Herbage yield and quality of *Brachiaria* cultivars, *Paspalum atratum* and *Panicum maximum* in north-east Thailand

M.D. HARE, P. TATSAPONG AND
S. PHENGPHET
Faculty of Agriculture, Ubon Ratchathani University, Ubon Ratchathani, Thailand

Abstract

Two field trials were conducted in north-east Thailand between 2003 and 2007 on upland free-draining soils, to compare dry matter yields and quality of *B. ruziziensis x B. brizantha* cv. Mulato (hybrid brachiaria grass), *B. ruziziensis x B. decumbens x B. brizantha* cv. Mulato II (hybrid brachiaria grass), *Brachiaria ruziziensis* (ruzi grass; common Thailand type), *B. decumbens* cv. Basilisk (common signal grass), *B. brizantha* cvv. Marandu and Toledo (palisade grass), *Paspalum atratum* cv. Ubon (atra paspalum grass) and *Panicum maximum* cv. Purple (guinea grass).

Toledo palisade grass produced highest dry matter (DM) yields overall and in the dry seasons, significantly more than most other cultivars. Leaf yields also favoured Toledo palisade grass and Mulato and Mulato II hybrids. Basilisk signal grass and Marandu palisade grass produced dry matter yields that were intermediate between those of the hybrid brachiarias and ruzi grass, particularly in the dry season. Purple guinea grass established slowly but production in the second and third years was equal to that of Toledo.

In both trials, the nutritive value of leaf material overall was moderate in all species, exceeding 10% crude protein in most species.

Toledo palisade grass, Mulato and Mulato II hybrid brachiarias and Purple guinea grass seem ideal replacements for ruzi grass on upland soils, but feeding studies are needed to determine if the apparent higher forage production can be converted into animal product.

Correspondence: M.D. Hare, Faculty of Agriculture, Ubon Ratchathani University, Warin Chamrab, Ubon Ratchathani 34190, Thailand. E-mail: michaelhareubon@hotmail.com

Introduction

Ruzi grass (*Brachiaria ruziziensis*), Purple guinea grass (*Panicum maximum* cv. Purple) and Ubon atra paspalum grass (*Paspalum atratum* cv. Ubon) are the most commonly grown grasses for livestock farming in Thailand. Of these grasses, ruzi grass has been the most widely grown species on upland soils (Stür *et al*. 1996; Hare and Phaikaew 1999). In recent years, production from Purple guinea has surpassed that from ruzi grass, because of higher yields and its success in fresh grass farming (Khemsawat and Phaikaew 2007; Phaikaew *et al*. 2007). Ubon atra paspalum is the main grass grown for forage production on low-lying, seasonally wet, waterlogged soils (Hare *et al*. 1999; 2003).

Thai farmers are seeking alternatives because the 3 grasses discussed above have production limitations during the dry season. Dry season production of ruzi grass in north-east Thailand is generally low (Thinnakorn and Kreethapon 1993; Hare *et al*. 2005). Forage production of Purple guinea declines rapidly during the dry season, and it is not tolerant of long (4-5 month) dry periods and is more productive on fertile soils (Cook *et al*. 2005). Ubon atra paspalum is often mistakenly planted by farmers on sandy soils, which rapidly dry out in the dry season and its low drought tolerance can lead to low dry matter yields and even plant death (M.D. Hare unpublished data).

In recent trials at Ubon Ratchathani University, 3 *Brachiaria* accessions, Marandu palisade grass (*Brachiaria brizantha* cv. Marandu), Basilisk signal grass (*Brachiaria decumbens* cv. Basilisk) and *B. brizantha* CIAT 6387, produced higher dry matter production than ruzi grass, particularly in the dry season (Hare *et al*. 2005). However, all 3 accessions produce negligible amounts of seed in Thailand and they have not become commercially available to farmers.

Hybrid cultivars of brachiaria bred at CIAT (Centro Internacional de Agricultura Tropical)

(Miles *et al*. 2004, 2006; Miles and Hare 2007) have shown high tolerance of prolonged periods of drought and quick regrowth during dry periods (Argel *et al*. 2006; 2007). They have also shown tolerance of soil acidity, and will grow well on infertile soils (Argel *et al*. 2006; 2007). Seed is also available in Thailand (Hare 2007).

We were interested in evaluating these hybrid brachiaria cultivars in north-east Thailand on infertile soils, with emphasis on yield in the dry season in comparison with other grasses. Two experiments compared dry matter yields and quality of hybrid brachiarias, ruzi grass, other brachiaria cultivars, Ubon atra paspalum and Purple guinea.

Materials and methods

The 2 field experiments were conducted in Ubon Ratchathani province, north-east Thailand (15°N, 104°E; elevation 130 m asl; AAR 1593 mm) from 2003 to 2007.

Trial 1 — Evaluation of brachiaria cultivars, Ubon atra paspalum and Purple guinea

This study was conducted at a site on the Ubon Ratchathani University farm in a 0.15 ha field from 2003 to 2006. The site was on an upland sandy low humic gley soil (Roi-et series) (Mitsuchi *et al*. 1986). Soil samples taken at sowing in May 2003 showed that the soil was acid (pH 4.6; water method), and low in organic matter (1.1%), N (0.04%), P (3.5 ppm; Bray II extraction method) and K (27.4 ppm). Prior to cultivation, the site had been planted to a mixture of grasses and legumes for 3 years (Hare *et al*. 2004). It was ploughed in March and again in April 2003 and then rotary-hoed to produce a fine seed bed the day before planting in May 2003.

Seven grasses, Mulato hybrid brachiaria, ruzi grass (common Thailand type), Basilisk signal grass, Marandu palisade grass, Toledo palisade grass, Ubon atra paspalum and Purple guinea were planted in 8 m × 5 m plots in a randomised complete block design with 5 replications. The trial was planted from May 12 to 14, 2003 with freshly dug rooted tillers, spaced at 30 cm × 30 cm. Rainfall was recorded at the trial site.

Field management and data collection are summarised in Table 1.

Table 1. Trial management and data collection.

	Trial 1	Trial 2
Sampling cuts (5 cm above ground level)	Six 0.25 m^2 quadrats/plot	Six 0.25 m^2 quadrats/plot
First wet season	Jul 21, Sep 9 & Oct 30, 2003	UBU[1] Jul 12, Aug 25 & Oct 11, 2004 LDC[2] Jul 13, Aug 26 & Oct 12, 2004
First dry season	Jan 8 & Apr 26, 2004	UBU Apr 26, 2005 LDC Apr 28, 2005
Second wet season	Jun 9, Aug 3, Sep 15 & Oct 28, 2004	UBU Jun 13, Jul 29, Sep 14 & Oct 26, 2005; LDC Jun 10, Jul 28, Sep 15 & Oct 27, 2005
Second dry season	Apr 25, 2005	UBU Dec 26, 2005 & Apr 26, 2006 LDC No cuts, grazed by cattle
Third wet season	Jun 9, Jul 25, Sep 16 & Oct 31, 2005	UBU Jun 12, Jul 25, Sep 11 & Oct 27, 2006; LDC Jun 13, Jul 26, Sep 12 & Oct 30, 2006
Third dry season	Dec 30, 2005 & Apr 25, 2006	UBU Jan 8, Mar 19 & Apr 25, 2007 LDC Jan 9, Mar 20 & Apr 26, 2007
Fertiliser		
At sowing	200 kg/ha N:P:K (15:15:15)	200 kg/ha N:P:K (15:15:15)
During trial	200 kg/ha N:P:K (15:15:15) after every second cut	200 kg/ha N:P:K (15:15:15) after every sampling cut
Forage collection and processing	At each cut, samples were weighed fresh and hand-sorted into leaves and stems. Dry matter yields were calculated from 300 g subsamples of leaves and stems dried at 70°C for 48 h. Samples from the dried material were analysed for total N (Kjeldahl method) in order to calculate crude protein levels (%N × 6.25) and for acid detergent fibre (ADF) and neutral detergent fibre (NDF) concentrations.	

[1] Ubon Ratchathani University.
[2] Land Development Centre.

Trial 2 — Evaluation of brachiaria hybrids and brachiaria cultivars

This study was conducted from 2004 to 2007 at 2 sites: on the Ubon Ratchathani University farm (UBU); and at the Ubon Ratchathani Land Development Centre (LDC). The upland soil at UBU was the same series as in Trial 1 and soil samples taken at sowing in May 2004 showed that the soil was acid (pH 5.1; water method), and low in organic matter (0.8%), N (0.04%), P (8.0 ppm; Bray II extraction method) and K (16.9 ppm). The site at LDC was on an upland sandy gray podzolic soil (Satuk series) (Mitsuchi *et al*. 1986). Soil samples taken at sowing in May 2004 showed that the soil was acid (pH 4.8; water method), and low in organic matter (0.6%), N (0.03%), P (3.2 ppm; Bray II extraction method) and K (31.3 ppm). Prior to commencing the study, the site at UBU had been planted to *S. guianensis* var. *vulgaris* x var. *pauciflora* cv. Ubon stylo for 3 years, while the site at LDC had been lying fallow for 2 years. Both sites were ploughed in March and again in April 2004 and then rotary-hoed to produce a fine seed bed the day before sowing.

Six grasses, Mulato hybrid brachiaria, Mulato II hybrid brachiaria, ruzi grass (common Thailand type), Basilisk signal grass), Marandu palisade grass and Toledo palisade grass, were planted in a randomised complete block design with 5 replications. The trial was sown on May 10, 2004 (UBU) and May 11, 2004 (LDC). Seed was tested for germination immediately before sowing and was sown in 50 cm rows at a rate of 10 kg/ha germinable seed. Plot size was 5 m × 5m. Rainfall was recorded at 200 m (UBU) and 300 m (LDC) from the actual trial sites.

Field management and data collection are summarised in Table 1. After each sampling, the plots were cut uniformly to 5 cm above ground level.

Data from both trials were analysed by analysis of variance, using the IRRISTAT program from The International Rice Research Institute (IRRI). Entry means were compared by LSD at P = 0.05 probability level.

Results

Rainfall

Rainfall at the UBU trial site was below the 14-yr mean of 1539 mm/annum in 3 of the 4 years of the trials (Table 2). Year 2004, was particularly dry, with total rainfall 30% below the mean and wet season rain finishing early, in mid-September. In contrast, very heavy rainfall (433 mm) fell in September 2005.

Rainfall at the LDC trial site was 10% below the 14-yr mean of 1613 mm/annum in the first 2 years of Trial 2 (2004 and 2005) and 10% above the mean in the third year (Table 2). Very heavy rainfall fell in August (398 mm) and September 2006 (486 mm).

Table 2. Rainfall at Ubon Ratchathani University (UBU) and the Land Development Centre (LDC) during the trials and the 14-yr mean (1992–2005).

Month	Rainfall											
	Mean		2003		2004		2005		2006		2007	
	UBU	LDC	UBU	LDC	UBU	LDC	UBU	LDC	UBU	LDC	UBU	LDC
						(mm)						
Jan	1	2	0	0	0	20	0	0	0	0	0	1
Feb	12	16	42	53	0	20	0	0	7	14	4	0
Mar	30	25	55	18	1	16	5	16	29	2	53	42
Apr	81	76	99	57	53	72	87	26	108	87	16	34
May	216	197	249	233	143	144	152	132	106	87		
Jun	249	264	234	147	206	374	278	334	70	216		
Jul	254	280	112	76	150	316	229	294	332	398		
Aug	278	320	335	332	297	245	285	300	368	486		
Sep	295	285	276	314	188	273	433	262	170	235		
Oct	90	108	28	44	4	3	26	34	207	229		
Nov	29	38	0	0	3	1	50	85	77	36		
Dec	4	2	0	0	0	0	0	0	0	1		
Total	1539	1613	1430	1274	1045	1484	1545	1483	1474	1791		

Trial 1 — Evaluation of brachiaria cultivars, Ubon atra paspalum and Purple guinea

In all wet and dry seasons, significant differences in DM production occurred between the different species (Table 3). Toledo produced very high yields in all wet seasons, averaging 12.9 t/ha, while Mulato averaged 10.2 t/ha. Dry season yields were much lower and more variable, with Toledo averaging 2.64 t/ha and Mulato 2.44 t/ha. Mean annual yields were 15.54 t/ha for Toledo and 12.61 t/ha for Mulato. These compare with an overall figure for all grasses tested of 11.47 t/ha (total yield), 9.44 t/ha (wet season) and 2.03 t/ha (dry season). Worst performance, both in the dry seasons and overall, was from Ubon atra paspalum and ruzi grass.

Ubon atra paspalum and Purple guinea averaged more than 75% leaf (DM basis) in the wet season and 90% leaf in the dry season, which was a significantly (P<0.05) higher leaf percentage than that produced by the 5 *Brachiaria* cultivars (Table 4). Both ruzi grass and signal grass produced lower (P<0.05) leaf percentages than the other *Brachiaria* cultivars in the wet season, while signal produced a lower (P<0.05) leaf proportion in the dry season than all other cultivars.

Crude protein concentrations, averaged over 3 years, ranged from 7.5 to 11.8% (leaf) and 5.1 to 7.3 % (stem) (Table 5). Ubon atra paspalum had lower (P<0.05) leaf and stem crude protein concentrations than the other cultivars. NDF and ADF concentrations varied between species and plant parts. Ruzi grass overall had lower ADF and NDF concentrations than other cultivars

Table 5. Mean crude protein (CP), acid detergent fibre (ADF) and neutral detergent fibre (NDF) concentrations in leaf (L) and stem (S) of 5 *Brachiaria* cultivars, Ubon atra paspalum and Purple guinea grass over 3 years (Trial 1).

Cultivars	CP		ADF		NDF	
	L	S	L	S	L	S
			(%)			
Mulato	9.8	7.0	31.3	36.8	59.0	65.2
Ruzi	11.8	7.3	29.7	35.3	56.4	65.9
Signal	10.3	7.0	30.7	39.2	59.5	68.0
Marandu	10.3	6.8	32.1	37.5	62.4	68.1
Toledo	10.0	6.7	34.3	38.9	62.9	67.3
Ubon paspalum	7.5	5.1	37.0	37.5	64.8	67.0
Purple guinea	10.4	6.7	38.1	42.6	65.5	69.7
LSD (P<0.05)	1.0	0.6	0.5	2.1	0.7	2.3

Table 3. Total dry matter yields of 5 *Brachiaria* cultivars, Ubon atra paspalum and Purple guinea grass over 3 years (Trial 1).

Cultivars	Total dry matter										
	Wet 2003	Dry 2003–04	Total year 2003–04	Wet 2004	Dry 2004–05	Total year 2004–05	Wet 2005	Dry 2005–06	Total year 2005–06	Wet average	Dry average
						(kg/ha)					
Mulato	11671	2558	14229	9488	1235	10723	9363	3526	12889	10173	2440
Ruzi	8883	1104	9987	7899	409	8308	7925	2461	10385	8236	1324
Signal	9279	1859	11138	8339	817	9156	9882	3591	13473	9166	2089
Marandu	9873	2302	12175	8741	990	9731	9080	3154	12234	9231	2149
Toledo	15105	2657	17762	11041	834	11875	12543	4438	16981	12896	2641
Ubon paspalum	7875	1649	9524	9099	689	9788	5049	1108	6157	7341	1148
Purple guinea	5527	1255	6782	10419	803	11212	11250	3830	15080	9065	2403
LSD (P<0.05)	2431	732	2857	NS	538	NS	2032	843	2211	1549	701

Table 4. Leaf percentage (DM basis) of 5 *Brachiaria* cultivars, Ubon atra paspalum and Purple guinea grass (Trial 1).

Cultivars	Leaf percentage										
	Wet 2003	Dry 2003–04	Total year 2003–04	Wet 2004	Dry 2004–05	Total year 2004–05	Wet 2005	Dry 2005–06	Total year 2005–06	Wet average	Dry average
						(%)					
Mulato	54.6	80.1	58.9	66.0	82.0	67.3	62.5	76.9	66.2	61.0	79.6
Ruzi	50.3	85.0	54.2	57.5	77.8	58.5	53.2	75.8	58.5	53.6	79.5
Signal	46.1	77.0	51.3	58.5	77.7	66.1	54.5	67.5	58.0	53.0	74.1
Marandu	57.7	78.7	61.6	67.1	85.1	68.9	67.6	79.0	70.5	64.2	80.9
Toledo	58.1	77.8	61.0	68.8	87.5	70.1	66.2	78.0	69.3	64.3	81.1
Ubon paspalum	77.4	89.5	79.5	78.6	86.0	79.2	72.2	94.1	76.0	76.1	89.9
Purple guinea	77.3	90.9	79.6	76.6	90.5	79.1	73.0	88.9	77.1	75.6	90.1
LSD (P<0.05)	6.1	5.7	5.6	2.4	7.7	2.6	3.5	3.2	4.1	2.7	3.9

(Table 5). Concentrations in stems exceeded those in leaves.

Trial 2 — Evaluation of brachiaria hybrids and cultivars

At UBU, total DM yield overall favoured Toledo (mean 16.3 t/ha/yr) with not much difference between the remaining hybrids/cultivars (Table 6). Toledo and Mulato had highest dry season production (mean 2.3 t/ha), with the least in ruzi grass (mean 1.2 t/ha). At LDC, total yield was highest in Toledo and Mulato (mean 10.6 t/ha/yr), with ruzi grass lowest (mean 8.5 t/ha/yr). Dry season production was highest in Mulato (mean 1.3 t/ha) and lowest in ruzi grass (mean 0.2 t/ha).

Mulato II produced a greater (P<0.05) proportion of leaf in the wet season (mean 72%) than the other hybrids/cultivars and ruzi grass and signal the least (mean 54%) at both sites (Table 7).

Table 6. Total dry matter yields of 6 *Brachiaria* cultivars at 2 sites over 3 years (Trial 2).

Cultivars	Dry matter yields										
	Wet 2003	Dry 2003–04	Total year 2003–04	Wet 2004	Dry 2004–05	Total year 2004–05	Wet 2005	Dry 2005–06	Total year 2005–06	Wet average	Dry average
						(kg/ha)					
						UBU[1]					
Mulato	7445	1495	8950	13648	3432	17080	10578	2020	12598	10561	2316
Mulato II	8601	673	9274	11605	3219	14824	10993	1566	12559	10399	1819
Ruzi	11021	322	11343	11907	2310	14217	10593	1012	11605	11174	1215
Signal	10161	543	10704	11198	2381	13579	9810	1442	11252	10390	1456
Marandu	8966	658	9624	10233	2455	12687	10703	1535	12238	9967	1549
Toledo	11212	701	11913	15903	3990	19893	15142	2041	17183	14086	2244
LSD (P<0.05)	1474	189	1522	1116	620	1421	1142	377	1299	837	310
						LDC[2]					
Mulato	9947	1219	11166	9543	—[3]	9543	10606	1403	12009	10032	1311
Mulato II	9041	831	9872	9667	—	9667	9957	1213	11170	9555	1022
Ruzi	10527	421	10948	7236	—	7236	7491	71	7562	8419	246
Signal	10437	821	11258	8605	—	8605	9657	975	10631	9566	898
Marandu	9131	775	9906	9950	—	9950	8282	822	9104	9121	799
Toledo	9990	750	10740	9263	—	9263	10090	901	10991	9781	826
LSD (P<0.05)	NS	198	NS	NS	—	NS	NS	662	NS	NS	323

[1] Ubon Ratchathani University. [2] Land Development Centre. [3] no data — grazed by cattle.

Table 7. Leaf percentage (DM basis) of 6 *Brachiaria* cultivars at 2 sites over 3 years (Trial 2).

Cultivars	Leaf percentage										
	Wet 2003	Dry 2003–04	Total year 2003–04	Wet 2004	Dry 2004–05	Total year 2004–05	Wet 2005	Dry 2005–06	Total year 2005–06	Wet average	Dry average
						(%)					
						UBU[1]					
Mulato	57.0	82.1	61.2	62.6	78.0	65.7	64.5	80.4	67.0	61.4	80.2
Mulato II	69.8	86.2	71.0	68.8	84.6	72.2	74.1	86.6	75.6	70.9	85.8
Ruzi	49.1	76.6	49.9	51.7	77.8	55.9	54.8	82.7	57.2	51.9	79.0
Signal	50.2	71.7	51.3	55.2	72.3	58.2	55.3	71.1	57.4	53.6	71.7
Marandu	61.7	83.2	63.2	62.2	80.0	65.6	68.5	79.5	69.9	64.1	80.9
Toledo	68.6	82.7	69.5	66.3	79.6	69.0	69.7	86.3	71.7	68.2	82.9
LSD (P<0.05)	1.7	6.6	1.9	2.0	4.1	1.8	2.5	5.1	2.2	1.2	2.7
						LDC[2]					
Mulato	58.5	82.5	61.1	65.6	—[3]	65.6	64.3	84.9	66.7	62.8	83.7
Mulato II	70.3	83.9	71.4	71.9	—	71.9	74.8	84.9	75.7	72.3	84.4
Ruzi	48.5	69.0	49.4	54.7	—	54.7	59.2	66.0	59.3	54.1	71.7
Signal	53.3	72.5	54.6	58.2	—	58.2	58.1	71.4	59.3	56.5	72.0
Marandu	62.9	79.6	64.3	66.4	—	66.4	67.5	82.0	68.9	65.6	80.8
Toledo	66.7	82.2	67.8	68.1	—	68.1	58.1	79.7	70.9	68.9	81.0
LSD (P<0.05)	3.5	9.1	3.6	3.4	—	3.4	5.7	11.7	5.6	3.1	7.8

[1] Ubon Ratchathani University. [2] Land Development Centre. [3] no data — grazed by cattle.

In the dry season, Mulato II produced a greater proportion of leaf at UBU (mean 86%), with signal grass the least (mean 72%). At LDC in the dry season, ruzi grass and signal grass produced a lower proportion of leaf (mean 72%) than the other hybrids/cultivars (mean 82%).

Crude protein concentrations ranged from 10.5 to 12.1% (leaf) and 6.9 to 7.9% (stem) (Table 8). Ruzi grass had higher leaf protein concentrations than the other hybrids/cultivars at UBU. Overall, ruzi grass had lower leaf ADF and NDF concentrations than other hybrids/cultivars and concentrations in stems exceeded those in leaves (Table 8).

Table 8. Mean crude protein (CP), acid detergent fibre (ADF) and neutral detergent fibre (NDF) concentrations in leaf (L) and stem (S) of 6 *Brachiaria* cultivars at 2 sites over 3 years (Trial 2).

Cultivars	CP		ADF		NDF	
	L	S	L	S	L	S
			(%)			
			UBU[1]			
Mulato	10.5	7.7	30.8	36.6	58.6	65.7
Mulato II	11.3	7.4	30.1	36.8	58.6	66.8
Signal	11.5	7.9	29.2	38.5	58.8	68.9
Marandu	10.7	7.2	31.9	37.2	61.9	67.8
Toledo	10.6	6.9	33.5	38.5	61.7	68.3
Ruzi	12.1	7.7	28.5	36.8	55.1	66.2
LSD (P<0.05)	0.56	0.58	0.52	0.63	0.77	NS
			LDC[2]			
Mulato	10.7	7.6	30.0	36.2	57.5	63.8
Mulato II	10.9	6.9	29.9	36.1	57.9	65.5
Signal	10.5	7.2	29.1	38.9	58.2	67.9
Marandu	10.9	6.9	31.0	37.2	59.8	66.7
Toledo	11.1	7.5	32.5	38.4	60.8	67.3
Ruzi	11.2	7.5	28.9	38.6	55.9	65.7
LSD (P<0.05)	NS	NS	0.67	0.90	0.74	0.67

[1] Ubon Ratchathani University.
[2] Land Development Centre.

Discussion

This study has shown that Toledo and the two brachiaria hybrids, Mulato and Mulato II, can produce more total dry matter and leaf dry matter, particularly during the dry season, than the 3 grasses commonly grown in Thailand, ruzi grass, Purple guinea and Ubon atra paspalum. The 5–7 month dry season in north-east Thailand is a critical period for forage production, and any species that can produce reasonable amounts of dry matter and remain leafy and green, will contribute significantly to the nutrition and performance of livestock.

The performance of Toledo was outstanding, as it produced the highest yields in all years in both experiments. This was achieved while still producing a very good leaf:stem ratio. This was particularly the case during the dry season, when nitrogen levels in available forage can be a critical limiting factor in the region (Hare *et al*. 1999). Concentrations of crude protein in available leaf material were always higher than 7%, which is the level considered critical for livestock production, because levels below 7% can depress voluntary intake of forage (Milford and Minson 1966).

Farmers who have examined Toledo in small demonstration plots have been critical of the grass because of the sharp leaf edges, which can cause discomfort to the handler. This makes the cultivar less suitable for cut-and-carry forage production than the lush-looking brachiaria hybrids, ruzi grass and Purple guinea, which have softer leaves. The perception is that this would lower market acceptance of Toledo, so currently no commercial seed production of Toledo occurs in Thailand. However, we consider that Toledo is better suited to grazing than to cut-and-carry production and might be a very suitable dry season forage grass on larger farms, where livestock are grazed, in Thailand.

Mulato (Trials 1 & 2) and Mulato II hybrid (Trial 2) also produced far more dry season forage than ruzi grass. It should be noted that ruzi grass performed very poorly, while Mulato performed very well, especially during the dry season, at the LDC site. It is the ability to produce green leaf in the dry season that makes these 2 brachiaria hybrids attractive to farmers (Argel *et al*. 2006; 2007). Farmers also find the upright and lush, soft leaf appearance of the brachiaria hybrids very attractive, and demand for seed within Thailand is growing rapidly. However, Mulato consistently produces low seed yields. As a result, the Mexican seed company that released these hybrids, Grupo Papalotla, has discontinued Mulato seed production and instead will concentrate on production of the heavier seeding Mulato II hybrid in Thailand and elsewhere (Hare *et al*. 2007).

Total dry matter yields, dry season yields and leaf yields of Basilisk signal grass and Marandu palisade grass were consistently intermediate between those of the brachiaria hybrids and those of ruzi grass. This supports results of a previous trial at Ubon Ratchathani University, where Basilisk and Marandu produced, on average, 50% more dry season forage than ruzi grass (Hare *et al*.

2005). However, both species produce very low seed yields (<10 kg/ha) in Thailand (Hare *et al*. 2005) and have never been commercially available to farmers.

Purple guinea grass and Ubon atra paspalum were included in the first trial because they are commonly grown in north-east Thailand. Both species produce an abundance of seed that is commercially available at US$3–4/kg. Poor production in the first wet season prevented Purple guinea from performing better in overall production, as performance in the second and third years was excellent. This superior dry matter production confirms why Purple guinea is now the most commonly grown grass in Thailand (Khemsawat and Phaikaew 2007; Phaikaew *et al*. 2007). The overall results for this grass in this study are probably an underestimate of its real productivity in this environment.

Ubon atra paspalum did not perform well in this study with dry matter production inferior to most of the other species. By the third year, its production was lower than that of ruzi grass. Since Ubon atra paspalum performs best on low-lying wet soils which are periodically flooded (Hare *et al*. 1999; 2003), and has low drought tolerance (Cook *et al*. 2005), particularly on upland sandy soils, farmers must select moisture-retentive sites on their farms for planting this grass.

The overall low production of ruzi grass in this study confirms earlier findings that ruzi grass was generally inferior to other brachiaria cultivars in north-east Thailand (Hare *et al*. 2005), especially in terms of dry season production, and it is obviously also inferior to Purple guinea.

For almost 30 years, ruzi grass has been the grass most commonly planted on upland soils in Thailand because of the availability of relatively cheap seed (US$2–3/kg) (Hare *et al*. 2005), despite poor dry season forage production. The results from the current study suggest that Toledo palisade grass, the brachiaria hybrids and Purple guinea would be more productive than ruzi grass on these upland soils, especially during the dry season. Further studies are needed to ensure that the increased dry matter production can be reflected in improved animal performance.

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