Table 6. Effect of cutting interval on dry matter yield of Ubon paspalum in 1999 (Trial 2).

Cutting interval (d)	DM yield (kg/ha)								
	Period 1 (120 d)			Period 2 (120 d)			Period 1 + 2 (240 d)		
	Leaf	Stem	Total	Leaf	Stem	Total	Leaf	Stem	Total
20	8 836 a[1]	2 820 b	11 656 b	7 119 b	2 832 b	9 951 b	15 955 b	5 652 b	21 607 b
30	9 572 a	3 600 b	13 172 ab	8 185 ab	3 363 b	11 548 ab	17 757 ab	6 963 b	24 720 ab
40	9 757 a	3 450 b	13 207 ab	8 370 ab	5 269 a	13 639 a	18 127 ab	8 719 a	26 846 ab
60	10 947 a	5 172 a	16 119 a	8 807 a	4 008 b	12 815 a	19 754 a	9 180 a	28 934 a

[1]Within columns and periods, means followed by a common letter are not significantly different at P = 0.05 by Duncan's Multiple Range Test.

Table 7. Effect of cutting interval on plant height and crude protein concentration of Ubon paspalum in 1999 (Trial 2).

Cutting interval (d)	Period 1 (120 d)				Period 2 (120 d)			
		CP (%)				CP (%)		
	Height (cm)	Leaf	Stem	Total	Height (cm)	Leaf	Stem	Total
20	43.7 d[1]	9.1 a	6.0 a	8.4 a	35.0 c	11.5 a	6.6 a	10.0 a
30	54.3 c	9.2 a	4.5 b	7.9 a	45.0 b	8.6 b	4.4 b	7.4 b
40	73.9 b	5.8 b	3.2 c	5.2 b	68.0 a	8.9 b	4.9 b	7.4 b
60	100.0 a	6.4 b	3.5 c	5.5 b	65.0 a	6.9 c	3.1 c	5.3 c

[1]Within columns and periods, means followed by a common letter are not significantly different at P = 0.05 by Duncan's Multiple Range Test.

produced 74% (21.6 t/ha) of the total DM yield from cutting every 60 days (28.9 t/ha) but crude protein concentration was nearly twice as high (10.0 *vs* 5.3%).

The levels of stubble and root material which remained at the end of Trial 1 (Table 5) help in some respects to explain the differences in DM yields from different cutting interval treatments. Delaying cutting increased the plant's stubble and root reserves thereby helping to increase the recovery rate after cutting.

Crude protein concentration of Ubon paspalum in these studies declined more rapidly with delayed cutting than crude protein concentration in other forages in Thailand. Crude protein concentration in *Pennisetum purpureum* declined from 8.9% with 30-d cutting to 7% with 50-d cutting (Anon 1996). Crude protein concentration in *Brachiaria ruziziensis* declined from 10.2% at 30-d cutting to 6.5% at 60-d cutting (Anon 1995a). Declines in CP concentration in *Panicum maximum* were from 8.8% at 42-d cutting to 6.6% at 70-d cutting (Anon 1995b). In these species, even at advanced maturity, crude protein concentrations were at or only slightly lower than the 7% critical level where nitrogen needed by rumen microorganisms becomes limiting (Milford and Minson 1966). Advancing the age of cutting in Ubon paspalum to 60 days produced crude protein levels on average more than 2 percentage units lower than the 7% critical level.

Hennessy (1980) suggested a higher critical crude protein concentration of 8.1% for tropical forages. Studies from Kenya on napier grass indicated that the critical protein level for milk production was 9% (Muia *et al.* 1999). This level was reached at 7–8 weeks of maturity in medium rainfall areas (800 mm/year) and at 9–10 weeks in high rainfall areas (1200 mm/year). However, both these maturity periods when applied to Ubon paspalum are too advanced to provide nutritious forage, either in the higher rainfall areas (1500 mm) in Thailand or in the lower rainfall areas (800 mm) in Florida (Kalmbacher *et al.* 1997b).

Data from our trials make it difficult to recommend an absolute cutting interval as the interval chosen will depend on what combination of yield and quality is desired. In addition, the different absolute concentrations for crude protein obtained in the two studies make it dangerous to suggest a harvesting frequency which will guarantee a crude protein level above 7%. Crude protein concentration of Ubon paspalum is also

affected by waterlogging and nitrogen (Hare *et al.* 1999d) and if fields become waterlogged and farmers fail to apply nitrogen, crude protein concentrations invariably do not exceed 6% on low fertility soils in Thailand (Hare *et al.* 1999a; 1999d).

On smallholder dairy farms in Thailand, cows average 7–8 kg/d raw milk (1400–1600 kg/lactation), have a lactation period of 200 days and a calving interval of 400–500 days (Chantalakhana 1994). Purchase of animal feed represents nearly 60% of farmers' direct costs and productivity increases are limited by feed supply. Dairy farmers growing Ubon paspalum may desire to cut at 20–30-d intervals in the wet season to maximise nutritive value, even though dry matter yields will be reduced, in order to try to reduce some of the animal feed costs which are mainly for the purchase of protein supplements. We have observed that dairy cattle are reluctant to graze Ubon paspalum pastures older than 40 days, probably because of the low palatability from low nitrogen levels and high stem content.

However, swamp buffalo (*Bos bubalis*) for draft and older native beef cattle (*Bos indicus*) readily graze mature Ubon paspalum and farmers rearing these animals may prefer a longer inter-harvest interval to increase DM yield. High quality forage appears to be of lesser importance for draft swamp buffalo and native beef cattle which are slaughtered only when they are quite old or at times of cash shortage. One dairy farmer does use swamp buffalo to graze and control excessive wet season growth of Ubon paspalum before cutting the 20–30-d regrowth for dairy cows.

In Florida it is recommended that *Paspalum atratum* cv. Suerte be cut at 21–28-d intervals in the main growing season (mid-June to early September), rather than at 40- or 60-d intervals, to maximise nutritive value to maintain livestock production even though dry matter yields are reduced (Kalmbacher *et al.* 1997b). Before and after these times when Suerte is growing less rapidly, the recommendation is to cut at 36–42-d intervals.

Both Suerte and Ubon paspalum are cultivars from the same parent plant and optimal cutting management is therefore most likely similar. Both are derived from a single collection from Brazil, BRA-009610, and introduced into Florida in 1990 and into Thailand in 1994. Cultivar Hi-Gane is the Australian release of cultivar Suerte. Previously it was thought that Suerte was from BRA-018996 but recent communication with Dr Bert Grof, who has examined samples and plots of cultivars Suerte, Hi-Gane and Ubon, confirms that all 3 cultivars are identical.

For dairy farmers in Thailand producing a high quality animal product such as milk, the shorter cutting interval for Ubon paspalum to maximise quality is similar to the intervals recommended for Suerte by Kalmbacher *et al.* (1997b). In the wet season, cutting Ubon paspalum at 20–30-d intervals (compared with 21–28-d for Suerte) maximises nutritive value. Even though the crude protein concentrations were low in Trial 1 for these 2 cutting intervals, mean concentrations were more than 2 percentage points higher than crude protein concentrations from 60-d-old forage. When cutting every 20 days, the data from Trial 1 suggest that the cutting height be raised to 20 cm above ground level to allow quicker recovery by plants.

Data for early dry season production were collected only in Trial 2 (Period 2) and suggest that the cutting interval can be extended to 40 days during this period which is similar to the 36–42-d interval recommended for Suerte (Kalmbacher *et al.* 1997b). With longer cutting intervals, cutting height is less important and cutting close to ground level will not affect forage yields or quality.

The nutritive value of Ubon paspalum is generally lower than that of other commonly grown tropical grasses in Thailand. For good dairy production based on Ubon paspalum pastures, regardless of cutting interval, there will still be a need to supplement with legumes and concentrates.

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Appendix 3

Method and time of establishing *Paspalum atratum* seed crops in Thailand

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Abstract

Seed crops of *Paspalum atratum* cv. Ubon established by sowing seed produced no seed at all in the first year of establishment in Thailand. By comparison, seed crops planted with tillers at the beginning of the wet season in May produced 132 kg/ha seed 5 months after planting in one trial and 330 kg/ha seed in a second trial. In the second trial, delay in planting tillers until June and July severely reduced seed yields from a high of 330 kg/ha when planted in early May to a low of 25 kg/ha when planted in mid-July. Inflorescences/m^2 and seeds/inflorescence had the greatest effect on seed yield.

Twenty village farmers in a small seed production project successfully harvested 1834 and 2207 kg of Ubon paspalum seed in 1998 and 1999, respectively. The method of hand knocking mature seed from seed heads into bags every day enabled farmers to harvest mean seed yields of 632 and 651 kg/ha in 1998 and 1999, respectively. This harvesting method, combined with slow drying in the shade and thorough cleaning, produced seed of a very high quality with a thousand-seed weight of 3.1 g, a seed purity of more than 99% and a germination of 81% in 1998-harvested seed and 91% in 1999-harvested seed after 5 months post-harvest storage.

Introduction

Paspalum atratum cv. Ubon is increasingly being used by dairy farmers in Thailand for growing on wet, waterlogged acid soils which were formerly rice paddy fields (Hare *et al.* 1999a; 1999b). A key attribute to its success and subsequent adoption by farmers is that Ubon paspalum seed is readily available as it is relatively easy to harvest compared with other tropical grasses in Thailand (Hare *et al.* 1999c).

Preliminary seed studies in Thailand found that seed yields of Ubon paspalum were affected by harvesting method and closing date (Hare *et al.* 1999c). Hand-knocking mature Ubon paspalum seed from seed heads into bags every day produced twice the amount obtained by threshing or sweating seed heads. Cutting seed crops late in the wet season, August and September in Thailand, produced little or no seed.

Successful forage seed production in Thailand has hinged on village farmers hand-harvesting seed of ruzi grass (*Brachiaria ruziziensis*) and Verano stylo (*Stylosanthes hamata*) (Hare 1993; Hare and Phaikaew 1999). In 1996, when we realised that there would be a future demand for Ubon paspalum seed, we contracted one village farmer to grow seed for us. We chose a farmer who had grown previous ruzi grass and Verano stylo seed crops for the Department of Livestock Development. In late May 1996, we gave the farmer rooted tillers of Ubon paspalum dug from mature plants which she hand planted in a 50 × 50 cm grid in a 1400 m^2 field. In September 1996, she harvested 47.5 kg of seed, equivalent to 340 kg/ha.

Neighbouring farmers in the same village saw her success and observed that seed production of Ubon paspalum appeared to be easier than that of ruzi grass and Verano stylo which they had grown for several years. In March 1997, we contracted 20 farmers, including the first farmer, to grow Ubon paspalum seed. Each farmer received 300 g of seed in March 1997 and they were instructed to plant the seed in a nursery and transplant strong plants to their fields in May–June. Each farmer was contracted to grow a field not exceeding 1600 m^2.

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Some farmers delayed transplanting the tillers until July as they wanted the soil to be very moist at the time of transplanting. They had frequently sown ruzi grass seed in June–July and harvested good seed crops in November. The result was that the fields planted in May and June averaged seed yields of 315 kg/ha and 65 kg/ha, respectively, whereas fields planted in July produced no seed. In a neigbouring province, the Department of Livestock Development also contracted farmers to grow Ubon paspalum seed. These farmers sowed their fields with seed in June (the traditional time for sowing ruzi grass seed crops in their village) and no seed heads were produced in the first year.

With this information, we established field experiments to determine: (a) which planting methods would give the best seed yields of Ubon paspalum; and (b) the most suitable time to establish seed crops. In addition, data were gathered from the village farmer seed project.

Materials and methods

Field experiments

The field experiments were conducted in Ubon Ratchathani province, Thailand (15°N, 104°E), on the Ubon Ratchathani University farm at 2 sites in a 2 ha paddock. Rainfall was recorded 1 km from the trial paddock (Table 1). The soil and site history have previously been described by Hare *et al.* (1999c).

Trial 1. Method of sowing

A trial commenced in May 1998 to study methods of establishing Ubon paspalum seed crops in a field planted with tillers in July 1996 with 50 × 50 cm grid spacings. This field produced no seed in 1996 but produced seed in 1997.

The trial was a randomised complete block design of 5 replications and 4 treatments:

1. Second-year plants established in 1996 (T1).
2. First-year plants sown by seed in 1998 at 12 kg/ha (T2).
3. First-year plants established in 1998 from tillers dug from second-year mature plants (T3).
4. First-year plants established in 1998 from seedlings grown in plastic bags (T4).

Plots for T2, T3 and T4 were cultivated within the 2-year-old field and all existing Ubon paspalum plants were removed. T1 plants were left intact but were cut at 5 cm above ground level on May 20, 1998, when the other treatments were planted. Seed in T2 was sown in rows 50 cm apart and lightly covered with soil. Tillers in T3 were divided from freshly dug plants and planted in a 50 × 50 cm spaced grid. Seedlings in T4 were established in a nursery from seed in March 1998 and had well developed roots when planted in a similar grid pattern on May 20. Plants in T3 and T4 were trimmed to 5 cm above ground at planting and all plots were cut to a similar height of 5 cm on July 1, 1998 to prevent lodging at seed harvest. Plots measured 5 × 6 m.

Fertiliser was applied at planting (40 kg N, 50 kg K, 20 kg S and 20 kg P/ha), on July 1 after cutting (20 kg N, 25 kg K, 10 kg S and 10 kg P/ha), on August 3 (25 kg/ha N) and on August 19, 1998 (20 kg/ha N).

On September 19, 1998, all inflorescences in eight 5 m rows in each plot were counted and then tied into 'living sheaves' (Kowithayakorn and Phaikaew 1993). Twenty inflorescences from each plot were 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 harvesting commenced on September 24 with daily knocking of seed from the 'living sheaves' into buckets. On October 9, all 'living sheaves' were cut, sweated in a shed for 3 days and then threshed. The seed was dried slowly in doors on newspaper and then cleaned through hand screens and a Dakota seed blower. Following cleaning, seed yields and thousand-seed weights (TSW) were corrected to 12% seed moisture content (SMC). Seeds per inflorescence were calculated by dividing seed yield/inflorescence (seed yield/m^2 ÷ inflorescences/m^2) by the weight of 1 seed (TSW/1000).

After harvest, the stubble was cut to ground level and the plots were left to grow for another seed harvest. In May 1999, the plots were cut close to ground level and fertilised with a compound fertiliser (NPK 15:15:15) at 156 kg/ha. The compound fertiliser was used because it was easily available. The same amount of fertiliser was applied again on June 18 and August 13, 1999. All plots were trimmed to 30 cm above ground level on June 13 and again to 50 cm above ground level on August 13, 1999 to prevent lodging. This last anti-lodging cut was 6 weeks

later than in the previous year because the plants in all treatments grew more vigorously in 1999. These heights were well above the height of the reproductive apices in the plants (Kalmbacher *et al.* 1995).

On September 20, 1999, all inflorescences in four 1 m rows in each plot were counted and 20 inflorescences from each plot were taken from just outside this area for reproductive analysis as detailed above. All inflorescences in eight 5 m rows were tied into 'living sheaves' and daily seed knocking commenced on September 24, 1999. All seed in 1999 was harvested by knocking and no seed was collected by cutting or threshing. The seed was dried and cleaned as in 1998 and seed yields and TSW were corrected to 12% SMC. Seeds/inflorescence were calculated as above.

Trial 2. Time of planting

This trial in 1999 studied the effect of planting date on Ubon paspalum seed production. The trial was adjacent to Trial 1 and was a randomised complete block design replicated 5 times with 6 planting date treatments, 2 weeks apart (May 7, May 21, June 4, June 18, July 2 and July 15, 1999). The field was cultivated in early May and, on the day of each planting, the plots to be planted were hand-cultivated again. On the day of each planting, mature plants were dug from an adjacent 2-year-old field and divided into single rooted tillers. These tillers were trimmed to a 10 cm height and hand-planted in a 50 × 50 cm spaced grid. Plots measured 4 × 5 m.

The plots that had been planted were fertilised with a compound fertiliser (NPK 15:15:15) at 156 kg/ha on June 18 and July 2 and all plots were fertilised at the same rate on August 13, 1999. The first 2 sowing date treatments only were trimmed back to 50 cm above ground level on August 13, 1999 to prevent lodging.

On September 23, 1999, all inflorescences in four 1 m rows in each plot were counted and 20 inflorescences from each plot were taken from just outside this area for reproductive analysis as detailed above. All inflorescences in six 4 m rows in each plot were tied into 'living sheaves' and daily seed knocking commenced on September 27, 1999 and continued in some plots until October 22, 1999. The seed was dried and cleaned as described previously and seed yields and TSW were corrected to 12% SMC. Seeds/inflorescence were calculated as above.

Data from all trials were analysed using the IRRISTAT program from IRRI.

Village farmer seed project

In March 1997, 20 village farmers signed contracts to produce Ubon paspalum seed. Each farmer was contracted to grow an area up to 1600 m^2 and the contract price was 100 baht/kg (43 baht/$US; Feb. 2001) for clean seed with a TSW above 2.5 g. All farmers were experienced in growing ruzi grass seed on their land. At the time of contract signing, each farmer received 300 g of seed. This seed was planted into nurseries in late March and seedlings were transplanted into the field from May onwards. Six farmers planted in May, 7 in June and 7 in July. All farmers hand-planted the seedlings in 50 × 50 cm grids.

Towards the end of September, 20 inflorescences were taken from each field for reproductive analysis. Inflorescences were then tied into 'living sheaves' and the seed knocked into large seed-net receptacles (Kowithayakorn and Phaikaew 1993). The seed was dried slowly on mats in the shade and then cleaned by winnowing on cane trays. This field-dressed seed was purchased in October 1997 and re-cleaned through a seed cleaner, mainly to get rid of dust, anthers and some small seed. We wanted all seed to be of a constant purity. The field-dressed seed was very clean and only about 2–3% reduction in weight resulted. Seed moisture content of the machine-dressed seed averaged 12% and seed yields and TSW were calculated from the machine-dressed seed.

During the dry season, November 1997 to April 1998, the fields were grazed and some were burnt in March 1998. All burnt fields recovered quickly. All fields were cut to 20–30 cm above ground level in early July to prevent lodging. Farmers applied fertiliser in June and early August. Harvesting commenced in late September 1998, with seed being knocked daily from 'living sheaves'. The seed was dried in the shade and the field-dressed seed purchased in late October 1998 and re-cleaned to remove dust, anthers and small seed. Seed yields and TSW were corrected to 12% SMC.

The fields were grazed over the dry season and some were burnt in March 1999. In May 1999, 3 farmers planted new fields with tillers but the other 17 farmers used their existing fields to produce a third seed harvest in October 1999. All