Seed production of two brachiaria hybrid cultivars in north-east Thailand. 3. Harvesting method

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Abstract

Two field trials were conducted during 2003–2005 in north-east Thailand to investigate the seed yield and seed viability of 2 brachiaria hybrid cultivars, Mulato (Brachiaria ruziziensis × B. brizantha) and Mulato II (B. ruziziensis × B. decumbens × B. brizantha) from a range of non-destructive manual harvesting methods and the method of manual ground recovery of fallen seed.

Tying light-weight nylon net bags over seed-heads at anthesis to collect seed yielded 82% and 38% more Mulato seed in 2003 and 2004, respectively, than 3 methods of hand knocking seed from seedheads. In 2005, the nylon net bag method produced twice as much seed of Mulato II (508 kg/ha) as 3 methods of knocking seed from seedheads (252 kg/ha). Seed yields from ground sweeping produced the lowest seed yields in 2004 (Mulato) and 2005 (Mulato II). Seed viability was lower in ground-swept Mulato II seed than in seed from other harvesting methods.

The difficulties of manually harvesting brachiaria hybrids by farmers in Thailand and prospects for improving seed yields are discussed.

Introduction

Low seed yields (less than 200 kg/ha) of 2 brachiaria hybrid cultivars, Mulato (Brachiaria ruziziensis × B. brizantha) and Mulato II (B. ruziziensis × B. decumbens × B. brizantha), have resulted in commercial seed prices being 3–4 times those of seed of other commercial brachiaria cultivars. The high price and limited availability of commercial seed have been obstacles to the widespread uptake of brachiaria hybrids by farmers.

Field trials commenced at Ubon Ratchathani University, Thailand, in 2003, to investigate agronomic management of brachiaria hybrids in order to increase seed yields. Two previous papers reported the effects of method and time of planting (Hare et al. 2007a) and closing date defoliation (Hare et al. 2007b) on seed production of Mulato and Mulato II. This paper reports the effects of harvesting method.

Harvesting of tropical grass seeds is done by a single destructive harvest of the standing crop, multiple non-destructive harvests from the standing crop or ground recovery of seeds shed from the standing crop (Loch and Souza 1999). In Australia, harvesting is mechanised, and in Brazil, harvesting, which was generally manual a decade ago, has become predominantly mechanised. In Thailand, as in other tropical developing countries, harvesting is predominantly manual, because of low costs and the ready availability of hand labour.

A single destructive harvest removes all the moist seedheads in one cut, either with a combine harvester or manually by sickles. Seedheads cut manually can immediately be threshed to remove seed or threshed after drying in a stook or sweating in a piled stack for a few days before threshing (Loch and Souza 1999). However, seeds from a single destructive harvest usually contain a very high proportion of immature seeds, which can be up to 70% in a seedlot (Hopkinson and English 1985). Improvements in management and direct heading of B. decumbens seed crops in

Readers should note that all Brachiaria spp. mentioned in this article, as well as humidicola, are now generally regarded by taxonomists as being of the genus Urochloa, taking this generic name, while retaining their earlier individual specific names. The use is spreading, is already found in seed-testing reports, and will probably be adopted eventually in pasture science. Meanwhile, Tropical Grasslands will treat both generic names as valid. Ed.
Australia have improved seed yields (Hopkinson and Clifford 1993). Seed crops are heavily fertilised to cause lodging and the seed allowed to fall and accumulate on the leaf mat, before being harvested in a single destructive harvest by powerful axial-flow combine harvesters.

The aim of multiple, non-destructive harvests is to avoid harvesting immature seeds and to leave these seeds intact after harvest to allow them to continue ripening on the plant. Multiple, non-destructive harvests are best done by hand (Kowithayakorn and Phaikaew 1993: Phaikaew et al. 1993). Generally, manual harvesting produces higher seed yields and better quality seed than machine harvesting (Humphreys and Riveros 1986). In countries that have a high wage structure, beater harvesters, brush harvesters and stripper harvesters successfully multiple harvest non-destructively a range of grass species (Loch and Souza 1999), but these species do not include brachiaria.

Ground recovery of fallen grass seed is the common harvesting practice in Brazil, either by manual sweeping, with tractor-mounted sweeping brooms or with specially designed self-propelled brachiaria seed harvesters (Loch and Souza 1999; Souza 1999). Ground-swept seed is favoured in the South American market because of its high germination, high vigour and low dormancy (Souza 1999). However, purity levels are low, ranging from 25–40% PGS in the formal seed trade market.

In Thailand, grass seed harvesting has always been carried out manually, progressing over the past 3 decades from single, destructive harvests to multiple, non-destructive harvests. Ground recovery of fallen seed is used to harvest only *Stylosanthes* species (Hare and Phaikaew 1999) and has not been practised with grass seed crops, because of the likelihood of wet conditions at harvest time. With single, destructive harvests, crops are either hand cut with sickles and immediately threshed (*B. ruziziensis* and *Paspalum plicatulm*), or cut and then sweated before threshing (*Panicum maximum*). Research studies, however, have found that higher seed yields in Thailand are obtained from multiple, non-destructive manual harvests, with seedheads tied into living sheaves and the seed knocked daily into seed-net receptacles (Kowithayakorn and Phaikaew 1993: Phaikaew et al. 1993). Daily knocking of *B. ruziziensis* (ruzi grass) yielded 50% more seed than cutting and sweating (233 vs 155 kg/ha) (Phaikaew and Pholsen 1993), and 95% more seed of *P. atratum* (Ubon paspalum) was harvested by daily knocking (230 kg/ha) than by cutting and sweating (118 kg/ha) (Hare et al. 1999). This method of daily knocking seedheads is now used by the majority of smallholder seed growers in Thailand to harvest ruzi grass, guinea grass (*P. maximum* cv. Purple) and Ubon paspalum.

Seed yields can be substantially increased by tying light-weight nylon net bags over the seedheads and allowing mature seed to fall into these bags. The seed is collected every 4–7 days from the bags. Guinea grass yielded 39% more seed by the nylon net bag method (793 kg/ha), than by knocking seedheads every 3–5 days (572 kg/ha) (Phaikaew et al. 1996). Ubon paspalum yielded 76% more seed with nylon net bags (636 kg/ha) than by knocking seedheads every 3 days (362 kg/ha) (Phaikaew et al. 2001). Neither of these studies compared daily knocking of seedheads with collecting seed in nylon net bags.

In order to increase seed yields of brachiaria hybrids, we investigated several multiple, non-destructive manual harvesting methods that are used to harvest other grass species in Thailand and the method of manual ground recovery of fallen seed as is used in Brazil. The hypothesis tested in this research was that the method of collecting seed from nylon net bags tied over seedheads of brachiaria hybrids would produce higher seed yield and better seed quality than other manual harvesting methods. The objective was to measure seed yield and seed quality from 3 harvesting methods: nylon net bag collection; the common method used by farmers in Thailand of knocking tied seedheads; and the method used in Brazil of sweeping seed from the ground.

**Materials and methods**

Two field trials were conducted in Ubon Ratchathani province, north-east Thailand (15°N, 104°E; 130 m asl; AAR 1593 mm) on the Ubon Ratchathani University farm in a 0.15 ha field from 2003 to 2005. Annual rainfall was recorded at the trial site (Figure 1). The field trial site was on an upland sandy low humic gley soil (Roi-et soil series) (Mitsuchi et al. 1986). Soil samples to 10 cm, taken in May 2003, showed that the soil was acid (pH 4.8; water method), and low in
有机物（0.9%），N（0.03%），P（4.9 ppm；Bray II提取方法）和K（53.6 ppm）。

Prior to cultivation, the site had been planted to Digitaria milanjiana cv. Jarra for 3 years.

**Trial 1 – Effect of harvesting method on seed yield and seed quality of Mulato**

In both 2003 and 2004, 5 harvesting methods were compared in a 4-replicate, randomised complete block field experiment, on second-year Mulato fields, planted in May 2002 and May 2003, respectively, with plants spaced at 50 cm × 50 cm. Each plot measured 4 m × 5 m.

The treatments were:
1. Knocking daily — seedheads tied up and knocked once every day.
2. Knocking every 2 days — seedheads tied up and knocked once every 2 days.
3. Knocking every 3 days — seedheads tied up and knocked once every 3 days.
4. Nylon net bag — nylon net bag tied over seedheads and seed collected every 7 days from the bag.
5. Ground sweeping — seed swept from the ground after all seed had fallen.

Pre-trial preparation included cutting the fields (5 cm above ground level) to remove all the forage at the beginning of June and August in both years. Fertiliser was applied to all plots on June 3, August 4 and September 20 in 2003 (160 kg/ha NPK 15:15:15 on each occasion) and on June 3, July 3, August 3 and September 3 in 2004 (200 kg/ha NPK 15:15:15 on each occasion).

At anthesis in mid-October of each year, all seedheads in the knocking and nylon bag treatment plots were tied and nylon net bags tied over seedheads in Treatment 4. In the knocking treatments (Treatments 1–3), seedheads were knocked in large cloth bags in the morning on the appropriate days to remove mature seed. In Treatment 5 plots, in the first week of December of each year, all plants were cut to ground level and removed, and the fallen seed hand-swept from the ground.

Harvested seed from Treatments 1–4 was dried slowly on trays inside a laboratory. Seed from Treatment 5 was already dry at harvest. Seeds were cleaned through hand screens and a South Dakota seed blower to 99.0% seed purity.

Data collection included seed yield and seed weight corrected to 10% seed moisture content and seed viability (tetrazolium tests TZ).

**Trial 2 – Effect of harvesting method on seed yield and seed quality of Mulato II**

In 2005, on a first-year-planted Mulato II field, 5 harvesting methods were compared in a 4-replicate, randomised complete block experiment. Mulato II tillers were planted at spacings of 1 m × 50 cm on May 31. Each plot measured 4 m × 5 m.

The treatments were:
1. Knocking daily — seedheads tied up and knocked once every day.
2. Knocking twice daily — seedheads tied up and knocked twice (morning and late afternoon) each day.
3. Knocking every 2 days — seedheads tied up and knocked once every 2 days.
4. Nylon net bag — nylon net bag tied over seedheads and seed collected every 7 days from the bag.
5. Ground sweeping — seed swept from the ground after all seed had fallen.

Pre-trial management included cutting the field on August 2, 2005 to 5 cm above ground level and removing all forage. Fertiliser was applied on August 2 (200 kg/ha NPK 15:15:15) and October 6 (200 kg/ha urea).

At anthesis in late October, all seedheads in the plots were tied in Treatments 1–4 and nylon bags were placed over seedheads in Treatment 4. Ground-swept seed in Treatment 5 was collected in the first week of December. Seed harvesting, seed cleaning and data collection were the same as in Trial 1.

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

**Results**

**Rainfall**

Rainfall at the trial site was below the 13-yr (1992–2004) mean of 1538 mm/annum in the first 2 years of the study (1430 mm and 1045 mm) and similar to the mean in the third year (1545 mm) (Figure 1). The second year, 2004, was particularly dry, with rainfall 30% below the mean. Wet season rain finished early in mid-September, 2004, and most seed crops in Trial 1 were severely moisture-stressed during seed-set
in October and November. In contrast, in 2005, 433 mm in September and 50 mm in November resulted in soil moisture levels remaining high during seed-set and seed-maturation in Trial 2.

**Trial 1 – Effect of harvesting method on seed yield and seed quality of Mulato**

Nylon net bags tied over the seedheads to collect seed produced the highest Mulato seed yields in both years (Table 1). The seed yield from nylon net bags was 82% (2003) and 38% (2004) more than the yield from the 3 methods of knocking seedheads. Knocking produced 90% more seed than ground sweeping in 2004 but similar yields in 2003.

Seed viability of Mulato was not affected by harvesting method in 2003, but in 2004, seed knocked every 2 days had lower viability than seed harvested by other methods (Table 1).

**Trial 2 – Effect of harvesting method on seed yield and seed quality of Mulato II**

The nylon net bag method produced the highest Mulato II seed yield, twice those from the 3 methods of knocking seedheads (Table 2). Sweeping Mulato II seed from the ground produced a much lower seed yield, lighter seed and seed with lower viability than other harvesting methods.

<table>
<thead>
<tr>
<th>Harvest method</th>
<th>2003</th>
<th>2004</th>
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<tbody>
<tr>
<td>Seed yield (kg/ha)</td>
<td>Seed viability (%)</td>
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<tr>
<td>Knocking daily</td>
<td>49.4</td>
<td>168.6</td>
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<td>Knocking every 2 d</td>
<td>40.6</td>
<td>123.9</td>
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<td>Knocking every 3 d</td>
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<td>Nylon net bag</td>
<td>83.8</td>
<td>8.89</td>
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<td>Ground sweeping</td>
<td>42.5</td>
<td>ns</td>
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<td>LSD P&lt;0.05</td>
<td>18.6</td>
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<th>Harvest method</th>
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<tr>
<td>Seed yield (kg/ha)</td>
<td>TSW¹</td>
<td>Seed viability (%)</td>
</tr>
<tr>
<td>Knocking daily</td>
<td>49.4</td>
<td>8.50</td>
</tr>
<tr>
<td>Knocking every 2 d</td>
<td>40.6</td>
<td>8.73</td>
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<td>7.99</td>
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<tr>
<td>LSD P&lt;0.05</td>
<td>18.6</td>
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¹ 1000-seed weight.

**Table 2.** Effect of harvesting method on Mulato II seed yields and seed viability (Trial 2).

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<th>Harvest method</th>
<th>2003</th>
<th>2004</th>
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<tr>
<td>Seed yield (kg/ha)</td>
<td>TSW¹</td>
<td>Seed viability (%)</td>
</tr>
<tr>
<td>Knocking daily</td>
<td>230.2</td>
<td>8.79</td>
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<tr>
<td>Knocking twice daily</td>
<td>271.2</td>
<td>8.68</td>
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<tr>
<td>Knocking every 2 d</td>
<td>254.6</td>
<td>8.94</td>
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<tr>
<td>Nylon net bag</td>
<td>509.4</td>
<td>9.03</td>
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<tr>
<td>Ground sweeping</td>
<td>87.3</td>
<td>8.20</td>
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<tr>
<td>LSD P&lt;0.05</td>
<td>73.2</td>
<td>0.38</td>
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</table>

¹ 1000-seed weight.
Discussion

Choosing an appropriate method to harvest brachiaria hybrids is extremely important for producing good seed yields, to enable high quality seed to be commercially available to farmers at a reasonable price. In South America, seed yields must reach at least 500 kg/ha in order to compete in price with other commercial brachiaria cultivars, which average 600–700 kg/ha from mechanised ground sweeping (Souza 1999). In our trials, only Mulato II produced more than 500 kg/ha by using the nylon net bag method to harvest seed.

The nylon net bag method produced substantially higher seed yields than knocking seedheads and ground sweeping for both Mulato and Mulato II. However, the highest seed yield of Mulato was just over 200 kg/ha, less than half that produced by Mulato II. After 3-years research, this was the highest seed yield we could achieve with Mulato in Thailand. Farmers in Thailand harvesting Mulato seed by daily knocking have also experienced very disappointing seed yields up to 100 kg/ha. With the persistently low seed yields, the Mexican seed company that released these brachiaria hybrids, Grupo Papalotla, has discontinued Mulato seed production in Thailand and instead will concentrate on Mulato II seed production.

In research trials, the nylon net bag method has consistently produced higher seed yields than knocking seedheads of guinea grass (Phaiakaw et al. 1996), Ubon paspalum (Phaiakaw et al. 2001) and now brachiaria hybrids in these trials. However, farmers have not adopted this harvest method for 2 reasons.

Firstly, experienced farmers, who give grass seed production their top priority, can achieve high seed yields, more than 800 kg/ha for guinea grass and Ubon paspalum and more than 600 kg/ha for Mulato II, by knocking seedheads 2 or 3 times per day (dawn, midday and in the evening). This attention to harvesting minimises losses from seed shedding. In our trials, harvesting is constrained by government working hours, with the first knocking between 08:00h and 10:00 h, and the second knocking between 15:00h and 17:00 h. Despite knocking twice daily, seed-shedding losses still occur.

Secondly, the nylon net bags are too expensive for farmers. Since Mulato II seedhead stems are fairly fragile, very light-weight nylon net material must be used to avoid breaking the stems with their weight. The nylon netting must be porous to allow air-flow through the bags. The netting is cut and sown into bags that have a small aperture at one end that can be untied every 4–7 days to collect seed. Each bag costs approximately US$0.25 (July 2006) and approximately 18 000 bags/ha are used for a cost of US$4500/ha. Farmers are currently being paid US$5/kg for Mulato II seed and, even if they produce 500 kg/ha, the cost of the nylon bags exceeds their gross returns. The bags can be used for several years, which reduces their cost per kg of seed produced, but apparently not sufficiently to be attractive to producers.

Some farmers, who are unable to give their full attention to daily grass seed harvesting, are examining using cheaper netting fabric and double row planting, so that more seedheads can be covered with one bag to reduce the number of bags. We are also studying the placing of cheap cloth mats down the rows to collect fallen seed.

Ground sweeping in our studies was unsuccessful. Yet in Brazil, this method has been the predominant seed-harvesting method of Brachiaria spp. for the past 2–3 decades, producing up to 700 kg/ha from either manual or machine sweeping (Souza 1999). In Thailand, we successfully sweep more than 900 kg/ha of stylo seed from the ground (Hare et al. 2007c). Hence, the fate of the fallen seed must be resolved. In Trial 2, ground sweeping Mulato II seed yielded 422 kg/ha less seed than from nylon net bags, but this amount of seed was not on the ground. The vegetative material was beaten to allow any seed in the foliage to fall to the ground before cutting and removing to clear the plots for sweeping.

We consider that some of the seed is eaten by ants and perhaps a smaller amount rots on the ground. Brachiaria hybrid seeds are relatively soft when they are shed and can be easily eaten by ants. Seed-harvesting ants are also active in stylo seed crops, but as stylo seeds are very hard, the ants eat only the seed testa and leave the hard seeds intact. Moist conditions during harvest, from either rain or heavy dews, could contribute to brachiaria hybrid seed rotting on the ground.

Despite very dry conditions in 2004, causing moisture stress from reproductive development until seed harvest, Mulato seed yields in Trial 1 in 2004 were nearly 3 times the yields produced in 2003, when crops suffered no moisture stress. The increase in seed yield was probably due to the increase in fertiliser (NPK), which increased from 160 kg/ha applied 3 times (2003),
to 200 kg/ha applied 4 times (2004). Similar seed yield increases occurred in the adjacent closing date defoliation trials, with increases in fertiliser increasing inflorescence numbers (Hare et al. 2007b).

A feature of the studies was the very high levels of pure viable seed, especially with Mulato II in Trial 2. We cleaned the seed to 99.0% purity and, with 90.5% seed viability, produced 89.5% pure live seed with nylon net bags (454 kg/ha pure live seed). These levels are many times greater than the Brazilian legal minimum seed quality standards of 10–24% pure live seed, although seed traded internally in Brazil is mostly 25–40% pure live seed with high levels of soil (Souza 1999). The highest quality Mulato II seed is produced in the first week of harvesting, when seed is green and hard at harvest and constitutes about 9% of the total seed harvest. Seed harvested after the first week is brown, light, soft and usually empty, but makes up nearly 90% of the seed lot. This light seed is of low viability (0–5%) and is removed during cleaning and winnowing. Experienced Mulato II seed producers in Thailand stop harvesting seed once this light brown seed starts to appear during harvesting, as they know that this seed will be blown off during seed cleaning. Less experienced farmers continue to harvest all seed, but end up with a large pile of light, empty seed outside their cleaning stations.

Achieving good seed yields of the current brachiaria hybrids has been a difficult process. After 3-years research, we have been unable to produce satisfactory seed yields of Mulato. To achieve over 500 kg/ha from Mulato II has been very encouraging. Several farmers are producing Mulato II seed yields of over 600 kg/ha. These yields are far better than experimental seed yields of ruzi grass (30–80 kg/ha) or other Brachiaria spp. (negligible seed yields) in earlier trials on the same site (Hare et al. 2005) and above experimental seed yields of ruzi grass (233–350 kg/ha) reported elsewhere in Thailand (Kowithayakorn and Phaikaew 1993; Phaikaew and Pholsen 1993). However, the seed yields achieved to date for Mulato II are lower than commercial seed yields of 650 kg/ha for Marandu (B. brizantha) and Basilisk signal grass in Brazil (Souza 1999) and of up to 1000 kg/ha for Basilisk signal grass in Australia (Hopkinson and Clifford 1993). The high signal grass seed yields in Australia were achieved only following nearly 20-years research and development in harvesting technology, which increased seed yields 10-fold.

We have conducted only 2-years research on seed production of Mulato II and consider that, with more agronomic management and improvements in harvesting methods, further increases in Mulato II seed yields in Thailand are possible.

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References


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