

# Brachiaria hybrids: potential, forage use and seed yield

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## ABSTRACT

A brachiaria breeding program initiated in 1988 at CIAT (Centro Internacional de Agricultura Tropical) combined desirable attributes found in accessions of *Brachiaria brizantha* and *B. decumbens*. Three apomictic hybrids have been released (cvs. Mulato, Mulato II and Cayman). Mulato showed agronomic potential but seed yields were low. Trials in Central America demonstrated the superiority of Mulato II, a vigorous grass with very deep and branched roots, giving it excellent drought resistance in the Brazilian Cerrado and Mexico. Mulato II has excellent nutritional value. Following trials in Mexico and Thailand, evaluating 155 new hybrids for 7 years, cv. Cayman was released due to strong waterlogging tolerance. Research conducted on growth, quality, production, persistence and seed yields of brachiaria hybrids in Asia, Central America and Africa from 2003 to 2013 is summarized in the paper.

**Additional keywords:** Forage quality, seed production, forage regrowth.

## INTRODUCTION

The registration of Mulato hybrid brachiaria (*Brachiaria ruziziensis* x *B. brizantha*) by Grupo Papalotla in 2004 (Miles *et al.* 2004) and the granting of Plant Variety Rights in 2002, marked a significant breakthrough for tropical perennial forage cultivars.

Up until 2001, *Brachiaria* spp. cultivars used commercially were derived without genetic modification directly from natural collected germplasm from Africa or selected from germplasm collections in Australia and in tropical America. The development in Belgium of a tetraploidized sexual ruzigrass (*B. ruziziensis*) (Swenne *et al.* 1981) and with further studies by Ndikumana (1985) and Valle *et al.* (1994), led to Dr Cacilida B. do Valle of Embrapa (Centro da Empresa Brasileira de Pesquisa Agropecuária) providing tetraploid, sexual ruzigrass to CIAT in 1988. The breeding program at CIAT, led by Dr John W. Miles, combined desirable attributes found in accessions of *B. brizantha* and *B. decumbens*.

In 2001, Grupo Papalotla was granted the exclusive rights worldwide, to produce, research, and commercialize the first generation of Brachiaria hybrids developed by CIAT from 2001-2010, under a contract of exclusivity signed with the Mexican seed company Grupo Papalotla. Mulato showed considerable agronomic potential but seed yields were low (Hare *et al.* 2007a). Trials in Central America then demonstrated the superiority of Mulato II, a vigorous grass with very deep and branched roots, giving it excellent drought resistance in the Brazilian Cerrado and Mexico. Mulato II seed yields in Thailand were between 60 and 100% more than the highest seed yields of Mulato (Hare *et al.* 2007b; 2007c). From 2003-2008, further detailed studies were conducted in Mexico and Thailand on 155 new brachiaria hybrid lines resulting in four lines, CIAT BRO2/1718, BRO2/1752, BRO2/1794 and CIAT BRO2/0465 being granted Plant Variety Rights. CIAT BRO2/1752 produced similar dry matter yields to Mulato II, but in trials in Mexico demonstrated good water logging tolerance.

This paper will summarize the considerable research conducted on growth, quality, production, persistence and seed yields of brachiaria hybrids in Asia, Central America and Africa from 2003 to 2013.

## REGIONAL EVALUATIONS AND RESEARCH

### Asia

Field studies at Ubon Ratchathani University, Thailand (15°N), between 2003 and 2007, showed that Toledo palisade grass (*Brachiaria brizantha*), Mulato and Mulato II produced more total dry matter and leaf dry matter, particularly during the dry season than other brachiaria grasses (Hare *et al.* 2009). Mulato II also produced significantly more leaf than the other brachiaria grasses in the studies (Hare *et al.* 2009). It has

been the production of green leaves by Mulato II that has made it extremely attractive forage for livestock (Mutimura and Everson 2012).

From 2005 to 2008, 15 hybrid brachiaria lines were evaluated at Ubon Ratchathani University for dry production and quality and seed production (Table 1). Only two lines, BRO2/0465 in the wet season in Trial 1 and BRO2/1752 in the wet season in Trial 2, produced more dry matter than Mulato II. BRO2/0768 was the only line that produced a higher percentage leaf DM than Mulato II, in the wet season of Trial 1 and in the dry season of Trial 2 (Table 1). BRO2/1794 produced significantly more seed than all the other hybrids in both trials. Mulato II, BRO2/1752, BRO2/0465 and BRO2/1718 produced similar seed yields, averaging 150 kg/ha.

**Table 1. Average wet season (May-October) and dry season (November-April) dry matter yields and leaf percentage of hybrid brachiaria lines from 2006 to 2008 in Ubon Ratchathani, Thailand**

Hybrid brachiaria	Dry matter yields				Leaf percentage				Pure seed yields	
	Trial 1		Trial 2		Trial 1		Trial 2		Trial 1	Trial 2
	Wet	Dry	Wet	Dry	Wet	Dry	Wet	Dry	(kg/ha)	
	(kg/ha)				(%)				(kg/ha)	
Mulato II	8674	2886	10566	2801	74	91	72	83	129	141
Cayman	9252	2837	12597	3059	62	84	55	79	136	108
BRO2/0465	11477	3050	11594	2861	68	86	66	78	166	144
BRO2/1794	9420	2655	11149	2901	58	81	55	77	277	244
BRO2/1718	8569	2517	10394	3318	69	87	67	76	172	197
BRO2/1747	8728	2950	10539	2752	61	83	56	77	88	107
BRO2/1245	8889	3348	10399	2773	68	79	64	79	76	37
BRO2/0771	9032	3447	10866	2955	74	82	71	82	52	76
BRO2/0799	9282	2646	10734	2492	66	86	63	83	114	90
BRO2/1372	7602	2966	8722	3212	70	83	66	77	36	22
BRO2/1728	9515	2966	10558	2834	61	83	56	80	99	79
BRO2/0768	8542	3219	10653	3078	80	90	74	88	142	123
BRO2/1485	8901	3287	11790	2984	71	80	65	80	39	55
BRO2/1452	7451	2343	7667	2126	67	79	67	80	85	113
MXO2/1423	8809	3090	11076	2624	62	78	56	75	61	24
MXO2/1263	10853	3178	10859	2670	66	83	66	80	84	83
LSD (P<0.05)	2060	751	1349	569	4.9	4.8	3.8	4.4	69	64

From 2008 to 2011, a further 28 hybrid brachiaria BRO6 lines were evaluated alongside Mulato II, Marandu, Toledo and promising BRO2 lines, 1794, 0465, 1718 and 1372. None of the BRO6 lines produced significantly more dry matter than Mulato II. Mulato II produced significantly higher percentage of leaf DM than all the other lines in both the wet season and dry season, except for BRO6/1922 in the dry season. Mulato II and BRO2/1718 produced significantly more seed than all the BRO6 lines. In this trial, BRO2/1794 produced less seed than Mulato II, BRO2/1718 and BRO2/0465.

Field trials conducted by the Thailand Department of Livestock Development (DLD) from 2004 to 2006 in northern Thailand (18°N; 319 m.a.s.l.), showed that Mulato and Mulato II produced significantly higher DM yields than ruzi grass, but ruzi grass produced 3-4 times the seed yields of Mulato and Mulato II (Phunphiphat *et al* 2007). In the dry season, Mulato and Mulato II produced 60% more DM than ruzi grass. In seed production trials conducted by DLD from 2007 to 2008 in northern Thailand at the same location, Mulato II produced significantly more seed (500 kg/ha) than Cayman (290 kg/ha), BRO2/1718 (250 kg/ha), BRO2/1794 (390 kg/ha), BRO2/0465 (145 kg/ha), Mulato (220 kg/ha), ten MXO2 lines (180 kg/ha), eight BRO4 lines (157 kg/ha) and twenty BRO5 lines (40 kg/ha).

In further trials conducted in Thailand by DLD, showed that digestible dry matter of Mulato II and three hybrid brachiaria lines was excellent. Leaf digestible matter averaged 75% and stem digestible dry matter averaged 60%.

Research from 2005-2007 at the Tropical Pasture Research Center, Chinese Academy of Tropical Agricultural Sciences (CATAS) in Hainan, China (19°N), on acid soils (pH 4.9-5.5), under medium annual rainfall of 1600 mm, found that Mulato and *B. brizantha* cv. Reyan 6 produced significantly more DM than Mulato II, *B. decumbens* and *B. humidicola*. Even though Mulato II had a higher leaf:stem ratio. In Guangxi, China (25°N), Mulato II was found to be very susceptible to winter cold, with only 5% plant survival in May, following two days below -1°C in December. This was similar to results from Florida, USA, where

Mulato II pastures can be considerably weakened by winter cold temperatures below 0°C and recover slowly in the spring (Vendramini *et al.* 2012).

### *The Americas*

Seed production trials were conducted at Warnes, Bolivia (19°S; 423 m.a.s.l.) from 2007 to 2010 on hybrid brachiaria lines BRO5, MXO2 and BRO4. Over four years, only one new line, MXO2/2552, produced more seed than Mulato II and this was due to the high seed yield in 2010. In 2009, seed yields were low overall, due to dry conditions during anthesis and seed set. Further trials from 2008-2010 at the same location, found that none of the BRO6 lines produced significantly more seed than Mulato II.

In Mexico, evaluations on the hybrid brachiaria collections commenced in 2005 at Santa Elena, Oaxaca (16°N, (4-8 m.a.s.l. 800-1200 mm annual rainfall, 6-8 months dry season) on very sandy soils, with low organic matter, low N and low P and a pH of 5.6. To date, studies have been conducted on 15 BRO2 lines, 38 BRO5 lines, 28 BRO6 lines and 74 BRO9 lines.

Within the BRO2 lines, four lines (1718, 0465, 1752 and 1794) were selected from the Mexico and Thailand studies and released after gaining PVR. Further trials with BRO2/1752 showed that it displayed superior waterlogging tolerance compared to Mulato II and 38 BRO6 lines. BRO2/1752 has been released as cultivar Cayman.

The potential dry matter production of three released cultivars (Mulato II, Cayman, BRO2/0465) found that 120 days after cutting, Mulato II produced 30 tonnes, Cayman 21 tonnes and BRO2/0465 18 tonnes of DM/ha. Hay was made from the 120 day-old forage and the regrowth after 30 days found that Cayman and BRO2/0465 produced significantly more dry matter (700-740 kg/ha DM) than Mulato II (100 kg/ha DM).

In the USA, studies at the University of Florida, Beef Research Unit (29°N; 45 m.a.s.l.) from 2010-2011, have been conducted on forage production, nutritive value and persistence of Mulato II and Cayman under grazing conditions (Lynn Solllenberger, Andre Soares, Joao Vendramini pers. comm.). Under intensive grazing every two weeks, both hybrids had significantly higher percentage of leaf (70-80%), crude protein (19-21% in leaves, 10-12% in stems) and IVDOM (73-75% leaf, 59-61% stem) than grazing every 4 and 6 weeks, similar to the high quality achieved under cutting in Thailand.

### *Africa*

Improved hybrid brachiaria grasses were evaluated in Rwanda (2°S) at a lower rainfall site (1400 mm/year) and a higher rainfall site (1800 mm/year) that had high Al levels (47 meg/100g of soil), against an indigenous signal grass (*B. decumbens*) and a naturalized buffel grass (*Cenchrus ciliaris*). At the low rainfall site, the improved brachiaria cultivars, BRO2/1485 and the local *B. decumbens* accession produced more dry matter than buffel grass and Brachiaria hybrids BRO2/0465 and BRO2/1452. Farmers were asked to rank the grasses and they selected Mulato II as the preferred cultivar at both sites, because of its production of green forage all year round without any input of fertilizer, high above ground biomass production, palatability, drought tolerance, quick regrowth, persistence, being a perennial, and being easy to cut and carry (Mutimura and Everson 2012).

## **COMMERCIAL PASTURE DEVELOPMENT**

In Vietnam, Mulato II is used as cut-and-carry forage for dairy farmers because of its high protein levels, high palatability and high digestibility (Raf Somers pers. comm.). In Thailand, Laos and Malaysia, expansion of Mulato II has been slow, due to the strong competition from far cheaper ruzi grass seed produced in Thailand.

In the Pacific region, over 10,000 hectares of Mulato II pastures have been established in Vanuatu since 2007 where it is primarily used for beef cattle grazing. In Africa, Mulato II pastures have been established on nearly 1000 smallholder farms in Kenya, Tanzania and Ethiopia and on larger farms in Congo and Uganda. In Rwanda, 50 hectares of Mulato II have been planted to provide planting material for farmers to plant vegetatively. In Burundi, Mulato II is currently being evaluated on research stations.

In the Americas, nearly 200,000 ha of Mulato II pastures have been established since 2005 for both dairy and beef cattle grazing.

## **COMMERCIAL SEED PRODUCTION**

Mulato II and Cayman seed production in Thailand and Laos is harvested by hand. In Thailand, the seed is ground-swept and in Laos the seed is harvested by knocking the seed from seedheads. The seed is hand cleaned by the farmers and then acid scarified in Thailand to reach 98% purity, 90% seed viability and 80% seed germination.

In Central and South America, seed is only produced in Mexico (Mulato II and Cayman) and Brazil (Mulato II). All the seeds are ground-swept using machinery (Pizarro *et al.* 2010). The seeds are cleaned and acid-scarified at a central locality in each country.

## CONCLUSION

Since 2003, considerable amounts of research have been conducted on 155 hybrid brachiaria lines in Central and South America and in Asia, and only one new named cultivar released, Cayman in 2011. The outstanding waterlogging tolerance of Cayman has added a new dimension to the hybrid brachiaria collection. Research is continuing to evaluate the new BRO9 collection to select lines that with high seed yields and high forage quality, that either display characteristics of persistence and tolerance to grazing, or have outstanding drought tolerance, or are upright with high dry matter yields for cut-and-carry forage systems, or display good shade tolerance.

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## REFERENCES

- Hare MD, Tatsapong P, Saiprasert K (2007a) Seed production of two brachiaria hybrid cultivars in north-east Thailand. 1. Method and time of planting. *Tropical Grasslands* **41**, 26-34.
- Hare MD, Tatsapong P, Saiprasert K (2007b) Seed production of two brachiaria hybrid cultivars in north-east Thailand. 2. Closing date. *Tropical Grasslands* **41**, 35-42.
- Hare MD, Tatsapong P, Saiprasert K (2007c) Seed production of two brachiaria hybrid cultivars in north-east Thailand. 3. Harvesting method. *Tropical Grasslands* **41**, 43-49.
- Hare MD, Tatsapong P, Phengphet S (2009) Herbage yield and quality of *Brachiaria* cultivars, *Paspalum atratum* and *Panicum maximum* in north-east Thailand. *Tropical Grasslands* **43**, 65-72.
- Miles JW, Valle CB, do, Rao IM, Euclides VPB (2004) Brachiariagrasses. In "Warm-season (C<sub>4</sub>) grasses" (Eds LE Moser, LE Burson, LE Sollenberger) *Agronomy Monograph* **45**, 745-783 (ASA, CSSA, SSSA, Madison, WI, USA).
- Mutimura M, Everson TM (2012) On-farm evaluation of improved *Brachiaria* grasses in low rainfall and aluminium toxicity areas of Rwanda. *International Journal of Biodiversity and Conservation* **4** (3), 137-154.
- Ndikumana J (1985) Etude de l'hybridation entre espèce apomictiques et sexuées dans le genre *Brachiaria*. PhD. Dissertation. Université Catholique de Louvain, Louvain-La-Neuve, Belgium.
- Pizarro EA, Hare M, Antezana Rojas JH, Ramon RR, Miranda IG, Chavez Chena A, Balbuena A, Miles J (2010). Harvest methods and seed yield potential in *Brachiaria* hybrids. In: Proceedings of the Seventh International Herbage Seed Conference (Eds GR Smith, GW Evers, LR Nelson) Dallas, Texas USA. 11 – 13 April 2010. pp: 33-37.
- Phunphiphat R, Phaikaew C, Phunphiphate W, Nakamane G (2007) *Brachiaria* hybrids regional adaptability test. 2. Yield and chemical composition of herbage, seed yield and seed quality of Mulato, Mulato II and ruzi grass at Lampang. In Forages: A pathway to prosperity for smallholder farmers (Eds MD Hare, K Wongpichet) *Proceedings of an International Forage Symposium*. pp 353. (Faculty of Agriculture, Ubon Ratchathani University, Thailand).
- Swenne A, Louant BP, Dujardin M (1981) Induction par la colchicine de formes autotétraploides chez *Brachiaria ruzizensis* Germain et Evarrd (Graminée). *Agronomie Tropical* **36**, 134-141.
- Valle CB, do, Glienke C, Leguizamón GOC (1994) Inheritance of apomixes in *Brachiaria*, a tropical forage grass. *Apomixes Newsletter* **7**, 42-43.
- Vendramini JMB, Sollenberger LE, Lamb GC, Foster JL, Liu K, Maddox MK (2012) Forage accumulation, nutritive value, and persistence of 'Mulato II' brachiariagrass in northern Florida. *Crop Sci* **52**, 914-922.