in Thai newspapers.

7 Overall Conclusion

The project has been able to successfully undertake applied research which has quickly reached the end-users through publications and seed sales.

Appendices

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- 8 Hare, M.D., Tatsapong, P., Lunpha, A. and Wongpichet, K. 2004 Effect of 210
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- 11 Phaikaew, C., Nakamanee, G. and Hare, M. 2005 Seed production of new 235
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- 12 Phaikaew, C. and Hare, M.D. 2005 Stylo Adoption in Thailand: three 236
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- 13 Lunpha, A. 2005 The effect of silage quality after ensiling in small 237
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Evaluation of forage legumes and grasses on seasonally waterlogged sites in north-east Thailand

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Abstract

Seven legumes sown in pure swards and 7 grasses sown with legumes and fertilised with N were evaluated in a series of trials at 7 low lying infertile sites in north-east Thailand over 2–3 years from 1997–2000. All sites have an average annual rainfall of 1400 mm.

The highest legume yield in pure swards was in the year of sowing from *Aeschynomene americana* cv. Lee, which produced over 14 t/ha DM at one site. All legumes failed to persist beyond the second wet season under cutting. *Stylosanthes guianensis* cv. Tha Phra (CIAT 184) showed some promise as a legume at some sites that were not deeply waterlogged but only in a few places was it able to persist into the second dry season. No legumes performed well enough to be recommended for such sites under the existing management system.

The best grasses on deeply waterlogged sites were *Paspalum atratum* cv. Ubon, *P. plicatulum* (common Thailand type) and *Setaria sphacelata* var. *splendida* cv. Splenda. These 3 grasses performed well at all sites and were the most consistent in terms of persistence and yield. On less waterlogged sites, *Panicum maximum* cv. Purple was very productive, producing in excess of 30 t/ha DM in the second 6-month wet season at 2 sites. *Brachiaria ruziziensis* (common Thailand type), *B. decumbens* cv. Basilisk, and *Digitaria milanjiana* cv. Jarra grew well only on sites that did not become inundated with water. No

legumes were able to persist in the nitrogen-fertilised (100–120 kg/ha N) grass swards beyond the second wet season.

Introduction

Preliminary evaluation trials were conducted from 1995–1998 on tropical pasture grasses and pasture legumes for seasonally wet and seasonally dry lowland pastures (1500 mm average annual rainfall) on infertile soils in north-east Thailand (Hare *et al.* 1999a). *Paspalum atratum* cv. Ubon was consistently the best grass, producing, on average, more than 20 t/ha DM in a 6-month wet season. *Setaria sphacelata* var. *splendida* cv. Splenda and *P. plicatulum* also grew well and *Digitaria milanjiana* cv. Jarra was very productive on better drained soils.

Legumes, however, did not persist on soils which were waterlogged for 3–5 months and then dry for several months and Hare *et al.* (1999a) were unable to recommend any legumes to farmers. *Stylosanthes guianensis* cv. Graham, *S. hamata* cv. Verano, *Calopogonium mucunoides* (common type) and *Macroptilium gracile* cv. Maldonado (Llanos macro) grew well in the first year but failed to persist after the second wet season. In further experiments, none of the legumes sown with *P. atratum* cv. Ubon or *Brachiaria mutica* persisted after the second wet season on low lying sites (Hare *et al.* 1999b).

As these evaluations were carried out on 3 sites only (Hare *et al.* 1999a; 1999b), we considered it necessary to conduct further small plot trials on several low lying sites to confirm that *P. atratum* cv. Ubon was indeed the best grass and to attempt to identify a suitable legume for these sites. In our first series of trials, Graham stylo showed promise, but in 1997 was devastated with anthracnose. At this time, *S. guianensis* CIAT 184, which was resistant to anthracnose, was growing well on well drained sites in Thailand following its success in South America

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(Amezquita *et al.* 1991), China (Guodao and Kerridge 1997) and parts of south-east Asia (Ibrahim *et al.* 1997). The Division of Animal Nutrition, Department of Livestock Development, had renamed CIAT 184 as Tha Phra stylo and were producing seed. However, there had been no evaluation of Tha Phra stylo on low lying sites.

The current research involved the following 3 experiments: evaluation of 7 grasses sown with legumes at 3 sites for productivity and persistence; evaluation of Tha Phra stylo in association with 7 grasses at 5 sites; and evaluation of 7 legumes for productivity and persistence at 3 sites.

Materials and methods

Trial 1 — Evaluation of grasses sown with legumes

This study was conducted at 3 sites in north-east Thailand (15–16°N): on the Ubon Ratchathani University Farm (UBU); at the Mukdahan Animal Nutrition Station (MUK); and in a village in Det Udom district of Ubon Ratchathani Province (DET). All sites are usually very wet from August–October with the site at DET deeply waterlogged during this period. The soils at UBU and DET are classified as sandy low humic gley soils (Roi-et soil series). The soil at MUK is also a low humic gley soil (Renu soil series) but contains less sand than the Roi-et soils. Prior to commencing the study, the site at UBU had been under native grasses (*Eremochloa ciliaris* and *Panicum repens*) for 7 years following long-term paddy rice cultivation. The site at MUK had been planted to various tropical grass pastures for 20 years and the site at DET had been cultivated for annual paddy rice production for generations by village farmers. Soil tests were conducted on samples taken in May 1997 just prior to sowing the experimental pastures. Annual rainfall was recorded 1 km from the UBU site, 500 m from the MUK site and 15 km from the DET site.

Seven grasses [*Paspalum plicatulum* (common Thailand type), *P. atratum* cv. Ubon, *Brachiaria ruziziensis* (common Thailand type), *B. decumbens* cv. Basilisk, *Setaria sphacelata* var. *splendida* cv. Splenda, *Digitaria milaniana* cv. Jara and *Panicum maximum* cv. Purple] were sown at 18 kg/ha in a randomised block design with 4 replications. High sowing rates are commonly used by farmers and researchers in Thailand to ensure an adequate stand as insurance against seed-eating ants, erratic early wet season rainfall

poor soil preparation. Four legumes [*Stylosanthes hamata* cv. Verano, *Macroptilium gracile* cv. Maldonado (Llanos macro), *Aeschynomene americana* cv. Lee (American jointvetch) and *Centrosema pascuorum* cv. Cavalcade] were each sown at 6 kg/ha with each grass species. Each plot measured 10 × 5 m.

The species were hand broadcast into well cultivated seed beds at MUK on May 7, at UBU on May 12 and at DET on May 14, 1997 and the seed lightly surface raked into the soil. The plots were fertilised at sowing with N (20 kg/ha), K (50 kg/ha), P (20 kg/ha) and S (20 kg/ha).

Plant counts were made in five 0.25 m² quadrats per plot, 6 weeks after sowing. Dry matter cuts were taken from five 0.25 m² quadrats per plot cut 5 cm from ground level, 3–4 times each wet season (May–October) and 2–3 times each dry season (November–April). The study was terminated at the end of April 2000.

At each cut, the samples were sorted into grass and legume and a 200 g subsample of each species from each plot was dried at 70°C for 48 hours and dry weight recorded. After sampling, all plots were cut to about 5 cm above ground level, the forage removed and the plots fertilised with N (20 kg/ha), K (50 kg/ha), P (20 kg/ha) and S (20 kg/ha). The amounts applied were based on experience and research (Hare *et al.* 1999c). Lesser amounts can result in plant deficiencies, especially in grasses, due to leaching of elements from these sandy soils. The average CEC on these soils is 2.3 meq/100 g, S 2–5 ppm and K 20–40 ppm.

Trial 2 — Evaluation of grasses sown with Tha Phra stylo

This study was conducted at 5 sites in north-east Thailand (15–16°N): on the Ubon Ratchathani University Farm (UBU); Yasothon Animal Nutrition Station (YNS); Yasothon Agricultural Technology College Farm (YAC); Sisaket Agricultural Technology College Farm (SAC); and the Ubon Ratchathani Agricultural Technology College Farm (UAC). Soils at all sites are classified as sandy low humic gley soils (Roi-et soil series) and are usually very wet from August–October with the site at SAC deeply waterlogged during this period. All sites, at some time in the past, had been used for paddy rice cultivation. Prior to commencing the study, the site at UBU had been under native grasses (*Eremochloa ciliaris* and *Panicum*

repens) for 8 years, the site at YNS under *P. plicatulum* pastures for 5 years, the site at SAC under paddy rice and the sites at UAC and YAC under a mixture of *P. plicatulum* and *Mimosa pudica*.

Soil tests were conducted on samples taken in May 1998, just prior to sowing the pastures. Annual rainfall was recorded as in Trial 1 for UBU, 100 m from the YNS site, 200 m from the SAC site and 15 km from the UAC site. No rainfall was recorded near the YAC site but, as it was only 15 km from the YNS site, data from this site were used.

Seven grasses (*P. plicatulum*, *P. atratum* cv. Ubon, *B. ruziziensis*, *B. decumbens* cv. Basilisk, *S. sphacelata* var. *splendida* cv. Splenda, *D. milaniana* cv. Jarra and *P. maximum* cv. Purple) were sown at 12 kg/ha together with *S. guianensis* cv. Tha Phra (CIAT 184) at 6 kg/ha in a randomised block design with 4 replications. Each plot measured 5 × 5 m.

The species were hand broadcast into well cultivated seed beds at UBU on May 7, at YNS and YAC on May 13, at SAC on May 14 and at UAC on May 15, 1998 and the seed lightly surface raked into the soil. The plots were fertilised at sowing with N (20 kg/ha), K (25 kg/ha), P (10 kg/ha) and S (10 kg/ha).

Plant counts were made in four 0.25 m² quadrats per plot, 6 weeks after sowing. Dry matter cuts were taken from four 0.25 m² quadrats at 5 cm from ground level in each plot 3–4 times each wet season and 2–3 times each dry season.

Cattle grazed plots at UAC before sampling in October 1998, so, on October 27, 1998, all plots were trimmed to 5 cm above ground level and fertiliser applied. At YAC, the trial was terminated after sampling in September 1999 due to uncontrolled grazing and, at SAC and UAC, observations ceased in October 1999 following repeated cutting by village farmers. At other sites, the trial was terminated at the end of April 2000.

At each sampling, the samples were sorted into grass and Tha Phra stylo and a 200 g subsample of each species was dried as in Trial 1. After each sampling, all plots were topped as described for Trial 1 and fertilised with the same amounts spread at sowing.

Trial 3 — Evaluation of legumes

This study was conducted at 3 sites (UBU, YNS and YAC) adjacent to Trial 2. Soil tests and rainfall were the same as in Trial 2.

Seven legumes (*Stylosanthes hamata* cv. Verano, *S. guianensis* cv. Tha Phra, *Centrosema pascuorum* cv. Cavalcade, *Calopogonium mucunoides*, *Macroptilium gracile* cv. Maldonado, *Pueraria phaseoloides* and *Aeschynomene americana* cv. Lcc) were sown at 12 kg/ha in a randomised block design with 4 replications. Each plot measured 5 × 5 m.

The species were hand broadcast into well cultivated seed beds at UBU on May 7, and at YNS and YAC on May 13, 1998 and the seed lightly surface raked into the soil. The plots were fertilised at sowing with N (20 kg/ha), K (25 kg/ha), P (10 kg/ha) and S (10 kg/ha).

Plant counts were made in four 0.25 m² quadrats per plot, 6 weeks after sowing. Dry matter cuts were taken from four 0.25 m² quadrats at 5 cm from ground level in each plot on 3 occasions in the first wet season, twice in the first dry season, once at YNS and twice at UBU and YAC in the second wet season and once in the second dry season at UBU. No cuts were taken at YAC and YNS in the second dry season.

At each sampling, total fresh weight was recorded and a 200 g subsample was dried as in Trial 1. After each sampling, all plots were topped as described for Trial 1 and fertilised with K (25 kg/ha), P (10 kg/ha) and S (10 kg/ha).

Data from all trials were analysed using the IRRISTAT programme for conventional analyses of randomised block experiments.

Results

Soil

Soils at all sites were acid, with pH ranging from 4.6 at UAC to 5.6 at YAC (Table 1). The soils were low in N (0.02–0.07%), P (2–11 ppm; Bray II extraction method) and organic matter (0.2–1.4%). All soils contained more than 60% sand except for the soil at UAC which was 67% silt.

Rainfall

Average rainfall for all trial sites from 1997–1999 was similar, ranging between 1300–1600 mm,

Table 1. Soil analysis of trial sites.

Site ¹	pH (1:5 water)	Total N	P	OM	Sand	Silt
		(%)	(ppm)	(%)	(%)	(%)
UBU Trial 1	5.3	0.02	7.9	1.0	66	34
UBU Trials 2 & 3	5.3	0.02	9.5	1.1	64	35
MUK	5.2	0.02	5.0	1.2	69	30
DET	4.9	0.02	2.3	1.4	61	39
YNS	5.4	0.02	4.9	1.3	85	14
YAC	5.6	0.04	7.4	0.6	62	37
SAC	5.2	0.03	11.7	1.1	64	35
UAC	4.6	0.07	4.2	0.2	31	67

¹UBU = Ubon Ratchathani University Farm; MUK = Mukdahan Animal Nutrition Station; DET = Village in Det Udon district of Ubon Ratchathani Province; YNS = Yasothorn Animal Nutrition Station; YAC = Yasothorn Agricultural Technology College Farm; SAC = Sisaket Agricultural Technology College Farm; UAC = Ubon Ratchathani Agricultural Technology College Farm.

and most sites experienced good wet season rainfall (Table 2). The site at YNS was the only site to have an early season moisture deficit in 1997 and 1998.

Trial 1 — Evaluation of grasses sown with legumes

Grasses. Plant density of most grass species was good at 6 weeks after sowing (Table 3), except for signal at all sites and Purple guinea at MUK. Plant densities at DET were 2–3 times higher overall than those at UBU and MUK.

Plicatulum produced the most dry matter (13 t/ha) at all sites in the first wet season (Table 4) followed by Ubon paspalum at UBU and DET and Purple guinea and ruzi at MUK. Purple guinea produced significantly less dry matter than plicatulum and Ubon paspalum at UBU and DET. At all sites, yields of signal and Jarra digit were less than half that of plicatulum in the first wet season.

In the first dry season, signal produced high dry matter yields at UBU and MUK but not at DET, and first dry season production of Ubon paspalum was also high at all sites (Table 4).

In the second wet season, Purple guinea produced in excess of 33 t/ha DM at MUK followed by Ubon paspalum, Jarra digit and plicatulum which produced more than 20 t/ha DM (Table 4). At UBU, Purple guinea, Splenda setaria, ruzi, Ubon paspalum and signal also produced more than 20 t/ha DM in the second wet season. Ruzi and Jarra digit died out at the DET site in the second wet season and signal and Purple guinea produced very low yields.

In the second dry season at UBU, there were no significant differences in dry matter production between species but, at MUK and DET, Purple guinea and plicatulum, respectively, were the most productive grasses (Table 4).

Ubon paspalum, plicatulum, Purple guinea and Jarra digit produced the highest dry matter yields at both UBU and MUK in the third wet season (Table 4). Ubon paspalum, Splenda setaria and plicatulum produced the highest yields at DET in both the third wet and dry seasons. In the third dry season at MUK, Purple guinea produced over 12 t/ha DM, which was nearly 40% more than the second most productive grasses, Ubon paspalum and signal (Table 4).

Legumes. Plant density of all legumes 6 weeks after sowing was considerably less than that of the grasses except at MUK, where total legume numbers were generally greater than grass numbers (Table 3). Verano stylo and Cavalcade plant numbers were sparse at all sites.

In the first wet season, legumes at MUK produced 4–5 times more dry matter than legumes at UBU and DET (Table 4). Calopo was the main legume at MUK, growing from buried seed from the previous pasture (data for individual legumes not presented). Llanos macro also grew well in the first wet season at MUK and UBU. Lee jointvetch was the best producing legume at DET in the first wet season. However, by the third cut in October 1997, legumes at all sites were very sparse.

Legumes in all plots died out during the first dry season but grew again from fallen seed as a minor component in the swards in the early part of the second wet season (Table 4). The main leg-

Table 2. Rainfall for the trial sites.

Month	Rainfall											
	UBU ¹			UAC			YNS			MUK		
	1997	1998	1999	1997	1998	1999	1997	1998	1999	1997	1998	1999
Jan	3	0	1	0	0	0	0	0	0	6	2	0
Feb	2	44	3	7	23	0	47	25	0	32	35	0
Mar	71	0	92	41	96	0	41	0	32	15	27	0
Apr	52	60	92	82	125	97	99	37	46	18	151	107
May	150	294	235	194	305	251	47	197	64	103	153	159
Jun	352	183	221	312	154	190	314	75	115	345	173	222
Jul	399	168	291	453	279	228	432	160	283	121	449	245
Aug	324	193	96	224	155	157	337	292	120	368	265	265
Sep	239	208	256	157	201	293	118	163	407	215	239	190
Oct	107	85	95	86	69	111	57	67	172	263	122	245
Nov	0	106	0	0	6	9	0	67	180	30	0	98
Dec	0	0	0	0	1	0	0	0	0	11	0	21
Total	1554	1341	1382	1556	1317	1368	1492	1083	1423	1422	1601	1448

UBU = Ubon Ratchathani University Farm; UAC = Ubon Ratchathani Agricultural Technology College Farm; YNS = Yasothon Animal Nutrition Station; MUK = Mukdahan Animal Nutrition Station; DET = Village in Det Udon district of Ubon Ratchathani Province; SAC = Sisaket Agricultural Technology College Farm.

Table 3. Plant populations (6 weeks after sowing) in grass-legume swards at UBU, MUK and DET (Trial 1)

Treatment	Grass	Lee jointvetch	Verano stylo	Cavalcade	Llanos macro	Total legume
(plants/m ²)						
UBU ¹						
Ruzi	52cd ²	11abc	3a	7a	22ab	43ab
Signal	22c	7bc	2a	7a	4c	20b
Jarra digit	69bcd	13abc	3a	8a	9abc	33ab
Ubon paspalum	109a	14ab	3a	11a	22ab	50a
Plicatulum	98ab	9bc	2a	11a	24a	46a
Purple guinea	42dc	21a	4a	8a	18abc	51a
Splenda setaria	89abc	3c	3a	7a	6bc	19b
MUK ¹						
Ruzi	59cd	60a	10ab	8a	32b	110a
Signal	17d	68a	11ab	9a	39ab	127a
Jarra digit	41cd	52a	8ab	8a	30b	98a
Ubon paspalum	140b	41a	10ab	5a	32b	88a
Plicatulum	245a	50a	11a	4a	54a	119a
Purple guinea	6d	48a	5ab	7a	33b	93a
Splenda setaria	111bc	66a	4b	9a	41ab	120a
DET ¹						
Ruzi	112dc	53a	9a	11a	18a	91a
Signal	28c	64a	7a	9a	21a	101a
Jarra digit	219cd	67a	9a	11a	19a	106a
Ubon paspalum	346bc	72a	10a	9a	17a	108a
Plicatulum	587a	66a	6a	11a	19a	102a
Purple guinea	169dc	60a	7a	9a	17a	93a
Splenda setaria	455ab	63a	7a	9a	19a	98a

¹UBU = Ubon Ratchathani University Farm; MUK = Mukdahan Animal Nutrition Station; DET = Village in Det Udom district of Ubon Ratchathani Province.

²Within columns and sites means followed by a common letter are not significantly different at $P=0.05$ by Duncan's Multiple Range Test.

umes were Llanos macro, Calopo and Lee jointvetch at UBU, MUK and DET, respectively. Following the first cut in the second wet season, legumes died out at all sites and failed to reappear for the duration of the trial.

Trial 2 — Evaluation of grasses sown with *Tha Phra stylo*

Plant populations of Ubon paspalum, plicatulum and Splenda setaria at 6 weeks after sowing exceeded 200 plants/m² at UBU, YNS and UAC and 100 plants/m² at YAC and SAC (Table 5). Density of signal, Jarra digit and Purple guinea was lower at 19–85 plants/m². The average densities of *Tha Phra stylo* at UBU and UAC (135 and 173 plants/m²) were higher than those at the other sites (71 plants/m²).

In the first wet season, Ubon paspalum and plicatulum tended to produce the most dry matter

at all sites (Table 6). However, there were few significant differences in dry matter production between most species. Signal and Jarra digit were the least productive species at all sites. Dry matter production at SAC was affected by severe waterlogging from August–October. *Tha Phra stylo* was generally sparse in the productive grass swards in the first wet season at UBU, YNS and YAC, contributing less than 5% of total dry matter (Table 6). At SAC and UAC, where grass production was lower than at the other sites, *Tha Phra stylo* represented a higher percentage of total dry matter.

In the first dry season, Ubon paspalum and plicatulum produced high dry matter yields at all sites (Table 7) followed by signal, Purple guinea and Splenda setaria. Jarra digit was the least productive species at all sites. In most plots, *Tha Phra stylo* contributed about 5% of total

Table 4. Dry matter production from grass-legume swards at UBU, MUK and DET (Trial 1).

Treatment (Year)	Wet (97)			Dry (97-98)		Wet (98)		Dry (99)		Wet (99-00)		Dry (00)
	G ²	L	T	G	G	L	T	G	G	G		
(t/ha)												
UBU ¹												
Ruzi	9.4b ¹	0.3bc	9.7bc	2.5d	22.6a	0.3c	22.9a	5.4a	9.5c	6.8a		
Signal	5.5c	2.2a	7.7cd	6.1a	20.3ab	0.7c	21.1ab	6.5a	9.6c	7.8a		
Jarra digit	6.1c	0.1c	6.2d	1.6d	16.7bc	1.8b	17.8bc	5.9a	10.3bc	5.9a		
Ubon paspalum	10.2b	1.4ab	11.6ab	5.8ab	20.9a	0.2c	21.1ab	5.3a	12.9a	6.7a		
Plicatulum	13.4a	0.7bc	14.1a	5.2abc	16.2c	0.1c	16.3c	5.2a	12.4ab	6.7a		
Purple guinea	5.1c	0.6bc	5.7d	3.5cd	23.6a	0.4c	24.0a	5.9a	10.6abc	7.5a		
Splenda setaria	7.5bc	0.7bc	8.2cd	3.6bcd	22.7a	2.4a	25.1a	6.8a	9.9c	7.9a		
MUK ¹												
Ruzi	12.4a	3.2b	15.7ab	4.9bc	19.1c	1.0b	20.1c	2.2dc	12.2b	5.8c		
Signal	6.0b	5.8ab	11.8bc	7.7a	18.7c	0.8bc	19.5c	3.2bc	11.4b	7.1b		
Jarra digit	5.4b	4.8ab	10.2c	5.0bc	22.3bc	0.5c	22.9bc	2.7cd	16.0ab	6.3bc		
Ubon paspalum	9.9ab	6.2a	16.1ab	7.0ab	26.3b	0.1c	26.4b	3.4b	17.5a	7.0b		
Plicatulum	13.6a	4.5ab	18.1a	4.5c	20.3c	0.1c	20.4c	2.3dc	15.1ab	4.7c		
Purple guinea	11.6a	6.8a	17.9a	7.6a	33.9a	1.1b	35.0a	4.2a	19.2a	12.4a		
Splenda setaria	8.6ab	5.1ab	13.7abc	3.5c	17.5c	2.1a	19.6c	1.7c	12.2b	4.7c		
DET ¹												
Ruzi	5.6c	0.06b	5.66c	0.02b	— ⁴	—	—	—	—	—		
Signal	3.3c	1.7a	5.0c	0.7b	4.9b	0.4a	5.3b	6.8b	3.2bc	0.4c		
Jarra digit	4.8c	0.05b	4.85c	0.04b	—	—	—	—	—	—		
Ubon paspalum	10.5ab	0.5b	11.0a	4.4a	14.6a	0.3a	14.9a	5.6b	10.2a	5.0a		
Plicatulum	13.0a	0.06b	13.06a	5.5a	13.9a	0.3a	14.2a	10.0a	6.1ab	3.6b		
Purple guinea	5.7c	1.3ab	7.0bc	1.1b	2.5b	0.5a	3.0b	1.0c	1.3bc	—		
Splenda setaria	9.6b	0.1b	9.7ab	4.5a	13.3a	0	13.3a	6.6b	9.6a	6.8a		

¹UBU = Ubon Ratchadani University Farm; MUK = Mukdahan Animal Nutrition Station; DET = Village in Det Udom district of Ubon Ratchadani Province.

²G = Grass; L = Legume; T = Total (G + L).

³Within columns and sites, means followed by a common letter are not significantly different at $P=0.05$ by Duncan's Multiple Range Test.

⁴Species not present.

sward dry matter yields in the first dry season but in some plots it died out (Table 7).

In the second wet season, all grass species produced well at UBU, with mean yield exceeding 16 t/ha DM (Table 8). Ubon paspalum, plicatulum and Purple guinea produced equally high yields at YNS and YAC. At UAC, Purple guinea produced nearly 7 t/ha DM more than Ubon paspalum and plicatulum but at SAC, yield of Purple guinea was only half that of these 2 species. Tha Phra stylo died out in all plots at YAC and was present in plots at other sites only at the first sampling cut (Table 8). By the second dry season, it was no longer present in any plots at all sites.

The trials at SAC, YAC and UAC were terminated early in the second dry season following uncontrolled grazing or cutting. In the second dry season at UBU and YNS, Purple guinea produced

higher dry matter yields than other species but these differences were significant only at UBU (Table 9).

Trial 3 — Evaluation of legumes

All legume species had achieved good plant densities at all sites at 6 weeks after sowing (Table 10). Plant numbers of Llanos macro, Tha Phra stylo and Lee jointvetch were high at UBU.

In the first wet season, Lee American jointvetch at YAC produced 14 t/ha, nearly 3 times more than the second best legume, Llanos macro (Table 11). Llanos macro produced nearly twice the amount of dry matter of other legumes at UBU except for Lee jointvetch.

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Table 5. Plant populations (6 weeks after sowing) of grass species and *Tha Phra stylo* at UBU, YNS, YAC, SAC and UAC (Trial 2).

Treatment	UBU ¹	YNS	YAC	SAC	UAC
(plants/m ²) Grass					
Ruzi	85c ²	95b	70bcd	61c	118b
Signal	43c	50b	20d	19c	46bc
Jarra digit	52c	47b	31d	25c	30c
Ubon paspalum	225b	228a	149ab	156a	232a
Plicatulum	351a	200a	188a	176a	270a
Purple guinea	85c	59b	45cd	54c	48bc
Splenda setaria	287ab	217a	122abc	111b	266a
<i>Tha Phra stylo</i>					
Ruzi	102a	69abc	50ab	67a	163ab
Signal	135a	113a	46ab	112a	237a
Jarra digit	150a	112ab	32b	78a	200ab
Ubon paspalum	144a	63bc	64ab	76a	131b
Plicatulum	168a	49c	39b	69a	122b
Purple guinea	125a	82abc	77a	63a	190ab
Splenda setaria	118a	99abc	43ab	92a	170ab

¹UBU = Ubon Ratchathani University Farm; YNS = Yasothon Animal Nutrition Station; YAC = Yasothon Agricultural Technology Farm; SAC = Sisaket Agricultural Technology College Farm; UAC = Ubon Ratchathani Agricultural Technology College Farm.

²Within columns and plant type, means followed by a common letter are not significantly different at $P=0.05$ by Duncan's Multiple Range Test.

Table 6. Dry matter production of grass species and *Tha Phra stylo* in the first wet season after planting at UBU, YNS, YAC, SAC and UAC (Trial 2).

Treatment	UBU ¹	YNS	YAC	SAC	UAC
(t/ha) Grass					
Ruzi	12.4ab ²	8.8abc	13.7a	3.4ab	6.8b
Signal	6.5bc	4.6cd	6.9b	0.6d	2.3cd
Jarra digit	4.6c	1.2d	4.2b	1.7cd	0.9d
Ubon paspalum	14.1a	9.8a	16.6a	4.4a	10.3a
Plicatulum	14.9a	9.2ab	13.4a	4.3a	9.7a
Purple guinea	13.5a	7.4abc	14.4a	2.1bc	5.0bc
Splenda setaria	9.3abc	5.0bcd	13.7a	2.2bc	6.3b
<i>Tha Phra stylo</i>					
Ruzi	0.87b	0.21b	0.06ab	0.38bc	0.05c
Signal	2.08a	0.68a	0.14ab	0.72a	1.44a
Jarra digit	1.81a	0.73a	0.05ab	0.17c	1.09ab
Ubon paspalum	0.79b	0.11b	0.09ab	0.34bc	0.34c
Plicatulum	0.63b	0.25b	0.03b	0.24c	0.29c
Purple guinea	1.94a	0.71a	0.24a	0.61ab	0.94b
Splenda setaria	1.15ab	0.32b	0.06ab	0.45abc	0.48c

¹UBU = Ubon Ratchathani University Farm; YNS = Yasothon Animal Nutrition Station; YAC = Yasothon Agricultural Technology Farm; SAC = Sisaket Agricultural Technology College Farm; UAC = Ubon Ratchathani Agricultural Technology College Farm.

²Within columns and plant type, means followed by a common letter are not significantly different at $P=0.05$ by Duncan's Multiple Range Test.

Table 7. Dry matter production of grass species and Tha Phra stylo in the first dry season after planting at UBU, YNS, YAC, SAC and UAC (Trial 2).

Treatment	UBU ¹	YNS	YAC	SAC	UAC
	(t/ha)				
	Grass				
Ruzi	3.2bc ²	4.6ab	3.2b	0.6b	2.6d
Signal	5.0ab	4.4ab	4.7a	0.2b	3.5bc
Jarra digit	2.9c	2.6b	0.8c	0.1b	1.0c
Ubon paspalum	4.5abc	4.4ab	5.0a	6.6a	4.9a
Plicatulum	4.8ab	3.7ab	5.0a	8.2a	3.8b
Purple guinea	5.5a	5.6ab	2.9b	0.7b	4.0b
Splenda setaria	3.4bc	6.7a	2.5b	6.2a	2.8cd
	Tha Phra stylo				
Ruzi	0.86a	0.20a	— ³	1.23a	0.27a
Signal	0.98a	0.30a	0.03a	0.86a	0.23a
Jarra digit	1.01a	0.31a	0.09a	1.01a	0.30a
Ubon paspalum	0.20a	—	0.04a	0.97a	—
Plicatulum	0.20a	0.03a	0.03a	1.14a	—
Purple guinea	0.20a	0.53a	0.09a	0.47a	0.08a
Splenda setaria	0.31a	0.52a	0.06a	0.20a	0.12a

¹UBU = Ubon Ratchathani University Farm; YNS = Yasothon Animal Nutrition Station; YAC = Yasothon Agricultural Technology Farm; SAC = Sisaket Agricultural Technology College Farm; UAC = Ubon Ratchathani Agricultural Technology College Farm.

²Within columns and plant type, means followed by a common letter are not significantly different at P=0.05 by Duncan's Multiple Range Test.

³Species not present.

Table 8. Dry matter production of grass species and Tha Phra stylo in the second wet season after planting at UBU, YNS, YAC, SAC and UAC (Trial 2).

Treatment	UBU ¹	YNS	YAC	SAC	UAC
	(t/ha)				
	Grass				
Ruzi	14.4a ²	14.9ab	16.7cd	0.6d	20.1b
Signal	13.6a	12.3b	12.5d	2.4cd	18.5b
Jarra digit	14.7a	3.4c	12.7d	4.8c	19.4b
Ubon paspalum	16.4a	17.4a	22.5a	17.1a	22.6b
Plicatulum	17.9a	16.2a	20.3abc	15.9a	23.9b
Purple guinea	18.2a	17.3a	21.7ab	8.1b	31.1a
Splenda setaria	18.6a	11.9b	17.3bcd	13.9a	20.4b
	Tha Phra stylo				
Ruzi	0.47ab	0.12a	— ³	0.89ab	0.14a
Signal	0.29ab	—	—	1.15a	0.30a
Jarra digit	0.57a	0.12a	—	0.53ab	0.16a
Ubon paspalum	0.06b	—	—	0.12b	0.21a
Plicatulum	0.09ab	—	—	0.04b	—
Purple guinea	—	0.12a	—	0.55ab	0.27a
Splenda setaria	—	0.31a	—	0.09b	0.33a

¹UBU = Ubon Ratchathani University Farm; YNS = Yasothon Animal Nutrition Station; YAC = Yasothon Agricultural Technology Farm; SAC = Sisaket Agricultural Technology College Farm; UAC = Ubon Ratchathani Agricultural Technology College Farm.

²Within columns and plant type, means followed by a common letter are not significantly different at P=0.05 by Duncan's Multiple Range Test.

³Species not present.

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Table 9. Dry matter production of grass species in the second dry season after planting at UBU and YNS (Trial 2).

Treatment	UBU ¹	YNS
	(t/ha)	
Ruzi	10.3b ²	5.2b
Signal	11.9ab	8.8a
Jarra digit	8.6b	1.7c
Ubon paspalum	9.8b	7.2a
Plicatulum	10.4b	8.6a
Purple guinea	14.5a	9.3a
Splenda setaria	10.9b	7.8a

¹UBU = Ubon Ratchathani University Farm; YNS = Yasothon Animal Nutrition Station.²Within columns, means followed by a common letter are not significantly different at P=0.05 by Duncan's Multiple Range Test.

Table 10. Plant populations (6 weeks after sowing) of legume species at UBU, YNS and YAC (Trial 3).

Treatment	UBU ¹	YNS	YAC
	(plants/m ²)		
Verano stylo	86c ²	97a	46c
Tha Phra stylo	173b	119a	108b
Cavalcade centurion	40d	51a	29c
Calopo	36d	60a	22c
Llanos macro	171b	86a	178a
Puero	60cd	56a	14c
Lee jointvetch	221a	53a	89b

¹UBU = Ubon Ratchathani University Farm; YNS = Yasothon Animal Nutrition Station; YAC = Yasothon Agricultural Technology Farm.²Within columns, means followed by a common letter are not significantly different at P=0.05 by Duncan's Multiple Range Test.

Table 11. Dry matter production of legume species at UBU, YNS and YAC (Trial 3).

Treatment	First wet season			First dry season		Second wet season		
	UBU ¹	YNS	YAC	UBU	YNS	UBU	YNS	YAC
	(t/ha)							
Verano stylo	3.7b ²	3.0a	3.9bc	1.3b	1.1ab	6.1a	0.6a	5.2a
Tha Phra stylo	3.4b	3.5a	3.9bc	3.7a	1.6a	7.1a	0.9a	2.5bc
Cavalcade	4.6b	1.8ab	4.0bc	0.4b	0.3b	0.8b	— ³	0.6cd
Calopo	4.4b	2.2ab	3.3bc	0.3b	0.1b	0.6b	0.2b	0.2d
Llanos macro	8.0a	3.3a	5.5b	4.6a	2.1a	1.9b	0.1b	3.2b
Puero	3.2b	0.2b	1.4c	0.2b	—	0.2b	—	1.0cd
Lee jointvetch	5.3ab	2.5a	14.0a	1.7b	—	2.3b	0.1b	0.7cd

¹UBU = Ubon Ratchathani University Farm; YNS = Yasothon Animal Nutrition Station; YAC = Yasothon Agricultural Technology Farm.²Within columns, means followed by a common letter are not significantly different at P=0.05 by Duncan's Multiple Range Test.³Species not present

In the first dry season, Llanos macro and Tha Phra stylo were the best performing legumes at UBU and YNS, followed by Verano stylo (Table 11). At YAC, no dry season data were collected as all legume plots were heavily smothered with *Mimosa pudica*.

However, all legumes at YAC re-established from fallen seed in the second wet season. These new plants plus surviving plants grew well and Verano stylo produced more than 5 t/ha DM (Table 11). At UBU, Verano stylo and Tha Phra stylo were very productive, producing 6 and

7 t/ha DM, respectively. Legumes at YNS were sparse and only 1 cut was taken at the end of the wet season.

In the second dry season, the trial at YAC was grazed and at YNS no legumes grew at all with two main weed species, *Melochia corchorifolia* and *Corchorus olitorius*, smothering the plots. At UBU, only Tha Phra stylo and Verano stylo grew, producing 4 and 0.6 t/ha, respectively. In the remaining plots, *Eremochloa ciliaris* grew vigorously.

Discussion

This study found that none of the legumes tested was able to persist either in pure swards or when growing with N-fertilised grass under cutting on low lying sites in north-east Thailand, confirming the results found earlier by Hare *et al.* (1999a). Establishment of legumes has never been a problem on such sites, with many legumes in pure swards producing over 4 t/ha DM in the first growing season and even reaching 14 t/ha DM, as was the case with Lee American jointvetch at one site (Table 11). The difficulty of legume persistence thereafter appears to be a combination of wet and dry conditions, competition from N fertilised grasses and cutting management.

We may have more success with legumes if we cut less frequently at a greater height, 20–30 cm above ground level, rather than cutting every 45–55 days to 5 cm above ground level. However, this would necessitate a change of management by village farmers who raise livestock.

Our philosophy in introducing legumes and grasses to village farmers is that the selected plants must be adapted to the current low cutting or continuous grazing management currently practised by livestock farmers. This is why Verano stylo has been so successful in upland, well drained soils in north-east Thailand. It tolerates heavy grazing and being a prolific seeder, even under these conditions, re-establishes itself each year (Hare and Phaikaew 1999). If we were to recommend less frequent and high cutting to livestock farmers, this would introduce an additional management factor for farmers to consider. Just getting farmers to establish improved species and apply fertiliser is an achievement in itself. Getting them to adopt a different cutting management for legumes will take time.

In these studies, nitrogen was applied frequently in order to study the potential of the grasses to produce on these very difficult infertile soils. Previous studies had found that, with either no nitrogen or less frequent applications, grasses quickly became very yellow and nitrogen-deficient (Hare *et al.* 1999c). Applications of more than 100 kg/ha N are far in excess of what smallholder farmers would apply to their pastures. Normal rates in villages would be either no fertiliser or 1 application of 20 kg/ha N in the wet season. Thus, pastures commonly die out within 2 years from a combination of lack of fertiliser and close and frequent grazing or cutting.

At the beginning of the study, we considered that *S. guianensis* CIAT 184 (Tha Phra stylo) would be successful. To a limited extent it was as, in pure swards, it persisted into the second wet season but only in a few plots into the second dry season. The cutting management we used may be a factor in its lack of persistence. *S. guianensis* CIAT 184 grew well in the American tropical rainforest ecosystem after one cut at 12 weeks of age (Amezquita *et al.* 1991). In China, it is usually cut only once a year when grown for feed meal production or as a cover crop (Guodao and Kerridge 1997). Where more frequent cutting has been practised in China, the sites have been on well drained, high pH (6.4), reddish brown, lateritic soils (Guodao and Kerridge 1997) and not on poorly drained, infertile, low pH, sandy soils like those used in the current study in Thailand. However, on well drained, upland soils in north-east Thailand, CIAT 184 grows very well, and in current trials at UBU, CIAT 184 and the hybrid stylo (ATF 3308 *S. guianensis* var. *vulgaris* × var. *pauciflora*), produced 9030 and 8470 kg/ha DM, respectively, in the first wet season and 4024 and 2639 kg/ha DM in the first dry season. The cutting was infrequent with only 2 wet season cuts and 1 dry season cut. In our own pasture programme at UBU, pure stands of Tha Phra stylo and the hybrid stylo (ATF 3308) are grazed to about 30 cm height and closed to grazing during the main flowering and seed-set period from December–February.

We expected to have more success with Lee American jointvetch given that an annual ecotype of *Aeschynomene americana* grows naturally in wet areas along roadsides and around swampy ungrazed wasteland in north-east Thailand. This native legume is rarely cut for forage and is

allowed to grow rank and set seed every year. Cutting once a year at the end of the dry season enabled Glenn American jointvetch to grow well for 3 years on seasonally flooded clay and solodic soils in the Northern Territory, Australia (Ross and Cameron 1991). It was able to re-establish each year from fallen seed. This current study showed that Lee has the potential to grow well here, as it produced 14 t/ha DM at one site in the first growing season. Studies of persistence mechanisms could result in management strategies that would improve persistence of Lee under cutting.

However, cropping farmers do have more success with legumes if they regard them as annual cash crops to sell to livestock farmers as fresh grass or hay and cut only once or twice a year. On well drained upland soils, several legumes are being promoted as cash crops by the Department of Livestock Development in Thailand for specialist fresh forage and hay production (Khemawatt and Phonbumrung 2002). The main legume is Cavalcade and more than 3000 farmers will grow up to 0.32 ha for sale to other farmers. They will not use the forage for themselves. The other legumes are Verano stylo and Tha Phra stylo. Under once or twice-a-year cutting all of these legumes grow very well but they have to be replanted each year as the last cut is before seed set.

This study found that, on sites deeply waterlogged in the wet season (DET and SAC), only 3 grass species (Ubon paspalum, plicatulum and Splenda setaria) were able to persist, confirming the earlier results of Hare *et al.* (1999a).

On sites that were wet but not severely waterlogged, Purple guinea grass was either equal in production to or more productive than these 3 species. Purple guinea is a good quality pasture grass and, on sites such as MUK, has the potential to produce in excess of 33 t/ha DM in a 6-month wet season. Even in the second and third dry seasons on these low lying sites, no species produced more dry matter during the dry season than Purple guinea grass. We therefore recommend Purple guinea grass as a "cut-and-carry" forage for non-waterlogged sites in Thailand. It is currently one of the best grass species recommended for planting in backyard forage plots and for hay and silage production by the Department of Livestock Development in Thailand (Khemawatt and Phonbumrung 2002).

Ruzi, signal grass and Jarra digit performed best on sites that did not become inundated with water in the wet season. However, even on these sites, they were not as productive as Ubon paspalum, plicatulum and Purple guinea grass. On the inundated sites, they either produced low yields or died out.

Rainfall during the studies (1997–1999) was average at all sites. However, rainfall in the 2000 wet season was 30–50% above average at most sites. Unfortunately, the trial areas had either been grazed or cultivated so no data could be collected from the grass species growing under wetter-than-normal field conditions. Observations from our university pastures showed that, under these very wet-waterlogged conditions, Ubon paspalum, plicatulum and Splenda setaria performed the best. Signal grass, ruzi, Jarra digit and Purple guinea struggled to survive in places that were inundated with water for periods longer than 1 month.

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ผลผลิตโคนมจากการเลี้ยงแบบปล่อยแทะเล็มใน แปลงหญ้าเขตร้อน 3 ชนิด¹

Dairy cow milk production from 3 different tropical grasses under grazing

กัญวาน ธรรมแสง ไมเคิล แฮร์ อาร์รีตัน ลุนผา และวรพงษ์ สุริยจันทร์พรทอง

คณะเกษตรศาสตร์ มหาวิทยาลัยอุบลราชธานี

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วิธีศึกษา

การเลี้ยงโคนมแบบปล่อยแทะเล็มตลอดเวลาทั้งกลางวันและกลางคืนยังไม่เป็นที่นิยมแพร่หลายสำหรับเกษตรกรผู้เลี้ยงโคนมในประเทศไทย ทั้งที่การเลี้ยงโคนมระบบนี้โคสามารถให้ผลผลิตน้ำนมและมีความสมบูรณ์พันธุ์ไม่แตกต่างจากการเลี้ยงแบบขังคอกและตัดหญ้ามาให้โคกิน และที่สำคัญคือการเลี้ยงโคนมแบบปล่อยแทะเล็ม เป็นวิธีที่ช่วยลดต้นทุนการผลิตน้ำนมได้ทั้งในแง่ความสะดวก ประหยัดเวลาและแรงงานของเกษตรกรตลอดจนลดปริมาณการใช้อาหารข้นลงได้มาก (Hongyantarachai et al. 1989, Prasanpanich et al. 2002 และ Tudsri et al. 2001) การทดลองครั้งนี้มีวัตถุประสงค์เพื่อ เปรียบเทียบผลผลิตน้ำนม องค์ประกอบทางเคมีของน้ำนม ผลผลิตของแปลงหญ้า และอัตราการปล่อยแทะเล็มของหญ้า เขตร้อน 3 ชนิดได้แก่ หญ้าพาลพาลัมอุบล (*Paspalum atratum* CV Ubon) หญ้าซิกแนล (*Brachiria decumbens*) และหญ้ายาร์ราดิจิต (*Dijlitaria millanjiana*)

สัตว์ทดลอง ใช้แม่โคนมลูกผสมที่มีระดับเลือดโคพันธุ์ขาว-ดำ ตั้งแต่ 75% ขึ้นไปจำนวน 9 ตัว สุ่มให้โคแทะเล็มในแปลงหญ้า 3 ชนิดดังกล่าวข้างต้น

ระยะเวลาและสถานที่ทดลอง ดำเนินการทดลองในช่วงวันที่ 14 กรกฎาคม - 27 ตุลาคม 2545 ที่ฟาร์มโคนมคณะเกษตรศาสตร์ มหาวิทยาลัยอุบลราชธานี แบ่งการทดลองออกเป็น 2 ช่วงคือ ช่วงระยะต้นและระยะกลางของการให้นม (Early and mid-lactation) ซึ่งมีค่าเฉลี่ยจำนวนวันให้นมเมื่อเริ่มการทดลองเท่ากับ 57 และ 113 วัน ตามลำดับ แต่ละช่วงใช้เวลาทดลอง 8 สัปดาห์ โดยแบ่งเป็นระยะปรับสัตว์ 1 สัปดาห์ และระยะเก็บข้อมูล 7 สัปดาห์ เมื่อสิ้นสุดการทดลองช่วงระยะต้นแล้ว ทำการสุ่มโคชุดเดิมและทำการทดลองช่วงระยะกลางของการให้นมต่อไป

การจัดการด้านอาหาร ปล่อยให้โคนมแทะเล็มหญ้าอยู่ในแปลงทดลองทั้งกลางวันและกลางคืน นำเข้าคอกเฉพาะเวลารีดนมตอนเช้าและตอนเย็น หญ้าแต่ละชนิดเริ่มต้นใช้พื้นที่ 3 ไร่ แบ่งเป็นแปลงย่อยแปลงละ 1 ไร่ ใช้การแทะเล็มแบบ



ตารางที่ 1 ค่าเฉลี่ยปริมาณน้ำนมที่ผลิตจริง ปริมาณน้ำนมที่ปรับค่ามาตรฐานที่ระดับไขมัน 4 % (4 % FCM) และการเปลี่ยนแปลงน้ำหนักตัวของโคนมที่แทะเล็มหญ้าเขตร้อน 3 ชนิด

ชนิดหญ้า	ปริมาณน้ำนมที่ผลิตจริง กก./ตัว/วัน			ปริมาณน้ำนมที่ไขมัน 4 % กก./ตัว/วัน			การเปลี่ยนแปลง น้ำหนักตัว (กก./วัน)	
	ระยะ ต้น ¹⁾	ระยะ กลาง ¹⁾	เฉลี่ย ²⁾	ระยะ ต้น ¹⁾	ระยะ กลาง ¹⁾	เฉลี่ย ²⁾	ระยะต้น	ระยะ กลาง
พาสพัลล์มอบล	18.9 ก	15.8 ข	17.4 ก	20.0 ก	16.1 ข	18.0 ก	-0.09 ก	0.08 ก
ซิกแนล	18.7 ก	13.9 ข	16.3 ก	19.11 ก	14.5 ข	16.9 ก	-0.18 ก	-0.09 ก
จาร์รา ดิจิต	19.4 ก	14.4 ข	16.9 ก	19.5 ก	14.5 ข	17.1 ก	-0.09 ก	0.01 ก
% CV			5.46			6.15		

¹⁾ ตัวอักษรที่เหมือนกันหลังค่าของการให้นมและระยะต้นระยะกลาง (แนวนอน) หมายถึง ไม่มีความแตกต่างกันทางสถิติที่ $P = 0.05$

²⁾ ตัวอักษรที่เหมือนกันหลังค่าเฉลี่ยของการให้นมทั้ง 2 ระยะ (แนวตั้ง) ไม่มีความแตกต่างกันทางสถิติที่ $P = 0.05$

ตารางที่ 2 ค่าเฉลี่ยและผลผลิตขององค์ประกอบทางเคมีในน้ำนมของโคที่แทะเล็มหญ้าเขตร้อน 3 ชนิด

ชนิดหญ้า	ไขมัน		โปรตีน		แลคโตส		ของแข็ง ไม่รวมมันเนย	
	(%)	(กก./วัน)	(%)	(กก./วัน)	(%)	(กก./วัน)	(%)	(กก./วัน)
พาสพัลล์มอบล	4.25	0.74	2.82	0.49	4.48	0.85	8.40	1.46
ซิกแนล	4.21	0.69	2.88	0.47	4.91	0.81	8.53	1.39
จาร์รา ดิจิต	4.06	0.68	2.84	0.48	4.76	0.81	8.34	1.41
% CV	6.14	7.88	4.74	6.04	6.45	10.13	2.61	6.88

หมายเหตุ ไม่พบความแตกต่างทางสถิติ ($P>0.05$) ระหว่างชนิดของหญ้า และระยะเวลาการให้นม

อัตราการปล่อยแทะเล็มการผลิตน้ำนมต่อพื้นที่ ถึงแม้ว่าที่แทะเล็มหญ้าต่างชนิดกันจะให้ผลผลิตน้ำนมเฉลี่ย/ตัว/วันได้ใกล้เคียงกันดังแสดง

ในตารางที่ 1 แต่เมื่อคิดในรูปของผลผลิตน้ำนมต่อหน่วยพื้นที่ (ตารางที่ 4) แล้วพบว่า โคที่กินหญ้าพาสพัลล์มอบลใช้พื้นที่แทะเล็มน้อยกว่าคือ

1. ไร่/ตัว ในขณะที่หญ้าชิกแนลและหญ้าจาร์รา พาลัมอุบลสามารถให้ผลผลิตน้ำนมสูงสุดคือ 56.7 ดิจิท์ใช้พื้นที่เพาะเล็ม 1.3-1.5 ไร่/ตัว และหญ้าพาส และ 47.5 กก./ไร่/วัน ในช่วงระยะต้นและช่วง ระยะกลางของการให้นมตามลำดับ

ตารางที่ 3 ผลผลิตและคุณภาพของหญ้าเขตร้อน 3 ชนิด ที่ปล่อยโคลงเพาะเล็มในช่วงระยะต้น และระยะกลางของการให้นม

ระยะต้นของการให้นม							
ชนิดหญ้า	ผลผลิตหญ้า น.น.แห้ง	สัดส่วน % ลำต้น : ใบ		โปรตีน % ในลำต้นและใบ		ค่าเฉลี่ย % และ ผลผลิตโปรตีน	
	(กก./ไร่)	ลำต้น	ใบ	ลำต้น	ใบ	%	กก./ไร่
พาสพาลัมอุบล	604 ก	30 ข	70 ก	6.7 ข	9.2 ข	8.5 ข	51.0 ก
ชิกแนล	504 กข	50 ก	50 ข	10.1 ก	11.7 กข	10.9 ก	55.0 ก
จาร์รา ดิจิท์	341 ข	54 ก	46 ข	8.5 กข	14.9 ก	11.4 ก	39.1 ข
ระยะกลางของการให้นม							
พาสพาลัมอุบล	443 ก	32 ข	68 ก	5.9 ข	9.0 ค	8.0 ค	35.9 ก
ชิกแนล	341 ข	45 ก	55 ข	8.9 ก	12.3 ข	10.8 ข	36.8 ก
จาร์รา ดิจิท์	244 ข	48 ก	52 ข	9.6 ก	14.7 ก	12.3 ก	30.0 ข

หมายเหตุ ตัวอักษรที่เหมือนกันหลังค่าเฉลี่ยในแนวตั้งหมายถึง ไม่มีความแตกต่างกันทางสถิติที่ $p = 0.05$

ตารางที่ 4 อัตราการปล่อยเพาะเล็มและผลผลิตน้ำนมต่อหน่วยพื้นที่ของโคนมที่เพาะเล็มหญ้าเขตร้อน 3 ชนิด

ชนิดหญ้า	อัตราการปล่อยเพาะเล็ม (ไร่/ตัว)			ผลผลิตนมต่อพื้นที่ (กก./ไร่/วัน)		
	ระยะต้น	ระยะกลาง	เฉลี่ย	ระยะต้น	ระยะกลาง	เฉลี่ย
พาสพาลัมอุบล	1.0	1.0	1.00	56.7	47.5	52.1
ชิกแนล	1.3	1.4	1.35	43.2	29.7	36.5
จาร์รา ดิจิท์	1.3	1.5	1.40	44.8	28.5	36.7

หมายเหตุ เป็นค่าที่ได้จากการคำนวณ ไม่ได้ทดสอบความแตกต่างทางสถิติ



สรุปและวิจารณ์ผล

งานทดลองครั้งนี้เลือกใช้แม่โคที่ให้นมค่อนข้างสูง ผลผลิตน้ำนมจึงสูงกว่ารายงานที่พบทั่วไปในประเทศไทย ซึ่งชี้ให้เห็นว่าโคที่ให้นมมากก็สามารถเลี้ยงโดยวิธีปล่อยแทะเล็มในแปลงหญ้าตลอดทั้งวันได้ สำหรับผลผลิตนมที่ลดลงในช่วงระยะกลางของการให้นมนั้นถือว่าเป็นลักษณะตามธรรมชาติของโคนมทั่วไป ผลที่ได้จากการทดลองนี้โคให้ผลผลิตน้ำนมและองค์ประกอบทางเคมีในน้ำนมใกล้เคียงกับงานทดลองที่ประเทศออสเตรเลียของ McAnchlan *et al.* (1994) ที่ปล่อยโคแทะเล็มในแปลงหญ้าเขตร้อน และมีการเสริมอาหารข้นให้อัตรา 0, 2, 4, 6 และ 8 กก./ตัว/วัน โดยให้วันละ 1 หรือ 2 ครั้ง ซึ่งผลปรากฏว่าผลผลิตน้ำนมโคเพิ่มขึ้นจาก 12.8 เป็น 20.0 กก./ตัว/วัน เมื่อไม่มีการเสริมอาหารข้นและให้อาหารข้นที่ 8 กก./ตัว/วัน ตามลำดับ ทั้งนี้การเพิ่มขึ้นของน้ำนมจะมีการตอบสนองในลักษณะเป็นเส้นตรงตามการเพิ่มของระดับอาหารข้นที่ให้ แต่เมื่อคิดในรูปปริมาณน้ำนมที่ปรับค่าไขมันที่ 4 % พบว่าโคจะตอบสนองได้สูงสุดเมื่ออาหารข้นให้อัตรา 6 กก./วัน ที่แบ่งให้วันละ 2 ครั้ง ในส่วนขององค์ประกอบทางเคมีในน้ำนม จากผลการทดลองครั้งนี้ถือว่าอยู่ในช่วงค่าปกติของโคนมในประเทศไทยที่สำรวจโดย ประวีร์ และคณะ (2545)

สำหรับการเปลี่ยนแปลงน้ำหนักตัวของโคพบว่า ในช่วงระยะต้นของการให้นมน้ำหนักตัวของโคทุกกลุ่มลดลงเล็กน้อย และน้ำหนักตัวของโคส่วนใหญ่เพิ่มขึ้นในช่วงระยะกลางของการให้นม อย่างไรก็ตามการเพิ่มน้ำหนักตัวของโคทดลองครั้งนี้มีค่าต่ำกว่าในรายงานของ Tudsri *et al.* (2001)

ที่พบว่า โคมีการเพิ่มน้ำหนักตัวประมาณ 66-200 กรัม/ตัว/วัน ทั้งนี้อาจเนื่องมาจากว่าโคทดลองชุดนี้ให้ผลผลิตนมสูงกว่า ร่างกายจึงมีการนำโภชนะไปใช้ (Nutrient partitioning) เพื่อการผลิตนมมากกว่านำไปใช้เพื่อการเพิ่มน้ำหนักตัว

จากข้อมูลด้านผลผลิตและคุณภาพของแปลงหญ้าพบว่า หญ้าพาสพาลัมบอลให้ผลผลิตน้ำหมักแห้งต่อไร่มากกว่าหญ้าชิกแนลและหญ้าจาร์ดิจิต จึงมีผลทำให้แปลงหญ้าพาสพาลัมบอลมีอัตราการปล่อยแทะเล็มได้มากกว่า และให้ผลผลิตน้ำนมต่อหน่วยพื้นที่ได้มากกว่าแปลงหญ้าอีก 2 ชนิด ซึ่งสอดคล้องกับรายงานของ Hare *et al.* (1999) ที่พบว่า หญ้าพาสพาลัมบอลสามารถเจริญเติบโตและปรับตัวได้ดีที่สุด และให้ผลผลิตสูงในสภาพแวดล้อมของ จ.อุบลราชธานี และพื้นที่ใกล้เคียง ซึ่งสภาพพื้นที่ส่วนใหญ่เป็นที่ลุ่ม ดินเหนียวในช่วงฤดูฝนและดินแห้งอย่างรวดเร็วในฤดูแล้ง ดินมีความเป็นกรด และมีความอุดมสมบูรณ์ต่ำ สำหรับหญ้าชิกแนลและหญ้าจาร์ดิจิต พบว่าให้ผลผลิตและคุณภาพใกล้เคียงกับรายงานที่ทดลองในเขต อ.ห้วยเม็ก จ.สระบุรี โดย Hongyantarachai *et al.* (1989) และ Prasanpanich *et al.* (2002) ที่ทดลองปล่อยโคแทะเล็มในแปลงหญ้ากินนีสีม่วง และ Tudsri *et al.* (2001) ที่ทดลองปล่อยโคแทะเล็มในแปลงหญ้ารู้อย่างเดียวหรือในแปลงหญ้าผสมถั่ว

อย่างไรก็ตามระยะเวลาของงานทดลองครั้งนี้ค่อนข้างสั้น และมีข้อจำกัดในเรื่องของจำนวนสัตว์ทดลองที่ใช้ ดังนั้นเพื่อให้ได้ข้อมูลที่มีความสมบูรณ์มากยิ่งขึ้น จึงควรมีการวิจัยเพิ่มเติมเพื่อหาระบบและวิธีการในการเพิ่มผลผลิตน้ำนมต่อหน่วยพื้นที่ให้



ได้สูงสุดเช่น การปล่อยโคแทะเล็มในแปลงหญ้า
ร่วมกับแปลงถั่ว ตลอดจนศึกษาถึงระดับของการ
เสริมอาหารขึ้นที่ให้ผลผลิตตอบแทนทางเศรษฐกิจ
สูงสุด เป็นต้น

คำขอบคุณ

คณะผู้วิจัยใคร่ขอขอบคุณสำนักงานกองทุนสนับสนุนการวิจัย (สกว.) ที่ให้การสนับสนุนงบประมาณในการดำเนินงานวิจัย และขอขอบคุณคณะเกษตรศาสตร์ มหาวิทยาลัยอุบลราชธานี ที่ให้ความอนุเคราะห์และอำนวยความสะดวกในด้านวัสดุอุปกรณ์ และเจ้าหน้าที่ในการปฏิบัติงาน

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กระทรวงเกษตรและสหกรณ์

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เล่มที่ 1

ประสิทธิภาพการผลิตของแม่โคพันธุ์บราห์มันและโคพื้นเมืองไทย
ที่เลี้ยงด้วยหญ้าพาสพาลัมอุบลในประเทศไทย *

Productivity of Brahman and Thai Indigenous cows grazing
Paspalum atratum cv. Ubon pastures in Thailand*

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บทคัดย่อ

การศึกษาเปรียบเทียบประสิทธิภาพการผลิตของแม่โคเนื้อพันธุ์บราห์มันและแม่โคพื้นเมืองไทย ภายใต้การเลี้ยงแบบปล่อยแพะเล็มในแปลงหญ้าพาสพาลัมอุบล (*Paspalum atratum* cv. Ubon) เป็นเวลาต่อเนื่องนาน 4 ปี ตั้งแต่ปี 2542-45 การทดลองใช้แม่โคบราห์มันจำนวน 12 ตัว และแม่โคพื้นเมือง 24 ตัว โดยปล่อยแพะเล็มในอัตราที่ใกล้เคียงกันคือ 1 หน่วยปศุสัตว์ (น้ำหนักตัว 450 กก.) ต่อพื้นที่แปลงหญ้า 2 ไร่ หรือน้ำหนักตัว 225 กก. ต่อพื้นที่แปลงหญ้า 1 ไร่ ในช่วงฤดูฝนประมาณ 200 วัน (เดือนพฤษภาคม - พฤศจิกายน) ปล่อยโคแพะเล็มในแปลงตลอดทั้งกลางวันและกลางคืน ในช่วงฤดูแล้งนำโคเข้าเลี้ยงในคอก ให้กินหญ้าหมักที่ทำจากหญ้าพาสพาลัมอุบล และเสริมด้วยอาหารข้นที่อัตรา 1% ของน้ำหนักตัวในระยะ 3 เดือนสุดท้ายของการตั้งท้อง

ผลการศึกษาพบว่าแม่โคพื้นเมืองไทยให้ผลผลิตมากกว่าแม่โคบราห์มันเกือบ 2 เท่า ซึ่งแม่โคบราห์มันให้ลูกเพียงปีละ 50% เท่านั้น และมีการสูญเสียน้ำหนักตัวมากหลังจากคลอดและให้นมเลี้ยงลูก และไม่สามารถกลับมาสวมพันธุ์หลังคลอดได้จนกว่าลูกจะหย่านม สำหรับแม่โคพื้นเมืองมีอัตราการผลิตลูกเฉลี่ย 85% ตลอดช่วง 3 ฤดูการผสมพันธุ์ และสามารถผลิตน้ำหนักลูกโคหย่านมได้ 84 กก./ไร่/ปี ซึ่งมากกว่าลูกโคบราห์มันถึง 2 เท่า

หญ้าพาสพาลัมอุบลให้ผลผลิตน้ำหนักแห้งเฉลี่ย 2.75 ตัน/ไร่ ในเวลาประมาณ 200 วันในช่วงฤดูฝน โดยมีโปรตีนเฉลี่ย 7.9% นอกจากนั้นยังสามารถผลิตหญ้าหมักได้ 10.1 ตัน/ไร่/ปี (น้ำหนักสด) และพบว่าแปลงหญ้าพาสพาลัมอุบลมีความคงทนได้ดีภายใต้สภาพการปล่อยสัตว์แพะเล็ม

ความสำคัญ : โคพื้นเมือง โคบราห์มัน ความสมบูรณ์พันธุ์ หญ้าพาสพาลัมอุบล การปล่อยแพะเล็ม

Abstract

A study in Thailand compared the productivity of Brahman cows and Thai Indigenous cows grazing Ubon paspalum (*Paspalum atratum*) pastures for 4 consecutive years from 1999-2002. 12 Brahman cows and 24 Thai Indigenous cows at 3.1 animal units/ha (1 au = 450 liveweight) grazed pastures during approximately 200 days each wet season (May-November). During the dry season, the cows were yarded and fed Ubon paspalum silage and some concentrate.

Thai Indigenous cows were nearly twice as productive as Brahman cows which only had a 50% calving rate. Brahman cows lost a lot of weight following calving and during calf rearing and did not get pregnant again until after the calves were weaned. Thai Indigenous cows had an average calving rate of

85% for 3 breeding seasons. Thai Indigenous cows produced 524 kg liveweight of weaned calves per ha/year which was twice the production from Brahman cows.

Ubon paspalum produced 17.2 t/ha DM during a 200 day wet season with an average crude protein content of 7.9% and 63 t/ha fresh silage/year. Ubon paspalum persisted well under grazing.

Key words: Thai Indigenous Cattle Brahman Fertility Paspalum atratum cv Ubon Grazing

บทนำ

ประเทศไทยมีการนำเข้าโคเนื้อพันธุ์บราห์มันตั้งแต่ปี 2497 โดยกรมปศุสัตว์ เพื่อใช้ในแผนงานปรับปรุงพันธุ์โคเนื้อของประเทศ จากนั้นได้นำมาผสมข้ามพันธุ์กับโคพื้นเมืองไทย จนปัจจุบันมีโคลูกผสมพื้นเมือง-บราห์มัน กระจายอยู่ทั่วประเทศเป็นจำนวนมาก และได้กลายเป็นโคพันธุ์ที่สำคัญในการสร้างสายพันธุ์โคเนื้อและโคนมลูกผสมของประเทศ (กิตติ 2527) สำหรับโคพื้นเมืองไทยจัดอยู่ในโคตระกูลอินเดีย (*Bos indicus*) เช่นเดียวกับโคบราห์มัน เป็นโคที่มีขนาดเล็ก เพศผู้โตเต็มที่น้ำหนักตัวประมาณ 300-350 กก. และเพศเมียน้ำหนักตัวประมาณ 200-250 กก. สีของโคพื้นเมืองจะแตกต่างกันไปในแต่ละท้องถิ่น โดยมีตั้งแต่สีเหลืองอ่อนไปจนถึงน้ำตาลแดงและสีเทาเข้ม ยกเว้นโคขาวลำพูนที่พบมากทางภาคเหนือของประเทศ ซึ่งมีลักษณะเฉพาะแตกต่างไปจากโคภาคอื่นคือ มีสีขาวตลอดทั้งตัว ที่บริเวณรอบตา จมูก เขา กีบ และรอบทวารหนัก มีสีชมพูอมส้ม (อนันต์ และคณะ 2544) แม้ว่าโคพื้นเมืองจะมีขนาดเล็กและน้ำหนักตัวน้อยกว่าโคบราห์มัน แต่มีแนวโน้มว่าโคพื้นเมืองมีความสมบูรณ์พันธุ์สูงกว่าโคบราห์มัน

เกษตรกรผู้เลี้ยงโคเนื้อส่วนใหญ่จะเลี้ยงสัตว์ไว้เพื่อเป็นรายได้เสริม ซึ่งมีการลงทุนด้านพืชอาหารสัตว์และอาหารข้นที่ต่ำ (Thumwasorn *et al.* 1996a) ปัญหาหลักในการผลิตโค-กระบือของเกษตรกรคือ การขาดแคลนอาหารหยาบคุณภาพดีที่จะใช้เลี้ยงสัตว์ได้ตลอดทั้งปี เกษตรกรส่วนใหญ่ไม่มีการปลูกพืชอาหารสัตว์ ในรายที่มีการปลูกก็มีพื้นที่แปลงหญ้าเพียง 1-2 ไร่/ฟาร์ม (Thumwasorn *et al.* 1996b) โดยทั่วไปมักปล่อยให้โคแทะเล็มหญ้าธรรมชาติตามพื้นที่สาธารณะซึ่งเป็นหญ้าที่มีคุณภาพต่ำ และในช่วงฤดูแล้งมักเสริมด้วยฟางข้าว Thumwasorn *et al.* (1996b) พบว่า แม่โคบราห์มันที่นำเข้าจากประเทศออสเตรเลียภายใต้สภาพแวดล้อมการเลี้ยงดูของเกษตรกรรายย่อยในหมู่บ้าน มีสภาพร่างกายที่ผอม โดยมีคะแนนความสมบูรณ์ของร่างกายอยู่ระหว่าง 3-5 คะแนน (ระบบเต็ม 10 คะแนน) ประมาณ 80% ของโคเหล่านี้มีน้ำหนักตัวต่ำกว่า 400 กก.

แม้ว่าได้มีการนำเข้าโคบราห์มันเข้ามาเลี้ยงเป็นเวลาเกือบ 50 ปีมาแล้ว แต่ไม่พบรายงานที่มีการวิจัยเปรียบเทียบการให้ผลผลิตกับโคพื้นเมืองในสภาพแวดล้อมเดียวกันเลย เกษตรกรรวมทั้งนักวิจัยจำนวนมากมักคิดว่า โคบราห์มันมีขนาดที่ใหญ่กว่าจึงน่าจะดีกว่าโคพื้นเมืองด้วย ดังนั้น วัตถุประสงค์ข้อแรกของการศึกษาค้นคว้าครั้งนี้เพื่อเปรียบเทียบอัตราการเจริญเติบโต ความสมบูรณ์พันธุ์ และผลผลิตลูกหย่านม ระหว่างโคทั้งสองพันธุ์ดังกล่าว ที่เลี้ยงด้วยหญ้าพาสพาลัมตลอดทั้งปี โดยที่พยายามใช้อาหารข้นในระดับต่ำในช่วงฤดูแล้ง

หญ้าพาสพาลัม (Paspalum atratum) เป็นหญ้าที่ให้ผลผลิตดีที่สุดจากงานทดสอบประเมินพันธุ์พืชอาหารสัตว์ในภาคตะวันออกเฉียงเหนือ ที่มีสภาพแวดล้อมแบบดินมีความอุดมสมบูรณ์ต่ำ เป็นที่ลุ่ม และดินมีความเป็นกรด ในฤดูฝนดินเปียกแฉะมีสภาพน้ำขัง แต่ดินจะแห้งอย่างรวดเร็วในฤดูแล้ง (Hare *et al.* 1999) ซึ่งปัจจุบันหญ้าชนิดนี้เป็นที่นิยมปลูกกันแพร่หลายในกลุ่มเกษตรกรผู้เลี้ยงโค-กระบือในภาคตะวันออกเฉียงเหนือ จากการทดลองเบื้องต้นในประเทศไทย โมเคิล แอร์ และคณะ (2546) รายงานว่า โคลูกผสมบราห์มันเพศผู้ตอนเมื่อปล่อยแทะเล็มในแปลงหญ้าพาสพาลัมในฤดูฝน ที่อัตรา 1 ตัว/ไร่ สามารถเพิ่มน้ำหนักได้ 0.50 กก./ตัว/วัน ที่รัฐฟลอริดา ประเทศสหรัฐอเมริกา Kalmbacher *et al.* (1997) ทดลองใช้โคลูกผสมบราห์มันเพศผู้ตอนปล่อยแทะเล็มในแปลงหญ้าชนิดเดียวกันนี้ที่อัตรา 3.3, 6.6 และ 10 ตัว/เฮกแตร์ พบว่าโคสามารถเพิ่มน้ำหนักได้ 0.71, 0.55 และ 0.49 กก./ตัว/วัน ตามลำดับ สำหรับในโคสาวเพิ่มน้ำหนักได้ 0.60 กก./ตัว/วัน เมื่อปล่อยแทะเล็มที่อัตรา 4.9 ตัว/เฮกแตร์ Kalmbacher *et al.* (1997) สรุปว่า หญ้า *P. atratum* จะเป็นหญ้าที่สำคัญในการเลี้ยงโครุ่น โคสาว ในเขตที่มีฝนชุกและร้อนชื้น สำหรับวัตถุประสงค์ข้อที่สองของการวิจัยครั้งนี้เพื่อ ศึกษาการให้ผลผลิต และความคงทนของหญ้าพาสพาลัม ภายใต้การเลี้ยงแบบปล่อยแทะเล็มในประเทศไทย